MERCY FOR ANIMALS

Public Health Impacts of Animal Agriculture

Contents

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Economies are a product of healthy human societies, which in turn rely on the natural environment—the original source of all clean air, water, and food. Human pressures, from deforestation, to intensive and polluting agricultural practices, to unsafe management and consumption of wildlife, undermine these services. They also increase the risk of emerging infectious diseases in humans—over 60% of which originate from animals, mainly from wildlife. Overall plans for post-COVID-19 recovery, and specifically plans to reduce the risk of future epidemics, need to go further upstream than early detection and control of disease outbreaks. They also need to lessen our impact on the environment, so as to reduce the risk at source.

Diseases caused by either lack of access to food, or consumption of unhealthy, high calorie diets, are now the single largest cause of global ill health. They also increase vulnerability to other risks—conditions such as obesity and diabetes are among the largest risk factors for illness and death from COVID-19.

Agriculture, particularly clearing of land to rear livestock, contributes about ¼ of global greenhouse gas emissions, and land use change is the single biggest environmental driver of new disease outbreaks. There is a need for a rapid transition to healthy, nutritious and sustainable diets. If the world were able to meet WHO's dietary guidelines, this would save millions of lives, reduce disease risks, and bring major reductions in global greenhouse gas emissions.

The pandemic is a reminder of the intimate and delicate relationship between people and planet. Any efforts to make our world safer are doomed to fail unless they address the critical interface between people and pathogens, and the existential threat of climate change, that is making our Earth less habitable.

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I. Introduction

It is happening. For years epidemiologists have been warning about a pandemic in the making, and unfortunately their predictions have materialized in the current COVID-19 global epidemic. Much remains for us to understand about this dramatic event that is generating profound suffering and placing human societies on the ropes. What is clear, though, is that this disease is a consequence of our interactions with nonhuman animals. COVID-19, however, is just the most recent example of a much larger threat to public health—one that in modern times manifests in animal agriculture, factory farming in particular. This report will illuminate the most pressing impacts and threats of animal agriculture for the health and well-being of human families and communities and how practices that challenge sustainability are leading us toward a global catastrophe.

II. Pandemic Disease Risk

A. Zoonotic Diseases

Zoonoses (singular *zoonosis*) are infectious diseases that can jump from a nonhuman animal to a human. The coronaviruses that cause COVID-19, severe acute respiratory syndrome (SARS), and Middle East respiratory syndrome (MERS) are all believed to have originated in bats and jumped either directly to humans or to an intermediate host animal before leaping to humans.[1] These viruses spread rapidly among humans and have reached epidemic and even pandemic scale.

Some zoonoses, such as mad cow disease, hardly ever transmit between humans but are frightening nonetheless, as they are always fatal.[2] The scarier thing is that even when zoonoses aren't transmissible between humans *at first* or transmit only rarely, as with mad cow disease and the deadly Nipah virus infection, the pathogens that cause them, such as the viruses behind AIDS, swine flu, and bird flu, are amazingly adaptive and often mutate into new strains that pass easily from one person to another.[3]

Others, such as Ebola virus disease,[4] so often result in death—violent, gruesome death—that although they do not spread between people as efficiently as the virus causing COVID-19, the notion of a pandemic mutant strain haunts the minds of epidemiologists worldwide.

While we are all now familiar with zoonoses originating in wet markets, many of us do not realize that the factory farms in our own communities provide conditions ripe for viruses to mutate, jump to humans, and create the next pandemic.

1. COVID-19

SARS-CoV-2 and COVID-19

Coronaviruses are a subfamily of viruses that typically cause respiratory and intestinal infections in animals and humans.[5] COVID-19 is caused by the new coronavirus SARS-CoV-2. Like the virus that caused the SARS outbreak in 2002–2003, SARS-CoV-2 enters human cells by binding to a cell receptor called ACE2.[6] SARS-CoV-2 is the seventh coronavirus known to infect humans. SARS-CoV, MERS-CoV, and SARS-CoV-2 cause severe disease, whereas HKU1, NL63, OC43, and 229E are usually associated with mild respiratory symptoms.[7]

Clinical Features of COVID-19

COVID-19 ranges from mild symptoms of upper respiratory tract infection (with or without fever) to severe pneumonia, and most reported cases are relatively mild.[8] A recent meta-analysis of eight studies (including 46,248 infected patients) showed that the most prevalent clinical symptom was fever, followed by cough, fatigue, and shortness of breath.[9] The most prevalent comorbidities were hypertension and diabetes, followed by cardiovascular diseases and respiratory system disease.[10] Case mortality rate was initially estimated at 2%–5%[11] but is now estimated at 0.5%–1%.[12] But to truly understand how deadly the virus is, scientists must discover how readily it kills different groups of people.[13] The risk of dying from COVID-19 can vary considerably, depending on age, ethnicity, access to health care, socioeconomic status, and underlying health conditions.[14]

Potential Origin

The first cluster of identified cases was related to the Huanan Seafood Market, a "wet" market in the Chinese city of Wuhan, where merchants sold a wide range of live and freshly slaughtered animals, including poultry, bats, and snakes.[15]

SARS-CoV-2 is currently thought to have originated in bats,[16] a hypothesis based on 88%–96% RNA sequence similarity to bat coronaviruses,[17] but definitive identification of the animal host depends on detection of the virus in a live infected animal. Coronaviruses with ACE2 binding mechanisms similar to SARS-CoV-2 have also been found in Malayan pangolins illegally imported into Guangdong province,[18] suggesting that the pangolin—who can act as a SARS-CoV-2 reservoir[19]—could have been an intermediate host between bats and humans.

Many other wild and farmed species capable of hosting a wide range of infectious zoonotic diseases were officially sold in Wuhan's wet markets. These animals, who were kept alive, caged, stacked, in poor condition, and often butchered on site, might also have played a role in the SARS-CoV-2 spillover to humans.[20]

An alternative hypothesis is that SARS-CoV-2 jumped directly from bats to humans, acquiring its characteristic ability to enter human cells using the ACE2 receptor through adaptation during undetected human-to-human transmission.[21]

Finally, a third hypothesis considers that SARS-CoV-2 might have accidentally been released from a lab investigating bat viruses. This "lab leak" hypothesis, however, lacks solid supporting evidence and was regarded as "extremely unlikely" by a recent WHO report on the origins of SARS-CoV-2, which also stresses that the virus's introduction through an intermediate nonhuman animal host is the most likely scenario.[22]

Human Interactions with Wildlife and Farmed Animals

Current evidence suggests that all human coronaviruses originated in nonhuman animals. The virus that causes MERS likely originated in bats and then jumped to dromedary camels before acquiring the ability to infect humans.[23] The SARS virus is believed to have originated in bats and then jumped to palm civets before infecting humans.[24] Other genetically diverse coronaviruses that are related to SARS-CoV and MERS-CoV have also been discovered in bats worldwide, including SARS-CoV-2.[25]

Domestic animals, such as camels, not only suffer diseases caused by coronaviruses but seem to play an important role as intermediate hosts that enable virus transmission from wild animals to humans. For instance, for a precursor of SARS-CoV-2 to acquire the ability to bind to human receptor ACE2, the nonhuman animal host would probably (1) live under densely populated conditions (to allow natural selection to proceed efficiently) and (2) possess similar cell-receptor binding characteristics.[26]

While there is no clear link between the origin of COVID-19 and animal agriculture, animal agriculture—factory farming in particular—provides favorable conditions for emerging viruses in terms of high stocking densities and human interaction with nonhuman animals, which facilitates natural selection and thus enables viruses to mutate and infect humans (i.e., "zoonotic transfer"). Animal agriculture has played a role in the emergence of other viral zoonoses, such as avian influenza, swine influenza, and Nipah virus, and scientists have not ruled out that this was also true for COVID-19.[27] To make matters worse, similar coronaviruses, such as the ones causing SARS and MERS, can infect farmed animals, who can further spread these deadly pathogens.[28] We now know that farmed mink can contract the virus that causes COVID-19, spread it to farmworkers after acquiring new mutations, and potentially become a reservoir for SARS-CoV-2.[29] Since scientists have found that animals such as cats, tree shrews, hamsters, and ferrets can also get infected by SARS-CoV-2 and transmit the virus to humans,[30] it would not be surprising if other farmed animals vulnerable to these types of viruses are already or will soon become vectors for COVID-19.

In our modern world—with frequent global travel, widespread animal transport, crowded human and nonhuman environments, and inadequate health care systems—given the frequent viral zoonotic outbreaks in recent years and their connection to wild animals and animal agriculture, another pandemic of this scale could happen again in the near future.

2. Avian Influenza

Although influenza viruses generally do not transfer between species, zoonotic influenza viruses—those that can infect humans through direct or indirect contact—can cause disease in humans ranging from mild illness to death.[31] Nonhuman animal influenza viruses that cross the species barrier are considered novel to humans and therefore have the potential to become pandemic threats.[32]

Avian influenza viruses have jumped to humans several times.[33] The World Health Organization has said that "the influenza virus is constantly evolving and while a future pandemic is a certainty, when and where it will start, and which virus strain it will be, are all unknown."[34] Symptoms in humans include conjunctivitis, fever, cough, sore throat, muscle ache, nausea, abdominal pain, diarrhea, vomiting, severe respiratory illness, neurologic changes, organ failure, and death.[35]

Avian influenza refers to strains of influenza A that infect bird populations and is categorized as either highly pathogenic avian influenza (HPAI) or low pathogenic avian influenza (LPAI),[36] with LPAI causing less severe disease in birds than HPAI.[37] There are several subtypes of avian influenza. Subtypes A(H5N1), A(H7N3), A(H7N7), A(H7N9), and A(H9N2) have previously infected humans.[38] As recently as February 2021, the World Health Organization reported that the HPAI subtype A(H5N8) had been detected in humans for the first time.[39] In May 2021, the first human case of A(H10N3) avian influenza was also made public.[40]

A particularly deadly strain of HPAI, A(H5N1) has been causing outbreaks in domestic poultry as far back as 1959.[41] The virus was discovered in 1996 in wild geese,[42] where it occurs naturally but where cases are generally asymptomatic.[43] A(H5N1) has infected domestic poultry populations worldwide, causing farmers to kill millions of chickens and turkeys.[44] The first case of human HPAI was discovered in 1997 in Hong Kong in association with a poultry outbreak. The first North American case was discovered in Canada in 2014, in a traveler who had recently been to China.[45] There have been over 700 human infections with A(H5N1) since 1997, and about 60% of people with confirmed infections have died.[46]

A(H7N9) was first detected in humans in Shanghai, China, in 2013 and has since exhibited some limited human-to-human transmission.[47] In the five years after the first case, 1,568 confirmed human cases, including at least 616 deaths (a case mortality rate of 39%), were reported to the World Health Organization.[48] A(H7N9) has been both high and low pathogenic but causes severe symptoms, including death, in humans.[49] Mass poultry vaccination in China seems to have curtailed spread of the disease in domestic bird populations. A(H9N2) is an LPAI that was first detected in turkeys in Wisconsin in 1966. Over the next 30 years, it spread through the United States and Europe, reaching China in the early 1990s and later becoming endemic in Africa and the Middle East.[50] H9 viruses are thought to spread "silently" in populations that also have H5 and H7 HPAIs. Human cases of A(H9N2) were first discovered in China in 1998 and subsequently in Egypt, Bangladesh, Pakistan, and Oman.[51] There has been only one death attributed to H9N2 and no evidence of human-to-human transmission, but ferret studies with H9N2 suggest that this virus could cause a pandemic through sustained human-to-human transmission.[52] H9N2 has also been found in pigs, who are considered potential "mixing vessels" for human and avian viruses.[53] Despite efforts to vaccinate poultry, H9N2 continues to spread.[54]

Thus far, most human infections of avian influenza have been caused primarily through contact with infected animals, and sustained human-to-human transmission has not been observed.[55] Infected birds shed the virus in their saliva, mucus, and feces. From there the virus can be inhaled or get into a person's eyes, nose, or mouth.[56] But given their high rate of mutation,[57] it may only be a matter of time before avian influenza viruses mutate in such a way that they become transmissible from one human to another and cause a pandemic.

3. Swine Influenza

Swine Influenza Viruses

Zoonotic influenza viruses typically result from reassortment, the swapping of gene segments among viruses. Because pigs are susceptible to avian, human, and swine influenza viruses, they can serve as effective "mixing vessels" when they are infected with different viruses simultaneously.[58] When novel zoonotic strains emerge, proximity to infected pigs or places where they are kept or exhibited can result in human infection[59] and potentially an epidemic.

2009 H1N1 Pandemic

The 2009 H1N1 "swine flu" pandemic was caused by a quadruple reassortment influenza A virus, with gene segments from avian, human, and Eurasian and North American swine influenza A viruses.[60] The first human illnesses related to the virus occurred in Mexico in March 2009,[61] and the virus spread quickly. On June 11, 2009, the World Health Organization declared the outbreak a pandemic, with nearly 30,000 confirmed cases in 74 countries.[62] A recent genome study of swine flu strains in Mexico revealed that the unique genetic makeup of the virus responsible for the pandemic was likely due to intercontinental transport of live pigs and that the virus had circulated among farmed pigs in central Mexico for a decade before crossing the species barrier and infecting humans.[63] The researchers warn that even low levels of live-animal transport can spread highly transmissible viruses long distances and that the seeding of diverse swine influenza viruses in countries with varying swine production practices increases both the probability that a virus will develop the ability to infect humans and the likelihood of pandemics.[64]

At the end of the pandemic, the WHO reported that by August 2010, more than 214 countries and territories had reported laboratory-confirmed cases, including at least 18,449 deaths.[65] The number of deaths is likely underestimated, as not all deaths associated with the virus were confirmed. A CDC modeling study of deaths associated with the 2009–2010 pandemic suggests that the actual number is likely 15 times higher than the WHO's figure, around 284,000.[66]

Most recently, during the COVID-19 pandemic, a novel strain of H1N1 with pandemic potential was discovered in humans working at a pig slaughterhouse in China.[67] Will this be the cause of the next pandemic, or will we learn our lesson early enough to prevent more human deaths and suffering?

4. Nipah Virus

Nipah virus is another emerging zoonotic pathogen found in pigs, pig farmers, and slaughterhouse workers. It can cause severe encephalitis (inflammation of the brain), and its case fatality rate is 40%–75%.[68] Human infections range from asymptomatic to severe, causing acute respiratory illness and fatal encephalitis.[69] Infected people initially develop symptoms such as fever, headaches, muscle pain, vomiting, and sore throat, which may be followed by dizziness, drowsiness, altered consciousness, and neurological signs that indicate acute encephalitis.[70] Some people also experience atypical pneumonia and severe respiratory problems, including acute respiratory distress.[71] Encephalitis and seizures occur in severe cases, progressing to coma within 24 to 48 hours.[72] Most people who survive acute encephalitis make a full recovery, but some survivors have suffered long-term neurological conditions.[73]

Nipah virus is considered a pathogen requiring biosafety level 4—the highest level of biosafety precautions, required for work with agents that could easily be aerosol-transmitted and cause severe to fatal disease in humans for which there are no available vaccines or treatments.[74] The virus is listed as an agent with high risk for public health and security due to its high mortality rate in people and the lack of effective vaccines or therapies.[75]

The natural reservoirs for Nipah virus and related members of the genus *Henipavirus* are fruit bats of the genus *Pteropus*.[76] Transmission of Nipah virus to humans may occur with direct contact with infected bats, infected pigs, and other domestic animals or from other infected people.[77] The virus was initially isolated and identified in 1999 during an outbreak of encephalitis and respiratory illness in Malaysia and Singapore among pig farmers, slaughterhouse workers, and people in close contact with pigs.[78]

Anthropogenic factors (the impact of human activities on nature), including agricultural expansion and intensification, were the underlying causes of the virus's emergence.[79] The growth of large intensive commercial pig farms in Malaysia with nearby fruit trees created an environment (perhaps as a result of deforestation programs[80]) where bats could drop partially eaten fruit contaminated with saliva containing Nipah virus into pig stalls.[81] The pigs could eat the fruit, become infected, and efficiently transmit the virus to other pigs in the densely populated farms.[82]

Outbreaks of Nipah virus in pigs and other domestic animals, such as horses, goats, sheep, cats, and dogs, were first reported during the initial Malaysian outbreak in 1999. The virus is highly contagious in pigs, who are infectious during the incubation period, which lasts from four to 14 days.[83] In the 1999 outbreak, Nipah virus caused a relatively mild disease in pigs, but nearly 300 human cases with over 100 deaths were reported.[84] Containing the virus required widespread deployment of personal protective equipment to people in contact with sick pigs and restrictions on transporting farmed animals.[85] Furthermore, more than a million pigs were killed, causing serious trade loss for Malaysia.[86]

Nipah virus has caused more recent outbreaks in Bangladesh and India,[87] and several other countries are considered at risk.[88] So far Nipah virus outbreaks have been self-limiting because the pathogen does not spread very easily from human to human. But the virus could mutate into a new strain with a more efficient person-to-person transmission and trigger a high-fatality pandemic similar to Ebola,[89] one potentially much more catastrophic than COVID-19.

5. BSE

Zoonotic Transmissible Spongiform Encephalopathy

In March 1996, a new human disease was identified when 10 cases of a degenerative neurological illness were reported in the United Kingdom.[90] Scientists soon linked the new disease—variant Creutzfeldt-Jakob disease (vCJD)—to a similar neurological disease that had ravaged cattle populations in the U.K. a decade earlier: bovine spongiform encephalopathy (BSE), or "mad cow" disease.

BSE and vCJD are transmissible spongiform encephalopathies (TSEs), a group of diseases that includes scrapie in sheep and goats (a fatal, degenerative disease affecting the central nervous system), chronic wasting disease in cervids (deer, elk, moose), and Creutzfeldt-Jakob disease in humans.[91] Also called prion diseases, TSEs are caused by abnormal, folded prion proteins, which collect in the brain and cause other proteins to fold, forming holes that give brain tissue a spongy appearance, resulting in progressive brain damage.[92] Unlike other infectious agents, like bacteria and viruses, prions are stable and relatively resistant to proteases (enzymes that break down proteins), high temperatures, UV radiation, and commonly used disinfectants.[93] TSEs are characterized by long incubation periods, typically years, and rapid progression once they manifest, and they are always fatal.[94]

"Mad Cow" Disease

The first confirmed cases of BSE were in Great Britain in 1986,[95] after the brains of two cows who had exhibited progressive neurological symptoms were studied, though unreported cases had likely occurred for several years.[96] Affected animals exhibit various physical and behavioral symptoms, such as trembling, stumbling, nervousness, and aggression.[97]

Scientists believe that the disease resulted from feeding cattle contaminated meat-and-bone meal (MBM) containing tissue from either scrapie-infected sheep or cattle in whom BSE had spontaneously occurred.[98] The disease then likely spread by feeding calves infected bovine MBM,[99] a theory supported by the higher prevalence of BSE among cows used for milk, as they are typically not suckled but are separated from their mothers soon after birth and fed greater quantities of feed supplements than are cattle raised for meat.[100] MBM is produced by rendering waste parts of various animals, commonly sheep and cattle, that are not suitable or used for human consumption. In the 1970s and 1980s, this included condemned materials and animals who died at farms, "fallen stock."[101]

The BSE epizootic in the U.K. peaked in January 1993, with about 1,000 new cases a week.[102] Bans on feeding ruminants and other farmed animals mammalian MBM have caused the number of cases to drop.[103] Since BSE was first identified in 1986, over 190,000 cases have been reported worldwide,[104] the vast majority (184,500) in the U.K.[105]

Variant Creutzfeldt-Jakob Disease

A decade after the first cases of BSE were reported, a related disorder appeared in humans in the U.K., causing a host of neurological symptoms, including loss of coordination and balance, loss of vision and speech, confusion, and spasms.[106] It was called variant Creutzfeldt-Jakob disease because of its similarities to classic CJD, though several features distinguish the two, such as significantly earlier onset (28 versus 68 years) and longer duration (13–14 versus four–five months) of disease among vCJD victims, as well as prominent psychiatric symptoms, including anxiety, depression, and social withdrawal.[107]

Clinical and epidemiological evidence has linked BSE and vCJD,[108] and scientists have concluded that the emergence of cases in the mid-1990s stemmed from the consumption of contaminated bovine meat that had entered the food system 10 years before.[109] While most cases of vCJD are due to eating meat contaminated with the agent of BSE, blood transfusions are responsible for at least three cases.[110] While plasma transfusion, organ and tissue transplants, and contaminated surgical instruments have not been implicated in transmission, they remain possible routes, as detection is difficult and the prions responsible are resistant to high temperatures, radiation, and common disinfectants.[111]

Worldwide, 229 cases of vCJD have been confirmed, and like BSE, most (177) have been in the U.K.[112] Some studies suggest that, for some, incubation periods can be much longer than 10 years and that many people may carry the vCJD-causing prions without developing symptoms.[113] A 2013 study, based on a large-scale survey of appendix samples in the U.K., suggests that as many as one in 2,000 people in the U.K. might carry the disease-causing prion.[114] Although a test to detect abnormal prions in blood was recently developed,[115] the possibility of so many "silent carriers" raises serious concerns about the safety of blood and tissue exchange. The extent of BSE's impact remains unknown.

B. The Role of Habitat Destruction in Disease Risk

The dramatic increase in deforestation and habitat destruction in recent decades is closely linked to animal agriculture, through cattle ranching, operating CAFOs, or growing feed crops, contributing to catastrophic environmental and conservation problems. Global warming and species extinction represent a contemporary sword of Damocles hanging over our heads. Although deforestation is a global phenomenon, one area that has seen the most destruction is the Amazon. Forest loss there affects not only local ecosystems and human communities but other regions around the world. For instance, scientists estimate that deforestation in the Amazon reduces rainfall in the coastal northwest United States by up to 20% and snowpack in the Sierra Nevada up to 50%.[116] As a driver of climate change, Amazon deforestation threatens agriculture in distant regions, promoting food insecurity.

While the environmental and conservation issues associated with deforestation and habitat destruction have become clear, we often fail to recognize their role in the emergence and spread of zoonotic diseases. Most infectious diseases affecting humans stem from nonhuman animals, and farmed animals are often natural reservoirs for many zoonotic pathogens.[117]

As we've seen with the deadly Nipah virus, for instance, human destruction of forests and other natural habitats for cattle grazing or construction of industrial farms brings wildlife and farmed animals closer together, heightening the risk of disease transmission between them and, ultimately, to humans. Other ongoing serious viral zoonoses with pandemic risk, such as avian or swine flu, are also a consequence of the interaction between wildlife, factory-farmed animals, and humans.

By allowing animal agriculture to keep destroying our global forests, we are playing with fire. Deforestation is not only aggravating climate change, endangering countless species and indigenous communities; it is actively contributing to the creation of the next human pandemic.

III. Antibiotic Resistance

Antibiotic resistance—the ability of bacteria to survive drugs designed to kill them—is one of the greatest global public health challenges of our time, according to the Centers for Disease Control and Prevention.[118] Since their discovery in the late 1920s, antibiotics have revolutionized the field of medicine.[119] They have saved millions of lives each year, alleviated pain and suffering, prevented the spread of infectious diseases,[120] and helped increase the average life span in the United States to nearly 80 years from 56 years in 1920.[121] But the rapid global emergence of resistant bacteria is endangering the efficacy of antibiotics.[122] Pathogens that cause serious medical problems such as tuberculosis, many sexually transmitted diseases, urinary tract infections, and pneumonia have become resistant to many antibiotics, rendering these conditions difficult and sometimes impossible to treat.[123] Thus, people around the world are dying from untreatable infections.[124] And the discovery of new, effective antibiotics has steadily declined.[125] We are entering the age of "superbugs," bacteria that have acquired resistance to a wide range of antibiotics. In fact, many experts believe we are already in a "post-antibiotic" era.[126]

Each year in the United States, at least 2.8 million people get an antibiotic-resistant infection, and more than 35,000 people die.[127] In most cases, antibiotic-resistant infections require extended hospital stays, additional follow-up doctor visits, and costly and potentially toxic alternatives.[128]

While some of this resistance is attributable to antibiotic overuse in human medicine, animal agriculture is a leading contributor.[129] The World Health Organization notes that in some countries, 80% of medically important antibiotics are used in animal agriculture.[130] In 2014 pharmaceutical companies sold nearly 21 million pounds of medically important antibiotics for use in farmed animals, more than three times the amount sold for use in people.[131] Meat production accounts for 73% of global antibiotic use, and because of the growing global appetite for animal protein, the occurrence of antibiotic resistance in disease-causing bacteria nearly tripled between 2000 and 2018.[132] Meat production has grown by 68%, 64%, and 40% in Asia, Africa, and South America, respectively, and the transition to high-protein diets in low- and middle-income countries has been facilitated by the global expansion of intensive animal production systems (and CAFOs in particular).[133] These drugs are routinely administered to cows, pigs, chickens, turkeys, and fish in their feed to increase growth rates and enable animals to survive in crowded, often filthy conditions. Antibiotics are a cheap way to address the issue of rampant infections.[134]

Antibiotic-resistant germs can quickly spread through communities, the food supply, healthcare facilities, and the environment (e.g., soil, water).[135] The gravity of the situation has led the WHO to recommend that farmers stop using antibiotics in healthy animals to prevent the spread of antibiotic resistance.[136] But even in regions where antibiotic use in animal agriculture is under public and institutional scrutiny, it is expected to rise. According to the USDA, agriculture-related antibiotic use in the EU and United States may still increase due to rising exports, outbreaks of farmed animal diseases once limited to other regions, and the need for higher doses because of reduced antibiotic efficacy.[137]

The threat of antibiotic resistance undermines progress in health care, food production, and life expectancy.[138] To help address this problem, in the short term, Mercy For Animals' corporate engagement team and animal welfare experts work to improve conditions for farmed animals, thus reducing the need for antibiotics. In the long term, we strive to create a world where no animal is raised for food.

IV. Foodborne Illness

Each year in the Americas, at least 77 million people fall ill and more than 9,000 die as a result of foodborne pathogens.[139] In the United States, over 47 million people fall ill, nearly 128,000 are hospitalized, and more than 3,000 die.[140] In China, at least 94 million people become ill annually from bacterial foodborne pathogens, with approximately 3.4 million hospitalizations and over 8,500 deaths.[141] Worldwide, the numbers are staggering; at least 600 million people become sick from eating contaminated food, and 420,000 die.[142] The majority of these illnesses and deaths result from consumption of animal products,[143] with factory farm runoff implicated as a cause of bacterial contamination of plant foods.[144] The bacteria that cause these illnesses, such as *Salmonella*, *E. coli*, and *Campylobacter*, are present naturally in the intestinal flora of farmed animals but reach humans' plates when farmed animals are overcrowded and forced to stand and lie in waste. Bacteria also come into contact with food when fecal-contaminated water and sludge are used to fertilize crops destined for human consumption. A report by Environmental Working Group found that nearly 80% of meat sold in the surveyed supermarkets was contaminated with deadly antibiotic-resistant bacteria.[145] Reducing consumption of animal products, and, ultimately, the number of factory farms, will alleviate much of the physical and financial burden of foodborne illness on our communities.

A. *Salmonella*

Salmonella is a group of bacteria that live in the intestinal tracts of many animals and is one of four key global causes of diarrheal diseases.[146] The CDC estimates *Salmonella* infections cause about 1.35 million illnesses, 26,500 hospitalizations, and 420 deaths in the United States every year.[147] In 2018, EU member states reported that outbreaks in their countries were mainly linked to eggs.[148] *Salmonella* strains sometimes cause infection in urine, blood, bones, joints, or the nervous system (spinal fluid and brain) and can cause severe disease.[149] *Salmonella* infections can stem from contaminated food and water and contact with infected animals, their feces, or their environment.[150] And because it does not require a living host, *Salmonella* can easily pass through food-supply chains, from animal feeding operations to households or foodservice establishments.[151]

Salmonellosis in humans generally results from consumption of contaminated animal products (mainly eggs, meat, and milk), although other foods, including green vegetables contaminated by manure, have been implicated in transmission.[152] Resistance to essential antibiotics is increasing in *Salmonella*, limiting treatment options for people with severe infections.[153]

B. *E. coli*

Escherichia coli (*E. coli*) bacteria are commonly found in humans and other warm-blooded animals.[154] Most strains of *E. coli* are harmless, but some, such as Shiga toxin-producing *E. coli* (STEC), can cause severe foodborne illness.[155] STEC live in the digestive systems of ruminant animals, and cattle are the major source for human illnesses. But other farmed animals, such as pigs and chickens, can also spread the bacteria.[156]

The most common STEC, responsible for the majority of foodborne illness from *E. coli*, is *E. coli* O157:H7, transmitted to humans primarily through consumption of contaminated foods, such as raw or undercooked meat and raw milk. Fecal contamination of water and plant foods, as well as cross-contamination during food preparation (through surfaces and utensils in contact with contaminated meat), can also lead to infection.[157] People of any age can become infected and seriously ill, though very young children and the elderly are more likely to develop severe illness and hemolytic uremic syndrome.[158] An estimated 265,000 STEC infections occur each year in the United States.[159] And rates of antibiotic resistance in STEC are rising rapidly.[160]

C. *Campylobacter*

Campylobacter is considered the most common bacterial cause of human gastroenteritis in the world and is one of the four key global causes of diarrheal diseases.[161] The bacteria can be transmitted directly or indirectly between animals and humans. With over 246,000 human cases annually, it is the most frequently reported cause of foodborne illness in the European Union.[162] The actual number of cases, however, is believed to be closer to 9 million each year.[163]

The most common bacterial cause of diarrheal illness in the United States, *Campylobacter* infections affect 1.5 million U.S. residents every year, according to CDC estimates.[164] Symptoms include diarrhea (often bloody), fever, stomach cramps, nausea, and vomiting.[165] Like other bacteria, strains of *Campylobacter* are becoming resistant to antibiotics commonly used to treat infection.[166]

Campylobacter can be carried in the intestines, liver, and other organs of animals and transferred to other body parts during slaughter. In 2015, National Antimicrobial Resistance Monitoring System (NARMS) tests found *Campylobacter* on 24% of raw chicken bought from retailers.[167] In fact, an estimated 20%–30% of campylobacteriosis cases in humans stem from direct consumption of chicken meat, while 50%–80% may be attributed to the chicken industry as a whole.[168]

V. Worker Health and Safety

As the animal agriculture industry has grown, so too has the exploitation of farm and slaughterhouse workers. They, their families, and the communities that surround factory farms suffer serious physical and psychological harms.

A. Slaughterhouse Worker Health and Safety

Temperature shock, puncture wounds, amputations, eye injuries, cuts, falls, fractures, carpal tunnel syndrome, exposure to pathogens and toxic substances, severe burns, back and shoulder injuries, and upper respiratory irritation and damage are among the many risks facing workers in the meatpacking industry. In fact, the U.S. Occupational Safety and Health Administration describes it as one of the country's most hazardous industries.[169]

In the United States, most slaughterhouse workers are people of color living in low-income communities where jobs are scarce.[170] All too often they are undocumented immigrants who have little to no access to legal assistance or medical care when abuses or injury occur.[171] After Canada placed stricter restrictions on foreign workers, Canadian slaughterhouses struggled to find people willing to do this work and, accordingly, have suggested offering the jobs to Syrian refugees.[172] In the United States, slaughterhouse workers earn only $13.68 per hour.[173] In Brazil, slaughterhouse workers often work grueling 15-hour days.[174]

Dizzying line speeds and unsafe working conditions cause workers to suffer a wide range of physical injuries, from overuse injuries, such as carpal tunnel syndrome, to dismemberment.[175] Sometimes they even cause death.[176] A Brazilian report finds that slaughterhouse workers are at risk of infectious diseases including brucellosis, leptospirosis, toxoplasmosis, and hepatitis.[177] Slaughterhouse workers are also one of the occupational groups most affected by COVID-19, with inadequate workplace physical distancing, poor sanitation, and crowded living and transportation conditions probably enhancing infection risk.[178] The meat industry has become a global health liability.[179]

Less overt, but no less serious, are the psychological issues that stem from killing thousands of animals per day. Slaughterhouse workers suffer higher rates of several psychological disorders, including anxiety, depression, and post-traumatic stress disorder,[180] and are more prone to anger, hostility, and aggression.[181]

B. Farmworker Health and Safety

Farmworkers also bear serious health and safety risks. Aside from dangers common to many types of agriculture (machinery, tools, chemicals), workers at factory farms face exposure to pathogens and waste-generated gases and animal-related injuries. Many workers suffer respiratory diseases due to exposure to airborne particles from dry fecal matter, feed, animal dander and skin cells, feathers, fungi, dry soil, and ammonia and other toxic gases emanating from urine and manure.[182] And because these workers are in close contact with animals and their waste, they face increased risk of contracting and spreading zoonotic pathogens.[183] Factory farm workers have a greater risk of contracting antimicrobial-resistant infections than the general population.[184]

A large percentage of farmworkers are people of color, including migrant workers from Mexico and other parts of Latin America.[185] Many of these workers lack authorization to work legally in the United States.[186] Motivated by the need to support their families, most workers have little choice but to continue working in conditions that pose serious physical and psychological risks.[187]

Self-employed farm operators and their families are also victims of industrial animal agriculture. On top of the operational hazards mentioned above, they experience the stress of being heavily invested in a business over which they have very little control. With few career options in rural areas dominated by one or two industries, some farmers turn to raising animals under restrictive contracts with meat corporations. Once they take on the colossal debt necessary simply to enter into business, they are stuck. They are responsible for managing the thousands of tons of waste their farms produce, and though they are often forced to raise animals genetically predisposed to suffer a variety of health problems, they bear the financial burden when the animals die.[188] If they speak up about their concerns, farmers risk losing their livelihoods.[189]

We consider farmers and farmworkers potential allies in the effort to build a better food system.

VI. Health Impacts for Rural Communities

One need not work in a slaughterhouse or factory farm to suffer the consequences of living near one. The psychological damage slaughterhouse workers incur reaches beyond the factory walls; studies find that the presence of a slaughterhouse in a community correlates with higher total arrest rates and rates of violent crime, including rape and other sex offenses.[190]

As the animal agriculture industry grows, the animal waste, antibiotics, and veterinary drugs that seep from these operations into the water, soil, and air also increases.[191] In the United States, animal agriculture produces between 335 million and 2 billion tons of animal waste per year; China exceeds 2 billion. The U.S. human population produces just 7 million tons of waste.[192] Unlike human waste, which undergoes rigorous treatment to remove harmful substances and pathogens, animal waste is often kept in enormous earthen pits and sprayed or spread onto surrounding land. This waste permeates farming communities—many of which are low-income communities of color—contaminating the air, water, and soil on which they depend.[193] This is more than just a smelly problem. Those who reside near factory farms suffer disproportionately from a plethora of health problems, including asthma and other respiratory conditions, eye irritation, nausea, headaches, and even mental illness.[194] In this alarming context, CAFOs in particular are a pressing environmental and public health problem. The CDC reports that the waste originating in CAFOs contains a variety of contaminants, such as nitrogen and phosphorus; pathogens such as *E. coli*; growth hormones; antibiotics; chemicals used as additives to the manure or to clean equipment; animal blood; silage leachate from corn feed; or copper sulfate used in footbaths for cows.[195]

These communities are also disproportionately exposed to infectious zoonotic diseases. For example, slaughterhouses have become COVID-19 hotbeds, placing people nearby at heightened risk of illness.

VII. Indirect Impacts: Diet-Related Chronic Diseases

High consumption of animal products is a well-established leading cause of the world's deadliest chronic diseases, including cardiovascular disease,[196] certain cancers,[197] and Type 2 diabetes.[198] Annually worldwide, almost 4 million people die from diabetes, and 90% of diabetes patients suffer from Type 2.[199] Over 9 million die of cancer from various causes,[200] and almost 18 million die of cardiovascular disease.[201] Once considered diseases of affluence that were common in Western cultures, Type 2 diabetes and heart disease have reached epidemic proportions in the growing economies of China and India.[202] Despite the vast human suffering that results from consumption of animals, global demand for meat is projected to increase 14% by 2027.[203] Thus, educating the public on the negative health impacts of meat, eggs, and dairy is of utmost importance.

A. Type 2 Diabetes

In 2014, the World Health Organization estimated that 422 million people (or one in 11 adults) were living with Type 2 diabetes (T2D) worldwide.[204] This is the equivalent of twice the population of Brazil. According to some estimates, the number has quadrupled in the past three decades.[205] Beyond dependence on insulin injections or other medications, T2D can lead to blindness, kidney failure, heart attack, stroke, and lower-limb amputation.[206]

Impacts of Meat Consumption

The relationship between a diet high in calorically dense foods, especially red meat and processed meat, and increased risk of T2D is well established.[207] While the degree of impact varies from one study to another, a plethora of studies concludes that increasing one's meat consumption raises the risk of T2D. One study linked an additional serving of processed meat per day (50 g or one hot dog) to a 27% higher risk of T2D; it linked an additional serving of bacon (50 g or about five slices) to a twofold higher incidence.[208] Another study found that an increase of one-half serving or more of red meat per day (42.5 g or about half the size of an adult's palm) resulted in a 48% elevated risk.[209] Finally, a third study revealed that people who consumed more than three servings of meat per day (serving size 100–150 g) had a twofold higher risk than those who consumed less than two servings per day.[210] Research suggests that dairy consumption has either no relationship with or a protective effect against T2D.[211]

Some research fails to establish a link between egg consumption and T2D[212] or has even found egg consumption beneficial.[213] According to other studies, however, egg consumption appears to be linked to elevated risk of T2D.[214] One study found that risk increased when consumption exceeded just one egg per week.[215] Researchers determined that eating at least one egg per day raised the risk of T2D by 58% in men and 77% in women.[216] Three separate meta-analyses support this finding, linking increased egg consumption with higher risk of T2D.[217]

The data on egg and dairy consumption yields conflicting results but suggests that consumption of animal products may at times interact with environmental or genetic factors to promote T2D.

Impacts of Plant-Based Eating

A large body of research and countless case studies reveal that T2D can be prevented, treated, and even reversed through plant-based eating.[218] Research into the dietary components of animal-based and plant-based diets that either contribute to or reduce the risk of T2D is ongoing. While total fat intake does not seem linked to T2D risk,[219] plant-based fats may be protective against T2D.[220] Greater intake of nuts is associated with decreased risk of T2D.[221] Higher intake of animal heme iron is associated with higher risk of T2D.[222] For patients suffering from heart and kidney disease resulting from T2D, one clinical trial found that swapping animal protein for soy protein reduced cholesterol and triglyceride levels while increasing kidney function.[223]

B. Heart Disease

Impacts of Meat Consumption

Research dating back to the 1980s[224] links increased meat consumption to elevated risk of cardiovascular disease. The risk is tied to increased saturated fat and cholesterol intake, apparently irrespective of whether the meat is red or white.[225] Research demonstrates that red meat consumption raises levels of a gut-generated chemical associated with heart disease.[226] One meta-analysis linked a single serving per day of processed meat (50 g or one hot dog) to a 42% higher risk of heart disease.[227] The pooled findings of two studies evaluating total meat consumption reveal that each daily serving of meat (100 g) raises the risk of mortality from ischemic stroke by 24%.[228]

Epidemiological research confirms the cardiovascular health risks of a diet high in animal protein. One study analyzed mortality, disease, and dietary data across populations in rural China, where meat consumption is low and vegetable consumption is high, and compared the data with that of the U.S. population. The results revealed that the Chinese populations had significantly lower cholesterol levels and mortality from coronary artery disease.[229]

The jury is still out on the cardiovascular impacts of dairy consumption. Some studies do not demonstrate that dairy consumption increases the risk of cardiovascular disease.[230] But scientists suggest that more focused research is needed.[231] There is a dire need for studies that compare diets high in dairy with diets that replace dairy with plant-based alternatives. One study that made this comparison found that the risk of cardiovascular disease dropped by 24% when dairy fat was replaced with plant fats.[232]

Egg consumption has also been shown to increase the risk of cardiovascular disease[233] and all-cause mortality.[234] One study found that just half an egg per day significantly raised these risks.[235] In studies that did not find an impact of egg consumption on cardiovascular disease in healthy adults, egg consumption did increase the risk of coronary heart disease in patients with diabetes.[236]

Impacts of Plant-Based Eating

The good news is that eating plant-based offers definitive heart-protective effects.[237] One study found that vegans had a 75% lower risk of developing hypertension when compared with meat eaters.[238] The same study found that risk of death from cardiovascular disease was up to 68% lower for vegetarians than for meat eaters.[239] Research also shows that when compared with "healthy" meat eaters, vegetarians have better antioxidant status and fewer plasma biomarkers (uric acid, C-reactive protein, and triglycerides) of coronary artery disease.[240]

C. Cancer

Impacts of Meat Consumption

One study found that the risk of esophageal, colorectal, liver, and lung cancers increased up to 60% when red meat was consumed at the highest levels (~125 g/day on a 2,000-calorie diet, or almost three McDonald's burger patties).[241] Individuals who ate the most processed meat (~45 g/day on a 2,000-calorie diet, or about five slices of bacon) had a 20% higher risk of colorectal cancer and a 16% higher risk of lung cancer.[242] A meta-analysis that controlled for smoking status revealed a clear association between red meat consumption and lung cancer risk.[243] A working group of 22 scientists from 10 countries met at the International Agency for Research on Cancer, reviewed the available research, and determined that there is sufficient evidence to conclude that processed meat is indeed carcinogenic to humans and that red meat is "probably carcinogenic to humans."[244]

GI, Pancreatic, and Colorectal Cancers

According to one study, women who consumed more than three servings of processed meat per week had a twofold higher risk of developing stomach cancer than women who consumed less than 1.5 servings of processed meat per week.[245] Another study found an increased risk of esophageal and stomach cancers in individuals who consumed the most red meat (~130 g/day on a 2,000-calorie diet).[246] A prospective cohort study of over 69,000 people showed that vegetarians had a decreased risk of gastrointestinal cancer.[247]

Several meta-analyses have concluded from the vast body of research demonstrating a link between high meat consumption and colorectal cancers that the risk of colorectal cancer increases 12%–49% depending on the type of meat and the study population.[248] Research suggests that this increase is attributable to carcinogens either in the meat or produced during cooking, which could promote carcinogenesis, or transformation of normal cells into cancer cells.[249]

A review of the relevant literature found that high consumption of both processed meat (50 g/day, or one hot dog) and red meat (120 g/day, or almost three McDonald's burger patties) is linked to an increased risk of pancreatic cancer (13% and 29%, respectively).[250]

Other Cancers

One study found that vegetarians had a 35% lower risk of prostate cancer compared with omnivorous people.[87] Coincidentally, a study funded by the National Cattlemen's Beef Association did not find an association between meat consumption and prostate cancer.[251]

Multiple studies, including a large meta-analysis, have found that even with adjustments for smoking levels, individuals who consume the most red meat (up to two servings per day) increase their risk of lung cancer up to 230%.[252]

Research suggests that meat consumption is linked to higher rates of endometrial cancer.[253] A study revealing that vegan women experience fewer cancers specific to women corroborates this finding.[254] A vegetarian diet has been demonstrated as protective against mortality related to breast cancer. One study found a 48% reduced mortality risk.[255]

Many components of plant foods are considered protective against cancer, including phytonutrients and antioxidants.[256] Consumption of plant foods, especially fruit, has been shown to reduce the risk of lymphatic cancers.[257]

While the jury is still out on the impacts of dairy on T2D and cardiovascular disease, much research demonstrates a link between dairy consumption and increased incidence of several types of cancer. High dairy consumption is associated with increased incidence of prostate cancer,[258] lymphatic cancers,[259] and testicular cancer.[260] A study of 1,941 women associated higher consumption of American cheese, cheddar cheese, cream cheese, and milk with a 53% increased risk of breast cancer, but it associated yogurt consumption with decreased risk.[261] Another study corroborated the protective effects of yogurt and also found low-fat dairy to be protective.[262]

Yogurt's protective effects may not be attributable to dairy but to the immune-boosting properties of probiotics, which are also present in naturally fermented plant-based foods, such as sauerkraut, kimchi, and kombucha.[263] These plant-based foods provide the immune-boosting properties of probiotics without the negative effects of insulin-like growth factor 1 (IGF-1), a compound known to contribute to cancer cell proliferation.[264]

High egg intake is related to increased risk of a variety of cancers, including of the oral cavity and pharynx, upper digestive tract, colon and rectum, lungs, breasts, prostate, and bladder.[265]

What About Chicken and Fish?

Most research linking meat consumption to disease focuses on red and processed meat. Evidence also demonstrates disease risks associated with dairy and egg consumption. So should people seeking to improve their health just switch to chicken or fish?

Chicken

As noted, chicken meat may lead to greater weight gain than other types of meat,[266] and some research shows that chicken consumption does not benefit lipoprotein levels compared with red meat, as is commonly believed.[267]

Cooking chicken at high temperatures is linked to increased cancer risk. High cooking temperatures generate carcinogenic compounds (e.g., heterocyclic amines, or HCAs).[268] But because of its high loads of disease-causing bacteria, such as *Salmonella*, chicken must be thoroughly cooked. Thus, the risk of HCA consumption is more serious for chicken than for red meat.

Most chicken meat in the United States is contaminated with pathogens that cause illness.[269]

In 2010, NARMS determined that 75% of chicken and turkey tested was contaminated with *E. coli.* Alarmingly, much of that *E. coli* was resistant to multiple antibiotics.[270] In 2015, a test of retail chicken samples revealed that 24% were positive for *Campylobacter*.[271] The strains of bacteria in chicken (as well as in beef) are increasingly resistant to antibiotics, making consumption even more dangerous.[272] Consumption of pathogen-contaminated chicken is also linked to urinary tract infections.[165] Scientists estimate that by 2050, drug-resistant bacteria could kill 10 million people each year and cost 100 trillion USD in global economic damage.[273]

Fish

Some research has linked fish consumption to reduced risk of heart disease and improved brain health.[274] Others have not demonstrated a strong association with cardiovascular health.[275] It is widely accepted that most benefits unique to fish come from omega-3 fatty acids,[276] which fish consume naturally.[277] Plant-based sources of omega-3 fatty acids have proved effective in preventing cardiovascular disease.[278] These include flaxseed oil, chia seeds, walnuts, and seaweed. Furthermore, increased vegetable consumption is associated with lower risk of dementia and slower rates of cognitive decline in older age—benefits also attributed to fish consumption.[279]

Fish are at particular risk for biomagnification of harmful substances.[280] This is because large predatory fish, such as tuna, swordfish, and cod, eat smaller fish who eat even smaller fish who eat mercury-contaminated algae. The amount of mercury in the animal at the top of the food chain is thus biomagnified. For this reason, people—especially children and pregnant women—are advised to consume meat from these fish in very low amounts.[281] Mercury toxicity damages the nervous system, impairs neurological development, and harms multiple other organ systems.[282] In addition to mercury, many fish are high in cancer-causing and neuroendocrine-disrupting polychlorinated biphenyls (PCBs).[283]

Meat, dairy, and egg consumption is linked to a wide variety of diseases, including several types of cancer, cardiovascular disease, metabolic syndrome, and Type 2 diabetes, all of which reduce life expectancy and quality of life. Fish consumption can result in chemical toxicity from mercury and PCBs. Plant foods, on the other hand, have been linked to reduced risk of disease, increased longevity, and improved quality of life.

VIII. Conclusion

Industrial animal agriculture is not just responsible for the tremendous suffering of billions of sentient farmed animals or the threat to the environmental conditions that all Earth's inhabitants need to thrive or even survive. As this report makes clear, animal agriculture—factory farming in particular—is also a main contributor to many of the most serious threats and challenges to the health and welfare of billions of humans worldwide. Epidemics, antibiotic resistance, diet-related diseases, and threats to the health and welfare of workers and rural communities—the suffering that factory farming inflicts on humans is also enormous. The great news is that the use of animals for food and other goods is now redundant. This is the time to transform the food industry by abandoning animal agriculture and fully embracing existing alternatives.

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