In the Age of Pandemics, Connecting Food Systems and Health: A Global One Health Approach

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1 The Challenges

Local, regional and global food security are affected by the occurrence of epidemics of zoonotic infectious diseases, caused by pathogens that spillover from animals to humans. Inversely, the susceptibility of animals and humans to infectious diseases is shaped by their health status, as largely determined by their nutritional status. Currently, this is clearly illustrated by the COVID-19 crisis (FAO and CELAC 2020; Swinnen and McDermott 2020). Diseases that affect animals and plants also continue to disrupt food security by interrupting the food supply. A One Health approach embraces the notion that the health of animals (also including aquatic species and insects), people, plants and the environment are inextricably connected. Simultaneously, innovations that address climate change, urbanization and mobility challenges should evaluate the risk for new and (re-)emerging human, animal and plant pathogens.

The COVID-19 pandemic lays bare the interwovenness of our food systems and health (FAO et al. 2020). In addition, the pandemic exposes how human health is shaped by socio-economic status and how health affects economic and social systems in return. The current pandemic was not the first, nor will it be the last. Here, we discuss the link between global food security and healthy people, animals, plants and environments, and how we can better prepare for, and minimize the chance of, future pandemics. We conclude that both public and private parties should strengthen their One Health approach to jointly realize resilient and strong global agri-food systems and health.

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1.1 Interconnection Among Ecosystems, Human and Animal Health – Zoonotic Infectious Diseases

COVID-19 is only one example of a zoonosis, a disease caused by the 'successful' transmission, spillover, of a pathogen from animals to humans. SARS-CoV-2 emerged from wildlife. There are ample similar examples; ~60% of emerging infectious diseases in humans originated from animals, and ~70% thereof originated from wildlife. Such spillover events occur most commonly where the agri-food system interfaces with natural ecosystems, as this is where humans, domesticated animals and wildlife interact.

Through humanity's long history with animal husbandry and consumption, hygiene practices have evolved, reducing the likelihood of successful spillover events (e.g., food safety, clean water, and the elimination of rodents from shelters). However, increasing mobility, population densities and urbanization, as well as the growing length and scale of the global food supply chains and pressure on natural ecosystems by changing land use and water flow, have created new challenges. For example, dams can impact the availability of fresh water, fishing opportunities and yield, and change the ecosystem, possibly leading to an increased risk of human disease (e.g., schistosomiasis). These transitions put the need for adaptation of current restoration, prevention, surveillance and intervention strategies in sharper focus.

1.2 Poor Human Health Facilitates Infectious Disease Spread

Sub-optimal human health adds to the favorable conditions for pathogen transmission. Poor nutritional status and impaired general health of individuals and populations, for example, due to the absence of nutritious foods and access to (affordable) health care, increase susceptibility to infectious diseases. Many of the common non-infectious diseases, including obesity, diabetes, cancer and cardio-vascular diseases, impair the body's immune response. These chronic conditions lower barriers to successful pathogen spillover from animals to humans, and subsequent pathogen transmission between people. Similar to other infectious diseases, COVID-19 disproportionately affects those with poor nutritional status and underlying health issues.

2 Impact of Zoonotic Infectious Diseases on Food Security

2.1 Direct Impacts

Large disease outbreaks disrupt overall mobility, the workforce and the supply chain (Wageningen University and Research 2020). Both the disease itself and the measures implemented to combat the COVID-19 pandemic hindered or disabled part

of the workforce and continue to do so. Such disruptions in the workforce affect food supply and, in many cases, workers' income or the economic viability of businesses in the food system (Egger et al. 2021). In addition, restrictions on travel limit the movement of workers, disrupting harvest and processing operations. Similarly, trade restrictions slow down and limit the movement of goods, affecting supply and demand.

2.2 *Indirect Impacts*

Cascading effects of the pandemic increase price volatility and disrupt food security and the livelihoods of those dependent on the food supply chain (Zurayk 2020). COVID-19, similar to, for example, past influenza outbreaks, has changed consumption patterns. Combined with travel and trade restrictions, this resulted in, among other things, uncertainties in the food supply chain that led to volatility in producer and consumer prices. These disrupted markets most severely affect vulnerable populations, e.g., low-income families – leaving them unable to acquire nutritious food – or small farm operations. Furthermore, the COVID-19 pandemic is estimated to have put about a third of the jobs in the food value chain at risk (451 million jobs out of ~1.3 billion), disrupting the livelihoods of ~1 billion people (Swinnen and McDermott 2020).

2.3 *SARS-CoV-2 and Other Infectious Pathogens in the Food Chain*

Zoonotic and other infectious pathogens can be transmitted via many different routes, including water and food products. The main transmission route of SARS-CoV-2 is the respiratory route, but anecdotal evidence is available of detection of SARS-CoV-2 genetic material in frozen products (e.g., ice-cream, fish) (Plowright et al. 2017). Currently, in February 2021, the movement of SARS-CoV-2 through the cold chain is still considered as a possible route of introduction of the pathogen to the urbanized center of Wuhan, China, from where it spread across the world.

The presence of pathogens in food systems may trigger interventions to stop pathogen spread. Although we focus on zoonotic pathogens here, animal and plant diseases and pests should be kept in mind. Similar to zoonotic pathogens, the range and outbreak frequencies of these disruptors of the food supply chain and health are expected to change due to the effects of climate change. Interventions to mitigate zoonotic and notifiable animal and plant pathogens, including transport bans, the destruction of crops, and culling, directly impact the food chain and the businesses and livelihoods of those relying on it.

3 Adapting the Agri-Food System to Limit Pathogen Risk

Reducing the likelihood of spillover and onwards transmission risks of pathogens can be achieved through (i) reducing the need for natural habitat disruption, (ii) smart management of both sides of the interface between natural ecosystems and the agri-food system, and vigilance at the human- animal interface within the agri-food system, and (iii) improving overall human, animal and environmental health.

3.1 Decreasing Habitat Disruption Through the Sustainable Intensification of Land Use

Sustainable intensification of land use could aid in limiting contact between humans and livestock with natural ecosystems and wildlife. To continue to meet the growing demand for food, further acreage expansion by conversion of natural habitats into agricultural lands is expected in several regions of the world. The pressure on natural ecosystems, caused by the expanding agri-food system, tends to negatively affect biodiversity and the resilience and health of wildlife, and increases the frequency of human, domestic animal and wildlife contact. These factors all contribute to increasing the chance of spillover occurring (Plowright et al. 2017). Hence, there is a clear need to reduce natural habitat disruption. Acknowledging that the demand for food will continue to grow, reducing habitat disruption may be achieved by using and encouraging sustainable intensification practices, and by reducing food waste and promoting the consumption of products with a smaller resource use foot print.

3.2 Smart Management and Vigilance at the Interfaces Through Surveillance and a Readiness to Intervene

Risk assessments should inform surveillance and readiness strategies to optimize pathogen detection and intervention. Over the past decades, we have created an increasingly connected network in which pathogens can spread, with the agri-food system being an integral part of this conduit (Bakalis et al. 2020). Here, the domains of food security, food safety and animal, environmental, plant and human health clearly overlap: from hunting practices to livestock farming, from butchering practices at home to slaughterhouses, from trade of live animals in markets and unsafe food preparation practices to contaminated food products in supermarkets, and the length and scale of parts of the global food system.

Detection efforts aimed at preventing pathogen spillover and spread throughout these highly connected networks can be optimized by mapping and assessing the risk, specifically, at the human and domestic animal-wildlife interface and in the transport (cold) chain. Regulation, targeted sampling and surveillance throughout

the system, complemented by appropriate hygiene and biosecurity measures, form the first steps to preventing shocks to the food system and health.

Optimized surveillance at the human-domestic animal-wildlife interfaces may enable early detection of (re)emerging pathogens and unexplained disease symptoms (e.g., undiagnosed pneumonia in the case of SARS-CoV-2). This early detection provides the opportunity for early interventions and a re-design of the system. Importantly, clear communication with producers and the public about biosecurity measures and a rapid and strong unified response are needed to prevent and control potential outbreaks.

3.3 Improving Overall Human, Animal and Environmental Health – A Global One Health Approach

The current pandemic presents opportunities for positive change (Monti 2021). This is the time for governments, the private sector and society as a whole to create more resilient food production and trade systems that put less strain on the environment and insulate vulnerable populations from shocks – instead of amplifying their vulnerability (as is happening with COVID-19).

Food security is essential to human health and wellbeing, and a healthy human population is less susceptible to pathogens (e.g., by reduced undernutrition, obesity, and resulting diseases). Governmental actions can lead the way to providing food security, by ensuring the functioning of the food supply chain and food systems (e.g., minimizing disruption in the trade of goods, providing employment services to migrant workers), and by communicating clearly to avoid mass panic and disproportional consumer behavior during disease outbreaks (PAHO 2021). The private sector can weigh their impact on health and the environment, considering that their supply chain may be disrupting natural habitats and that unknown pathogens may emerge at their farms, be transported in their cold chains, or disproportionately affect their staff. These actions, serving the global and national good, should be governed through global institutions to ensure governance of the food system and health for all. We, humans should also recognize the impact of the consumption choices that we make on a daily basis.

The interconnectedness of environmental, human and animal health can be leveraged in food systems to find unconventional opportunities to improve health (Fasina et al. 2021). Further research and an improved understanding of the role of food systems in the context of Global One Health may provide additional entry points via the food system for sustainable, culturally acceptable and economically feasible interventions.

4 Towards Food System Resilience

Resilient systems allowing for rapid recovery are needed to minimize direct and indirect health effects of shocks to the food system. Shocks, small and large, will continue to disrupt food systems, although efforts to prevent and minimize shocks

(as described above for zoonotic infectious diseases) may reduce the frequency and severity of shocks.

Management of the interdependencies between health and food systems to improve health for all presents many challenges, including the need for a change in mindset. Nevertheless, the elements that connect the food system with environmental, animal, plant and human health, as well as human health systems, are becoming more visibly connected in global, regional and national initiatives (Berthe et al. 2018). The 2021 UN Food Systems Summit is one example of such an initiative using an interconnected approach to set the stage for global food system transformation to achieve the Sustainable Development Goals by 2030. Another example is the September 2020 initiative to create a One Health High-Level Expert Council by UN Environment, FAO, OIE and WHO to address risks at the human-animal-environment interface. Furthermore, there is the materiality matrix in corporate sustainability reports, wherein stakeholder interests and a company's social, economic, and environmental impact are weighted. Also, the European commission is moving towards a code of conduct for participants in the food supply chain. Such a code of conduct could be considered at a global level. When consumers, producers and governments combine their efforts and take a Global One Health approach to re-designing the agri-food system, significant steps can be made towards food system resilience and better health.

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