The Spread of Zoonotic Diseases: Analysis of Livestock Regulation in the US and Ethiopia

PARTH PATEL[1]

Zoonotic diseases pose a significant threat to human and animal health. These diseases are transferable from animal to human or vice versa through various means such as direct contact with bodily fluids (urine, blood, fecal matter), touching an infected animal, consumption of water or food contaminated with the disease, through aerosol particles that travel in the air and dirt, and via vectors carrying the disease (an insect infects a person with the pathogen they brought over from an animal). Zoonotic diseases have surged in recent decades, affecting livestock and humans. For instance, Bovine Spongiform Encephalopathy (BSE), more commonly known as Mad Cow Disease, which emerged in 1986 and affected the cow's central nervous system, spread from cows to humans, possibly through consumption of BSE-infected cow meat (FDA). The human variation of the disease, referred to as variant Creutzfeldt-Jakob disease (vCJD), infected about 233 people, resulting in deaths as well among those infected (CDC). The disease spread in many countries, gaining traction and attention from international and national organizations, including the World Health Organization (WHO) and the Center for Disease Control (CDC). Besides Mad Cow disease, other zoonotic diseases, including Anthrax, Brucellosis, Campylobacteriosis, Escherichia Coli (E. coli), and Rabies, have also seen increased incidence rates.

Scientists Delia Grace and Brian Perry claim that poor infrastructure contributes to the spread of these diseases. They note, "when public resources are being allocated, livestock is often the Cinderella sector, under-appreciated and inappropriately funded" (Perry and Grace, 2009). The issue of regulatory measures and adequate funding for livestock management is most critical in developing countries. Population density, compounded by limited resources, weak infrastructure, and poor regulation, adversely impacts the spread of diseases in developing countries. In contrast, developed countries, such as the U.S. and the U.K., have both the necessary infrastructure and an extensive list of rules and regulations for the transportation, importation, and exportation of livestock compared to developing countries, curtailing the spread. Besides funding and regulation, poverty is a crucial difference between the developed and developing countries' ability to manage zoonotic disease. In rich countries, livestock owners have better access to veterinarian healthcare and livestock insurance, preventing the spread of zoonoses and providing economic stability to livestock owners. However, in poorer regions, livestock keepers not only lack the financial means to control disease spread but also, zoonotic diseases influence their livelihood, which leads to zoonoses operating as a poverty trap.

The livestock industry is worth over 2 trillion dollars globally, with the U.S. producing 100 billion pounds of meat annually and growing in production by 2-3% yearly (Dent, 2020). In *Economic Aspects of Zoonoses: Impact of Zoonoses on the Food Industry*, Martins, Häsler, and Rushton (2014) discuss how, throughout the 1960s and

[1] Parth Patel is a 2021 Law and Society graduate from Ramapo College.

70s, there was a drastic change to how Europe, North American countries, and Japan started to take a more severe approach to deal with transboundary and endemic animal diseases. For instance, the Center for Disease Control (CDC) was instituted in the United States. They invested significantly in human skills and instituted veterinary organizations, education, and infrastructure (Martins, Häsler, and Rushton, 2014). The countries and regions that have allocated funding to the handling and prevention of endemic diseases have better control of foodborne illnesses than those underfunded. The situation is different in Ethiopia.

Ethiopia is the fastest-developing region in the world; the GDP is predicted to triple, and the population will double by the year 2050. (Bernstein, 2020). Ethiopia has been struggling with widespread zoonoses and has been unable to gain control for decades. This unfortunate circumstance has resulted in the death of livestock and illness within their population. The country is also heavily reliant on agriculture, making up 45% of GDP and 85% of the labor force, while livestock agriculture accounts for 15% of the country's GDP (World Bank, 2020). With such a heavy reliance on livestock agriculture, more investment in infrastructure could help livestock owners control and monitor. There is no way to eliminate zoonoses in livestock. Yet, various practices in varying regions help ensure that zoonoses are not spread through food consumption or from one animal to another, and the transmission rates for humans and animals are reduced. For instance, the Food and Drug Administration (FDA) in the United States, has restricted the use of any high-risk parts of cows or other animals in making animal feed (FDA, 2020). Furthermore, organizations such as the CDC, the FDA, the Food and Agriculture Organization (FAO), and others work to ensure livestock are disease-free before and after being slaughtered. They perform sample testing in which they test a select few out of a herd to check for diseases while inspecting meat and poultry after being killed. Bringing over practices and laws such as these to developing economies would help lower the spread of diseases.

The real question, however, is how do we implement these systems in areas with minimal to no proper facilities to care for their livestock effectively? The answer ties back to funding. If these areas are allocated the appropriate budget and infrastructure needed to maintain healthy livestock, it will lead to economic and health benefits. Many 'backyard farmers' who are left with infected livestock have no choice but to sell and eat the meat themselves because it is one of their primary food sources. My report will examine livestock zoonoses by comparing livestock management practices and regulatory frameworks in the United States and Ethiopia. I will draw from US practices to reflect on the economic and regulatory components of livestock management, zoonotic diseases, and their impact in Ethiopia. The international community needs to ensure that there are systems and measures put into place globally to protect the health and well-being of the human population. Zoonotic viruses are gaining the ability to grow and mutate rapidly, leaving many vulnerable to life-threatening diseases. There are still diseases that have been eradicated in developed countries but continue to infect those in developing nations, such as Ebola. In recent years, we have already seen how the novel coronavirus (Sars-COV-2) has impacted society and destroyed millions of lives. By creating and instilling these systems and laws into play, it can guarantee the well-being of society. The CDC has confirmed that COVID-19 originated in an animal host, and due to pathogen spillover, the virus was transmitted to a human host. This virus is the

perfect example of why action must be taken at the international level to support developing economies in developing systems to track and control zoonotic diseases.

Livestock History, Laws, and Procedures

Zoonotic diseases have been present in society since the domestication of animals. While the domestication of animals and settled agriculture enriched human ability to produce food, the proximity of humans and animal livestock has given rise to viral pathogens with zoonotic origins. The risk of infectious diseases has intensified further in the modern context, as industrial agricultural systems, including livestock farming, have increased livestock densities, limited movement of animals, reduced production inputs such as sanitary standards, and thus, neglected care of animals and workers.

Livestock agriculture is a growing global industry, and most countries are connected to the global supply chain of animal production. Establishing proper frameworks and methods to run the livestock sector sufficiently can help strengthen the market by creating a system that ensures safety and stability in areas heavily dependent on this source of agriculture. This section will highlight the history, laws, and procedures established in the United States and Ethiopia to manage the livestock industry and control diseases. Both the U.S. and Ethiopia rely heavily on the livestock agriculture market and have different strategies and levels of resources for livestock monitoring and controlling the spread of disease.

United States

The United States is ranked fourth globally for cattle production placing it before Ethiopia (Ritchie, Rosado, and Roser, 2017). It is estimated that in the United States, it costs about five hundred to one thousand dollars per year to maintain one cow's lifestyle, which includes feed and care. Besides being a leader in livestock agriculture in terms of productivity, the U.S. has also created an advanced system of organizations and government-assisted programs to ensure the safety and livelihood of all livestock and reduce the chances of zoonotic diseases.

Livestock History

Livestock products were sold in small-scale quantities before factory farms and meatpacking plants were introduced. One primary reason behind this is the population levels and the means of living. In the 18th and 19th centuries, population structure and housing differed from what we see today. "Families spent most of their time producing food, shelter, and clothing for their use. Ninety percent of the U.S. population was on farms in the 1800s (compared to about 2.0% now)." (Bray, 1997). From the start to the mid-1800s, as farming grew, virtually no laws and procedures were set to determine the quality of livestock production and the livestock themselves. The waste runoff would often leak into water supplies, leaving entire communities disease-ridden. Additionally, even with the introduction of the meatpacking industry, sanitation, and meat quality did not improve dramatically. While efficient processing methods such as the conveyor belt and refrigeration systems reduced the growth of bacterial and viral infection, they did not eliminate the spread of diseases.

Livestock Laws

Towards the end of the Industrial Revolution, many provisions were set by the United States Government to increase livestock production and supply. During the rise of the meatpacking industry from the 1840s to 1860s, there was little government interference and regulation set on workers' labor conditions and slaughtering conditions of animals. It was not until the creation of the United States Department of Agriculture (USDA) that it overlooked all domestic livestock to ensure that it was safe to consume and in healthy standing. This was the beginning of the Bureau of Chemistry, the predecessor of the Food and Drug Administration. The Food and Drug Administration created a universal system of rules and regulations within the agricultural livestock food supply.

In 1906, two federal laws on livestock safety were passed in the United States. The first was the Pure Food and Drug Act, which "prevented the manufacture, sale, or transportation of adulterated or misbranded foods, drugs, medicines or liquors." (Institute of Food Technologists, n.d.). The second law passed was called the Meat Inspection Act, which "prohibited the sale of adulterated or misbranded meat and meat products for food and ensured that meat and meat products were slaughtered and processed under sanitary conditions" (Institute of Food Technologists, n.d.). This law was a milestone in reducing disease spread within the livestock sector. Improving slaughtering and sanitation conditions would decrease the spread of zoonotic diseases drastically.

Furthermore, Congress had revised the Pure Food and Drug Act in 1938 with new provisions which consisted of "requiring safe tolerances be set for unavoidable poisonous substances, authorizing standards of identity, quality, and fill-of-container for foods, authorizing factory inspections, and adding the remedy of court injunctions to the previous penalties of seizures and prosecutions." (Institute of Food Technologists, n.d.). Additionally, in 1957, the Poultry Products Inspection Act was passed, which mandated inspections and randomized testing to ensure the safety of pre-packaged meats from any diseases (Institute of Food Technologists, n.d). In 1970, the Center for Disease Control (CDC) started to keep records of foodborne illnesses; being able to track infections was the start of modern disease tracking. Consequently, the FDA, CDC, and USDA share data to prevent disease spread.

Ethiopia

The continent of Africa has the fastest-growing population in the world. According to the United Nations, Africa's population could double by 2050, approximately 2.43 billion. As the trend has shown, with the increase in population comes an increase in demand for livestock. According to Ugo Pica- Ciamarra, a Livestock Economist for the FAO, "To meet the growing need for meat and dairy products, we expect to see an increase in mid-size farms emerging around cities in many African countries. However, if this happens quickly without regulation, it could present a public health concern" (cited in FAO 2019). The FAO has these concerns since we have seen livestock disease spread in the past. Typically, when there is a densely populated area near livestock, there is a higher chance of disease spread. However, if proper infrastructure and regulations are set in place, the spread of the disease will be limited. Also, areas prone to disease outbreaks must create a universal system between all bordering countries to

track potential outbreaks properly. For instance, Ebola is a disease that was first documented in 1976; however, it is still prevalent in many countries in Africa, especially in Ethiopia. The main reason for this is that the virus will still spread from its natural reservoir, commonly carried by fruit bats found in many areas settled by human life. The African continent has a wide variety of wildlife, so regulations and procedures must be implemented before another significant outbreak. A wide variety of potentially lethal outcomes come with a lack of proper actions to control the issue. There is the possibility that "unregulated farms in highly populated areas could also lead to increased use of antimicrobials which contribute to antimicrobial resistance in humans, and bad waste management which results not only in unpleasant odors but also contributes to environmental degradation and can contaminate soil and local water sources." (FAO, 2019). Creating this control and regulation system is essential to monitor livestock disease spread efficiently.

Ethiopia has the second-largest human population and largest livestock population on the continent (Pieracci et al., 2016). The Ethiopian livestock sector consists primarily of 'backyard farming,' where community populations live close to livestock. This sector is critical to the Ethiopian economy since the country is heavily dependent on agriculture, with 80% of the country's population residing in direct contact with domestic animals. (Lindahl and Grace, 2015). Direct contact between humans and domesticated animals creates a breeding ground for zoonotic diseases. In addition, most livestock keepers live in impoverished conditions with limited access to veterinarian care, sufficient water supplies, and proper waste disposal methods. Lack of access to these services and tools leaves livestock owners and community members at significant risk of spreading and contracting zoonotic diseases. The main reason for these consequences is the lack of coordination between government agencies and local communities in engaging with these groups to educate livestock owners on zoonotic diseases while compiling a plan to assist livestock owners in creating a system that will expand the livestock sector while reducing the spread of diseases.

Differences in Livestock Regulation

A significant difference exists between the United States and Ethiopia is regarding regulations and laws to manage livestock. While the United States government regulates the livestock industry in many aspects, including sanitation and quality checks, Ethiopia lacks regulatory frameworks to help eliminate the spread of zoonotic diseases, specifically in the livestock sector. This is particularly concerning as this area of the African continent is more prone to zoonotic disease spread due to human proximity to animals that are carriers of the disease. Ethiopia has high mortality rate from zoonotic diseases in the last half-century, whose main effects consist of diarrheal diseases and common respiratory infections (Misganaw et al., 2017).

In the United States, several departments work in correlation to ensure the safety of livestock agriculture and monitor disease spread to eradicate it, and support farmers. For example, farmers in the United States can purchase livestock insurance, which covers any losses or damages that may occur in their herd. This would include the restocking of the herd if any diseases were found. Further, there is access to veterinary assistance when livestock becomes ill. Accessing these types of services enables a more

successful farming industry with less financial loss and disease spread. Over the last decade, there has been some assistance in creating systems that would benefit Ethiopian livestock keepers and communities. The CDC has implemented some guidelines regarding following Ethiopia's One Health Approach, which looks at the intersection between human and animal health. These steps are a start; however, they had minimal impact on controlling zoonotic disease spread.

Ethiopian Zoonoses Regulation Plans

In 2015, the CDC and FOA collaborated with Ethiopia to create a system that prioritizes zoonotic diseases for inter-sectional engagement following the One Health Approach, which the CDC established. The One Health Approach was built in 2009 and is a collaborative, multisectoral, and transdisciplinary approach that works at local, regional, national, and global levels (CDC 2016.). This approach aims to show that the health of animals and humans is connected, and we must focus on the health of both species to maintain a healthy environment.

One Health plan created out of this collaboration is the Growth and Transformation Plan for the government of Ethiopia. This plan aims to increase the livestock population and maximize their productivity within the sector (CDC, 2016). They established a workshop held at the Ethiopian Public Health Institute (EPHI), intending to create a list of the five most impactful zoonotic diseases that spread through Ethiopia. The five diseases selected were Rabies, Anthrax, Brucellosis, Leptospirosis, and Echinococcosis. Once this was established, the Ethiopian government launched the creation of the Global Health Security Agency (GHSA). The purpose of the GHSA was to ensure the effective prevention and creation of control programs to be implemented for the five prioritized diseases that were selected at the workshop and establish a platform that would build collaborations with different human and animal health agencies that would need to be established (CDC, 2016). Using the One Health Approach while simultaneously establishing organizations in Ethiopia to combat the selected zoonotic diseases has helped pave the way to a more reliable system for tracking zoonoses.

While the system for tracking and monitoring human outbreaks is beneficial, it is slow in detecting outbreaks and does not focus on the animal health sector. The FAO's *Zoonotic Disease Spotlight, Ethiopia: The case for an expert elicitation protocol on zoonoses* states, "Good quality data are essential for formulating policies and programs that support the sustainable development of the livestock sector. However, livestock stakeholders, particularly the Ministries in charge of animal and public health, often face what is referred to as "the zoonotic disease and antimicrobial resistance (AMR) information trap" (FAO, 2018). This refers to the limitations on access to programs and methods to track and gather information pertaining to AMR. The FAO is strongly urging the Ethiopian government and other ministries in charge of animal and public health to collect this data to start establishing policies and programs that would identify future outbreaks. If information is unavailable, then proper programs and plans cannot be implemented, resulting in the potential collapse of the country's entire livestock market and risking the chances of it forming into a pandemic.

Zoonotic diseases will always be prevalent in the livestock industry. There is no way to eradicate all past and future diseases, but steps can be taken to monitor and mitigate the spread. The United States has developed many protocols to combat zoonoses properly, which have seen tremendous success. Likewise, similar protocols could be developed in Ethiopia as well. Addressing zoonoses are essential to reduce poverty. Many Ethiopian livestock keepers live in some form of poverty, unable to access some basic needs to meet the necessary standard of life. This may include limited access to sustainable water sources, access to veterinarian care, and proper waste disposal. The following section will highlight how zoonoses is a 'poverty trap' in Ethiopia.

Poverty Trap

The term 'Poverty Trap' refers to the impact that zoonotic diseases have on populations that reside in close contact with animals, resulting in a cycle of poverty. This mainly occurs when zoonoses bring upon conditions that leave livestock farmers at a disadvantage. According to Dr. Aristarchos Seimenis, there is a significant socio-economic change that is being experienced due to zoonoses in countries such as Ethiopia, and it mainly affects poor and marginalized areas (Seimeinus, 2012).

Livestock agriculture is a growing market that allows farmers the opportunity to make money. Rural farming lands in Ethiopia are highly reliant on their livestock sector since it plays a fundamental role through economic and socio-cultural means. These households rely on livestock as a food supply, source of income, asset saving, source of employment, soil fertility, means of livelihood, and method of transport (Bettencourt, Tilman, Narciso, Carvalho, & Henriques, 2015). However, lack of funding and regulations for proper waste management imperil how farmers raise livestock and ensure the safety of the animals and humans living near them. When zoonotic diseases arise in populations, it affects them in many different ways. When local farmers are hit with zoonoses within their livestock, they face health issues due to consuming the contaminated meat and livelihood loss due to the loss of entire herds.

Zoonoses leave those in poor populations sick and dying from easily preventable diseases in other parts of the world. When community members fall ill or pass away, it can result in hardship for many families and villages. For instance, if the family's primary caretaker gets sick, they are left with the burden of helping them recover when there is already limited access to medical care and facilities in the area. If the caretaker were to pass away, the family and others in the community would be left with the burden of caring for the livestock. Also, once the disease starts to spread, it will make its way through the livestock population reasonably quickly, especially when there is a significant lack of veterinarian care available in this region. When zoonoses start to spread between animals, it's not long before the entire herd is contaminated and no longer suitable for agricultural purposes, mainly because this region has a lack of veterinarian care. The impact of losing a whole herd or the majority of your livestock population is highly devastating for local farmers in Ethiopia. It can result in losing their only source of income and food to being forced to eat the contaminated meat, resulting in various illnesses that in terms can be fatal. Often, the choice for many Ethiopian farmers to dispose of their sick livestock is not a choice. Doing this will eliminate their source of income and result in drastic consequences such as a lack of funding for

children's education and potential malnutrition. Without proper measures in place to reduce the spread of zoonotic diseases, these livestock owners are forced into a cycle of poverty where the disease continues to spread, and their livestock productivity decreases as a consequence.

There are three main factors to consider when evaluating poverty traps and creating a plan to overcome the issue. These factors include laying down the groundwork for basic necessities of infrastructure, healthcare, and education about the livestock sector. The focus on infrastructure consists of a system for proper irrigation and waste disposal management. When a booming livestock sector has no access to irrigation systems, it creates conditions in which sanitation and waste management practices are non-existent and can lead to mass zoonoses spread. Also, establishing an organized healthcare system focusing on the care and vaccination of humans and animals would reduce the spread of many zoonotic diseases in Ethiopia. Combining the One Health approach with establishing additional aid to open healthcare centers revolving around human and animal welfare will give rural farmers in Ethiopia a chance to lower zoonosis rates within their livestock sector and their communities. Lastly, education programs on zoonotic diseases, especially for healthcare professionals in Ethiopia, are needed to help these individuals learn how to detect and combat the zoonotic diseases that are prevalent in the area, such as rabies and brucellosis. By showing advancements in all three of these fields, Ethiopian communities will be better prepared to avoid falling into poverty traps by improving the overall health of their livestock and community.

More proper infrastructure, such as water irrigation and waste management systems, must be developed in rural Ethiopian farmlands. Irrigation systems create a safer, healthier environment because they allow for proper sanitation. Without a constant, regulated water supply, managing sanitation efforts on farmlands and providing sufficient drinking water to their livestock can become challenging. Water irrigation systems allow those living on the land to practice sanitation practices such as frequent handwashing, bathing, and cleaning the household. When basic sanitation practices cannot be performed, there is a greater chance of zoonotic diseases spreading across the population. The build-up of animal feces in close quarters to human populations can result in widespread disease. Close living arrangements near animals allow humans to carry bacteria, viruses, and other diseases into their living spaces, spreading to all household members. One study was done by the Agricultural Water Management in which they conducted an empirical analysis using household-level data from select villages in southern Ethiopia, which showed that size of landholding, access to irrigation, water supplies on-farm land, and water conservation practices are all-important determinants of household welfare and could lead as potential pathways in methods of reducing poverty (Hanjra, Ferede, and Gutta, 2009). All these tools and forms of assistance listed tie into helping combat zoonoses in livestock.

Another significant reason why many zoonotic diseases are prevalent in Ethiopia is the lack of education. There needs to be more awareness of foodborne and zoonotic diseases within the society, and since some of their cultural practices include consuming raw milk and undercooked meat, this is a considerable risk (Hiko, Yilkale, and Serda, 2018). The Journal of Health Education Research & Development published a study

regarding community knowledge of zoonotic diseases in Bahir Dar City, Ethiopia. The study surveyed men and women across a cross-section of workers ranging from teachers, students, office workers, veterinarians, health workers, farmers, and restaurant workers to understand their disease awareness levels (Hiko, Yilkale, and Serda, 2018). The survey included many questions on zoonotic diseases such as rabies, bovine tuberculosis, anthrax, and brucellosis. The results determined that aside from rabies, which is the most prevalent zoonotic disease in Ethiopia, there needed to be a higher level of community knowledge of other forms of zoonoses. When certain zoonotic diseases heavily influence an area, the occupants need to understand how these diseases originate, spread, and impact and how to take preventative measures to stop the spread. Furthermore, the study showed limited knowledge on how to consume livestock byproducts safely. In one study conducted in Ethiopia, researchers found that 39% of women and 30% of men believed that humans do not get the disease from animals, including about 64% of women and 50% of men agreeing that drinking raw milk is not a health risk (Smith, Mulema, n.d.). This shows that there is a lack of awareness of factors that lead to the spread of zoonotic diseases.

When livestock zoonoses act as a poverty trap for those in underdeveloped areas, livestock owners are faced with very harsh consequences. Although most of Ethiopia's livestock agriculture is located in rural areas, there are many states within the U.S. in which populations live in rural areas that practice backyard farming and have successful livestock production and low disease transmission rates. The main reasons these areas can have sustainable livestock populations are the existing infrastructure, the availability of modern veterinarians, healthcare, and widespread education. For these populations to escape poverty, they must receive assistance in creating systems to overcome zoonoses in backyard farming settings.

The following section will highlight a few recommendations to break the cycle of the livestock poverty trap.

Breaking the Cycle of Livestock Poverty Trap

The first crucial step would be for the United Nations to dedicate aid and funding to departments such as the Ministry of Agriculture (MOS) in Ethiopia to assist local farmers and livestock keepers build sustainable infrastructure in which livestock productivity increases and zoonotic disease transmission decreases. This would include installing irrigation systems, water treatment facilities, proper waste sanitation disposal methods, and creating a surveillance system that would monitor zoonoses within every village in the country. These infrastructures cost a lot of money to develop and implement; hence, funding and aid are necessary to grow the livestock sector successfully without zoonotic diseases taking a toll on its progress. A significant cause of zoonotic disease spread is due to contamination from animal fecal matter. When there is a proper waste management system in place, it eliminates unsanitary conditions on farms and creates a lower risk of waste contaminating water supplies. Also, when irrigation systems are infected, water treatment facilities will eliminate all existing pathogens inside the water and deem it usable for those in the region.

The second step would be to expand veterinary and human healthcare, including primary care facilities and vaccination centers. When livestock keepers cannot provide

adequate care for their animals, it will almost at all times result in the spread of zoonotic diseases amongst the animal population. In developed countries such as the U.S., many livestock keepers have regular vaccination practices and check-ups to ensure their health and reduce the chances of their livestock becoming infected with zoonoses. There is a significant lack of vaccine availability for animal and human populations in underdeveloped countries such as Ethiopia. If livestock keepers can find veterinarian care and vaccine availability, it often comes at a price that most cannot afford. To avoid these outcomes, proper healthcare and vaccination centers would allow members of these communities any opportunity to control the spread of certain zoonotic diseases. Currently, the WHO has two approved vaccinations against the Ebola virus. These vaccines are now in a global stockpile for emergencies and future outbreaks for those most at risk. This is due to the shortage of vaccine distribution, and the WHO cannot roll out mass vaccination practices. However, based on our lessons from the coronavirus pandemic, it is imperative for international organizations to put more effort into funding vaccines for zoonotic diseases, including vaccination of both human and animal populations. One Health Approach is an important model that focuses on attending to zoonoses by focusing on the intersection between people, animals, and their shared environments. By accounting for animal and human health at the same level, doing so will create a system in which diseases are easily detected and eliminated in both populations.

Finally, the cycle of poverty traps can be broken through further educational and awareness-building programs. Through community interventions, we can see that reinvesting in education in communities does, in turn, lead to lower transmission rates for diseases. This would be done by educating populations on zoonotic diseases, how they spread, and ways to combat them. A report titled *Ethiopia: Women Making a Difference on the Front lines of Dangerous Zoonotic Disease Spread* discusses the story of Bizunesh Ayele and her journey in learning about zoonotic diseases and their impacts (Smith and Mulema 2020.). They discuss that community conversations were key to spreading information about the nature of zoonoses and its spread. This approach gathered members of the community to discuss their current knowledge and practices regarding livestock byproducts such as meat and dairy products. For instance, one member who participated in this conversation, named Bizunesh, stated, "Our family used to consume raw meat and milk... My husband and I used to give these to our five children. Now that we know that disease is spread from animals to humans through infected raw meat and milk, we boil our milk and cook our meat before consuming it" (Smith and Mulema 2020). Implementing more community-based programs throughout Ethiopia would allow communities to gain knowledge on zoonotic diseases, which will allow for advancement in skills to combat zoonoses, such as proper safety procedures for raw meat and milk. Through the help of the MOA, they can create a separate agency in charge of setting up' community programs to spread knowledge on zoonotic diseases. Establishing education and healthcare programs and irrigation systems would allow rural farmers in Ethiopia to lower zoonose rates, thus allowing for a more productive livestock sector that would lead them out of poverty, not back into the repetitive cycle that zoonotic diseases create.

Like the U.S., where the government has invested significant money and human resources to establish specific mechanisms and facilities for livestock owners to limit the

spread of zoonoses within their population, Ethiopia could step up governmental assistance from entities such as the Agricultural Transportation Agency and the Ministry of Agriculture to help establish these systems.

The next chapter discusses the macro and microeconomic impacts of zoonoses.

Macro and Microeconomic Impact of Zoonoses

Zoonotic diseases have economic costs at both macro and microeconomic levels. Narrod, Zinsstag, and Tiongco (2012) found that these two levels could measure the estimation of financial expenses for zoonotic diseases. The macro level refers to the national economy and environment, while the micro level concerns smallholder farmers' health and food security. Their model showcases how zoonotic diseases can affect economic conditions on both the national scale, involving government agencies and entities, and on a smaller scale, how they affect the livelihood of farmers and farm occupants.

Macroeconomic Impact

Zoonotic diseases impact the national economy and the environment. The most critical and direct macroeconomic costs of zoonotic diseases result from the slaughtering of livestock populations due to widespread disease spread, leading to a loss in livestock inventory. Reducing livestock further affects the availability of livestock supply and impinges household income, especially for smallholder farmers. The drop in farm incomes has a significant bearing on national income. Besides, income, community scare, and drop in consumption lower consumer pricing. When the prices of livestock supply drop, less income is brought into the livestock economy overall.

According to the World Bank, the direct cost of zoonotic diseases from the 2000s is estimated to be more than $20 billion and over $200 billion in indirect losses to significant economies worldwide (World Bank 2010). In 2008, the USDA's economic report on the impacts of foreign animal diseases estimated that a single disease could reduce livestock and impact trade. For instance, the report notes that foot-and-mouth disease (FMD) outbreak, a highly contagious zoonotic viral disease that affects cloven-hoofed animals, including cattle, buffalo, camels, sheep, goats, deer, and pigs (Australian Department of Agriculture, n.d), also lowered pork prices. They reported that pork prices (cutout value) fell from $63.33 to $53.26 per cwt in the first quarter after the outbreak began, while prices of live hogs in the first quarter fell from $56.52 to $45.20 per cwt (USDA). Pork and hog prices decline because of increased domestic supplies that result from import bans imposed by trading partners. The report shows that trade impacts are more prominent than depopulation shocks. This price drop can cause a drastic economic change, leading to farmers losing profits and having to take losses on their livestock.

Additionally, trade bans also eliminate livestock income and add to financial hardship. This results in defunding essential programs and government entities responsible for monitoring and controlling zoonotic disease spread. This would mean that areas already struggling would have to choose areas where they can make cutbacks. Since livestock is an important revenue stream in Ethiopia, losses occur when they

cannot trade their healthy livestock and eradicate their infected ones. The USDA's Economic Impact of Foreign Animal Disease also discussed the impact of export restrictions and their role in macroeconomic effects. During the Foot and mouth disease outbreak, these observations found that in high outbreak scenarios, the price per cwt was lower than in standard outbreak scenarios. This is because there were still limitations and bans on exports in high outbreaks, but the bans were lifted in familiar outbreak scenarios (Paarlberg, Seitzinger, Lee, & Mathews, 2008). In more developed areas, precautions have been implemented for disease surveillance and other methods to limit transmission. These methods allow zoonotic disease rates to be controlled and limited, resulting in a standard outbreak scenario. However, in developing regions, absent methods and systems result in high outbreak scenarios and cause trade bans that remain in place until the outbreak is handled. In high outbreak scenarios, the situation takes longer to control, and more money must be invested to maintain the outbreak. This will lead to lower meat prices on the consumer level and lower sales/profit for domestic food producers.

Microeconomic Impact

Zoonotic diseases impact local smallholder farmers' income, land, food insecurity, and overall well-being. In 1987, livestock accounted for nearly 15% of Ethiopia's GDP. Almost 80% of Ethiopians rely on agriculture as their primary income and subsistence. Zoonosis outbreaks therefore results in economic destitution, not only from the immediate financial loss but also, the added costs of feeding family, restocking livestock supply to regenerate their form of income etc.

Furthermore, in situations where Ethiopian livestock owners face diseases within their livestock, many are reluctant to dispose of the infected livestock for various reasons. Dr. Ibrahim, an epidemiologist at the Jigjiga University in Ethiopia, has attributed livestock's economic value as a primary factor. He estimated that one cow could cost a minimum of USD 130 (United States dollars). This may not seem like much to many, especially farmers in developed areas like the United States and the United Kingdom, but this amount is astronomical for Ethiopians, given that the average per capita income in 2018 was USD 790 (Kushner, n.d.). The limited governmental assistance in treating the outbreak forces many livestock owners and farmers to consume contaminated meat since they cannot afford to restock their livestock pile.This is why it is vital to have transmission reduction methods in place to avoid further economic hardship that farmers and families face when hit with zoonotic outbreaks.

The following section explores the need for public investment to better the economic conditions

Public Investments to Improve Economic Conditions

The first step on the macroeconomic level would be to ensure proper and accurate disease surveillance is set into place. Currently, Ethiopia is taking its approach to zoonotic diseases through the One Health Approach, which the CDC established. As much guidance as the One Health Approach offers, there will never be a positive deterioration of zoonoses if the systems set into place are not provided with the proper resources and equipment to do their job. For instance, in a research study titled

'Mapping the epidemiological distribution and incidence of major zoonotic diseases in South Tigray, North Wollo and Ab'ala (Afar), Ethiopia,' the authors found that the data recording system in veterinary clinics and health posts was " very poor" (Menghistu, Hailu,Shumye, and Redda 2018). If the systems health officials use to monitor, track, and record zoonotic diseases are insufficient, relaying that information and using it to help slow the spread will not be helpful if the data is not stored correctly. Additionally, there should be limitations and regulations on trade bans if proper testing and implementation are done to ensure no risk of zoonotic disease transmission. To do this, veterinarian practices must be equipped with adequate resources to monitor and track where these diseases originated efficiently and how fast they spread.

Further, to prevent diseases from overwhelming livestock populations, it is necessary to give livestock holders access to vaccinations and medical treatment. The best method to reduce economic losses from livestock is to control disease within the animals themselves. If animals were given routine check-ups and proper vaccinations, there would be a significant reduction in disease transmission rates among the public. This is because if entire herds are vaccinated, it leaves little room for diseases to transmit between them. Also, proper veterinarian care could help keep track of diseases and limit their spread.

Currently, zoonosis rates have tripled, with several new zoonotic diseases having formed due to pathogen spillover (Rozenbaum, 2020). Pathogen spillovers are rare when viruses move from one species to another. The current COVID-19 pandemic resulted from a spillover event in which the Sars-Cov-2 virus jumped from an animal host to a human. This resulted in the virus now being able to be spread from human to human. Additionally, today, 60% of emerging infectious diseases in humans are zoonotic (World Health Organization 2014.). With the rate at which zoonoses are spreading throughout our world, it is of utmost importance to invest in mechanisms for preventing zoonotic diseases while also investing in public health.

The spread of zoonoses impacts the health of humans, animals, and local/global economies, especially in developing economies. While in developed economies, such as the United States, prevention programs, including vaccines and investments in public health, have curtailed the spread of zoonotic disease, this is not the case in developing economies. Communities face obstacles such as illness, food insecurity, and economic depreciation due to zoonoses. In addition, given the lack of state funding, the WHO and the U.N. should provide financial and infrastructural support to developing nations to build better livestock management systems. International organizations must work together to establish mechanisms to track and eliminate zoonotic diseases to ensure global health security. For example, the novel Sars-COV-2 virus was first recorded in December 2019 in the Wuhan province of China, quickly spread worldwide, and was considered a worldwide pandemic in March 2020. The WHO recently stated that COVID-19 most likely spread months before the first reported case in Wuhan, China (WHO 2021). This conveys the importance of disease surveillance and monitoring of zoonotic diseases.

Zoonoses' rise in any region threatens safety everywhere. Over time, if untreated, these diseases will spread beyond their borders and carry over into other areas. Global health security is at a greater risk once the situation is out of control, similar to the

ongoing coronavirus pandemic. SARS-COV-2 has resulted in economic depreciation, as well as cost the lives of millions. This is a perfect example of how zoonotic diseases can affect the world as a whole, not just the individual areas in which they generate and are most prevalent.

Recommendations to Reduce the Spread of Zoonotic Diseases:

Investment in Public Goods

The first crucial step in combating zoonotic diseases, specifically in developing regions such as Ethiopia, would be to direct investments into public goods and services such as proper farming infrastructure, sufficient access to veterinarian care and human health/ vaccination clinics, and appropriate livestock restocking supply. This will enable these regions to gain adequate access to tools that will help them gain control of persistent zoonotic diseases and monitor and prevent future outbreaks while ensuring human and animal health and well-being in those areas. The World Health Organization notes that improving the control and prevention of NZDs requires multidisciplinary, intersectoral and cross-cultural efforts by health, agriculture, environment and other sectors of society at the national level. This section discusses control and prevention methods such as the creation and expansion of agricultural infrastructure, animal and human healthcare, and economical livestock assistance.

Infrastructure

Since livestock agriculture is such a big part of Ethiopia's economy, averaging around 15-17% of the country's GDP (Asresie and Zemedu 2015), it is crucial to develop and systemize efficient infrastructure in the livestock sector and in the general agriculture sector to ensure that the economics stay balanced and disease spread is monitored and eliminated. The first step to advanced infrastructure would be to develop proper irrigation and water treatment facilities. In a region such as Ethiopia, there is no substantial irrigation system to help transport water for crops, livestock needs, and living purposes. Lack of irrigation also leads to disease spread in many ways. For instance, when there is a lack of accessible water access, it limits farmers' ability to keep their livestock and farming land clean. Animal reservoirs, which contain domesticated and wild animals infected with pathogens, are the leading cause of the spread of zoonotic disease. These reservoirs form primarily due to a lack of sanitary conditions.

Furthermore, along with irrigation, there must be sufficient water treatment facilities that treat water before being pushed through irrigation systems. Ethiopian farmlands rely on lakes and natural bodies to retrieve the water they need. These bodies of water can often be contaminated with pathogens due to waste spill-off. Contaminated water sources often lead to illness and the further spread of zoonoses within the community. Thus, establishing proper irrigation and water treatment programs in these regions will enable many farming communities to have efficient livestock production.

Another form of infrastructure that will help livestock prosperity is the creation of feeder roads and milk production centers. The design of feeder roads will help bring economic opportunities to the region. These roads will allow farmers to transport their livestock and crop products throughout the area. It is shown that feeder roads are the prominent link between farmers' ability to access their sales. Currently, a 16-million-

dollar program called the Feeder Roads to Strengthen the Livelihoods and Resilience of Rural Communities is set in place to construct a 160-meter-long bridge in rural areas of South Sudan. This bridge will give those in South Sudan access to travel and sell their goods. Also, milk production centers are a significant key to stopping the spread of zoonoses. Currently, it is a common practice in areas like South Sudan, Ethiopia, and other developing countries for members of the community to drink unpasteurized milk. This causes illnesses and even death. By creating milk production centers, milk can be pasteurized and deemed to be safe from infectious pathogens. Also, creating new feeder roads and milk production centers creates jobs and gives opportunities to those residing in the area to gain economic success.

Another method of infrastructure that needs to be implemented is proper livestock markets and slaughtering facilities. The creation of livestock markets will allow farmers to distribute and sell their livestock. This will ensure a more sufficient trading and buying system, further enhancing the economy. Livestock markets will also allow community members to buy and trade goods in exchange for livestock products such as meat. Also, slaughtering facilities will ensure that all livestock are slaughtered in a safe and sanitized area where there is minimal risk of disease spillover.

Human and Animal Healthcare

Investments in the healthcare sector are crucial in combating zoonotic diseases and eliminating their impact. As the One Health Approach states, zoonotic diseases must be looked at through the intersectionality between humans and animals. It is necessary to focus on both sides of the issue in order for the overarching goal to be resolved. There needs to be an implementation of veterinarian laboratories and services, vaccination centers, and veterinary quarantine stations. Veterinarian assistance is required in order to ensure that livestock is healthy and free from harmful pathogens that could be spread to other livestock or humans. The primary issue in developing areas is that when livestock get sick, there is a significant lack of veterinarian care available, and the care that does exist is not affordable for most farmers. If these animals are unable to be treated, they will continue to remain sick and infect other animals in the herd. This will lead to further zoonotic disease spread while also affecting food security. These farmers will then lose their livestock to either disease or be forced into consuming infected meats for survival. Also, the creation of veterinarian quarantine centers would allow livestock owners to quarantine any animals that have tested positive for a variety of zoonotic diseases and receive the proper treatment they need to recover. Enabling this initiative can allow many farmlands to stop developing animal reservoirs where zoonoses spread at the highest rates. By eliminating the source of the disease and isolating it like we would do to treat humans, mitigate the spread of these harmful diseases. These centers would also provide adequate veterinary care and vaccinations required to get the livestock back into healthy working conditions.

Moreover, there need to be community interventions and programs that bring awareness to the dangers of zoonotic diseases, how they form, and proper preventative measures to ensure the lowest risk of contamination. A few intervention programs have been established in different regions throughout Africa, and success has been shown within the education sector. Such interventions have demonstrated significant progress in disincentivizing community members from prior practices that are harmful, such as

consuming raw milk or meat. In turn, this has been transitioned to safer practices such as boiling milk and thoroughly cooking meat before consumption.

International Funding and Support

A critical element of protocols to curtail the spread of zoonotic disease is funding to develop monitoring systems and vaccination. Funding is an important challenge in developing countries, primarily due to resource constraints of local governments, and hence, international support is necessary to fund programs to help combat the spread of zoonotic diseases.

The World Health Organization intervention can establish disease monitoring systems by following best practices in the region. For instance, Zambia's disease surveillance, the Livestock Infrastructure Support Project 2013, is an excellent example of designing livestock service centers that focus on developing livestock markets and integrating food security and poverty issues into livestock management. The plan increases employment opportunities in livestock husbandry and health while increasing livestock product value chains. The economic benefits generated by proper management systems have increased farmer support for better animal husbandry practices.

The United Nations and G20 should lead in supporting developing nations to implement systems that reduce the spread of zoonoses. The U.N. oversight and monitoring will help build coordination among states and stakeholders. It will also prevent state parties from abandoning projects and ensure that workers, livestock, and economic conditions improve. The financial loss caused by zoonotic diseases, estimated at $20 billion in direct losses and $200 billion in indirect losses (World Bank, 2010), demands action from the developed economies. Many scientists and experts estimate it would cost between $800 billion and $1 trillion to institute worldwide measures to control and lower disease transmission rates. At the same time, this seems like a high price; sars-cov-2 has resulted in over $26 trillion in worldwide economic damages (KFF Health News 2021). Hence, a proper framework should be implemented to help track and stop the spread of various viruses and diseases.

Conclusion

Every pandemic the world has encountered throughout history has been of zoonotic origin. The world population has increased tenfold, accentuating the risk of zoonotic diseases. With a growing human population and consumerism comes a high demand for meat. Livestock is the largest growing sector in developing countries (Thornton, 2010). It is essential to recognize the significance of zoonotic diseases in terms of frequency, intensity, and spread, as well as the harm they cause to our health and well-being.

As the coronavirus pandemic has shown, zoonotic diseases are not only detrimental to the health and well-being of society but also cause economic losses at the macro and micro levels. For instance, zoonoses have led to many livestock owners losing their livelihood, and the resulting poverty has limited their ability to take preventive measures to monitor and control the spread of diseases. This amplifies the importance of controlling and monitoring zoonoses in developing areas such as Ethiopia, as these countries have the highest animal contact between domesticated and wild animals and lack the infrastructure to monitor them. The sharing of common ground between wild

and domesticated animals increases the propensity to spread zoonoses. Once the zoonotic disease infects livestock, it can be easily transmittable to the farmers, consumers, and other occupants of the land that come into contact with domesticated livestock. If zoonoses are not detected promptly, the pathogen can travel from one region to another in hours. Therefore, the importance of animal veterinarians and vaccination services should be widely available to farmers in developing areas. This would limit the chances of diseases arising and spreading within their herd while also allowing for professional assistance from veterinarians to perform randomized testing for various zoonotic diseases.

International organizations, including the World Health Organization, G-20, and the United Nations, need to develop effective international mechanisms to control major zoonotic outbreaks. International support and collaboration will help to limit outbreaks in the developing world, lead to significant increases in quality of life for both humans and animals and ensure financial security for livestock owners and countries that heavily rely on livestock agriculture. There needs to be more international collaboration and support structures on how zoonoses are affecting the lives of millions of people every day, which would allow the development of a preventive rather than retroactive framework to address zoonotic diseases.

Reference

Asresie, A., & Zemedu, L. (2015). Contribution of livestock sector in Ethiopian economy: A review. Advances in Life Science and Technology, 29, 79. https://www.researchgate.net/publication/378215399_Contribution_of_Livestock_Sector_in_Ethiopian_Economy_A_Review

Berntsen, Z. (2020, April 15). How susceptible are African countries to zoonotic disease outbreaks? The Palladium Group. https://thepalladiumgroup.com/news/How-Susceptible-are-African-Countries-to-Zoonotic-Disease-Outbreaks-

Bettencourt, E. M., Tilman, M., Narciso, V., Carvalho, M. L., & Henriques, P. D. (2015). The livestock roles in the well-being of rural communities of Timor-Leste. Revista de Economia e Sociologia Rural, 53(Suppl 1), 63-80. https://doi.org/10.1590/1234-56781806-94790053s01005

Bidaisee, S., & Macpherson, C. N. (2014). Zoonoses and one health: A review of the literature. Journal of Parasitology Research, 2014, pp. 1–8. https://doi.org/10.1155/2014/874345

Bray, R. W. (1997). History of meat science. American Meat Science Association. https://meatscience.org/about-amsa/history-mission/history-of-meat-science

Center for Disease Control (2016). Prioritizing Zoonotic Diseases in Ethiopia. https://archive.cdc.gov/ncezid/pdf/global/global-stories-zoonotic-ethiopia-H.pdf

Dent, Michael (2020). The Meat Industry is Unsustainable. IDTechEx. March 25. https://www.idtechex.com/en/research-article/the-meat-industry-is-unsustainable/20231

Ethiopia - Livestock. (n.d.)., from http://countrystudies.us/ethiopia/95.htm#:~:text=Livestock%20production%20plays%20an%20important,l5%20percent%20of%20total%20GDP.

Food and Agriculture Organization. FAO urges African governments to regulate the urban livestock sector. (n.d.). http://www.fao.org/africa/news/detail-news/en/c/1204899/

Food and Agriculture Organization (FAO) (2018). Africa Sustainable Livestock 2050: Zoonotic Diseases Spotlight Ethiopia - The Case for an Expert Elicitation Protocol on Zoonoses. http://www.fao.org/3/i8493en/I8493EN.pdf.

Food and Agriculture Organization (2019).FAO urges African governments to regulate urban livestock sector. August 14. https://www.fao.org/africa/news-stories/news-detail/FAO-urges-African-governments-to-regulate-urban-livestock-sector/en

Food and Drug Administration (2020). All About BSE (Mad Cow Disease). https://www.fda.gov/animal-veterinary/animal-health-literacy/all-about-bse-mad-cow-disease#:~:text=The%20USDA%20also%20makes%20sure,BSE%20are%20working%20very%20well.

Grace, D., Lindahl, J., Wanyoike, F., Bett, B., Randolph, T., & Rich, K. M. (2017). Poor livestock keepers: Ecosystem–poverty–health interactions. Philosophical Transactions of the Royal Society B: Biological Sciences, 372(1725), 20160166. https://doi.org/10.1098/rstb.2016.0166

Hanjra, M. A., Ferede, T., & Gutta, D. G. (2009). Pathways to breaking the poverty trap in Ethiopia: Investments in agricultural water, education, and markets. Agricultural Water Management, 96(11), 1596-1604. https://doi.org/10.1016/j.agwat.2009.06.008

Hassell, J. M., Begon, M., Ward, M. J., & Fèvre, E. M. (2017). Urbanization and disease emergence: Dynamics at the wildlife–livestock–human interface. Trends in Ecology & Evolution, 32(1), 55-67. https://doi.org/10.1016/j.tree.2016.09.012

Hiko, A., Yilkale, B., & Serda, B. (2018). Community knowledge towards zoonotic diseases and attitude to one health approach in selected city of Ethiopia. Journal of Health Education Research & Development, 6(4). https://doi.org/10.4172/2380-5439.1000276

Institute of Food Technologists. A Historical Look at Food Safety. https://www.ift.org/news-and-publications/blog/2019/september/a-historical-look-at-food-safety

KFF Health News (2021). Heading Off the Next Pandemic. https://kffhealthnews.org/news/infectious-disease-scientists-preventing-next-pandemic/

Klous, G., Huss, A., Heederik, D. J., & Coutinho, R. A. (2016). Human–livestock contacts and their relationship to the transmission of zoonotic pathogens: A systematic

review of the literature. One Health, 2, 65-76. https://doi.org/10.1016/j.onehlt.2016.03.001

Kushner, R. L. (n.d.). Zoonoses in Ethiopia. One Health Newsletter, p. 13. https://www.cdc.gov/onehealth/pdfs/hammett-ethiopi-workshop-508.pdf http://www.fao.org/3/i8493en/I8493EN.pdf

Kutzer, K. (n.d.). Student project: Factory farming: Overview. Pace University School of Law. https://libraryguides.law.pace.edu/factoryfarming

Lindahl, J. F., and Grace, D. (2015). The consequences of human actions on risks for infectious diseases: A review. Infection Ecology & Epidemiology, 5(1), 30048. https://doi.org/10.3402/iee.v5.30048

Lipman, R. (2015). Zoonotic diseases: Using environmental law to reduce the odds of a future epidemic [Abstract]. Virginia Environmental Law Journal, 33(1), 153–171.

Martins, S. B., Häsler, B., & Rushton, J. (2014). Economic aspects of zoonoses: Impact of zoonoses on the food industry. In Zoonoses - Infections Affecting Humans and Animals (pp. 1107-1126). Springer. https://doi.org/10.1007/978-94-017-9457-2_45

McDaniel, C. J., Cardwell, D. M., Moeller, R. B., & Gray, G. C. (2014). Humans and cattle: A review of bovine zoonoses. Vector-Borne and Zoonotic Diseases, 14(1), 1-19. https://doi.org/10.1089/vbz.2012.1164

Menghistu HT, Hailu KT, Shumye NA, Redda YT (2018). Mapping the epidemiological distribution and incidence of major zoonotic diseases in South Tigray, North Wollo and Ab'ala (Afar), Ethiopia. PLoS One. Dec 31;13(12):e0209974. doi: 10.1371/journal.pone.0209974.

Misganaw, A., Haregu, T. N., Deribe, K., Tessema, G. A., Deribew, A., Melaku, Y. A., ... Naghavi, M. (2017). National mortality burden due to communicable, non-communicable, and other diseases in Ethiopia, 1990–2015: Findings from the global burden of disease study 2015. Population Health Metrics, 15(1). https://doi.org/10.1186/s12963-017-0145-1

Narrod, C., Zinsstag, J., & Tiongco, M. (2012). A one health framework for estimating the economic costs of zoonotic diseases on society. EcoHealth, 9(2), 150–162. https://doi.org/10.1007/s10393-012-0747-9

Paarlberg, Seitzinger, Lee, Matthews Jr. (2008). Economic Impacts of Foreign Animal Disease (Economic Research Report 57). United States Department of Agriculture.

Perry, B., & Grace, D. (2009). The impacts of livestock diseases and their control on growth and development processes that are pro-poor. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1530), 2643–2655. https://doi.org/10.1098/rstb.2009.0097

Pieracci, E. G., Hall, A. J., Gharpure, R., Haile, A., Walelign, E., Deressa, A.,Belay, E. (2016). Prioritizing zoonotic diseases in Ethiopia using a one health approach. One Health, 2, 131–135. https://doi.org/10.1016/j.onehlt.2016.09.001

Ritchie, H., Rosado, P., and Roser, M. (2017). Meat and Dairy Production. Our World in Data. https://ourworldindata.org/meat-production

Rouse, K. L. (n.d.). Meat Inspection Act of 1906. In L. R. Pilant (Ed.), Encyclopedia of White-Collar & Corporate Crime (pp. 287–290). SAGE Publications. https://doi.org/10.4135/9781412914260.n287

Rozenbaum M, (2020). The increase in zoonotic diseases: the WHO, the why and the when? Posted by: Category: Research & medical benefits, 6th July. https://www.understandinganimalresearch.org.uk/news/research-medical-benefits/the-increase-in-zoonotic-diseases-the-who-the-why-and-the-when/

Seimenis A.(2012). Zoonoses and poverty - a long road to the alleviation of suffering. Vet Ital. Jan-Mar;48(1):5-13. PMID: 22484998.

Smith, G., & Mulema, A. (2020, December 10). Ethiopia: Women making a difference on the front line of dangerous zoonotic disease spread. International Livestock Research Institute. https://www.ilri.org/news/annual-report/protecting-women-ethiopia-front-line-dangerous-zoonotic-disease-spread

Thornton PK, Gerber P. (2010). Climate change and the growth of the livestock sector in developing countries. Mitigation and Adaptation Strategies for Global Change 15 (2):169-184.

Tomley, F. M., & Shirley, M. W. (2009). Livestock infectious diseases and zoonoses. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1530), 2637-2642. https://doi.org/10.1098/rstb.2009.0133

World Bank (2010). People, Pathogens and Our Planet. Volume 1: Towards a One Health Approach for Controlling Zoonotic Diseases. Report No. 50833-GLB. https://documents1.worldbank.org/curated/en/214701468338937565/pdf/508330ESW0whit1410B01PUBLIC1PPP1Web.pdf

World Bank. (2020). World Bank Provides Additional Support for Agriculture Growth and Better Livelihood Opportunities for Ethiopia's Small Holder Farmers . Press Release No: 2020/042/AFR. Retrieved from https://www.worldbank.org/en/news/press-release/2020/09/15/world-bank-provides-additional-support-for-agriculture-growth-and-better-livelihood-opportunities-for-ethiopias-smallholder-farmers

World Health Organization, Regional Office for the Eastern Mediterranean. (2014). Zoonotic diseases: Emerging public health threats in the Region (Sixty-first session of the Regional Committee for the Eastern Mediterranean). https://www.emro.who.int/fr/about-who/rc61/zoonotic-diseases.html

WHO (2021). WHO-convened global study of origins of SARS-CoV-2: China Part. https://bit.ly/3wjUXze.

Woods, A. (2011). A historical synopsis of farm animal disease and public policy in twentieth-century Britain. Philosophical Transactions of the Royal Society B: Biological Sciences, 366(1573), 1943-1954. https://doi.org/10.1098/rstb.2010.0388