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Review article

Theoretical and practical aspects of risk communication in food safety: A review study

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ABSTRACT

Currently, food safety hazards have introduced as one of the most important threats to public health worldwide. Considering numerous crises in the field of food safety at global, regional, and national levels, and their impact on the physical and mental health of consumers, it is very vital to evaluate risk communication strategies in each country. Food safety risk communication (FSRC) aims to provide the means for individuals to protect their health from food safety risks and make informed decisions about food risks. The purpose of this study is to present FSRC as one of the key parts of risk analysis, its importance considering the prevalence of food contamination and recent crises related to food. Additionally, the stages of implementation of FSRC are mentioned. In FSRC, it is essential to comply with the principles and prerequisites. There are various strategies for FSRC nowadays. Different platforms for FSRC are rapidly evolving. Choosing and evaluating the appropriate strategy according to the target group, consensus of stakeholders, cooperation and coordination of risk assessors and risk managers have a significant impact in order to improve and implement FSRC.

1. Introduction

Nowadays, food safety hazards have globally turned into one of the most significant threats to public health. Food safety hazards may occur throughout the food chain [1]. Contamination in food is caused by microbiological hazards [2], residues of veterinary drugs [3], heavy metals [4], toxins [5] and pesticide residues [6], etc. The COVID-19 pandemic, caused by SARS-CoV-2, has also raised concerns around the world [1]. There is no evidence of possible transmission of the 2019 coronavirus disease (COVID-19) through food products. However, in a report on an outbreak in China in mid-June 2020, contamination of food with the causative agent of the COVID-19 pandemic, SARS-CoV-2, was discovered [7]. Additionally, food consumers all over the world are facing the risks of unsafe food due to fraud in seafood [8], edible vegetable oil [9], processed foods, edible agricultural products, beverages, meat, tea [10], etc. Conducting risk analysis can help in controlling and prevention of risks in the food chain from farm to fork [11]. Risk analysis came into existence as an institution in the 18th century with the emergence of modern cities that protect their residents through public service systems centrally organized. Expert-driven risk assessment gained dominance at the end of the 1940s with the introduction of various quantitative approaches (e.g., operations research and system assessment) [12]. In the United States, food safety had been a matter of importance for a long time preceding the establishment of the Society for Risk Analysis in 1980; however, a dearth of systematic approaches existed to evaluate food-associated risks [13]. This issue was followed by publishing numerous reports of food

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contamination, reaching a climax in a novel by Upton Sinclair, "The Jungle", calling attention to food and worker abuses in the meat-packing industry [14].

Major developments in agricultural and food technology noticeably gave rise to food production. Nevertheless, chemical exposures to agricultural and other activities led to considerable modifications to federal food laws, such as the Delaney Clause, particularly aiming at chemicals that cause cancer. In the 20th century, giving quantitative risk evaluation approaches higher scientific status in an influential National Research Council report further systematized food safety risk assessment [13]. The Food and Agriculture Organization (FAO) of the United Nations and the World Health Organization (WHO) have developed the food safety risk assessment [15].

The FAO/WHO conference (1991) regarding food standards, chemical agents in foods, and food trade suggested including the Codex Alimentarius Commission (CAC) responsible for the regulation of risk assessment in its decision-making process [16]. The CAC approved the conference's suggestion to establish its food safety and standards decisions regarding risk analysis and stimulated the related Codex committees to make their standard-setting methods consistent in 1993 [17].

Food safety risk analysis is composed of three interrelated constituents, namely risk assessment, risk management, and risk communication. This division was made based on the European Parliament in 2002 [18]. Risk assessment signifies a process based on science composed of several phases, such as identification and characterization of hazards, exposure analysis, and risk characterization [19]. Currently, risk assessments are carried out for the protection of food safety worldwide by different organizations within the United Nations. One of the most important organizations is the Codex Alimentarius, which has various committees related to food additives (Codex Committee regarding Food Additives: CCFA), food contaminants (Codex Committee regarding Contaminants in Food: CCCF), and pesticide residues (Codex Committee regarding Pesticide Residues: CCPR), operating globally to protect consumers' health, to ensure optimal measures for global food trade and coordinate and unify procedures in establishing standards. Additionally, the International Agency for Research on Cancer (IARC), in cooperation with the WHO, carries out activities related to risk assessment and coordination between epidemiological and laboratory studies and their relationship with cancer and control measures related to this disease. Since its inception, the IARC has assessed more than 1000 compounds (e.g., biological, chemical, radiological and behavioral, like shift work and consuming hot beverages) and categorized them based on their possible cancer development in humans [13].

The second part of the risk analysis process is risk management which is a procedure of problem identification, information request, risk assessment, and action initiation for the identification, evaluation, selection, implementation, monitoring, and modification of measures taken to change the rate of unacceptable risk to tolerable or acceptable. Risk management provides scientifically sound, cost-effective, integrated measures to decrease risks and also considering environmental, economic, social, political, cultural, and legal ethical factors [20]. A requirement for risk management at the national level is the global availability of data on sources and levels of hazards in foods. According to the international standard organization, risk management is defined as "coordinated activities to direct and control an organization with respect to risk". ISO 31000 defines risk management as a process that has six main activities: (1) communication and consultation. (2) creating context. (3) risk assessment. (4) risk treatment; (5) monitoring and review; and (6) recording and reporting. Recently, technologies in the form of smart solutions and automation have been integrated with management functions and due to the rapid progress of technology in social technical systems, risk management is faced with the challenges of considering emergency behaviors and non-linear causal relationships, regarding the management of risks that arise from the interaction of people and systems [21].

Finally, risk communication is considered in the procedure of risk analysis, which has a two-way relationship with risk assessment and management. Risk communication refers to the process of exchanging data and views about risks and factors associated with risks between risk evaluators, consumers, risk managers, and other stakeholders [22]. Food safety risk communication (FSRC) is the basis for risk management and risk assessment [23].

Today, people all over the world are bombarded with food messages in various ways (cooking magazines, TV shows, food blogs, etc.). Most of this information may be contradictory and not have a scientific and expert aspect, thus causing confusion for consumers [24]. No study is existed to present the implementation and different strategies of FSRC. Therefore, the purpose of this study is to introduce FSRC as one of the important parts of risk analysis, its importance considering the prevalence of food contamination and recent crises related to food. Also, the stages of implementation of FSRC are also mentioned. Finally, suggestions have been made in order to improve the effectiveness of FSRC in the future.

2. History of Food Safety Risk Communication

At first, risk communication mainly indicated crisis management, putting emphasis on the minimization of organizational risks in crisis situations. Until the 1980s, risk communication was not systematically combined with control and prevention programs, and there was no clear scope for information exchange between risk managers and the community. In general, in society, the risk management process was ignored until the risk reached a tolerable level. In the 1980s, the knowledge and awareness of the dangers threatening human health developed rapidly. At this time, risk managers became familiar with the concept of the food chain and the challenges brought about by long-term exposure, bioaccumulation, and delayed and chronic impacts of various chemical pollutants. During this period, food trade was created in an industrial and international way; however, physical measures, such as the inspection of products and factories producing food products, by local government authorities did not have the necessary efficiency and effectiveness in risk management. This situation motivated the food safety decision-makers to transfer some of the fundamental rules and methods of risk communication to society for risk management. During this period, risk managers realized that citizens did not have an understanding of scientific issues, written laws to control risks in food, and necessary interventions, and they were unable to play a role in reducing risks in comparison to expert guidelines. As a result, communication and legal measures aimed at creating food safety were

pursued unilaterally, and only real data and indicators related to avoiding critical conditions were provided to consumers through the media. In this process, information related to food safety was expressed as negative news by the media [12]. Additionally, in these years, communication campaigns in many scientific fields of study with reference to past events have depended on a deficit approach, supposing that consumers are only deficient in proper information. The purpose of these campaigns was to provide information for consumers to make the right decision. This method was widely accepted; nevertheless, it was not an effective and efficient method.

In 1992, it was focused on two substitute risk communication models that guided techniques to communicate food safety issues. The first one, used mostly by regulatory agencies, industries, and commodity groups, was a technique that sought to prove to the community that the United States food supply was among the safest worldwide. Established on the rules of social utility and paternalism, the fundamental reasoning of this technique was that the generally unknowledgeable community could not perceive the complicated matters entailed in the determination of the relative safety of a special chemical, pesticide, or biotechnology product. Therefore, experts are required for decision-making. The second emerging structure of risk communication reflected a more Jeffersonian approach. This viewpoint asserts that decisions on food safety are critical; therefore, they should not be taken by the experts. The community must be responsible for making the last decisions [25].

In the mid-1990s, a new model emerged that asked for public participation and made risk communication a two-way process. The purpose of communication activity at this stage was to develop the collection of information from the community. Within the 1990s and 2010s, numerous reforms were made for public participation, and socially acceptable conditions were formed. Collaborative strategies were employed to democratize risk communication between different departments. During this period, risk communication specialists and departments started to work professionally in the government bodies of countries. In public participation, there was a presupposition that consumers are somewhat aware, which can be the desired foundation for developing knowledge and changing attitudes [12]. For example, in a 2003 study in North Dakota, United States, an interdisciplinary, 3-day food safety training program was run for state agriculture and health department personnel, state meat inspection personnel, and rural veterinarians. The results of this course showed that the training led to an increase in the knowledge of food safety matters associated with the production and consumption of beef from the farm to the table [26].

Until the 2010s, the policy related to food safety was defined based on the presupposition that consumer behavior related to information is rational, and the limitation of human abilities in relation to a coherent understanding of risk and a consistent behavioral response was ignored. By passing time, it became evident that cognitive biases have an effect on behavioral biases, and attitudinal changes are difficult to create when they are dependent on education and awareness. Applying behavioral insight in policymaking is a hopeful ideology in the development of risk communication and is involved in the identification and perception of false consumer beliefs. Afterward, the conditions move toward execution, where policy instruments can be developed according to behavioral insights. According to the conceptualized human acts and daily activities, effortlessly practical measures can be designed and incorporated into consumer lifestyle with no change in fixed routines, considering the theory of practice, allowing the examination of human routine activities from a social science viewpoint.

This issue required a fundamental alteration in the working method of authority. In addition to two-way communication, surveys should be conducted in line with the real perceptions of consumer behavior [12]. Good examples of the above-mentioned situation can be observed during the coronavirus disease 2019 (COVID-19) pandemic. When some food safety officials surveyed individuals to gauge their understanding of the actions and fears regarding the pandemic food safety aspects and to examine consumer behavior under quarantine conditions. The COVID-19 pandemic gave rise to a condition of panic around the world. In this situation, trust in

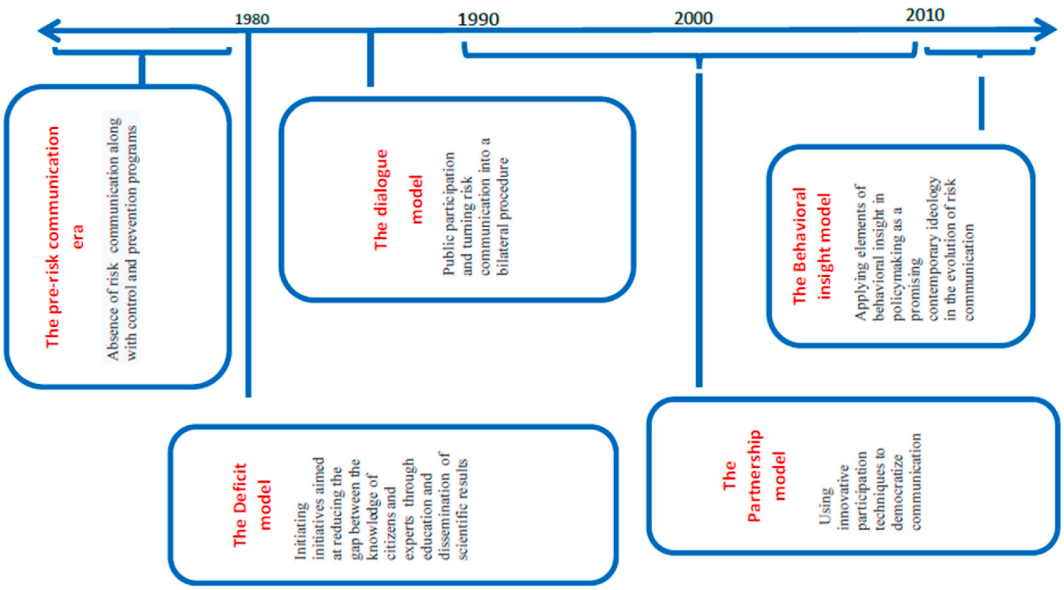

Fig. 1. History of food safety risk communication.

governments and scientific information is very important to reduce unnecessary fears and inappropriate perceptions of risk. Different messages were sent about its risk and the way of containing corona. In a study in several Arab countries based on a web-based survey, 1074 individuals from Jordan, Lebanon, and Tunisia were studied regarding their understanding of food and nonfood risks from infection and the impact of information sources, trust, and attitudes toward risk communication by local authorities. Based on the results, 70% of the participants were worried that COVID-19 can be transmitted through food. The understanding of risk of touching infected surfaces and food packaging and exposure to COVID-19 patients while food shopping was even higher. Only in less than half of the participants, the information provided by local authorities was regarded as reliable, and the related risk communication and reaction to wrong rumors were timely, efficacious, and apparent. Nevertheless, the satisfaction degree in the Jordanians was significantly higher compared to the Lebanese and Tunisian participants. The demographic determinants, trust in information, and viewpoints toward authority's performance in risk communication had no effect on risk understanding. Participants' knowledge was restricted on the basis of their information main sources, like local news media broadcasts, social media, and reports by the WHO. The conclusion was that inessential fear rises among the community when risks affecting health are unspecified [27]. Fig. 1 illustrates the history of FSRC from 1980 up to the present.

3. Importance of risk communication in food safety

FSRC is critical to protect animal, environmental, public, plant, and health and individuals' quality of life [28]. Risk communication is crucial for risk analysis and an indivisible component of the Risk Management Framework. The lack of risk communication leads to an increase in food-borne diseases and, subsequently, an increase in the burden on health care systems, an impact on the economic situation, and a threat to people's livelihoods. Because of the importance of this issue, WHO has created the Global Foodborne Infections Network (GFN). One of the tasks of this network is to strengthen cooperation and interdepartmental communication between microbiologists and epidemiologists in fields related to food [29]. In risk analysis, it is very important for people to understand the possibility of some hazards in food and their serious consequences if they occur [30]. If the information and cognitive gap between the sender and the receiver about the real risk and the risk perceived by the audience is resolved, risk communication will reduce the probability of risk [31]. Foodborne pathogens cause 600 million cases of illness and 420,000 mortalities every year [32]. Examples of recent food-related crises are listed in Table 1.

In a scenario where the public is increasingly concerned about food risks, risk communication can increase consumer self-care [46]. In a study conducted by Rembischevski et al., 2022 it was shown that most of the participants were worried about the chemical and technological risks related to food. This condition necessitates the use of effective risk communication strategies [47]. Also, in a study conducted by Sleboda et al., 2021, the positive effect of communication was shown on a group of consumers who initially had a negative attitude about GM foods and considered it risky [48]. Examples of recent chemical challenges related to food are mentioned in Table 2.

4. Prerequisites and principles of risk communication in food safety

When food safety issues are announced, it is necessary to communicate properly in order to reduce concern and increase consumer's trust [58]. Trust plays a significant role in the formation of risk perception and interpretation for consumers [59]. When the communication is transparent, continuous and inclusive, people's trust in the food safety system increases [60]. In a survey conducted in the United States, many participants trusted government agencies, health care professionals, and scientists to communicate food safety during COVID-19 [61]. The perception of risk is also important. Several factors affect the understanding of risk, like the risk perception, control, benefits from risk acceptance, information-related studies, and, most significantly, trust [62]. Based on the evidence, if a distrusted source offers information leading to an increase in its own vested interest, the information can affect individuals'

Table 1
Examples of some recent food-related crises in the different countries.

Causative agent	Country	Year of occurrence	Contaminated food	Reference
Fipronil[a]	European Union	2017	Egg	[33]
Listeria monocytogenes	South African	2017–18	Polony[b]	[34]
Listeria monocytogenes	Australia	2018	Melons	[35]
E. Coli, Salmonella spp	Iraq	2018	Water	[36]
Needle[c]	Australia	2018	Strawberry	[37]
Dioxin	Tropodo, Indonesia	2019	Egg	[38]
Shigella Sonnei	Al- Mafraq	2019	Hummus	[39]
Ethylene oxide	Europe	2020	Sesame seeds	[40]
Bongkerkic acid	China	2020	Homemade fermented corn noodles	[41]
Salmonella Enteritis	China	2020	Cake	[42]
Vibrio Parahaemolyticus	Thailand	2020	Sea food	[43]
Salmonella Typhimurium	Finland	2021	Frozen tomato cubes at a restaurant	[44]
Norovirus	Texas	2022	Ray oysters	[45]

[a] A kind of pesticide to treat red mite in poultry.
[b] Bologna sausage.
[c] Putting a sewing needle in fresh strawberries for economic profit.

Table 2
Examples of recent food chemical agent with challenges and probable adverse effects on health.

Chemical agent	Food/Dishes related to food	Challenges	References
Microplastic particles (MPs)	Reusable plastic bottled water, Single use plastic bottled water, Glass bottled water, Tap water, Raw water (ground water), seafood	The probable adverse impact of MPs on the environment and human diet	[49,50]
Heavy metals (Pb, Cd, As, Sn, Hg)	The possibility of the presence of Pb (in wine, seafood, fruits, meat, bread, and vegetables), Cd (in drinking water, dried seaweed, freshwater fish, shellfish, and mushrooms), As (in fish and shellfish), Sn (in metal canned foods), Hg (in fish and fish products)	Reducing the standard limits of heavy metals in animal and agricultural food products by Codex Alimentarius Commissions and European Union	[51]
Pesticide residues	Plant basis Foods	Increasing the productivity of food production, improving the quality of food, concern about the continuous human exposure to pesticides even in small amounts	[6]
Food additives	Packaged food, drink, sauces, sweets, soups, chewing gum, mustard yogurt, etc.	The bold role of using food additives in modern food industry, more use of artificial food additives, reducing the use of natural food additives	[52]
Polycyclic aromatic hydrocarbons (PAHs)	High temperature cooked red meat, deep-fat frying	The inevitable exposure of humans to PAH pollutants, due to the presence of these environmental pollutants everywhere and the carcinogenic and mutagenic effects of PAHs	[53]
Migrating substances	Bamboo, melamine cups, plastic packaging materials	The presence of melamine and formaldehyde resin, existence of migration of endocrine-disrupting chemicals into food from plastic packaging materials	[54,55]
Acrylamide/Furan	Starch-based foods such as bread, potatoes, biscuits, etc.	The possibility of carcinogenicity of acrylamide and Furan	[56]
Allergen	Peanut	The possibility of anaphylactic shock	[57]

attitudes oppositely to that being promoted before anything else. This impact is most probably to occur under conditions where the attitudes of an individual were not well-formed or shaped prior to receiving the information. That is to say, the information receivers will be more opposed against the messages promoted by the information source compared with the time before receiving [63]. The relationship of trust with risk and food safety concerns has been extensively examined in media and information-related investigations. Furthermore, the communication during the crisis and after it (especially the crises related to the safety of food products), affects the perception, trust, attitude and intention of consumers towards food producing companies [64].

Economically, trust in institutions or individuals (i.e., the suppliers of food or government/regulators) should be considered regarding consumers' buying behavior. Determining who, why and how a consumer trusts definite sources or suppliers of information is an essential constituent of food safety projects. Five different components are identified in the structured and operational definition of trust in information, including the perceived expertise degree of the source, no bias in information, stability over time, fairness, and good faith [65]. Some papers demonstrated that trust and the information source are critical drivers of risk understanding and trust in the information offered by the media and independent sources enhances risk understanding as well as worries; nevertheless, trust in public authorities reduces them [27]. FSRC is needed to be established on good communication rules as necessary parts to develop and maintain trust. The central rules of desired risk communication consist of openness, transparency, timeliness, and responsiveness [66]. Open and honest communication following the rule of transparency is broadly considered the key to developing trust [67]. For a long time, transparency has been considered a central constituent of modern democracy and public service reform and has lately been regarded as an antidote to distrust by assisting in the prevention of secrecy and promotion of public responsibility.

The topic of wider transparency in policymaking from the perspective of numerous policymakers is essential to rebuilding public trust [68]. Transparency is closely associated with the notion of openness and is essential to effective risk communication. Techniques for increasing transparency comprise making all policy decisions and correlations between policymakers and other central stakeholders publicly accessible. All uncertainty should be accepted and described to increase transparency [69]. Risk communication should occur in an open environment with chances for questions and dialog with presenters who perceive the risks and are able to communicate effectively [70]. Openness is crucial in maintaining the reputation of an organization and helps in developing trust. It involves making essential documents accessible; accordingly, stakeholders have access to scientific outputs, acknowledge all actual risks, and react to worries about perceived risks [69].

Communication in a timely manner is crucial to protect public health, assisting in developing and maintaining trust, and preventing the rumor and misinformation development. Responsiveness is the level to which those accountable for food safety deal with the risk communication requirements as well as expectations of the targeted group in their communications. As an example, individuals might distrust risk messages if they do not deal with their perceptions and worries however, include only technical information regarding risk evaluations. Consequently, for responsive risk communication, the target audience's information needs and communication expectations should be perceived and such issues in communication activities should be address [66]. A timely response is essential because it demonstrates that the organization is rapid in dealing with issues, contributing to its credibility and reliability. Trust can reduce in regulatory agencies when there is a delay in information flow. Governments have been criticized in the past due to delays in response and communication and a dearth of coordination between various agencies [69].

Furthermore, planning is crucial to build effective FSRC [66]. For example, in a study conducted in China, it was shown that consecutive food safety crises have panicked the local public and sounded the alarm in the public health system's crisis preparedness regarding food safety issues. The Office of Crisis Management of the US Food and Drug Administration, the Rapid Alert System for Food

and Feed in European countries and the European Crisis Management Academy aimed at coordinating emergency and crisis reaction activities regarding food safety issues; however, the local food authorities have been found with inadequate emergency and crisis management for food safety [71]. Concerning an increase in public worries regarding food safety, the Risk Assessment and Communication Division (RACD) and the Food Surveillance and Control Division were subsumed in the founded Centre for Food Safety (CSF) in 2006, to boost food safety regulatory actions and enhance the liaison and negotiation with the national and international food authorities [72].

Therefore, it is necessary to design a local food safety crisis management plan that includes preventive, emergency and reform phases based on the revised crisis preparedness model. There is also a necessity for cross-border communication with overseas health authorities, close intersectional collaboration in government, balancing economic and political issues, public culture considerations, and the education for food safety [73]. Risk communication investigators from inside and outside the food field have started to perform several case studies to further clarify this issue. In a study, it has paid particular attention to public understanding and acceptance of genetically modified foods and the communication of scientific uncertainty [74]. Additionally, there are many studies investigating and analyzing the communication of risk, science, and uncertainty associated with the bovine spongiform encephalopathy crisis affecting the United Kingdom and also the rest of Europe in the mid-1990s and beyond [68].

5. Risk communication strategy in food safety

Communication aimed at achieving food safety may be based on a hazard or risk approach [75]. Factors (physical, chemical and biological) that potentially cause adverse effects on health are named hazards, and the possibility of adverse effects caused by being exposed to hazards is called risks [76]. Hazards related to chemical and microbiological agents have differences in terms of detection methods (faster laboratory detection of chemical agents than microbiological agents), acute effects (microbiological agents), lifelong effects (chemical agents), continuous effects (chemical agents) and case-based effects (Microbiological factors), and the possibility of control (many chemical risks and lack of control of microbiological factors in the field) [77]. Hazard-based communication includes various aspects related to food hazard appraisal and affects the consumer's understanding of food risk uncertainty [78].

Considering society's awareness regarding the contaminants in food and their adverse effects on health, risk communication is one of the daily requirements in today's society [79]. Risk communication takes place in three forms including care communication, consensus communication and crisis communication [80]. Regarding care communication, it is possible to refer to the communication after the food risk assessment that was done by the evaluators of this field; this affects the consumer's correct understanding of the risk and the consumer's decision regarding the use or non-use of the food in question [81]. Consensus communication which is about encouraging different groups and stakeholders to participate and work together for risk management [82]. Crisis communication is about when a disaster has occurred [83]. Regarding crisis risk communication, it is possible to mention the outbreak of listeriosis in 2008, due to the contamination of Maple Leaf Foods products and the death of more than 20 people. In this situation, the company took attention to psychological and operational crisis management than legal crisis management. In the short term, the company's products were recalled. For the long-term action of this company, people's safety was prioritized by raising food safety standards as well as distributing the necessary measures in the virtual space and making promises in order to prioritize the interests of consumers [84,85].

Microbial or chemical contamination of food may occur throughout the chain [86]. Regarding the presence of chemicals in food, scientists may raise the issue of uncertainty about the existence of risk. Therefore, information in this field should take uncertainty into account and help to make informed decisions and increase consumer understanding [87]. When a microbial outbreak of food occurs, the best way is to quickly share relevant information through various information channels, as well as express empathy, responsibility

Fig. 2. Different strategies for transmission of messages related to food safety in risk communication.

and commitment, in order to protect the safety of consumers [88]. Due to the presence of various communicators, such as scientists, media, government agencies, industry, and consumer groups, the risk communication process in food safety has numerous complications [24].

All these groups have a common goal, which includes sharing information and messages related to food safety threats to improve attitudes and performance objectively [89]. In today's world, conventional risk communication will not be successful by itself, and original and imaginative techniques are required to interact with consumers, which are achieved through all accessible media channels openly and transparently [90].

The evidence demonstrates that giving relevant risk messages to susceptible consumers and targeted groups needs comprehensive and thorough knowledge on the information receivers. The features of these groups might differ in cultures and countries and different cases. Consequently, it might be essential to gather further information on the way of presenting risk communication and reaching the target groups through channels. The messages should be repeated on a regular basis and presented in a way that is in line with the needs of consumers to lead to a change in their behavior in choosing healthy and safe food [91]. A literature review demonstrates that focusing on a group of individuals and perceiving the knowledge, attitudes, and understanding of those comprising that group can result in the effective communication of food safety messages [92].

In today's world, the Internet is at a great rate turning to the top information channel and is one of the strategies that is widely used at the international level to transmit information and messages related to food safety risks. On the other hand, social media and web-based tools and games can rapidly inform specific target groups [91]. The transmission of effective messages to the target group should be carried out through various means of communication, should contain reliable information, and should be quickly published and repeated at appropriate times [93]. Various strategies have been defined to convey messages related to food risks in the world Fig. 2, which are discussed below.

5.1. Risk communication by games

Game-based learning (GBL) has been used to teach and engage youths and children about health [94]. Games are multidimensional structured systems that allow players to take part separately or in teams in competitive, voluntary, mental, physical or activities dealing with fantasy and challenge elements, considering particular principles and limitations to achieve an aim defined by the game and ultimately resulting in a quantifiable outcome [95].

Learning as an active process and learners build their perceptions through collecting facts, experiences, and practices. As a result, games are potential learning environments due to their features associated with the way individuals learn, namely, the activation of previous context, knowledge, feedback and assessment, experiential, transfer, and social [96]. In developing a game, food safety educators as well as game designers use the Learning Games Design Model [97]. Young individuals do not have enough knowledge about food safety. Therefore, food safety training can have an essential role in increasing science-related knowledge.

The research and GBL methods developed a computer detective game, termed Poison Riddle, by which students can actively investigate food safety knowledge by acting as a science detective to solve a task regarding food poisoning at home in a virtual world. For the evaluation of the learning efficacy of this game, 109 students at high school were chosen as a sample. The game could aid students in the improvement of their knowledge on microbial food safety. The majority of students showed positive participation perceptions as well as gaming behaviors associated with the game. Moreover, the students successfully solving the game task obtained more food safety knowledge, positive gaming behaviors, and marked sequential behaviors than students who were not successful in task solving [98].

Another example of the communication of safe food hygiene practices is the Ninja Kitchen online video game. In this game, players have challenges with cooking different meals safely in a dinner setting. Ninja Kitchen has 15 levels; each level brings novel game challenges to the players. In the game, important food safety concepts (such as the dangers of leaving food in the danger zone), and prevention of cross-contamination (through cleaning plates, hands, and work surfaces) following preparing high-risk foods (like unwashed vegetables and raw meat), cooking animal protein at a safe temperature is introduced and/or enhanced. The Ninja Kitchen game is set in a modern-day dinner where the Sensei can offer Ninja food safety wisdom, take orders of the customers, and then prepare and serve the food. Players gain scores through practicing safe food handling. Players lose scores, and customers suffer graphic foodborne diseases when contaminated food is served by players. Players' scores can be used to buy more supplies and advice to increase their scores. Following the Learning Games Design Model, the target group is widely engaged during game development through extensive and intensive user testing to evaluate likings associated with the character's personality and appearance, difficulty and design level, and setting of the game. Gameplay styles, stories, and music with these preferences are continuously reviewed and verified. This iterative process helps ensure that the ultimate product is engaging and produces an educational product with high quality that satisfies the requirements and interests of students in food safety [99].

Another instance of games related to risk communication in food safety is the educational projects carried out in Italy to transfer food risk knowledge to young individuals (age range: 16–18 years). The video game "A mysterious poisoning" was developed to offer appropriate information regarding safe milk handling activities and decrease health concerns, such as serious ones. This online tool was offered to 359 upper secondary school students from four provinces of Italy. The video game included all steps of the milk supply chain, from stable to table, making players aware of the important moments of milk contamination and identify safe milk handling activities. By accomplishing some tasks, students assisted a detective in exploring the reason for food poisoning outbreak. This video game offered a chance for students to assess their knowledge regarding the product and receive more information. The data gathered using two questionnaires distributed prior to and following the controlled use of the video game indicated that this serious game could change players' understanding of risk exposure and their cognitive correlations, especially by raising their knowledge levels regarding

the risks related to raw milk consumption [100].

Game/quiz-based learning can involve children and young individuals in food safety and eating information. As an instance, the United States Department of Agriculture created two small online games, including MyPlate Blast Off and Track and Field Fuel-Up to teach students regarding nutrition [101]. The employment of online games/quizzes has spread to the mobile world, and the target group is not now only children. For example, Just Food Fun is a smartphone quiz on food literacy. In China's 2019 Food Safety Publicity Week, the government in cooperation with Alibaba, launched a smartphone quiz game testing players of all ages regarding food safety, and food science, nutrition, and technologies, leading to 1.7 billion participation times in a week [102]. Potluck Panic is another web-based game in order to educate food safety and increase perception and promote attitude of students regarding food safety issues [103,104].

5.2. Risk communication through social media

Social media are particular communication platforms that have witnessed exponential growth in utilization and effect recently, democratizing the communication process and providing risk communicators with a way of applying those principles recommended to be at the center of risk management and communication [105]. Today, social media platforms are widely used to share diverse topics and as a channel for targeted communication to audiences [106]. Due to the increasing use of social media by people to obtain information, these media can affect people's attitudes in various fields [107].

Communication through social media is like a contagious disease that can be transmitted from person to person. The messages of these media, which are widely used, with their influence on people's beliefs, attitudes and behavior, can affect the weakening or strengthening of people's health in various fields [108]. Commercial advertisements of various foods and beverages by celebrities on social platforms, without considering the adverse effects of these foods on health, are effective in inappropriate food choices of social media visitors [109]. On the other hand, if used correctly, these media can become a useful tool for communication and sharing food safety news [110]. Facebook, Twitter, and YouTube are examples of social media platforms that can be used in the field of food safety [111].

An instance of using numerous formats of digital media is Safe Eats, an intervention based on social media developed for youths to alter food hygiene practices. After designing the Safe Eats Facebook page as a fan page, images from the United States Department of Agriculture's Kitchen Companion were utilized to depict safe food handling activities. All designed educational materials were posted on Facebook for four weeks, with the student-driven curriculum format and design; student input in focus groups served as a guide to content development, the type of developed intervention, and the included constituents. This study aimed at designing and assessing an intervention based on social media for youths to enhance food safety viewpoints, activities, and knowledge. Introductory studies were carried out, and online focus groups were foregathered for guiding the intervention. The treatment and control groups included college students. The findings obtained from pre-tests and post-tests demonstrated that subjects in the Safe Eats Facebook intervention results in the enhancement of food safety perspectives, activities, and knowledge. The participants declared learning more from the intervention compared to a traditional lecture; however, the integration of lecture and Facebook led to higher knowledge points compared to those obtained from the intervention alone. The students spending more time on the Facebook page showed greater advancements in food safety viewpoints and behaviors [112].

On the Twitter platform, users share their experiences and attitudes in various fields, including healthy food [113]. On YouTube, there are many videos on various topics of food safety [114,115]. It was shown in Meng Li et al.'s study in 2019, if YouTube visitors use authentic videos in the field of food poisoning, YouTube can be useful in the field of public communication [116]. The existence of unreliable videos on YouTube, for example, in the field of food safety during the Corona epidemic, makes it necessary to increase the awareness of visitors through the development of educational interventions in this field [114].

The usage of microblogs or Weibo is another social media in China that integrated food safety influences and behaviors on risk communication through a social media platform, along with central demographic variables. The results of the investigation demonstrated that the cognitive learning of food safety risk, an environmental risk over which the public has slight control, is able to bring about negative emotions. Such negative impacts affect the individual's risk assessment, understanding, and preventive behavior. Precisely, the findings showed that microblog or Weibo utilization in China was associated with the general awareness of a chain of food safety events and factual awareness, along with preventive behaviors related to food safety risks [117].

Food risk notification through bloggers have turned out to be a universal medium for information exchange. Regarding online risk communication, food bloggers are actors as they transfer applied information about food preparation and essential stages of food safety (i.e., preserving, cooking and handling). In addition, they can reach user networks in a quick and capillary manner [118]. In the Brombin et al.'s study (2021), the methodological process related to role of food bloggers demonstrated that a prevalent reason for creating a food blog is the love for food and the behavior of caring for themselves and others through food. Food bloggers feel accountable for taking care of their users by offering accurate information associated with health and safety. Communication through blogs is on the basis of the shared experiences of users, thereby representing a type of knowledge closer to direct practice. Interaction with these new actors in the domain of food is essential for institutions traditionally devoted to the enhancement of public health as well as food safety [119].

Another example of communication through educational websites regarding hygiene, prevention, infection, and antibiotic resistance, is that free of charge educational resources are offered by e-Bug (www.ebug.eu) under the supervision of the Public Health Organization in England [89]. This website is loaded with a variety of helpful resources for utilization in educational environments, including lesson plans, worksheets, games, and interactive activities. On this website, there is training in the field of food hygiene. Training sessions have been created with the aim of increasing the confidence of trainers to educate food hygiene and safety in the safe

consumption project [120]. The e-Bug resources about food hygiene are only accessible for individuals 7–11 years old, indicating a gap in targeted food safety education for 11–18-year-old individuals as a main group to address, because older students might be cooking for themselves, friends and families, and developing lifelong food hygiene habits [121].

5.3. Risk communication through mass media

Mass media include a novel social institution involving the generation and distribution of knowledge in the broadest sense of the word. This system has several salient features, such as using somewhat modern technology for the (mass) generation and dissemination of messages, the social regulation and systematic organization of this work, and directing messages at potentially large target groups not known to the sender and free. The mass media institution is essentially open, operating in the public domain to offer regular communication channels for the type of messages determined by what is technically and culturally possible, socially allowed, and in demand by many individuals [122].

Mass media are communication devices on a large scale to transmit data to a large audience, including books, newspapers, radio, television, magazines, and the Internet. All individuals are at exposure of the media text partly as radio audiences in the morning while preparing for college, school, or work, reading the newspaper or watching breakfast television. In the book entitled "Mass Media and National Development", mass media were declared as a bridge to a wider world and as a vehicle to transfer new opinions and models from the north to the south and in the south, from urban to rural areas [123]. It was shown that mass media play an important role in disclosing food safety information and affecting the strategic choice of government food enterprises and regulators [124].

5.4. Risk communication through print media

Print media have a role in communicating the risks and benefits of food quality and safety issues to the public to raise awareness. Newspapers are involved in spreading awareness on different aspects of information relevant to the community. Nearly all dailies and popular magazines do publish educative papers on different topics, like health, including nutrition, science, legal matters, fashion, business, women's problems, and careers. Newspapers are a major source of health and nutrition information for numerous readers [125]. In a study titled "What the Newspapers Say about Milk Safety in Kenya and Whether Consumers Trust and Value the Information", the content of the article was transmitted through print media for the activists of production and storage of milk and dairy products. This newspaper article provided information about the reason for the production of low-quality and unsafe milk and about the changes that should be made for the improvement of the product's safety and quality. Print media are involved in food safety communication; therefore, the collaboration of print media with the regulating authorities would strengthen food risk communication and governance. It is necessary for this partnership to boost, for consumers, the educative value of the content published in print media

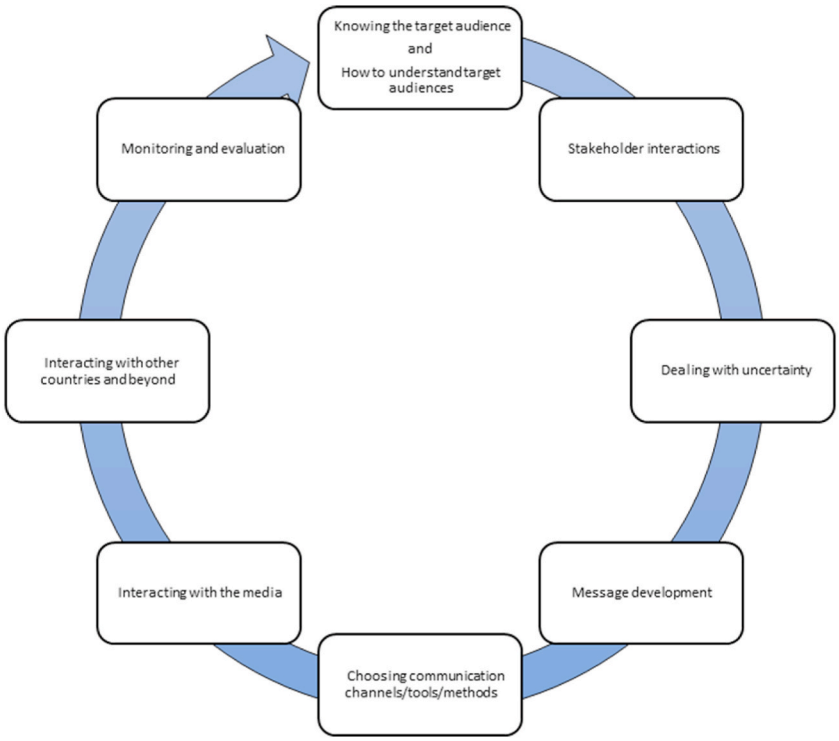

Fig. 3. Stages for operationalizing of the food risk communication.

and improve the role of this media in food safety communication and complementary governance [126]. The most important findings obtained from the assessments of 311 studies from newspapers in Greece were related to genetically modified foods as the most referenced food hazard. In the text of newspaper, simultaneous reference to over one food hazard was commonly mentioned. The most of the studies were shown with informative content as well as a periodicity for food hazards were presented in the media coverage [127]. The findings of another study revealed a positive association between the newspaper coverage of food safety issues and consumer recall of food safety incidents regarding the intensity and recency of media coverage [128]. Newspapers are extremely reliable and major information sources regarding food science, food recalls, technology, food policy and foodborne illness outbreaks, according to another study in Turkey. Nevertheless, newspapers were reported as extremely unreliable by 10% of the participants under 25 years of age [129].

A national study was carried out on the Italian population responsible for purchasing and preparing food for their households. The aforementioned survey studied sources of information most commonly utilized by Italian consumers when they have a question about food safety to gain a helpful understanding regarding food risk communication. There were correlations between the participants' choices of information sources on food safety with their socio demographic and behavioral characteristics, objective knowledge, trust in several authorities, and self-perception concerning risk exposure [130]. In a study carried out in China, mass media and interpersonal channels were regarded as the primary sources on public knowledge regarding food safety misinformation. Additionally, the level of public trust in government agencies and different kinds of mass media influenced on the information dissemination effectiveness. Generally, the awareness of the level of public trust in various information channels and sources makes it also possible to help regulate the food safety information supply distribution among various channels [131].

6. Food Safety Risk Communication in practice

It is essential to integrate crucial messages to form in practice to implement effective risk communication [132]. Such issue consists of constant enhancement of the organization of communication efforts and functional methods on the way of the identification and understanding of the target audience and their information needs and the way of the effective engagement and interaction with stakeholders [133]. The different stages of operationalizing the food risk communication are shown in Fig. 3.

6.1. Identification and understanding the target audience

Risk communication is about individuals; as a result, it is essential to identify and understand the target audience before developing the message [134]. For effective communication regarding risks, it is crucial to examine dynamic changes in the degree and nature of public understanding related to particular hazards. This perception can be utilized as the foundation to develop best practices in communicating risks. Increased perception of individual distinctions in understanding and information requirements between various public members and major stakeholders brings about the facilitation of information delivery [63]. It is necessary for risk communication to be informed by the awareness of consumer risk understanding and information requirements, including individual distinctions in consumer likings and needs and preferences in these issues associated with sociohistorical context related to regulation. Moreover, it is required to communicate information on what is performed to identify, prevent, and manage food risks to consumers, with consistent messages concerning preventative plans, enforcement systems, and scientific unpredictability and variability related to risk assessments [135]. The development of effective risk communication regarding food safety matters requires the understanding of consumer perceptions, needs, behaviors, and the way they are different among various consumers [136].

Successful risk communication is essential to effective risk management. This issue develops public trust in the ability of organizations to deal with risks. Multiple articles have drawn special attention to the significance of successful risk communication in making individuals able to have informed choices and take part in decision-making on the manner of risk management.

Timely, precise, apparent, objective, consistent, and complete risk information is provided for individuals through successful risk communication. The significance of trust in successful risk communication is considered a primary theme in the risk communication literature. Psychological, sociological, and cultural factors creating risk misperceptions and misunderstandings are the main challenges to successful risk communication [137].

Individuals usually are of the opinion that food has zero risk that is not important; as a result, the explanation of the fact that food is not sterile is a challenge indicating a constant level of risk that the end-user has to manage to prevent getting the disease. The perceptions of risks often vary between consumers and professionals. Moreover, a total disconnection sometimes exists between consumers' perspectives and the true risks related to a process or product. There are several major determinants of consumer risk understanding, including whether the hazards are natural or technological in origin, whether they have a chronic or an acute effect, and the consumers' degree of trust in the messages received [90].

Considering that the majority foodborne pathogens are endemic to many parts of the food system (i.e., farms, operators, and industries), a zero-risk condition in food production is unachievable using the currently accessible technology. The risk per serving and the (expected) number of cases offer supportive information that is integrated for a better understanding of the risk to the human health of a given product. The risk per serving is virtually zero in most food products, leading to a minor possibility of a consumer getting an illness. Nevertheless, from a governmental point of view, the (expected) number of cases for most consumed products may be somewhat large, leading to a related risk. Consequently, due to the absence of zero risk for food products, the remaining risk has to be assessed by suitable risk metrics [138]. One of the primary objectives of FSRC is the enhancement of stakeholders' perception of food safety risk assessment and management and makes individuals able to make knowledgeable judgments regarding food consumption and production. A study was carried out in China to examine consumers' intention for participation in FSRC, which

combined protection motivation theory (PMT). The PMT primarily gives a detailed account of the impacts of fear appeal on health threats and the way it can motivate people's reactions in a self-protective manner [139].

The effect of behavioral and normative beliefs on the consumer's intention to display a given behavior is highlighted by the Theory of Reasoned Action (TRA). Based on the TRA, intentions consist of two conceptually various determinants. The first intention predictor is the consumer's attitude toward the behavior, referring to the degree to which a consumer has either a favorable or unfavorable assessment of the behavior in question. The second intention predictor is a social factor named subjective norm, referring to the consumer's understanding of contingent social pressures to display the behavior in question. The information was gathered from 676 accepted online survey responses from random consumers in northeast China. The obtained findings revealed attitude as a central factor that mediates the relationships between perceived severity, self-efficacy, response efficacy, and consumers' intention to take part in food risk communication [140]. In another study that was about the theory of protection motivation and food safety behavior of consumers in response to COVID-19, the results demonstrated that female subjects showed a higher probability of engaging in protective measures while food shopping, followed hand hygiene measures after shopping, and utilized online food delivery services in the COVID-19 pandemic. Nevertheless, foods should be purchased from trusted restaurants or takeaways [139]. In another study, the attitudes of Italian consumers toward food risks were evaluated by examining their sociodemographic and behavioral characteristics using a computer-assisted telephone interview survey method. In the aforementioned study, PMT in Italian consumers was important in food risk communication [141].

In food risk communication, it might be essential in numerous cases to consider the overall configuration of both risks and benefits. A range of probable relationships might be present between food risks and benefits. All foods have various positive and negative impacts [142]. In a study, the risk-benefit assessments (RBAs) of foods, containing a formal public health evaluation and then communication and management, has been founded as a scientific field of study. RBAs, combining toxicology, nutrition, and microbiology, have been growingly carried out for many foods and food components. The findings were usually declared by the studied group to examine distinctions in health outcomes as well as target communication. The reinforcement of the associations between risk-benefit management decisions, a formal RBA, and dietary suggestions communicated to the public would enhance transparency and potentially public health outcomes [143].

An instance is oily fish, which has attracted research interest related to health risks (mercury) and benefits (omega 3) [142]. It is extensively recognized that seafood is important for a healthy diet. However, there are concerns over the risks related to contaminants, bringing about a communication dilemma regarding this nutritional-toxicological conflict. Despite the fact that health benefits are more important than the risks for individuals, it is required to exert caution for susceptible groups. The interactive Fish Choice tool, designed within the safe Seafood project, gives information to consumers regarding health benefits and risks associated with the seafood consumption pattern. The aforementioned study evaluated the acceptance of the Fish Choice tool via an online survey in five European countries, including Norway, Belgium, Portugal, Ireland, and Spain. Approximately two-thirds of consumers were of the same opinion that they utilized the provided information at the time of selecting seafood species, eating frequency or portion size. The greater objective of reutilizing the tool was reported for heavy users of seafood. The aforementioned study showed primary evidence that for risk-benefit communication about seafood, online adapted tools, like Fish Choice, were assessed as user-friendly and helpful [144]. These diverse configurations of risks and benefits and the attached level of uncertainty to them provide suggestions for the needed measures of risk communicators, for instance, regarding the needed speed of response or the level of needed involvement of consumers. For the objective of being able to develop prevalent methods to communicate coherent messages over member states, the communication suggestions of food benefit/risk configurations should be recognized for further routine dangers and food crises [142].

Another study in the field of risks and benefits of foods was conducted in Denmark. The Danish population was suggested through Danish dietary guidelines to increase the consumption of fish; however, they were recommended to decrease the consumption of red and processed meat for the prevention of nutrition-associated illnesses. Nevertheless, the entire risk-benefit balance of such replacement might be affected by contaminants in these foods [145].

A multitude of food-associated risk and benefit information is provided for European consumers, and consumers are usually responsible for interpreting the information, commonly incompatible. This condition is particularly evident during periods of food crises and can have major public health significance. It is not always easy to communicate scientific findings and risk evaluations into simplified instructions and advice that nonscientists, such as the media or public, can effortlessly understand, particularly in case of incompatible, undermined, or compound information about a special food or its features.

The results of food risk assessment should be understandable to the general public. There is a need for appropriate strategies and tools in relation to communicating the risks and benefits of foods. The Food RisC project included research packages utilizing qualitative and quantitative methodologies, developing a structure for the investigation of food risk/benefit topics, examining the effect of modern and traditional media on food communication, assessing the structure for the development of communication plans and tools. The above-mentioned project primarily aimed to develop targeted strategies and implement them in Europe regarding the issue of effective communication in society related to foods. In this project, the tools of theoretical models and new measurement paradigms on the basis of social marketing strategies were combined around consumer segmentation. The utilization of the tools and guides helps policymakers, food authorities, and other end-users in the development of prevalent strategies to communicate logical messages to consumers in Europe [142].

6.2. *Interactions of stakeholders*

The majority of risk communication subjects involving food safety explicitly include suggestions for various individual businesses, consumer organizations, government departments, and industrial groups, and people. The coordination of communication efforts in

such stakeholder groups is only as major as the organization of other response efforts and is needed to be a necessary, fundamental section of the response strategy [146]. This issue is especially primary and challenging in emergency conditions when messages are usually required to be altered regularly and developed in a very short time structure in negotiation with many agencies and stakeholders compared to normal situations [147]. Food safety crises have a tendency to be at a continually increasing rate universal. Moreover, a successful response can only be obtained via the involved stakeholders' coordination and proper preparation. Distinctions in food laws, responsibility, and transparency in various countries make the problem complicated. In addition, ethical matters should be dealt with at a worldwide scale, given the universal nature of most food supply chains. Food systems are fragmented and varied, associated with numerous stakeholders that include large informal sectors (e.g., distribution and nonorganized retail) with minor or no organization [148].

Food safety regulators are considered an essential constituent of FSRC. A central risk communication strategy was designed for food safety regulators. The strategy is a contributor to the minimization of food risk impacts by affecting stakeholder behavior or enhancing interactions between the food regulatory and relevant stakeholders. Regulators could apply successful risk management by the development of efficacious communication actions regarding food safety hazards, thereby decreasing the serious consequences brought by food risks. Further attention has been given to preventing and controlling FSRC; accordingly, the government takes a comprehensive response strategy and suitable measures for the improvement of communication effectiveness [32].

6.3. Dealing with uncertainty

It is necessary that communication helpfully considers differences between various kinds of uncertainty, for instance, the difference between outcome uncertainty ("what might actually occur and with what probability") and evaluation uncertainty ("to what extent are the findings of the analysis probable to change with extra information"). The increase of societal and political pressure has been targeted toward the maximization of transparency in risk management practices, to some extent due to decreased public trust in these same practices. Therefore, the uncertainties related to technical risk evaluations, on which decisions on risk management are established, will more and more be subject to stakeholder and public scrutiny. Consequently, it is vital to communicate this uncertainty in a direct and understandable manner concentrated on the information needs of the target audience [63]. It is required to pretest and assess all communication forms proposed by regulatory agencies to discover if messages and communication plans have their intended impacts [149].

The communication of scientific uncertainty is a rather contested need of risk communication. Uncertainty shows a representation of the best knowledge at a particular point in time and must be carefully taken into account in risk analysis [18]. In a study, a questionnaire was designed aiming to evaluate the way the general public described uncertainty related to food risks. The obtained findings demonstrated that individuals would like to have information on food risk uncertainty immediately after the identification of uncertainty. The individuals further accepted uncertainty related to the scientific process of risk management than uncertainty as a result of a dearth of interest or action by the government. The results showed that risk communication should be concentrated on "what is being done to reduce the uncertainty" [150]. The issue of how regulators, policymakers, and experts are needed to best communicate uncertainty and whether it is logical for them to do so in the first place has drawn much attention to the food field [151].

6.4. Development of messages

New food safety messages sent by means of novel media should strengthen food safety from farms to fork. Targeting a segment of the population and understanding their knowledge, attitudes, and perceptions can result in the effective communication of food safety messages. Effective messages with reliable data are appropriate to the target audience. These types of messages are fast distributed and repeated. The application of media regularly accessible by consumers is important. The assessment of the impact of all features of food safety messages and media is needed for validating the food safety communication success.

A successful food safety message goes beyond sending information to affect an individual's attitude and behavior. The messaging should challenge self-satisfaction and food handlers' false perceptions of assurance. The identification of personal accountability for food safety was reported as a prerequisite for displaying appropriate food safety behaviors. Individuals with an "It will not happen to me" attitude might disregard risk communications, assuming that these messages address more vulnerable individuals. Therefore, it is essential to address perceptions of food safety risks, the views of optimistic bias, and the control illusion [92].

The evidence demonstrates that relaying related risk messages to susceptible consumers and target groups needs in-depth knowledge of the information receivers. The aforementioned groups' characteristics might differ across cultures and countries and for different cases; as a result, it might be essential to gather more information on the way of presenting risk communication and channels to reach target groups. Messages should be repeated on regularly and provided as relevant (i.e., fewer statistics and more stories that they can associate with). The use of social media, web-based tools, and games has the possibility of quickly reaching specific target groups. The achievement of behavioral changes depends on the consumers' understanding of the relevancy of risk information [91]. Food risks and the foodstuff safety in the after-effects of contamination are greatly sensitive issues for communication. News media pay extensive attention to food risks, requiring messages to be carefully drafted to decrease harm and prevent unnecessary boycotts. When a food risk is considered eliminated, communication efforts should rebuild trust in consumers [152].

6.5. Choosing channels, tools, and methods for communication

The information associated with food safety is provided by the private sector and governmental agencies. For successful and

efficient food safety education and communication, it is obligatory to identify information sources that are both trusted and used [153]. At present, there is a wealth of risk information available in plenty of channels, and individuals have to find meaning in this information overload [154]. Several factors, including the objective of risk communication, the nature or content of messages (urgency), as well as their use and accessibility by the target audience, affect the success of various communication channels [24]. Individuals gain information about food safety and risk via numerous various communication channels, including media (e.g., television, radio, and newspapers) and online sources (e.g., search engines and trusted organizations' websites). Additionally, social media are sources of food safety and risk information. By the engagement of individuals through social media, the staff responsible for risk communication can offer precise and timely information to help alleviate the social intensification of false or misleading information on food safety. To this end, communicators (i.e., competent authority's staff accountable for designing FSRC approaches and performing equivalent activities) must be aware of where consumers are searching for food safety risk information on social media. It is essential to perceive present studies on the way social media are currently utilized, particularly for FSRC, to most successfully use social media as a risk communication tool for food safety. This information and identification of currently suggested best practices allow for better application of social media [155].

6.6. Interaction with the media

A vital part of the majority of risk communication approaches is the interaction with the media. For the objective of successful interaction with the media, it is crucial to be informed about several central parameters that manage media coverage of risk topics, such as cover-ups, fear, blame, conflict, David versus Goliath (the conflict between imbalanced competing interests, where the underdog can defeat the odds and win the stronger opponent), visual effect, and high-profile personalities or issues [66]. Social media are considered a major tool to communicate immediate information about food safety risks, allowing users being in interaction with each other and message producers. The interactivity, timeliness, and free participation of social media have captivated numerous users in comparison to traditional media, resulting in constant growth in the individuals' number on social media websites. This issue offers a good chance for research on FSRC [32].

Social media as a communication form have several benefits. A capacity for two-way communication is one of the central advantages of social media, potentially increasing transparency about food scares and making the incorporation of a consumer voice possible. Moreover, a capacity for two-way communication permits food regulators to observe public worries and reactions to communication about food scares, identify emerging topics, and respond to public misconceptions [156].

6.7. Interaction with other countries and beyond

Globalization has brought about a dynamic market, which has drastically reinforced interchanges of information and goods and the flow of individuals to countries. This international phenomenon provides the consumer with an option from a wide range of foods from different places. Nevertheless, challenges exist for the improvement of food safety and security globally. The main question is the way of guarantying food safety while raising the food supply chains' complexity. Food manufactured in an especial place generally has preservatives, ingredients, additives and from various and faraway origins. Countries take a number of food control measures, but their regulatory and institutional frameworks extensively differ, because of the difference in the definitions of a food crisis, food incidents, and risk management approaches [148]. Emergency communication with global stakeholders makes national food safety authorities able to examine the work and emergency through strategies to risk evaluation before their execution. This issue might permit countries to integrate sources, discover methods to deal with the emergency as a whole, and support countries that might not have the potential to carry out thorough risk evaluations [157].

The universal risk management system is associated with international regulations and mechanisms, like the International Food Safety Authorities Network (INFOSAN). The WHO should become aware of serious food crises. Therefore, communication between food authorities globally is advanced by the United Nation through the INFOSAN platform with the required mechanisms of action. The INFOSAN is developed to successfully share experience and information, with the development of collaborations nationally and internationally [148]. For instance, the European Food Safety Authority (EFSA) tries to give all interested parties information through communicating risks in an openly based on the independent scientific advice of its scientific experts, thereby causing to build public confidence in the way risk is evaluated in the European Union. Nevertheless, the authorities recognize that scientific findings cannot always be effortlessly turned into simplified regulations or advice that nonscientists can effortlessly perceive. Consequently, bridging the gap between consumers and science is a major issue, which is dealt with the EFSA through the close organization of its communications with national food safety institutions in the member states [158].

6.8. Monitoring and assessment

The assessment constituent of any risk communication process is crucial and consists of an evaluation of its total success. This success can be described with regard to the level to which stakeholders have evolved the perception of the involved risks and the way of their management [159]. Monitoring risk communication and assessing attempts regarding risk communication in the course of a food safety incident and following its investigation are crucial to perform risk communication activities as successfully as possible [75].

It is obligatory for organizations to devote themselves to monitoring and evaluation and then invest appropriately [160]. Risk communication approaches should be officious and deal with the most important risks and risk-decreasing practices. Campaigns involved in risk communication should reach target groups by means of the most appropriate communication channels for each group.

Risk communication should be assessed to ensure consumers perceive the messages and trust information sources. Ultimately, follow-up should make sure that the behaviors of consumer food safety have enhanced [75]. For instance, the Communication Directorate harmonizes its activities with national authorities to help ensure European consumers receive coherent messages on issues concerning them and in an understandable structure. Additionally, the EFSA harmonizes its actions with the European Commission to make sure about coherence in communications, especially where risk evaluation results might have suggestions for risk management and finally consumer protection [158].

7. Conclusion and closing remarks

During the past decades, FSRC has undergone an evolutionary path from the perspective of systematization, consumer participation, challenges, and communication methods. Considering the numerous food crises evaluating the risk communication strategies in each country in the field of food safety is vital. The consensus among all individuals participating in the process is very important. Cooperation and coordination between risk assessors and risk managers should always improve in order to strengthen FSRC. It is necessary to define and present new priorities and approaches of FSRC according to the desired goals. Nowadays, it is not possible to accurately predict technological developments. Due to the rapid evolution of communication platforms and the transition of audiences to new technologies, FSRC can be very effective through the creation of dedicated communication platforms. The integration of platforms with popular social media is influential in a transparent and scientifically valid manner regarding with different audience groups.

Establishment internal and external communications is considerable in order to control the risks in the communication process. Coordination among risk assessors, risk managers, and the general public in both types of communication should be considered. The understanding of communication needs in any society depends on a wide range of psychological, social, economic, cultural, and geographical factors. Part of the advertisements related to food safety should be broadcasted in a format that is attractive and understandable to the public. Moreover, teaching health and food safety in schools in the form of attractive games can have a significant impact on increasing the knowledge and awareness of students and conveying the necessary knowledge in the field of health and food safety to their families and friends. Considering the role of social media and smartphones, it is suggested to apply these tools to successfully communicate food safety risks. With the observing the movements of developments in the communication and technology, it might be expected that several intelligent technological assistant agents will surround the consumer within a few decades. This assistant technology, or more likely a system of technologies could express situation-dependent messages. Rapid analytical tools or applications for detection of food contaminants could communicate to the consumers in order to choose appropriate food. It seems that effective FSRC goes to replacing traditional risk communication with fast, accessible, and personalized services.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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