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Moving health to the heart of agri-food policies; mitigating risk from our food systems

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ABSTRACT

Our food systems are progressively more industrialized and consolidated with many modern food value chains involving multiple countries and continents, and as such being associated with changes in risk profile and impacts of emerging and re-emerging diseases. Disease outbreaks that sweep through a single region can have massive impacts on food supply, while severe outbreaks of human pathogens can disrupt agricultural labor supply or demand for products perceived as 'unsafe'. Market pressures have generally rewarded production of cash crops for fuel and energy dense, low nutrient processed foods over production of fruits and vegetables for local consumption. Climbing rates of food-related NCDs and pre-existing conditions leave the population increasingly susceptible to infectious diseases that are often driven by or arise from the food system. Therefore disease and diet from our food systems cause impacts on human health, and human health issues can impact on the functioning of the food system. The COVID-19 outbreak is the most recent example of food system driven disease emergence and of massive supply and demand shocks in the food system, experienced as a direct and indirect result of this disease. The effects of the food system on disease spread (and vice versa) must be addressed in future plans to prevent and mitigate large scale outbreaks. Health policies must acknowledge the food system as the base of our health system, as must agri-food policy recognize the pre-eminence of human health (directly and indirectly) in decision making.

1. Introduction

The health of the global population is underpinned by our food systems, yet these systems are often only nominally included in health policy. In recent times, attention has been given to reformulation and marketing policies in moderate attempts to reduce climbing rates of obesity and non-communicable diseases (NCDs) (OECD, 2019). Others focus on reducing foodborne pathogens by regulating processing and enacting trade restrictions (Trienekens and Beulens, 2001). Many of these policies focus on downstream actors and processes in the food system and neglect the foundations of how our food is produced. While such interventions are easier to enact, they have limited effects on health and are generally reactionary and insufficient to reverse the trajectory of increasing health burdens. In this manuscript we review some of the major human health externalities driven by our current food systems, with an emphasis on livestock-systems and their linkages to the wider food system, the impacts of our response to these externalities and outline key areas in which better integrated health & agri-food policy may mitigate these factors.

2. Role of food-systems in driving externalities associated with human health

Although the interactions between food systems and our health are many and complex, we outline here four key health externalities arising from these systems of concern across the globe; 1) the dual burden of malnutrition, 2) foodborne disease, 3) antimicrobial resistance and 4) emergence of novel pathogens.

Despite an increasing ability to produce sufficient calories for the growing human population, distributional inequalities have produced a situation where we face the dual burden of chronic under-nutrition (Black et al., 2013) and a global pandemic of overweight and obesity and related NCDs, often within the same geographical locality (Shrimpton and Rokx, 2012). Diet related risks are estimated to be responsible for 255 million (234-274mn) Disability Adjusted Life Years (DALYs) a year globally, and dietary improvements could potentially

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prevent one in every five global deaths (Afshin et al., 2019). Diet related risks also monopolize large portions of many national health-care budgets (PHE, 2017). From 2020-2050, it is estimated that an average of 8·4% of healthcare expenditure in the 36 Organisation for Economic Co-operation and Development (OECD) member countries will be spent treating obesity-related diseases, equivalent to US dollars (USD) purchasing power parity 311 billion per year (OECD, 2019).

Current food systems exploit demand for affordable, convenient, and tasty food to encourage consumption of nutritionally poor, ultra-processed foods in both high, middle and low income countries. As economic markets incentivize expanded food value chains, they inevitably produce food with more and more processing to improve taste, texture, and longevity (Swinburn et al., 2019). The processed state of these foods, not necessarily the macronutrient content or energy density, induces increased calorie intake and weight gain associated with exposure to ultra-processed foods (Hall et al., 2019). Marginalized groups in high income countries are often reliant on these highly processed, energy-dense, nutrient poor foods to meet their energy needs. Ultra-processed foods can be aspirational in Low and Middle Income Countries (LMICs) and are becoming more affordable and convenient (Swinburn et al., 2019). These foods (and the value chains that produce and market them) are among the most impactful determinants of the growing global burden of food-related NCDs.

Food-related NCDs also increase susceptibility to infectious disease. For diseases such as Zika, West Nile, and dengue death is rare in the absence of any pre-existing conditions (Badawi et al., 2018; Chan-Yeung and Xu, 2003) and preliminary analysis suggests that the likelihood of adverse outcomes in SARS-Cov-2 are significantly higher in patients with hypertension and diabetes (Zhou et al., 2018). This increased risk may be driven by upregulation of the SARS-CoV-2 receptor ACE2 or heightened inflammation in people with these comorbidities (Pinto et al., 2020). These diet-related co-morbidities are visible symptoms of underlying structural inequalities which result in marginalized communities bearing disproportionate disease burdens (Garg et al., 2020; ICNARC, 2020).

Whilst the quantity and nutritional quality of our global diets gains increasing attention, foodborne diseases are also associated with a substantial human health burden, with approximately 33 million DALYs lost annually through 31 of the major foodborne diseases, the burden of which are disproportionately borne by LMICs (Jaffee et al., 2018; Li et al., 2019). Thirty-five percent of this burden is attributable to pathogens from animal source foods (ASFs) (Li et al., 2019), the increasing demand for which, particularly across LMICs, is a major driver in an increasing foodborne disease burden (Quested et al., 2010). Specific aspects of livestock value chains associated with an increase foodborne disease risk may differ across 'informal' and 'formal value chains. High prevalence foci of the zoonotic tapeworm *Taenia solium*, etiological agent of neurocysticercosis, are found where free-ranging pig husbandry practises coincide with low levels of sanitation and insufficient implementation of meat inspection (Singh et al., 2020). Informal value chains, which supply 85–95% of food needs in sub-Saharan Africa, and the poorly regulated slaughter, processing and retail practises associated with them can result in extensive microbial contamination of products, which may not be sufficiently mitigated by consumer food preparation practises (Jaffee et al., 2018).

The formalisation of livestock value chains does not completely mitigate all foodborne disease risks. Longer value chains with increasing number of processing or handling steps between 'farm and fork' provide opportunities for cross-contamination, adulteration or spoilage without sufficiently enforced regulation. The progressively intensified systems of livestock production seen increasingly across the globe may also exacerbate the risk posed by microbial hazards. Intensive systems bring animals into close proximity under circumstances which induce metabolic and psychological stress (Humphrey, 2006; Martínez-Miró et al., 2016), increasing the contact opportunities and susceptibility of these populations for disease transmission, including those pathogens which have important implications for food safety. This is particularly evident in monogastric systems, where intensive production contributes to over half of the global pork production and over 70% of global poultry production (Steinfeld et al., 2006; Thornton, 2010), and where *Campylobacter* and *Salmonella* spp. have been increasingly prevalent (Carrique-Mas et al., 2014). In order to mitigate the effects of high pathogen challenge, which also have production-limiting effects, intensive livestock systems have been heavily reliant on antimicrobials for prophylactic, treatment and growth promotion reasons (Van Boeckel et al., 2015).

Resistant bacteria reside in humans, animals, food and the environment and there are no barriers to the transmission of resistance genes between these sites or amongst bacterial species (Holmes et al., 2016). Pathways for the spread of resistant organisms, from within animal populations to humans, are well recognized and result from the selective pressures from antimicrobial use in livestock. Consequently, antimicrobial use in food-producing animal species represents an important driver of antimicrobial resistance (AMR) (Marshall and Levy, 2011). The human health burden from AMR is forecasted to reach 100 trillion USD by 2050 with a worldwide mortality around 10 million (O'Neill, 2016).

In response to the AMR crises, there is growing international pressure to reduce the use of antimicrobials within livestock systems and to prohibit the use of antimicrobial growth promoters (AGPs) in livestock. Trade-offs exist, however, between the risks of antimicrobial use and the pressure to ensure global food security. A ban on AGPs could be associated with a reduction in the value of global meat production of between 13 and 44 billion USD (Laxminarayan et al., 2015) and restricting the use of antimicrobials for prophylactic and therapeutic use whilst retaining current intensive husbandry practices will impact both productivity and animal welfare.

Lastly, disease emergence and transmission are of growing concern within our intensive, increasingly homogenous and interconnected food systems. Lack of genetic diversity has become commonplace in our global food systems, within both livestock and crop production (Bennett et al., 2018; Khoury et al., 2014), and is a risk factor for heightened susceptibility to outbreaks of plant and animal disease. This 'monoculture effect' is best illustrated in agronomy, where non-diverse cropping can lead to large scale losses, such as those suffered through rice blast (Zhu et al., 2000) and the Panama disease epidemic of bananas in the 1960s (Ordonez et al., 2015). Similar genetic susceptibilities exist within livestock. Porcine Reproductive and Respiratory Syndrome virus, a major disease burden to the global pork sector, has led to exacerbated losses within genetically homogenous herds as compared to herds with a wider genetic pool (Lunney et al., 2010; Halbur et al., 1998).

As well as the emergence of production limiting pathogens within livestock systems, the emergence of novel, zoonotic pathogens from our food systems is at the forefront of the global consciousness, of which SARS-CoV-2 is only the latest example in an increasing frequency of such events. Novel zoonoses have emerged most commonly from wild mammals such as rodents and bats, which have either adapted to anthropogenic habitat changes, or have increased contact with humans or livestock through agricultural incursions into habitats or establishment of bush-meat value chains (Johnson et al., 2020). Examples of direct pathogen spillover from wildlife directly to humans, predominantly associated with formal or informal bushmeat value chains, include HIV and Ebola (Hahn et al., 2000; Kock et al., 2019). There is also a potential threat to human health from the transmission of disease from wildlife into livestock populations and then further propagation through intensive production (Wilcox et al., 2014). In 1998 cases of the novel febrile encephalitis, Nipah virus (NiV), emerged amongst pig farmers in Malaysia. The intensification of mango and pig production within a localised geographical area are believed to have provided a pathway for the virus, circulating in fruit bats, to infect an intensively managed commercial pig population and subsequently spread to farmers (Pulliam et al., 2012).

3. Effects of infectious disease on food systems and food security

Zoonotic and non-zoonotic disease outbreaks and our responses to the presence or risk of these pathogens can destabilize food systems, leading to increased food insecurity and downstream health and economic effects. Fig. 1 illustrates several of the key disease outbreaks of the previous three decades which have had profound impacts on human health and food-security.

In Europe, outbreaks of Bovine Spongiform Encephalitis (BSE) and Food and Mouth Disease (FMD) led to large scale supply and demand shocks in the beef and dairy industries. The use of meat and bone meal in cattle feed was associated with the mid 1980's emergence of the degenerative prion disease BSE, which was later found to cause new-variant Crutzfeldt-Jacob disease (nvCJD) in humans (Anderson et al., 1996). This led to a raft of mitigation measures with short and long-term costs, including large scale culling programmes, new harvesting and processing regulation, a ban on animal by-product use in animal feeds and restrictions on beef and other animal products (including milk, semen and embryos) export from affected countries (Kimball and Taneda, 2004; Thiermann, 2004). The effects on the food system and health from the FMD outbreak in the UK 2001 also extended beyond production losses (Knight-Jones and Rushton, 2013). Trade restrictions between FMD free and FMD affected countries were sometimes extended to unrelated products. Culls produced public outrage against the livestock industry that outlasted the outbreak itself, which together likely contributed to the observed spike of depression and suicide among farmers (Thomas et al., 2003). In areas where a large proportion of the population is dependent on agriculture for both income and food supply, such as Ethiopia, endemic FMD has direct effects on the food security of farmers by reducing milk production and oxen availability for cropping (Knight-Jones and Rushton, 2013).

Pork is now the most frequently consumed meat per capita worldwide and is responsible for over half of meat consumption in Asia (Ritchie and Roser, 2019). Introduction of African Swine Fever Virus (ASFV) into China, home of approximately 50% of the global herd (Ritchie and Roser, 2019), resulted in rapid spread throughout the naive pig population. Over 10% of pigs have died or been culled (FAO, 2019), causing an estimated \$140 billion in direct economic losses (Moore, 2019) and reverberations through industries including feed mills, veterinary services, restaurants, and tourism. Pork prices soared to a peak of 110% year-on-year (Moore, 2019), increasing demand for and price of other meat products and leaving poorer households at increased risk of food insecurity and malnutrition (Rocha et al., 2016). Similar patterns were seen across the same region less than a decade before in response to outbreaks of highly pathogenic avian influenza where aggressive containment measures drove increases in meat prices and heightened local food insecurity (Burgos et al., 2012). LMICs, particularly those in Southeast Asia, are the site of the majority of industrialized poultry farming. Large scale flocks are more likely to contract HPAI (H5N1) than small, personal flocks (Otte et al., 2008) and experience the greater share of economic effects. Yet smallholders, traders, slaughterers, and transporters are at greatest risk of personal negative health outcomes as a result of such diseases, as they often belong to poor households that are unable to weather economic shocks and are sensitive to food insecurity and malnutrition.

The West African Ebola outbreak of 2014 provides an example of severe, localized effects of an outbreak on the food system due to travel restrictions and market closures (Mann et al., 2015). Panic buying caused shortages of some items and dramatic increases in prices. Labor shortages resulted in decreased food production and loss of income across communities, particularly in rural regions (de la Fuente et al., 2019). Nutrition operations were a low priority among humanitarian response groups and were inadequately supplied (Kodish et al., 2019). They also neglected to consider the needs of communities that did not have Ebola outbreaks but had become food insecure from food production losses. After the outbreak, many Ebola disease survivors were denied the opportunity to purchase food due to lingering fear of infection.

On a global scale, the ongoing COVID-19 outbreak has also led to massive perturbations in food systems. Lockdowns and retail closures directly cause food insecurity among vulnerable populations, national stockpiling has prompted some countries to halt or reduce exports of staple grains and legumes (Reuters, 2020), and travel restrictions have inhibited farmers across Europe from hiring seasonal migrant workers to harvest fruit and vegetable crops (Carroll et al., 2020). Workers in food retail and transport that remain employed are experiencing unexpected health risks, severely reducing the ability of some sectors of our food-systems to operate as has been particularly noticeable in the

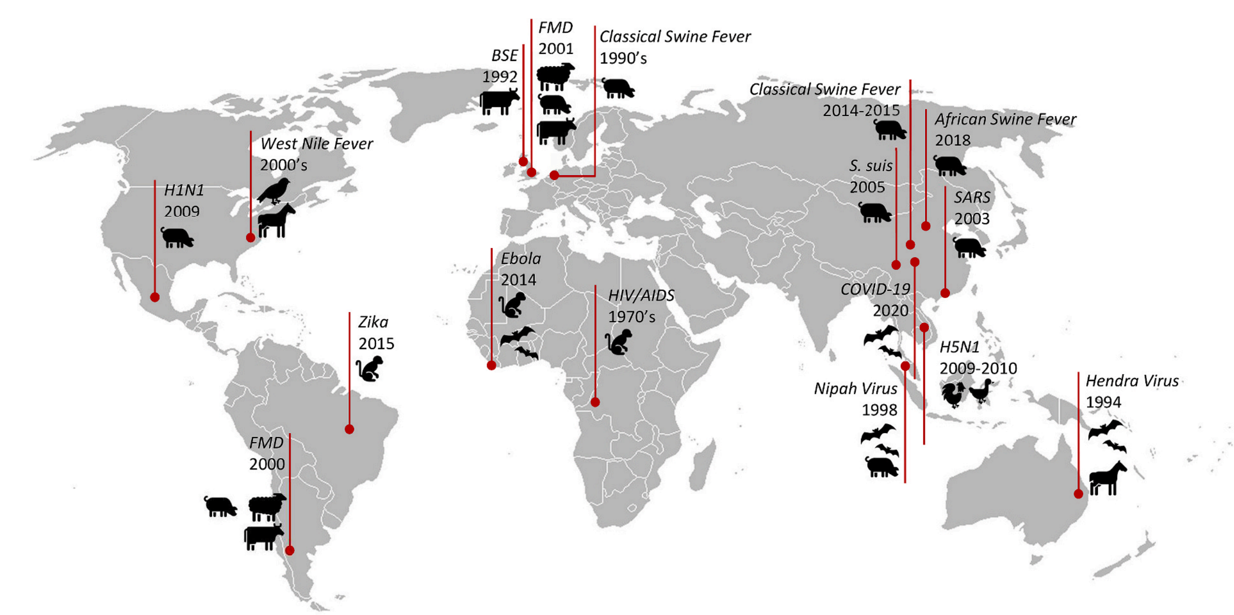

Fig. 1. Notable disease outbreak and pathogen emergence events by year and location of emergence or highest impact, with key animals involved in transmission. BSE = bovine spongiform encephalitis, COVID-19 = coronavirus disease 2019, FMD = foot and mouth disease, HIV/AIDS = human immunodeficiency virus infection and acquired immune deficiency syndrome, SARS = severe acute respiratory syndrome, S. suis = *Streptococcus suis*.

vulnerability of meatpackers and subsequent COVID-19-related shutdown of some meat processing plants in USA (Apostolidis, 2020). Workers provided with little protection or compensation have in some instances organized strikes to protest their lack of economic and health protection (McGinnis, 2020) and lengthy screening proceedures or social-distancing measures have the potential to dramatically reduce production capacity in some sectors (Hailu, 2020). Once social distancing protocols are lifted, medium to large enterprises will likely be best poised to recover and many small businesses integral to local food systems will be unable to bounce back, producing economic knock-on effects on wholesalers, processors, and producers across the supply chain.

While food insecurity surges as a result of control measures, food waste is also increasing. It is estimated that over a third of all food produced for human consumption is wasted (FAO, 2011), a figure which will grow as shopping patterns change from multiple small shops per week to larger, more infrequent shops (Cranfield University, 2020). Food systems lack the flexibility needed to adjust to rapidly evolving situations within disease outbreaks, causing still more waste (Evans, 2020). Restaurant and coffee shop closures have decreased demand for milk and dairy farmers have been told to pour milk down the drain, yet supermarkets have restricted purchase of milk and other core products (Keane, 2020). Closures of large meat processing plants due to worker illness will result in large scale culling of animals across the USA. Meanwhile, emergency assistance agencies are running low on supplies to support the deluge of the newly food insecure (Power et al., 2020).

4. Integrating health & agri-food policy as a tool against outbreaks and food insecurity

Despite the undeniable link between our food systems and health, the Sustainable Development Goals (SDGs) do not explicitly link these areas other than within the context of malnutrition (UN, 2015). Public health policies must pay greater consideration to the role of food systems as the baseline of population health, while agri-food policies should consider human health as their *raison d'être*. Agri-food policies can promote health in direct and indirect ways – globally 27% percent of employment is in agriculture, this rises to 60% in low income countries (World Bank, 2020). Sustainable agriculture supports economic prosperity, environmental wellbeing, and social equity (i.e. the triple bottom line), all of which further support stable access to healthy diets and healthy environments. Well executed, integrated health-agri-food policy should improve baseline health, mitigate infectious disease risks and increase the resilience of our food systems to protect food security, particularly for the most vulnerable. Herein we highlight some key examples of these policies in action, where further strengthening is required, and the dynamics that complicate enactment of health-centered agri-food policy (Fig. 2).

4.1. Improving population health through diet

Evidence-based health-agri-food policies that support access and uptake of healthy diet and exercise, particularly in communities with high inequality, can help reverse the growing trend towards obesity and minimize morbidity and mortality from infectious disease. A multi-pronged approach is needed to set healthy food preferences at an early age, change the environment to encourage healthy choices (particularly

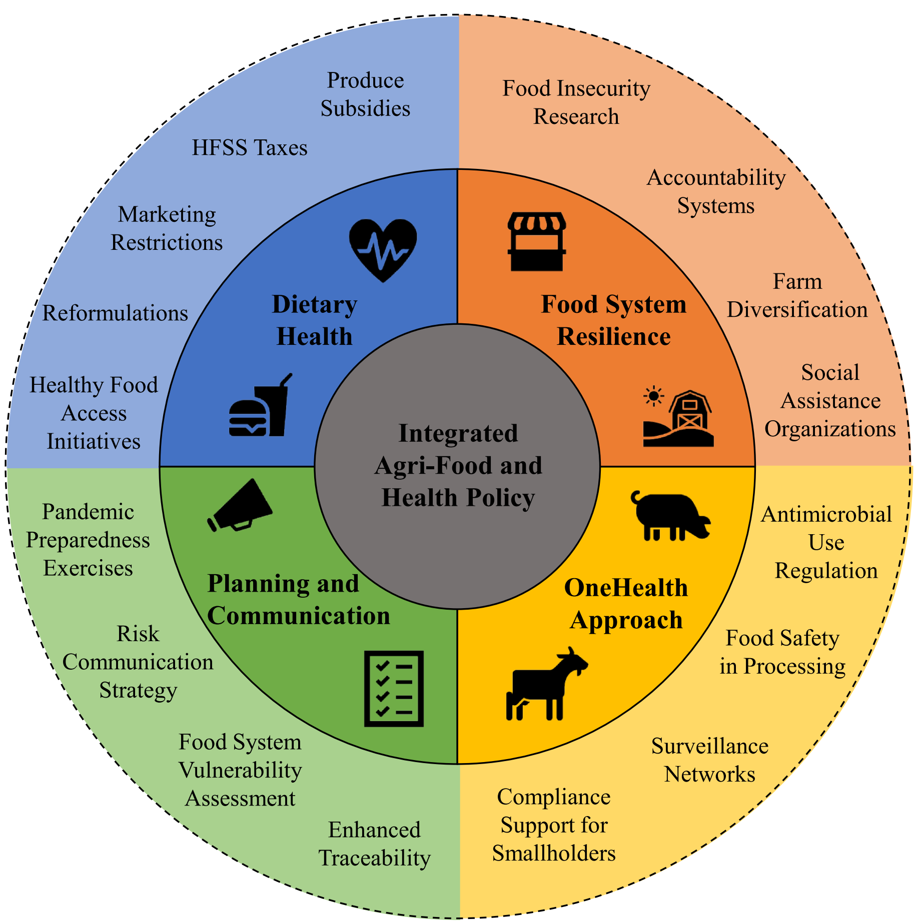

Fig. 2. Integration of Health and Agri-Food Policy. Current and recommended agri-food and health policies to reduce the frequency and impact of disease outbreaks.

at the point of purchase), and reduce barriers to expression of healthy preferences (Hawkes et al., 2015). Policies that limit consumer exposure to less healthy foods by reducing portion sizes, reformulating foods, and regulating advertising are often blocked or weakened by lobbying groups (Swinburn et al., 2019). There is little immediate financial motivation to adopt more environmentally and health friendly standards, though social demand is increasingly reorienting markets to value transparency and social and environmental aspects of corporate performance. Policy interventions that rely on behavioral change, such as consumer awareness campaigns and front of pack labeling, are relatively easier to enact but have limited longevity or effectiveness in the presence of other food stimuli or under stress (Hill, 2009; Leng et al., 2017). The dynamics surrounding the adoption, implementation, and effectiveness of regulatory health policy are exemplified by the high fat, salt, and sugar (HFSS) taxes that have been adopted across diverse nations with a wide range of outcomes (World Health Organization Regional Office for Europe, 2015). Most slightly reduced consumption of HFSS foods but it is unclear what affect, if any, these taxes have on other health indicators in isolation. Low income consumers that rely on affordable, energy-dense foods may be unduly burdened by HFSS taxes but benefit from alternative price interventions such as subsidization of fruit and vegetables (Neff et al., 2009). While current regulatory interventions in isolation have minimal effect on downstream health indicators, they provide precedent for future regulatory policy and encourage action surrounding the role of large companies in shaping the food environment.

Significant improvements in global population health will require cooperation of people and companies involved in food systems to fundamentally change how they operate, but some communities have overhauled their local food environments with a ground-up, systemic approach that bypasses many of the barriers encountered on a national level and inspires awareness and innovation. In Baltimore, USA, policies have been enacted to re-familiarize consumers with the systems and people that produce their food (Department of Planning, 2018), incentivize wholesaler produce distribution to small convenience stores, and encourage grocery chains to move into low income communities. City government also supports local ownership of food retail outlets in underserved neighborhoods, cultivating economic growth, a sense of community, and the agency to improve the health issues people see in their neighborhood. Baltimore's food policy initiatives demonstrate how to mobilize community members to incorporate agri-food policies across city operations and government, business and economic development, and community organizations to combat the multifactorial roots of poor dietary health.

4.2. Mitigating infectious disease risk in food systems

Even prior to the COVID-19 pandemic the international community had been aware of the increasing threat from emerging zoonotic pathogens, the 'dual burden' imposed by endemic zoonoses on livestock productivity and human health, the biological and chemical hazards present in our food and the looming spectre of a post-antibiotic world. The protection of consumers from zoonoses and foodborne diseases acquired from the consumption of diseased animals or via unhygenic slaughter and processing has been a concern for centuries and formal meat inspection, still broadly recognisable today, was instigated in Europe in the 1880's (Edwards et al., 1997). The multi-faceted nature of infectious disease risks within our food-systems and the plethora of public and private actors working within them, with differing roles and responsibilities has driven calls for an integrated 'One Health' approach, endorsed at the highest level by the WHO, OIE, FAO tripartite and the World Bank.

Despite growing acceptance of this concept internationally and the establishment of several regional and national One Health units, there are still major challenges in operationalization. Power struggles between ministries for 'ownership' of the movement, poorly integrated policies, lack of interoperability in data systems, and resource constraint for frontline services have all been identified as key barriers, and the multiplication of One Health initiatives, specifically those with single issue focus, may risk undermining the strength of the moment (Spencer et al., 2019). This splintering and 'siloisation' of One Health can be illustrated by Kenya, where four separate One Health bodies now exist with separate remits for zoonoses, AMR, aflatoxins and pesticides but with no over-arching co-coordinating mechanism across these areas, and with other one health issues such as foodborne disease lacking an inter-ministerial 'home' (Kimani et al., 2019).

Although challenges exist, the One Health approach has been repeatedly employed to mitigate animal and human disease threats, as exemplified by the 2017 response to colistin resistant *E. coli* (CREC) in China (Wang et al., 2020). Colistin is used predominantly in the livestock sector but is an important antimicrobial of last resort for human disease. Following the discovery of widespread distribution of colistin resistance gene *mcr-1* in *E. coli*, the Chinese Ministry of Agriculture and Rural Affairs banned use of colistin as a growth promoter in livestock. Three years on, significant reduction was observed in the relative abundance of *mcr-1* in pigs, CREC carriage in pigs and chickens, human carriage of mcr-*1* positive *E. coli*, and human infection with CREC. A clearly defined problem and solution, strong political support, and effective inter-agency enforcement contributed to the success of this policy and provides guidance for future approaches to threats to animal and human health.

The One Health approach will only be as strong as its constituent parts; environmental stewardship is often missed completely, whilst veterinary and human public health systems have often been chronically under-funded in favor of support to primary food production and curative human medicine. Strengthening these capacities and meeting countries' commitments under the International Health Regulations and the OIE Pathway for Veterinary Services programmes is integral to the Global Health Security Agenda (Belay et al., 2017). The capacity building activities within the GHSA thus far have relied predominately on external donor funding. Ultimately, the sustainability of these activities will require resource commitments by national government and a greater acknowledgement of the role of private actors across food systems (Kelly et al., 2017). There an increasing number of private standard setting organizations to enhance global food safety such as the Global-Good Agricultural Practises standard (King et al., 2017). Private standards can be excessively high, which improves food safety but may be unattainable for smallholders or farmers in LMICs, effectively shutting them out of global markets and further highlighting the need for a collaborative, multi-sectoral approach to food safety.

4.3. Reducing shocks through traceability, communication, and preparedness planning

Responses to emerging pathogens and outbreaks are often fear driven and reactionary. During the swine flu (H1N1) outbreak, Egypt culled their entire pig population, despite pigs not transmitting the virus to humans (Atlani-Duault and Kendall, 2009). Traceability systems have become more sophisticated and widespread and can support narrower outbreak responses, yet retailers and governments often issue blanket recalls and import restrictions during health crises (Van Der Vorst, 2006). Similar to other components of food safety programs, development of and compliance with better traceability systems largely rest with private companies and may not be harmonized with standards set by public health bodies. To improve response time and accuracy during outbreak events, quality traceability systems across the value chain must be combined with transparency and communication with decision makers. Prior to such events, governments should develop and train networks of communication that connect food systems agents, trustworthy spokespeople, and consumers to minimize panic and reactionary measures (WHO et al., 2019).

National outbreak preparedness plans and risk reduction strategies concerning diseases that originate outside the food system typically do not include considerations for protecting food systems but should be a key factor in planning potential response efforts (Ortu et al., 2008). Localities can contribute to outbreak preparedness by conducting food system vulnerability assessments using fault tree analysis across a range of emergencies (Biehl et al., 2018). Even when food systems are considered in planning exercises, insufficient follow through, lack of resources, or unwillingness to allocate available resources may render such exercises meaningless. Policymakers must prioritize action following planning exercises, as emerging infectious disease and food safety events are increasingly likely as food systems become more globalized.

4.4. Strengthening resilience of food systems and communities

Corporate concentration of agricultural sectors both horizontally and vertically has resulted in centralizing control of large swaths of the food system among a few companies, reducing the resilience of food system to internal and external shocks (Howard, 2017). These oligopolies have vast lobbying power, making it difficult to enact structural change. Positive change at this level will require market incentives and non-governmental accountability systems similar to what is seen in current efforts to combat climate change (Heymann et al., 2015). Reliance on food imports also increases vulnerability to food insecurity. An estimated 1/6th of the global population in 2000 were dependent on food imports for their basic dietary needs (Fader et al., 2013), leading to an unequal power dynamic between net-exporters & net-importers and undermining the development of locally appropriate value-chains.

At the production level, agri-food policies which support local farmers and smallholders can strengthen food system resiliency by increasing the diversity of local food systems and protecting against economic shock. One example is the UK government Department for the Environment Food and Rural Affairs' Farm Diversification Grant Scheme, which helped farmers in the UK develop a diverse portfolio of income sources (Turner et al., 2006) for this reason. Support for agricultural diversification among smallholders in LMICs can improve food security, reduce poverty, and strengthen resilience to climate change and market instability, resulting in long term increases in productivity (Joshi et al., 2007; World Bank, 2018). However, there are several obstacles to farm-level adoption of diversified farming systems, including start-up costs, potential initial productivity losses, lack of access to technical guidance or support, and market disencentives such as commodity crop subsidies and insurance (Harvey et al., 2014). Some farm level barriers can be overcome with an institutionally organized systems or landscape approach that incorporates multiple stakeholders to achieve a collective diversification goal. Policymakers should work to increase accessibility of diversification tactics, support research to provide further evidence and guidance for diversification, and ensure follow through on these commitments. While the 55 countries in the African Union have pledged to enhance financial investment in agriculture, only nine are on track to reach agricultural research spending goals (Vilakazi and Hendriks, 2019).

At the consumer level, stable access to food during periods of crisis can be ensured by policies that support emergency food access and flexibility within supply chains. The COVID-19 outbreak underscores the need for policies to support and improve access to food assistance agencies, which not only supply emergency food but also help those in need access benefits, job training, and medical resources (Environmental Audit Committee House of Commons, 2019).

5. Conclusion

Food systems have wide and far-reaching impact on health, economy, and society locally and globally, while health issues and our response to them have major impacts on how food systems operate. A sustainable and healthy food system supports fair wages for individuals across the food value chain, provides affordable, nutritious, diets that are culturally acceptable, operates in an environmentally sustainable manner, and is resilient and adaptable. Foodborne disease and emerging infectious disease events should naturally decrease as food systems approach these ideals. This vision is far-removed from the current reality but provides a set of priorities through which agri-food policies should be developed. Major challenges exist concerning the reorientation of market incentives and food systems standards, heightened accountability, changes in land use, and cooperation between countries and corporations. Yet, consumers are increasingly aware of the broader effects of current food systems and are beginning to widely challenge the status quo. The severity of the current COVID-19 outbreak and its unusually far-reaching impacts on food systems will hopefully provide the stimulus and opportunity to for both high level decision makers and the wider consumer base to more seriously focus on restructuring our food systems to better support the health of the global population.

Declarations

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Declaration of competing interest

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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