IMPACT OF CLIMATE CHANGE ON FOOD SAFETY: RISKS AND IMPLICATIONS

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INTRODUCTION

Climate change represents an increasingly significant global challenge of modern society, with particularly important risks and implications for food safety and human health. Food safety refers to the continuous physical, social, and economic access to sufficient quantities of safe and nutritionally balanced food for the entire population. Changes in temperature, the hydrological cycle, and the increasing frequency of extreme climate events are key drivers of risk that disrupt primary production, food quality and availability, and the stability of the food supply chain, consequently increasing risks to public health. Climate change is directly associated with foodborne infectious diseases, particularly those of zoonotic origin, as the distribution, survival, and seasonality of pathogens are significantly altered due to changes in environmental conditions. Health risks in humans are further exacerbated through the impact of climate change on animal populations. Heat stress and inadequate nutrition in livestock reduce animal immunity, increasing the need for antibiotics and other veterinary drugs, thereby contributing to the development of antimicrobial resistance as well as chemical contamination of food of animal origin intended for human consumption. In plant production, unfavourable climatic conditions promote the development of mycotoxins, leading to increased use of pesticides and other chemicals, which further compromises food safety. Climate change also affects the availability of safe water, with direct implications for hygiene conditions, food production, and the spread of infectious diseases. Prolonged warm seasons increase the risk of food spoilage during storage and transport, resulting in economic losses due to increased food waste and higher costs. Epidemiological projections indicate that climate change will increase population exposure to risk factors associated with a wide range of non-communicable diseases, such as malnutrition and undernutrition, leading to increased morbidity and mortality rates, particularly among children and other immunocompromised groups, especially in developing and least developed regions. Growth retardation in early childhood may have lifelong health consequences, including the intergenerational transmission of the effects of malnutrition.

The aim of this study was to identify risks to food safety caused by global climate change and to analyse their implications for the food supply chain and human health.

MATERIALS AND METHODS

Materials and Methods

This study was conducted as a narrative literature review aimed at identifying and analysing the effects of climate change on food safety and human health.

LITERATURE SEARCH

A systematic search of the scientific literature was performed across three major databases: *"Pub Med", "Scopus" i "Web of Science".*

TIME FRAME

The search included articles published within the last ten years in order to ensure the relevance and timeliness of the analysed data.

ELIGIBILITY CRITERIA

Eligibility criteria included peer-reviewed, full-text articles published in English that addressed: microbiological and chemical risks to food safety, risks associated with the food supply chain, and the implications of these risks on human health.

EXCLUSION CRITERIA

Studies that did not directly address the relationship between climate change and food safety or that were not available in English and in full text were excluded from the analysis.

MICROBIAL RISKS

CHEMICAL CONTAMINATION

MYCOTOXIN OCCURRENCE

Author(s), year of publication	Title of the paper	Study design	Aim of the study	Climate-related factor	Assessed risk	Key results
Manchal N, Young MK, Castellanos ME, Leggat P, Adegboye O. 2024.	A systematic review and meta-analysis of ambient temperature and precipitation with infections from five food-borne bacterial pathogens	Systematic review and meta-analysis	To assess the association between ambient temperature and precipitation and the incidence of infections (gastroenteritis and bacteraemia) caused by Salmonella, Shigella, Campylobacter, Vibrio, and Listeria species.	Ambient temperature, precipitation (including extreme events)	Incidence of gastroenteritis and bacteremia. Quantification through different epidemiological measures (RR, OR, IRR). Meta-analytic IRR for extreme climate events	The review found consistent evidence that higher ambient temperature is associated with increased incidence of gastroenteritis caused by *Salmonella, Shigella, Vibrio, and most Campylobacter* infection. Most included studies also reported a positive association between precipitation and the occurrence of these infections. The relationship between temperature, precipitation, and infection incidence remained consistent across different study designs and effect measures. Meta-analysis results showed that extreme temperature and precipitation were associated with a modest increase in bacteraemia risk. Continued climate change could increase morbidity, hospitalisation rates, and antibiotic use associated with these pathogens.
Balta I, Lemon J, Murnane C, Pet I, Vintila T, McCleery D, et al.2024.	The One Health aspect of climate events with impact on foodborne pathogens transmission	Narrative / integrative review paper	To assess how climate factors influence the transmission of foodborne pathogens and antimicrobial resistance (AMR) through the food chain, within the framework of the One Health approach	Temperature,precipitation, floods, storms, hurricanes, cyclones, humidity and dust	Increased transmission and spread of foodborne pathogens (Salmonella, E. coli, Campylobacter, Vibrio, Listeria, S. aureus) - Spread of antimicrobial resistance - Contamination of the environment, food and water	Increased ambient temperature is associated with enhanced survival, growth, and environmental persistence of bacteria such as *Salmonella, Campylobacter, and Listeria*. Higher temperatures can also increase the likelihood of contamination along the food production and supply chain. Extreme weather events, particularly heavy rainfall and flooding, contribute to the spread of pathogens by transporting contaminants from farms and sewage systems into water sources. Water contamination is identified as a critical pathway for the dissemination of pathogens such as Vibrio and *E. coli*. Climate conditions also contribute to the dissemination of antimicrobial resistance and alter interactions between pathogens, hosts, and environmental reservoirs. The findings highlight a strong link between climate change and increased risk of foodborne infections, emphasizing the need for integrated One Health mitigation strategies.
Moreau F, Darnell E. 2024.	The influence of climate change on pathogenic microbial spread: pathological perspectives	Perspective / narrative review	To analyze how climate change affects the spread of pathogenic microorganisms and their pathological consequences in humans and animals	Increase in temperature, changes in precipitation , air humidity, extreme events (floods, droughts, hurricanes)	Increased transmission of infectious diseases (foodborne, waterborne and vector-borne).Spread of bacterial, viral and other pathogens. Disturbances in sanitary and water systems- higher risk of infections	Elevated ambient temperatures directly accelerate microbial replication rates, particularly for bacterial pathogens such as *Salmonella, E. coli, and Vibrio cholerae*, thereby increasing their environmental load and transmission potential. Warmer aquatic environments promote the proliferation of waterborne pathogens, especially *Vibrio species*, leading to a higher frequency of outbreaks in coastal and marine-associated populations. Temperature increases shorten pathogen incubation periods within vectors, enhancing transmission efficiency of vector-borne diseases (e.g. *dengue, Zika, chikungunya*). Changes in precipitation patterns and humidity create favourable ecological niches for pathogen persistence, facilitating sustained transmission via contaminated food and water systems. Extreme climate events (floods, droughts, storms) disrupt sanitation and water infrastructure, resulting in direct contamination pathways and rapid dissemination of pathogenic microorganisms.
Lake IR, Barker GC. 2018.	Climate change, foodborne pathogens and illness in higher-income countries.	Narrative review article	To review the likely consequences of climate change on foodborne pathogens and related human illness in higher-income countries	Climate variability and change affecting temperature, environment and food systems	Risk of increased incidence and altered patterns of foodborne diseases and pathogen behaviou	The relationship between climate variables and pathogen transmission in higher-income countries is highly complex, involving food systems, environmental pathways, and human behaviour, which limits predictive capacity. Higher temperatures enhance replication rates of bacteria (e.g. *Salmonella, Campylobacter*). Climate influences animal reservoirs, affecting pathogen transfer to humans. Integration of surveillance systems supports better identification of climate-driven risks across pathogen sources. Integration of human, animal, and plant surveillance systems (One Health approach) is critical for identifying emerging threats.
Garcia-Cela E, Marcon Gasperini A. 2024	Climate change and mycotoxins: a growing food safety concern	Editorial	To assess the impact of climate change on mycotoxin contamination in food products	Temperature, humidity, water activity	Increased fungal growth, mycotoxin production, crop susceptibility, emergence of new fungal species	Climate change is identified as a major driver of mycotoxin risk, influencing fungal ecology and contamination across the food chain. Environmental changes (temperature, humidity, and weather variability) directly affect the growth of toxigenic fungi such as Aspergillus and Fusarium. Climate change is likely to increase mycotoxin contamination, especially aflatoxin B1. Southern European regions show higher prevalence of aflatoxins and ochratoxin A, indicating climate-related regional differences in contamination patterns. Extreme events (e.g. heat, drought, or moisture changes) are implied contributors to fungal proliferation and toxin occurrence in food systems. Climate-driven contamination affects both plant and animal food chains, including the occurrence of aflatoxin M1 in milk. Models predict higher risks in southern Europe with warmer temperatures. Crop distribution shifts may introduce new pathogens and vulnerabilities.
Duchenne-Moutien RA, Neetoo H. 2021.	Climate change and emerging food safety issues: a review.	Review	Global (with emphasis on food safety worldwide)	To review how climate variability and change influence food safety risks	Foodborne pathogens, chemical hazards (pesticides, heavy metals), emerging diseases	Higher ambient temperatures enhance the replication, persistence, and toxicity of foodborne pathogens, increasing infection risk. Floods, storms, and heatwaves disrupt food systems, leading to higher risks of contamination and foodborne disease outbreaks. Climate change disrupts cold chain systems. Environmental changes lead to higher levels of pesticides, mycotoxins, and heavy metals entering the food supply. Climate-driven pest resistance results in greater pesticide application, increasing chemical exposure in food. Increased disease pressure and environmental stress may lead to greater antimicrobial use and emergence of resistant pathogens. Combined impacts of climate factors (temperature, precipitation, hazards) result in higher incidence of foodborne illness and long-term health risks (bioaccumulation).
Harmon O'Driscoll J, Healy MG, Siggins A, McGinley J, O'Brien E, Wang J, et al. 2025.	Quantifying the influence of climate change on pesticide risks in drinking water.	Review	To quantify how climate change impacts pesticide contamination in drinking water and assess associated human health risks	Temperature precipitation, changes in growing season length	Pesticide runoff, water contamination, human health risks.	In Ireland, climate change is projected to increase pesticide contamination and health risks in drinking water, with strong regional variability and growing disparities requiring localised risk management strategies. Altered weather conditions (e.g. precipitation, temperature) affect pesticide transport and fate, leading to higher exposure levels. Climate change leads to measurable increases in human health risk from pesticide exposure. Average risk increases of ~18% under RCP4.5 (2050) and ~38% under RCP8.5 (2100) were estimated. Future pesticide exposure is strongly dependent on local climatic conditions. Existing regulatory frameworks are not adequately designed to account for future climate-driven risks. he study introduces a probabilistic, climate-integrated risk assessment framework that quantifies pesticide concentrations and associated human health risks in drinking water, capturing environmental variability, spatial heterogeneity, and future climate uncertainty to support targeted mitigation and policy decision-making .
Lazarević-Pašti T, Tasić T, Milanković V, Pašti IA. 2025.	Food Safety in the Age of Climate Change: The Rising Risk of Pesticide Residues and the Role of Sustainable Adsorbent Technologies	Multidisciplinary narrative review	To review how climate change influences pesticide residues in food and water, and explore sustainable adsorbent technologies for mitigation	Rising temperatures, altered precipitation, pest pressure, crop phenology shifts	Pesticide persistence, water and food contamination, health risks from low-dose and mixture exposures	Climate change significantly increases pesticide residue levels in food and water. Rising temperatures, changing precipitation, and increased pest pressure lead to more intensive and prolonged pesticide application, raising contamination levels. It affects persistence, mobility, and accumulation in the food chain, increasing long-term exposure risks. Carbon-based adsorbents (especially from agro-industrial waste) can remove pesticide residues from food and water, supporting circular economy approaches and future food safety systems.
Delcour I, Spanoghe P, Uyttendaele M. 2016.	Literature review: Impact of climate change on pesticide use.	Literature Review	To review how climate change impacts pesticide use, fate, and implications for human exposure, regulation, and technological development.	Temperature increase, changes in precipitation patterns, pest and pathogen dynamics	Pesticide use volume, environmental concentration, dissipation, degradation, ecotoxicity, and consumer exposure risks	Due to higher pest and pathogen pressure driven by rising temperatures and altered precipitation patterns, pesticide application will increase in amount, frequency, and diversity of products used. Climatic factors such as temperature rise and rainfall variability significantly influence pest outbreaks, thereby indirectly increasing pesticide demand. Higher temperatures and moisture lead to increased volatilisation and faster degradation, reducing environmental persistence in some cases. Increased rainfall can enhance pesticide dissipation and redistribution, affecting environmental concentrations and exposure pathways. Pesticide application practices and regulations need adaptation to future climate conditions.
Assunção R, Martins C, Viegas S, Viegas C, Jakobsen LS, Pires SM, et al. 2018.	Climate change and the health impact of aflatoxins exposure in Portugal—an overview.	Narrative review	To assess the impact of climate change on aflatoxin contamination and health risks through food exposure in Portugal.	Increased temperatures, reduced precipitation, extreme weather events (heatwaves, droughts)	Mycotoxin contamination, food safety risks, health impacts (liver cancer, DALYs)	Due to its geographical location, Portugal is expected to experience decreased precipitation and more frequent extreme weather events, which can favour mycotoxin (aflatoxin) contamination. Warmer conditions (e.g. +2 °C scenario) are projected to promote aflatoxin B1 occurrence in cereals (maize, wheat) in Europe, including Portugal. Current exposure is associated with estimated hepatocellular carcinoma (HCC) cases (0.52–2.00 cases) and disease burden (8.0–30.9 DALYs) Need for surveillance and risk mitigation strategies.
Zai FH, McSharry PE, Hamers H. 2024.	Impact of climate change and genetic development on Iowa corn yield	Review	To identify how climate variables influence biological and chemical contaminants of preharvest foods and associated food safety risks in Canada	Temperature, precipitation, drought, extreme weather events	Biological and chemical contaminants (bacteria, viruses, toxins), foodborne and waterborne illnesses	First comprehensive mapping of climate change impacts on contaminants in preharvest foods in Canada; findings support risk prediction and mitigation strategies. Climate change negatively affects Iowa corn yields through increased heat and drought stress, while genetic improvements have significantly boosted productivity, partially offsetting but not fully overcoming future climate-driven yield declines. Yields decrease with high summer temperatures (especially July), wider diurnal temperature range in June, and low rainfall during June–August. Advances such as earlier planting, longer reproductive phase, and improved thermal accumulation contributed to an average yield increase of ~1.8% per year. Genetic development partially offsets climate impacts but may not fully compensate
Casu A, Camardo Leggieri M, Toscano P, Battilani P. 2024.	Changing climate, shifting mycotoxins: a comprehensive review of climate change impact on mycotoxin contamination.	Comprehensive review	To analyze how climate change impacts mycotoxin contamination, fungal ecology, and their evolution in crops	Increased temperature, altered humidity, extreme weather events	Mycotoxin production, fungal dynamics, crop contamination, evolution of fungi, modified mycotoxins	Rising temperatures enable the migration and increased abundance of thermophilic fungi, including major mycotoxin producers such as Aspergillus flavus and Fusarium graminearum. Abiotic stress factors (e.g. drought, heat) weaken plant resistance, making crops more vulnerable to fungal infection and toxin production. Climate change alters mycotoxin profiles and co-occurrence patterns Changing fungal interactions will influence the type, prevalence, and simultaneous occurrence of multiple mycotoxins in food systems. Increased frequency of droughts, floods, and temperature extremes contributes to higher variability and overall risk of contamination along the food chain
Myers SS, Smith MR, Guth S, Golden CD, Vaitla B, Mueller ND, et al.2017.	Climate change and global food systems: potential impacts on food security and undernutrition	Review study	To assess how climate change affects food systems, food security, and undernutrition	Rising temperatures, droughts, rainfall variability, elevated CO_2, extreme weather	Food insecurity, undernutrition, micronutrient deficiencies	Climate change is projected to reduce crop yields, especially for maize and wheat in tropical regions, while also lowering nutrient quality of staple foods. Increased food insecurity and micronutrient deficiencies may contribute to higher rates of malnutrition, childhood stunting, infectious diseases, and mortality among vulnerable populations.
Hadley K, Wheat S, Honegger Rogers H, Balakumar A, Gonzales-Pacheco D, Davis SS, et al.2023.	Mechanisms underlying food insecurity in the aftermath of climate-related shocks: a systematic review.	Systematic review	To examine mechanisms linking climate-related shocks with household food insecurity	Floods, droughts, hurricanes, heatwaves, wildfires, sea-level rise	Household food insecurity and health vulnerability	Climate-related shocks consistently worsened food availability and access at household level, particularly among socially and economically vulnerable groups. Disruptions in food systems increased risks of malnutrition, poor dietary quality, chronic stress, and adverse physical and mental health outcomes following disasters.
Mirzabaev A, Bezner Kerr R, Hasegawa T, Pradhan P, Wreford A, Tirado von der Pahlen MC, et al.2023.	Severe climate change risks to food security and nutrition.	Review study	To evaluate severe climate change risks to food security and nutrition	Climate change, warming, extreme weather events	Food insecurity, nutritional instability, public health risks	Severe climate change threatens agricultural productivity, food supply stability, and nutritional quality through heat stress, water scarcity, and extreme weather events. These impacts are expected to increase hunger, micronutrient deficiencies, diet-related diseases, and health inequalities, particularly in low-income and climate-sensitive populations.
Fanzo JC, Downs SM.2021.	Climate change and nutrition-associated diseases.	Review study	To assess the relationship between climate change and nutrition-associated diseases	Rising temperatures, environmental degradation, food system instability, extreme weather	Malnutrition, obesity, diabetes, cardiovascular diseases	Climate change negatively affects both food quantity and quality, increasing risks of undernutrition as well as obesity and diet-related non-communicable diseases. Disruptions in sustainable food systems may worsen health inequalities and increase the global burden of chronic diseases, especially in vulnerable populations.

CONCLUSION

Evidence from multiple review studies demonstrates that climate change substantially increases food safety risks by promoting microbial growth, chemical contamination, and mycotoxin occurrence across the food chain. Rising temperatures and extreme weather events disrupt food production, storage, and distribution systems, enhancing contamination pathways and reducing food availability and quality. These combined effects contribute to increased human exposure, a higher disease burden, and elevated risks of food insecurity and malnutrition, particularly in vulnerable populations. Overall, the findings emphasise the need for integrated One Health approaches and climate-resilient food systems to effectively mitigate interconnected risks to food safety and public health.

EXTREME WEATHER

PUBLIC HEALTH

ONE HEALTH APPROACH