



One Health in food safety and security education: A curricular framework



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ABSTRACT

The challenges of producing and distributing the food necessary to feed an anticipated 9 billion people in developed and developing societies by 2050 without destroying Earth's finite soil and water resources present extremely complex problems that lack simple solutions. The ability of modern societies to adequately address these and other food-related problems will require an educated workforce trained not only in traditional food safety, security, and public health, but also in other areas including food production, sustainable practices, and ecosystem health. To help address the need for such an educated workforce, a curricular framework was developed to assist those tasked with designing education and training for future food systems workers.

One sentence summary: A curricular framework for education and training in food safety and security was developed that incorporates One Health concepts.

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1. Introduction

The challenges of producing and distributing the food necessary to feed an anticipated 9 billion people in developed and developing societies by 2050 without destroying Earth's finite soil and water resources present extremely complex problems without simple solutions. The ability of modern societies to effectively address these and other food related problems will require an educated workforce trained not only in traditional food safety, security, sanitation, hygiene, and public health, but also in other areas including food production, sustainable practices, waste management, and ecosystem health. Furthermore, success in dealing with complex food related problems will be best achieved through ways that embrace a collaborative One Health approach for effective problem-solving.

One Health approaches to problem-solving are best described as being transboundary or cross-disciplinary. Inherent in a One Health approach is the idea that experts working together to solve complex problems will be more successful than experts working within an isolated field. The need for using One Health approaches in solving complex societal health problems has been well documented [1–4].

Modern food safety problems are complex in nature and do not have simple solutions; as such, they have been described as 'wicked problems' [5]. Finding effective solutions to these wicked problems will require a One Health approach that considers not only the problem itself, but also the interconnected web of upstream factors related to the particular problem [5].

Education in the area of food safety has traditionally embraced disciplines of microbiology, sanitation, hygiene, food science, and public health as well as good agricultural practices, good manufacturing practices, and implementation of principles of risk assessment through hazard analysis and critical control points. These subjects have been critically important in provisioning of safe plant and animal-based food sources to modern societies. Nevertheless, recent examples have emerged wherein solutions to particular food safety problems required cross-disciplinary approaches that involved researchers and subject matter experts from diverse fields, e.g. wildlife specialists, veterinarians, epidemiologists, toxicologists, and microbiologists [6,7].

To our knowledge no well-defined curricular framework exists for guiding education and training in food safety and security that embraces the many diverse disciplines that are involved in production and provisioning of safe and secure food supplies. To help address this need we designed a One Health in food safety and security curricular framework to assist those tasked with designing education and training for future food systems workers including

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Food Safety/Security Leadership & Management		Food Safety/Security Foundations		Suggested Foundational Sciences	
Subtopic	Major Topic	Subtopic	Major Topic		
Agricultural Dynamic Management	Core	Global Food Supply	Local and Global Food and Feed Supply and Safety	Cell Biology	
Risk Analysis		Regulatory Oversight of Food & Feed Safety		Cross Cultural Competency/Anthropology	
Epidemiology					
Biosecurity	Food & Feed	Food- and Waterborne Illnesses	Food- and Waterborne Illnesses: Sources & Prevention	Economics	
Food Safety Plans		Public Health		Food science	
Pest Management		Health & Hygiene		Genetics (animal & plant)	
Sanitation & Disinfection		Sanitation & Disinfection		Inorganic Chemistry	
Feed Manufacturing		Food & Feed Adulterants and Contaminants		Math	
Ecosystem Monitoring	Agriculture & Ecosystem	Pre- and Post-Harvest Food Safety	Food Security	Microbiology	
Water & Waste Management		Food Safety Diagnostics		Molecular Biology	
Impact Assessment		Tissue Residues & Antibiotic Resistance		Nutrition (animal & human)	
Habitat Conservation		Emerging, Zoonotic & Regulatory Diseases		Organic Chemistry	
Sustainable Agricultural Practices		Threats to Food Availability		Parasitology	
Poverty and Food	Food & Society	Animal & Plant Production	Food Production	Pharmacology	
Susceptible Populations		Genetically Modified Organisms		Plant Biology	
Agronomics		Workplace Safety		Sociology	
		Animal Welfare		Statistics	
		Ecosystem Contamination		Toxicology	
		Ecosystem Services	Ecosystem	Virology	
One Health Core					

Fig. 1. A curricular framework for food safety and security education and training that incorporates principles of One Health.

food sanitarians, producers, manufacturers, researchers, teachers, and policy-makers.

2. Curricular framework design

During the design phase, brainstorming exercises were conducted to identify subjects, issues, concepts, and/or ideas related to food safety and security when viewing these subjects in the broadest-possible context. The identified subjects, issues, concepts and ideas were subsequently categorized into 3 tiers: basic sciences, food safety/security foundations, and food safety/security leadership & management. Suggested foundational sciences include traditional sciences as well as social sciences (see Fig. 1). Education and training in the food safety/security foundations (lower tier) is designed to provide awareness-level knowledge in a variety of different topics. Food safety/security leadership & management (upper tier) education and training will provide more in-depth understanding of problems and their related causes such that learners gain knowledge and skills needed to develop solutions to complex problems surrounding with the provisioning of

safe and secure food supplies amidst finite resources. The importance of sustainability of planetary resources for food production is stressed throughout this framework through topical material in ecosystem health and sustainable farming practices.

Food safety/security foundations contains 5 major topics: (1) local and global food and feed supply and safety; (2) food- and waterborne illnesses: sources and prevention; (3) food security; (4) food production; and (5) ecosystem. Major topics in food safety/security leadership & management are: (1) core; (2) food & feed; (3) agriculture & ecosystem; and (4) food & society. Subtopics within each of these major topics are arranged according to subject matter.

Concept statements accompany each subtopic within food safety/security foundations and food safety/security leadership and management (see Tables 1 and 2); these succinctly describe what a student should know following learning within the listed subtopic. For example, the concept statement associated with 'Food- and Waterborne Illnesses' in the major topic of 'Food- and Waterborne Illnesses: Sources & Prevention' is: "Students know the causes of food- and waterborne illnesses in different food types, and resulting public health impacts."

Table 1
Concept statements associated with each subtopic in food safety/security foundations.

Major topic	Subtopic	Concept statement
Local and global food and feed supply and safety	Global food supply	Students know about global food supply chains, including the effects that human populations, the environment, politics and international relations can have on food supply, demand, security, and safety
	Regulatory oversight of food & feed safety	Students know an overview of the regulatory bodies and food/feed safety regulations that govern local and global food/feed safety and contemporary issues that shape development of these standards
Food- and waterborne illness: sources & prevention	Food- and waterborne illnesses	Students know the causes of food- and waterborne illnesses in different food types, and resulting public health impacts
	Public health	Students know public health principles related to identifying, sourcing, and preventing causes of food- and waterborne illnesses
	Health & hygiene	Students know the principles of human health and hygiene for preventing and mitigating food- and waterborne illness and of the role of food sources, storage practices, and preparation in affecting risks for developing food- and waterborne illnesses
	Sanitation & disinfection	Students know the principles of sanitation and disinfection for preventing food- and waterborne illnesses that can be used on the farm, in the processing plant, and in retail establishments
	Food & feed adulteration and contamination	Students know types of food and feed adulterants and contaminants and methods to detect and prevent food adulteration and contamination
	Pre- and post-harvest food safety	Students know pre- and post-harvest practices including good agricultural practices (GAPs) and good manufacturing practices (GMPs) to reduce contamination of food and risk of foodborne illness
	Food Safety Diagnostics	Students know about traditional and modern methods for diagnosing food- and waterborne illnesses and how national databases are used for managing outbreaks of food- and waterborne illnesses
Food security	Tissue residues & antibiotic resistance	Students know how and why antibiotics are used in animals, the roles and responsibilities of veterinarians under legislation, and of the impacts that antibiotics can have on human health and food safety including the development of antibiotic resistance and tissue residues
	Emerging, zoonotic & regulatory diseases	Students know about emerging diseases, zoonoses, and diseases of regulatory importance that affect public health, food safety, and food security including risk factors for emerging/zoonotic diseases, the role that food and feed have in the spread of these diseases, and methods to prevent spread
	Threats to food availability	Students know about factors that threaten food supplies or that restrict access of human populations to food and methods to prevent food insecurity
Food production	Animal & plant production	Students know traditional and alternative plant and animal-origin food production practices and the effects that certain production practices have on food safety
	Genetically modified organisms	Students know about genetically modified organisms (GMOs) used in modern food production, food safety issues of GMOs, and of roles that GMOs may have in helping to satisfy global food supply demands
	Workplace safety	Students know about farm worker safety and health hazards associated with agriculture, regulations governing farm worker safety, and management methods and strategies to promote farm worker safety
	Animal welfare	Students know principles of animal welfare and practices to ensure welfare of production animals
Ecosystem	Ecosystem contamination	Students know about the role of human activity on the development of different types of environmental contamination and the consequences of contamination on ecosystem health
	Ecosystem services	Students know concepts of ecosystem services, planetary health, and planetary boundaries and of the impacts of human activity including food production on ecosystem health, biodiversity, strategies to minimize such impacts, and tradeoffs that are made to sustain life for the world's population

Table 2
Concept statements associated with each subtopic in food safety/security leadership & management.

Major topic	Subtopic	Concept statement
Core	Agricultural dynamic management	Students know methods to identify current and future problems in order to design and implement effective, sustainable solutions to address problems related to animal and plant-based production agriculture, and ecosystem health
	Risk analysis	Students know basic principles of risk analysis, including risk management, risk assessment, and risk communication as it relates to production of safe human food and animal feed and health of ecosystems involved in such production
	Epidemiology	Students know applications of epidemiologic principles and study design to assist in food- and waterborne outbreak investigations
Food & feed	Biosecurity	Students know biosecurity principles and applications of these principles to protect food (including animal and plant) and water sources from pests and diseases that threaten food safety and security
	Food safety plans	Students know components of food safety plans including the Hazard Analysis & Critical Control Point (HACCP) approach to identifying, evaluating, and controlling hazards to human food and animal feed and know how to write food safety and HACCP plans
	Pest management	Students know effective management strategies for animal and plant pests and diseases and methods to manage pests and diseases that minimize risks to ecosystem health
	Sanitation & disinfection	Students know sanitation control strategies, practices, monitoring, and regulations in pre- and post-harvest food production to prevent foodborne illnesses
	Feed manufacturing	Students know animal feed manufacturing processes, regulations, and testing practices and roles of these processes, regulations, and testing practices in helping to ensure feed and food safety
Agriculture & ecosystem	Ecosystem monitoring	Students know methods for monitoring ecosystem health to prevent contamination of food and feed and illness in humans and animals (wild and domestic), and for monitoring the impacts of food production practices on ecosystem health
	Water & waste management	Students know methods and system design for treatment, disposal, and utilization of wastes associated with food and agricultural production and methods to mitigate ecosystem contamination
	Impact assessment	Students know how to conduct environmental impact assessments, about the use of impact assessments in shaping public policy, and development of methods to adapt to ecosystem health changes brought on by human activities
	Habitat conservation	Students know ecological issues and controversies surrounding loss of species and habitats on land and in water and the impacts of modern agriculture on natural habitats and methods to mitigate these impacts
	Sustainable agricultural practices	Students know methods to conserve resources while supporting demand for increasing food and feed production for a growing global population
Food & society	Poverty and food	Students know the relationship between poverty and food safety and security, the causes and effects of regional and global poverty, and strategies to reduce poverty through improved food safety and security
	Susceptible populations	Students have knowledge of the types of populations that are most susceptible to food- and waterborne illnesses and of risk factors and mitigation strategies to reduce susceptibility to food- and waterborne illnesses in these populations
	Agronomics	Students know how to apply economic theory to optimize food and fiber production and distribution while maintaining ecosystem health

Spanning both lower and upper tiers is a core stream that is designed to provide students with skills needed when applying a transdisciplinary collaborative approach in addressing food safety and security problems. The use of practical examples in this core stream will impart awareness, knowledge, and skills in areas such as communication, informatics, values, ethics, leadership, team work, collaboration, critical thinking, systems thinking, adaptation, medical ecology, research methods, and awareness of diversity and cross-cultural differences.

3. Discussion/conclusion

The challenges that modern societies must face when addressing problems associated with increasing demands for safe and secure food supplies while preserving Earth's natural resources are global challenges. The curriculum presented here should be applicable throughout the world where different systems of food safety/security rules, regulations, resources, and consumer preferences prevail. The use of this curricular framework in designing food safety education and training programs also helps to address previously articulated needs for new curricula that encourage cross-disciplinary communication [2].

Considering the diverse subject areas included in this curricular framework, a question arises of where such a curriculum should be taught. In the authors' opinion this curriculum should be taught in a One Health in food safety and security center that brings together faculty from diverse disciplines in schools of agriculture, veterinary medicine, human medicine, and public health. The

areas of expertise represented by this faculty would be diverse and include a variety of sciences including food, agriculture, animal, plant, and environmental. Prior to the establishment of such centers it is anticipated that teachers would contact learners using distance learning tools and that some content could be delivered to learners using applications of modern educational technology. Indeed, such methods are anticipated to be useful in delivering the equally expansive curriculum encompassed by the Food and Drug Administration's National Integrated Food Safety System that is being designed to assist in implementing the Food Safety Modernization Act [8].

Placed within the larger global context of resource availability and sustainability [9–11], it should be clear why interdisciplinary approaches will be critical for solving complex food systems problems and why an effective workforce will need broad-based knowledge to help address such problems. We anticipate that this workforce will include food systems workers including food sanitarians, producers, manufacturers, researchers, teachers, and policy-makers. Such individuals, having received the breadth of information provided within the context of this curricular framework, should be well-positioned to help address the myriad of complex problems that currently are and will continue to be associated with food production on this planet. The challenge of producing and distributing enough safe food for the 9 billion anticipated people on Earth in 2050 without destroying its natural resources is indeed a wicked problem and it is hoped that this curricular framework can be useful in educating and training food systems workers tasked with solving such problems.

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