Animal Markets and Zoonotic Disease in the United States
AUTHORS

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IMAGES

Wherever possible the photographs used in this report depict practices inside the United States. However, given that many forms of animal industry are closed to the public or otherwise prohibit photography, in cases where no U.S. images were available, representative photographs were sourced from other countries, such as Canada, to depict analogous practices inside the United States.
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INTRODUCTION

There is a well-worn pattern in the face of emerging diseases whereby nations assign blame elsewhere, ignoring risks that lie closer to home. This practice of finger-pointing plays out on an international stage, while the accompanying “it can’t happen here” mentality stifles meaningful and much-needed domestic reform. Perhaps nowhere is this attitude more palpable than in the United States. For many Americans, concepts such as “bushmeat” or “wildlife farming” seem foreign, but they refer to practices that are common within the United States as well, differentiated only by the language we use to describe them.1

More emerging infectious diseases originated in the United States than in any other country in the world during the second half of the 20th century.2 3 4 And it was the United States that was the likely source of the deadliest disease outbreak of recent record. The 1918 Influenza pandemic—a disease that infected roughly 500 million people, one-third of the world’s total population, killing 12 times as many in absolute terms as has COVID-19 to date—appears to have been born of humble origins deep in the American Heartland.5 6 7 The virus killed more Americans than World War I, World War II, and the

1. For example, Americans consume wild-caught animals, but refer to their type of meat as “game,” as opposed to “bushmeat” when referring to wild-caught animals eaten abroad. Americans also raise captive-bred wildlife species in great numbers, many for human consumption.
2. Reporting bias may explain part of this finding, as outbreaks are perhaps less likely to be noticed, reported, documented, and diagnosed in countries that lack sufficient health resources.
INTRODUCTION

Vietnam War, combined. Still, in 2023, the United States will spend 1,650 times more on military defense than on pandemic preparedness.  

More recently, in 2009, the influenza strain H1N1, known as “swine flu,” swept through the United States, infecting more than 100 million Americans and hospitalizing over 900,000. Two of the primary carriers of influenza, pigs and poultry, are produced in the United States by the millions and billions annually—with higher numbers of each than almost any other country on earth. The United States is also the largest importer of wildlife in the world, bringing more than 220 million live wild animals and their diseases across its borders each year. Yet, despite the serious risks and magnitude of disease exposure, the United States is not prepared to address these threats, many of which are chronically overlooked and under-regulated.

The United States, with its 3.8 million square miles of land, nearly 3,000 species of native wildlife, 10 billion livestock and poultry, and 328 million people, presents a massive and complex case study of how humans and other animals interact, often in the most intimate and artificial of ways. Animal use in the United States is as diverse as it is ubiquitous, though such use rarely permeates the public consciousness. While public-facing human-animal interactions may appear highly-controlled or sanitized, much of the larger picture falls outside this frame.

For example, by some estimates, there are as many exotic pets in the United States as there are cats and dogs, and many of these exotic pets are brought in from abroad, while others are bred out-of-sight in warehouses, backyards, and basements. Animals are everywhere, but much of the activity involving them goes unnoticed, concealed by opaque supply chains. There are 30 livestock animals involving them goes unnoticed, concealed by opaque supply chains. There are 30 livestock animals

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8. This is true even without accounting for population size. The CDC estimates that the 1918 pandemic killed 675,000 Americans, while 580, 135 servicemen and women died in WWI, WWII, and the Vietnam War according to the Department of Veterans Affairs. Roughly 392, 393 of these deaths occurred in combat. “America’s Wars,” Department of Veterans Affairs, last updated September 2019, https://www.va.gov/opas/publications/factsheets/fs_americas_wars.pdf.
9. Since the nation’s founding in 1775, there have been fewer deaths in combat (656,513) than deaths from the 1918 flu, which lasted just eighteen months. (This figure includes deaths in the American Civil War), “History of 1918 Flu Pandemic” Centers for Disease Control and Prevention, last modified March 21, 2016, https://www.cdc.gov/flu/pandemic-resources/1918-commemoration/1918-pandemic-history.htm.
17. However, in addition to these “black swan” events, the United States, like the rest of the world, also struggles under the daily burden of common zoonotic diseases—endemic and often overlooked, but smoldering at a low level all of the time. For example, many well-known, endemic diseases, from salmonellosis to Lyme disease are transmissible from animals. The USDA estimated that the cost of salmonella infections alone cost the United States over $4 billion annually, though this pathogen is just one of many that regularly cause illness. “Cost Estimates of Foodborne Illnesses,” USDA, last modified March 10, 2021, https://www.ers.usda.gov/data-products/cost-estimates-of-foodborne-illnesses/; A. Sanyaolu, C. Okorie, N. Mehraban, O. Ayodele, S.K. Tshitenge et al., “Epidemiology of Zoonotic Diseases in the United States: A Comprehensive Review,” J Infect Dis Epidemiol 2:021 (2016), 10.23937/2474-3658/1510021.
Human-animal interactions have given and will again give rise to zoonotic outbreaks that claim American lives.

produced annually for every person in the United States, yet only a handful of us interact with them directly. Still, when disease outbreaks spill over, they have the potential to extend far beyond these few individuals. Human-animal interactions have given and will again give rise to zoonotic outbreaks that claim American lives.

Zoonotic disease experts with whom we spoke likened disease outbreaks to forest fires, with large populations of wild and captive animals representing dried-out trees and kindling. The purpose of this discussion is to examine the sparks—the actions we take that can and have given rise to outbreaks of zoonotic disease.22 Some of these actions are deliberate, while others are as careless as flicking a cigarette butt out of a car window.

We catalog and assess the scope of animal commerce in the United States, noting the kinds of transactions that can act as flashpoints for zoonotic spillover, an event through which pathogens are transmitted from animals to humans. In this report, we identify 36 distinct types of consumer-facing animal markets and supply chains, documenting the risks and the regulatory landscape surrounding each. Underpinning this research are two driving questions: Does the practice in question pose a risk of zoonotic transmission? And if so, is current regulation sufficient to mitigate that risk?

We begin with a discussion of sources: the supply-side markets that fuel animal industries. From there, we discuss a range of consumer-facing animal markets.23 While some of these markets are well documented, others operate almost entirely out of view—of both the public and, often, of regulators too. We hope to bring these under-examined markets into clearer focus and, with them, the endless, dizzying array of ways Americans use and consume animals. A number of observations about existing policy emerged from our research that cut across and color multiple markets, helping to illuminate the institutional, informational, behavioral, and enforcement challenges that characterize U.S. regulatory postures.

At the end of this discussion, we are left with the uneasy but unavoidable conclusion that, at present, the United States has no comprehensive strategy to mitigate zoonotic risk. While zoonotic risk cannot be eliminated, it can be reduced. Closer examination of these policy insights may foster ideas regarding how regulation can be better conceptualized and designed both to reflect and reduce such risk. This report provides a springboard for such conversations and begins laying the groundwork for much-needed reform. Recognizing the risks is an important first step, for only then will we be able to make clear-eyed appraisals of whether each practice is worth the danger it poses and what might be done to tip the scales in favor of prevention.

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23. Though the list of markets included here is not exhaustive, it is intended to provide some sample of the types and forms that animal-based commerce takes in the United States.
CONTEXT AND CULTURAL USE OF ANIMALS

Globally, the United States is an epicenter of demand for animals and animal products. High levels of wealth and demand per capita, combined with the sheer population of the United States, make the country a premier consumer market for animals. The United States is the world’s largest importer of both domestic animals and of wildlife.24

In 2019, the United States legally imported more than 224 million live wild animals and 883 million wildlife products worth over $4.3 billion.25 26 27 In addition, over 22 million livestock animals were imported, at a value of roughly $3.5 billion.28 29 30 With these animals comes the potential for new disease outbreaks.

The United States’ role in fueling the emergence of zoonotic disease manifests itself in two ways: the problems it creates here and the problems it places elsewhere. Wealth and consumption habits in the United States drive extractive practices in search of animals and animal products across much of the

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developing world that, in turn, drive spillover risk upstream in the supply chain. A South American farmer on the Gulf of Mexico may climb a tree and collect Amazon parrot nestlings, place them in plastic water bottles, and smuggle them into the United States for sale. A bat in Indonesia may be captured in a net trap, encased in plastic, and shipped to the United States in the form of a paperweight. Other types of consumer demand can also play an indirect role in precipitating zoonotic disease spread abroad. For example, America’s dependence on heavy metals to build laptop computers necessitates intensive mining in central Africa, and in the process, creates opportunities for deadly viruses such as Marburg, a cousin to Ebola with a fatality rate of 80%, to spill over from fruit bats to gold miners. Yet, wherever a disease originates, it can arrive in the United States by plane within 24 hours.

Further, most wildlife is imported legally into the United States without disease testing or any kind of physical inspection. These animals go on to live in our homes—in our backyards, basements, and bathrooms, kept as exotic pets. Others are displayed in roadside zoos or processed for their parts and products. Some estimates suggest nearly 80% of these imported animals are captured from the wild, with the rest bred overseas in captive breeding facilities. They have brought with them new diseases—mpox (previously known as “monkeypox”), parrot fever, Herpes B, Ebola-Reston and others—infecting both their owners and native wildlife populations.

The United States is also a leading producer of animals, domestically breeding both livestock and captive wildlife in great numbers. While captive-wildlife breeding spans a wide range of species, livestock breeding concentrates on only a handful of species, predominantly chickens, cows, and pigs. Over 10 billion land animals are produced in the United States for human consumption each year, a number that continues to rise, sometimes by as much as 200 million animals per year. Forty-one percent of the land in the United States is dedicated to livestock production—with one-third of the

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32. These types of items are, by far, the most common commercial items for bats coming into the United States and 93% of bats and bat products entering the country are sourced from the wild. These types of practices undermine biodiversity and ecosystem health. Tanya Sanerib and Sarah Uhlemann, “Dealing in Disease: How U.S. Wildlife Imports Fuel Global Pandemic Risks,” Center for Biological Diversity, September 2020, https://www.biologicaldiversity.org/programs/international/pdfs/Dealing-in-Disease_Center-wildlife-imports-report-9-28-20.pdf.
country’s area occupied by livestock, while another 8% of the country is used to grow feed to maintain the livestock. Today, the majority of crops grown in the United States are not fed to humans, but to animals. Producing these crops requires significant amounts of water. Cattle feed production alone accounts for 23% of total U.S. water use, 32% of water use in the Western United States, and 55% in the Colorado River basin, which supplies water to 40 million people across seven states.

Americans eat more meat per capita than any other country in the world and almost twice as much as most—214 lbs per person annually. To supply this tremendous demand, the United States employs an intensive, industrialized system of animal production. Over 98% of U.S.-produced livestock comes from 21,000 highly-concentrated factory farms. A single facility can contain more than five million animals, a headcount greater than the human population of 27 of the 50 states. While this model of animal production limits some aspects of disease risk, it amplifies others. Disease outbreaks at these facilities can happen regularly—and on an immense scale. In 2015, for example, 50 million laying hens were killed to contain the spread of highly pathogenic avian influenza, costing taxpayers one billion dollars. In 2022, a similar strain moved through commercial flocks in the United States, reaching 46 states and resulting in the death of over 57 million birds.
The scale of animal use in the United States is partly a function of cultural values. Dominion over and use of animals, both wild and domestic, is a central tenet of America’s cultural identity as well as the nation’s dominant religions. Underpinning these traditions are the ideological remains of “manifest destiny,” a desire to settle the continent and subdue its inhabitants. For the most part, nature in the United States is not valued intrinsically, but for its ability to meet real and apparent human needs.

The United States prides itself on its capitalist economy, cultural independence, and perceived strength. These values present unique regulatory challenges and, occasionally, obstacles to collective action. While some types of animal use are highly regulated in the United States, most are not.
Animal markets in the United States are managed by a patchwork of regulations at the federal, state, and local levels. Each of the 50 states is free to create its own legislation, so long as the state law does not conflict with federal legislation. States typically can impose regulations that are more, but not less, stringent than federal law. While the federal government’s authority is limited to those powers enumerated and granted by the U.S. Constitution, states enjoy broad power to regulate for the general welfare of their citizens. Where no relevant federal regulations exist or where regulations are inadequately enforced, state and local governments play an outsized role in managing animal markets and zoonotic outbreaks.

There is no single, unified federal or state authority responsible for the prevention, detection, and regulation of zoonotic disease. Rather, regulatory authority is divided among different government agencies, each tasked with overseeing particular types of animals or activities. Often, these distinctions are made along arbitrary lines.

There are some limitations to this principle. For example, “some states operate with what is known as the Dillon rule which says that localities only possess those powers that have been specifically granted to them by the state legislature. In contrast, in home-rule states, local governments have discretion to make a wide range of policy decisions without direction by the state.” Mark Rozell, Clyde Wilcox “What State and Local Governments Do,” in Federalism: A Very Short Introduction (New York: Oxford University Press, 29), 57.
These agencies operate like puzzle pieces from different puzzles. The result is a poorly-interlocking system whereby animals are divided into artificial categories and governed along similarly arbitrary divisions of administrative authority. Troublespots and gaps arise when animals are governed by regulatory categories such as “wildlife” or “livestock” but do not fit neatly into either category. While disease can jump freely from wildlife to livestock to humans and back, the U.S. regulatory system struggles to exercise this same kind of flexibility. And because zoonotic disease touches on many different policy areas—including human health, environmental health, and animal health—it often falls on the fault lines between agencies, resulting in a lack of unified and comprehensive government action.

54. For example, marine fish fall under the Department of Commerce, while freshwater fish fall under the Department of the Interior.

55. For example, the USDA considers fur-bearing animals such as minks to be outside of their purview, while the FWS considers them farmed animals and does not regulate such operations. These blindspots are particularly pronounced around captive wildlife breeding, an industry that enjoys relatively scant regulatory oversight, despite posing some of the most serious risks of zoonotic transmission.
Agencies rarely work closely in concert with one another, and when they do, it is often an uncomfortable marriage. Diverse agency interests, cultures, and mandates act as barriers to collaboration, as do logistical obstacles that make information and data sharing more difficult. The result, too often, is siloing—a lack of coordinated effort and a piecemeal approach to policy making. Budget shortages and understaffing amplify these problems and make it difficult for officials to handle the sheer volume of animals they oversee.

To further complicate matters, animals are regulated differently from one state to the next and differently within states depending on their function. These discrepancies, both with respect to whether activities are regulated and by whom, can result in confusion within and across states, creating opportunities for disease to pass undetected into and through the United States.

**Federal Agencies**

At the federal level, most native free-ranging wildlife, as well as wildlife imports, fall under the jurisdiction of the Department of the Interior’s U.S. Fish and Wildlife Service (FWS) whose mandate is to manage fish, wildlife, and natural habitats. However, the agency’s mission does not include disease control, but instead focuses primarily on enforcing conservation regulations. The FWS import inspectors only physically inspect a fraction of the live animals coming into the United States, approving the rest on paperwork alone. Furthermore, the FWS inspectors have no independent legal authority to test incoming wildlife for disease.

The FWS operates with only 113 inspectors distributed across major international airports, ocean ports, and border crossings, tracking millions of wildlife imports valued at $4.3 billion annually. The port of Los Angeles, which imports and exports more wildlife than any other U.S. port, employed only six FWS inspectors to monitor the port’s seven airports and seaports in 2020.

Also under the Department of Interior is the U.S. Geological Survey (USGS), the Department’s sole scientific arm. The USGS researches wildlife health and carries out disease testing for mass mortality events among wildlife. However, USGS does not have the ability to promulgate regulations.

Unlike other native wildlife, marine fisheries and marine mammals are regulated by the Department of Commerce through the National Oceanic and Atmospheric Administration (NOAA).

56. For example, exotic animals in Texas are treated as livestock for certain regulatory purposes, a classification that enables them to be hunted on captive hunting preserves. Yet, the state simultaneously exempts exotic animals from slaughter regulations typically enforced on livestock.
58. However, the FWS is sometimes tasked with carrying out directives imposed by other agencies such as the USDA or CDC.
NOAA is involved with climate modeling for future zoonotic disease outbreaks and investigates unusual mortality events in marine life.

The U.S. Department of Agriculture’s Animal and Plant Health Inspection Service (USDA APHIS) is the agency responsible for ensuring the health of livestock animals including cattle, poultry, sheep, and swine.62 The USDA enforces legislation related to biosecurity measures, slaughtering protocols, and food safety. The USDA is also responsible for inspecting millions of livestock at the border, as well as meat imports, to prevent foreign animal diseases from entering into the U.S. food system.63 APHIS inspects live animal imports at 15 land ports along the Mexican border, 20 land ports at the Canadian border, and 30 airports across the United States.64 The agency determines the inspection intensity based on the associated disease risk for both the animal type and exporting country, yet diseases can escape detection, especially when only a small percentage of animals are tested.65 Testing also is limited in domestic production.66

The USDA maintains a list of “notifiable diseases” which, if detected by a lab or veterinarian, must be reported to state health officials, who then relay that information to the USDA.67 Significant governmental resources are dedicated to protecting agricultural animals because of their economic value and the potentially devastating consequences of a disease outbreak.

APHIS is also tasked with regulating both wild and domestic animals used in research, entertainment, zoos, commercial breeding facilities, and a collection of other industries under the Animal Welfare Act. However, this legislation exempts most farmed animals, most animals used in research, as well as many other types of animals and animal operations.68

The USDA’s Food Safety Inspection Service (FSIS) oversees the slaughter and processing of livestock, as well as the packaging and sale of most livestock products. About 7,800 FSIS inspectors staff 6,800 federally inspected meat processing plants, which together slaughter more than 9.9 billion animals per year.69 70 71 However, the USDA generally does not regulate livestock animals until this last stage of production. The USDA maintains that it has no authority to regulate the treatment of livestock prior to slaughter, for example.72 73 74 75

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62. The USDA only oversees poultry operations with more than 1000 chickens.
63. While APHIS manages live animal imports, USDA’s Food Safety Inspection Services oversees meat and animal product imports.
66. For example, with respect to Bovine spongiform encephalopathy (i.e. “mad-cow disease”), the USDA notes that, “The goal of our BSE surveillance program... has never been to detect every case of BSE.” “BSE Surveillance Information Center,” USDA, accessed May 31, 2023, https://www.usda.gov/topics/animals/bse-surveillance-information-center.
68. Animal Welfare Act, 7 U.S.C 54 §2131.
72. However, the agency is tasked with enforcing the “Twenty-Eight Hour Law” which requires transporters to offload animals to provide them food and water if being transported by truck for more than twenty-eight consecutive hours.
The Department of Health and Human Services’ Centers for Disease Control and Prevention (CDC) imposes regulations governing select species including dogs, turtles, civets, African rodents, bats, and nonhuman primates. The agency’s focus is on protecting human health, and it can place restrictions, bans, quarantines, or increased permitting requirements for any species considered a public health threat. While the CDC has broad legal authority to prevent infectious diseases from entering or moving within the United States, it regulates animals only sparingly. Each of the CDC’s species-specific regulations was imposed in response to a particular zoonotic disease outbreak for which those animals are known carriers. However, CDC regulations, in covering only a small handful of species, exclude thousands more that carry these same diseases or others. In most cases, the CDC relies on other agencies such as the USDA to enforce its regulations in markets and at ports of entry as it cannot provide enough staff itself to carry out these inspections.

Last, the Department of Homeland Security’s U.S. Customs and Border Protection (CBP) works in coordination with the FWS, the USDA, the CDC, and a range of local agencies to regulate entry and exit of shipments of live animals and animal products at the border. Upon arrival to the United States, CBP holds and refers the shipment to the responsible agency or agencies.

State Agencies

In addition to these federal agencies, each state has its own slate of administrative agencies. Among these are departments of wildlife, departments of agriculture, and departments of public health (though the titles of each may vary from one state to the next).

Free-roaming wildlife is regulated predominately at the state level. State wildlife agencies own, manage, or regulate 464 million acres of land and 167 million acres of lakes, rivers and wetlands. Collectively, these agencies operate on an annual budget of $5.6 billion with approximately 50,000 employees. Their primary function is to oversee and promote hunting and fishing, which constitutes their largest source of revenue through license sales.

76. The CDC notes on their website that the agency regulates cats but a general certificate of health is not required (though some states and airlines do require these health certificates. “Bringing an Animal into the United States,” Centers for Disease Control and Prevention, last modified January 11, 2022, https://www.cdc.gov/importation/bringing-an-animal-into-the-united-states/index.html.
77. Section 361 of the Public Health Service Act, 42 U.S. Code § 264.
78. This authority is given to the Department of Health and Human Services and shared by both the CDC and FDA. 42 U.S. Code § 264.
Due to how these agencies are structured in terms of both funding and agency composition, they tend to favor consumptive uses of wildlife (i.e., those that involve killing the animal) over non-consumptive uses, even though only 3%–4% of the American public engages in hunting.84 85 86

State departments of agriculture promote and regulate ranching and agribusiness within the states. These departments are also tasked with overseeing food safety as well as the movement of animals to and across state lines. While these agencies generally do not address the treatment or handling of livestock animals, they sometimes have broad discretion to regulate animal health and may implement protocols for reducing the spread of infectious disease.87 In addition, they are required to report the detection of certain diseases to the USDA.

By contrast, state and local departments of public health regulate animals in very limited ways. They may impose sanitation guidelines involving whether animals are allowed in restaurants, or specific requirements for rabies vaccinations, for example, as well as laws governing the ownership of dangerous animals.88 However, departments of public health tend to be involved primarily after a zoonotic outbreak has happened, focusing more on response than prevention.

84. Many state agencies require that a majority of state wildlife board seats are held by consumptive users (hunters, fishermen, and trappers), rather than non-consumptive users such as wildlife watchers, scientists, or others. Some states go so far as to prohibit non-consumptive users from serving on the state boards that govern wildlife policy. The result is a “value gap” between those setting wildlife policy and the public at large. Estimates suggest that hunters are over-represented in policy decision-making roles by a factor of 18x (with 75% of commissioners hunting compared to roughly 3-4% of the general public). “2016 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation,” U.S. Fish and Wildlife Service, October 2018, https://www.census.gov/content/dam/Census/library/publications/2018/demo/fhw16-nat.pdf.


SOURCE MARKETS

Animals entering consumer-facing markets in the United States come from a limited but diverse set of sources. Within the United States, animals can be sourced from the wild or from breeding operations that produce wild or domestic animals. Animals sourced internationally are imported both legally and illegally and may be bred in captivity, captured from the wild, or bred as livestock in their native countries. Many of the consumer-facing markets discussed below derive animals from more than one supply source. Similarly, many animals move through multiple markets, as they are used and then reused in different supply chains, coming into contact with other animals and other species along the way. The movement of animals carries with it the movement of pathogens. As such, the course of these journeys carries implications for the spread of zoonotic disease. Across each of these supply chains are human-animal touchpoints, where disease can spillover to humans.

89. A domestic animal is part of a species that has been born or bred for many generations to live alongside humans. Wild animals, regardless of whether they are born in captivity or in their natural habitats, remain genetically wild, even if they are tame enough to tolerate human presence.
Animal Imports

Hundreds of million live animals enter the United States every year, each with the potential to introduce new or existing pathogens to local human, wildlife, and livestock populations.\(^91\) The United States is the number one importer of animals in the world, for both wildlife and livestock.\(^92\)\(^93\)\(^94\) About 224 million live wild animals and 883 million wildlife products worth over $4.3 billion are legally brought into the United States annually, representing roughly 20% of the legal global wildlife market.\(^95\)\(^96\)\(^97\)\(^98\)\(^99\)

90. This graph illustrates the flow of animals from market sources through consumer-facing markets to end uses. This graph does not reflect relative sizes of market flows.


99. Wildlife products can carry bacteria, such as Francisella tularensis which causes Tularemia or Bacillus anthracis, which causes Anthrax and was imported into the United States through contaminated bongo drums made from goatskin. Dead animals or animal parts can also be hosts to many different parasites such as mites, fleas or ticks, spreading other diseases like Lyme disease, typhus, and lice. “Animal Transmitted Diseases,” Washington State Department of Health, accessed June 2, 2023, https://doh.wa.gov/you-and-your-family/illness-and-disease-z/animal-transmitted-diseases/

Four in five of these animals are captured from the wild, while the remaining fifth are sourced from captive breeding facilities overseas. They may bring with them non-native diseases that pose a risk to humans, livestock, and native species.

One of the only resources available to track wildlife imports is the Law Enforcement Management Information System (LEMIS) database managed by the FWS. But since 2014, FWS has withheld much of the data, leaving many Freedom of Information Act requests unfulfilled. As a result, there is incomplete information available about what wild animals are entering the country and where these animals are coming from.

Animals entering the United States move through both legal and illegal channels. Though most wildlife imports are legally declared, there is a significant volume of trade that passes into the country illegally. Some estimates place the magnitude of this illegal trade at over $1.4 billion, just over a third of the size of the legal import market. Wildlife trafficking encompasses a wide range of species from all continents, including exotic birds, sea turtles, coral, caimans, crocodiles, and primates. Between 2007 and 2017, nearly one in three wildlife seizures in the United States was made in El Paso, Texas.

Animals are hidden for illegal import in a variety of ways, including salamanders in plastic bags, tiger cubs in duffel bags, and addax antelope in horse trailers. Smuggling can also be carried out by hiding illegal animals among legal ones, forging permits, misusing real permits, or, on rare occasions, by bribing.
customs and border officials. It is assumed that a significant portion of the illegal trade market into the United States is enabled by the Internet and related cyber technology. Once in the United States, it is common for smuggled wildlife to be shipped via FedEx or U.S. Postal Service to domestic customers.

While the illegal trade smuggles protected species into the country for sale, in many cases the legal trade offers only nominally more oversight. An overwhelming majority of live wild animals are never physically inspected upon entering the country, nor are they quarantined. FWS has no legal authority to check wildlife imports for disease unless mandated to do so by another agency such as the CDC or the USDA.

The widespread lack of disease testing with respect to wildlife entering the country may come as a surprise to many Americans because other public-facing aspects of the process appear to be better controlled. For example, a resident attempting to travel back to the United States with their companion animal may be required to go through veterinary checks and a 30-day quarantine period, while a commercial wholesaler importing hundreds of sugar gliders or other wild animals would not be subject to either process. Similarly, an individual cannot bring meat from abroad back to the United States, but one can import live wild animals from those same countries with very little scrutiny.

On the domestic side, each year the United States imports more than 22 million live farmed animals (including cattle, hogs, sheep, and chicken) and 3.6 billion pounds of meat and chicken. This large volume of imported farmed animals and related products helps feed the large demand for meat in the United States. Further, the United States exports some of the same animals it imports, making disease tracing even more complicated.

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108. Personal interview with retired Ohio police officer and expert on exotic pets and large cats, May 18, 2021.
Disease surveillance of livestock imports is more robust than that of wildlife, in part because of the economic risks posed to domestic producers. The USDA mandates testing for a handful of diseases associated with outbreaks in the past, including foot-and-mouth disease, Newcastle disease, and avian influenza. Such testing, however, is carried out through random sampling of larger populations and generally applied only to livestock and poultry, though other species of imported wildife may carry these same diseases.115 116

Captive Breeding of Wild Animals

Thousands of species of native and non-native wild animals are captively bred in the United States, some of which are high-risk hosts for zoonotic diseases. Estimates suggest these animals number in the tens of millions.117 118 Captivity concentrates animals of the same and different species in densities rarely found in nature, both making them susceptible to a wider range of diseases and, potentially, making them more likely to share these diseases with humans, exposing them at higher “doses.” These captive-bred animals serve a number of commercial uses including food, medicine, and other consumptive uses. They also satisfy demand from zoos and circuses, exotic pet stores, biomedical research institutions, and others. Yet, hundreds of these species fall outside the bounds of regulation as neither livestock nor free-roaming wildlife, exposing gaps in oversight.

Many captive-raised animals, such as mink, foxes, rabbits, guinea pigs, mice, coyotes, and turtles, are housed in large numbers in close confinement, enhancing the likelihood of disease spread.119 Genetic diversity, healthy immune systems, and space between animals, all of which act as a natural buffer to disease outbreaks, are typically lacking in captive breeding operations.120 121 122 This risk is sometimes compounded by interspecies contact as well as close contact with humans.123 While some captive breeders focus exclusively on one species, many raise multiple types of domestic animals and wildlife, creating a mixing ground for interactions among species that would never occur in nature, and along with it, opportunities for the development of new and dangerous pathogens.

Thousands of species of native and non-native wild animals are captively bred in the United States, some of which are high-risk hosts for zoonotic diseases.
Some large wholesale dealers keep tens of thousands of animals together at a single site, often in close confinement and with little veterinary care. A study of one such wholesaler warehouse in Texas documented more than 26,400 animals of 171 species, including 30 invertebrates, 39 amphibians, 78 reptiles, and 24 mammals. Some 80% of the animals were sick, injured, or dead—with average losses of 872 animals per day. These operations, which sometimes both breed animals and import others from abroad, allow pathogens to spread between species, while signs of disease may go unnoticed given the high rates of turnover.

Captive breeding programs also have the potential to introduce disease to native wildlife. For example, a wild mink, living near a Utah fur farm, tested positive for COVID-19, suggesting transmission from captive mink to wildlife, a pathway that could allow the disease to spread uncontrollably through wild populations and risk creating new permanent reservoirs of the disease in nature. The same can be true of transmission from captive wild animals to livestock. Many captive breeding operations also produce other animals—for example, close to 70% of bison farms produce additional livestock such as cattle. Captive wild animals can spread disease to cohabitating livestock, as well as dogs, cats, and other companion animals. Yet, despite these risks, captive breeding operations enjoy scant regulatory oversight.

**Wildlife**

There are close to 3,000 native species of wildlife in the United States, occupying both private and public lands. Among them are 428 species of mammals and 784 bird species ranging from American bison to golden-cheeked warblers. In addition to these 3,000 native species, USGS estimates that there are an additional 6,767 invasive species living across the United States that were brought into the country from elsewhere and released—either accidentally or intentionally—by humans. These

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125. An estimated 3,500 reptiles were discarded weekly (a mortality rate of 72%) along with 2,600 other animals including prairie dogs, sloths, and small rodents, though many of these deaths were not recorded. The study found that the deaths and sickness of the animals were the result of disease and other causes attributable to poor conditions: including cannibalism, crushing, dehydration, emaciation, hypothermic stress, infestation, starvation, overcrowding, stress, and other injuries. The dealer had no disease testing protocols in place before animals were shipped to consumers. Shawn Ashley 1, Susan Brown, Joel Ledford, Janet Martin, et al., “Morbidity and Mortality of Invertebrates, Amphibians, Reptiles, and Mammals at a Major Exotic Companion Animal Wholesaler,” *J Appl Anim Well Sci* 17, No. 4 (2014): 308-21, doi: 10.1080/10888705.2014.918511.


invasive species include ring-necked pheasants, burmese pythons, and feral swine. Many of these animals, which have taken hold in native ecosystems, were brought to the United States in service of the markets discussed in this report and used in hunting, farming, entertainment, or to be kept as pets. The presence of invasive species can undermine ecosystem health, degrading biodiversity, and in the process, allowing new and existing diseases a stronger foothold in the United States.131

Of the 2.27 billion acres of land in the United States, roughly 40% is publicly owned, divided between state and federal lands.132 While federal legislation protects a handful of endangered or threatened species, the vast majority of wildlife regulation occurs at the state level. Wildlife in the United States generally is held under the public trust doctrine, meaning it belongs to the government and the people, rather than private landowners. Hunting on public lands happens under licensing systems at the state level that regulate a number of hunting criteria, often including seasons, species, and quotas as well as what weapons or traps may be used. Private hunting preserves are also licensed by the state and typically charge a fee to hunt on private property.133

**Livestock and Other Domestic Animal Production**

Domestic animal and livestock breeding includes both small breeding operations, such as backyard breeders of birds and dogs, all the way up to large, concentrated animal feeding operations that produce millions of chickens, pigs, and cattle (referred to as “CAFOs”, the acronym for Concentrated Animal Feeding Operations, which are also colloquially called “factory farms”). Roughly 98% of livestock bred in the United States move through large-scale industrialized systems of production.134 135 These operations have become a ubiquitous part of the American landscape and food system.136 137 138 Facilities can stretch more than a mile long and contain millions of animals, some with populations larger than the City of Los Angeles.139

Facilities can stretch more than a mile long and contain millions of animals, some with populations larger than the City of Los Angeles.

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132. Roughly 70% of public land is owned by the states, while the remaining 30% is managed by the federal government. Public lands are concentrated in the Western United States and in particular, Alaska. Carol Hardy Vincent, Laura A. Hanson, and Laura A. Hanson, “Federal Land Ownership: Overview and Data,” Congressional Research Service, last modified February 21, 2020, https://sgp.fas.org/crs/misc/R42346.pdf.


134. CAFOs are regulated under the National Pollutant Discharge Elimination System (NPDES) of the EPA. “Animal Feeding Operations (AFOs),” United States Environmental Protection Agency, last updated February 16, 2023, https://www.epa.gov/npdes/animal-feeding-operations-afos.


There are over 21,000 CAFOs in the United States, with another 450,000 smaller but similar operations.140 141 142 Chickens, pigs, and cattle are the primary species raised in these facilities. In aggregate, American CAFOs produce over 9.4 billion chickens, 125 million pigs, 380 million laying hens, and close to 40 million beef and milking cows each year.143 144 145 146 Tyson Foods, the largest chicken processor in the United States, slaughters an average of 35 million chickens per week, while the Cargill meatpacking plant in Dodge City, Kansas slaughters over 5,800 cows, producing two million pounds of meat per day.147 148 Industrial animal agriculture in the United States is highly concentrated in the hands of a few corporations, who wield enormous financial power. Tyson Foods, Cargill, JBS S.A., and Smithfield Foods collectively control over 80% of cow slaughtering and processing in the United States.149 JBS and Smithfield together control 63% of pig slaughtering and processing, while a similar few companies produce over 60% of American poultry products.150

In addition to industrial animal agriculture, backyard poultry operations have become more popular in the United States in recent decades. These operations range from a couple of birds up to flocks of a thousand, and they often contain a variety of species such as chickens, ducks, geese, peafowl (peacocks), guinea fowl, and turkeys. Some companion animals, such as dogs and cats, are also produced by backyard breeders, while others are raised in facilities that more closely resemble factory farms.151

Livestock operations of all sizes contribute to the nation’s risk of zoonotic outbreaks. While small-scale producers may offer animals better welfare and more space, they often have lower biosecurity and amplify risk by aggregating multiple species at the same location. By contrast, industrial animal agriculture, which focuses on a single species, may have higher biosecurity, but presents a much larger risk in terms of both scale of production and the production practices employed, putting workers and surrounding communities at risk.¹⁵²

The animals themselves are not the only source of disease risk. Safe management and disposal of animal carcasses and animal waste has proved challenging as both processes can spread pathogens. For example, in North Carolina, the state’s 9 million swine produce over 62 million pounds of manure each day and 10 billion gallons of waste each year.¹⁵³ ¹⁵⁴ A single swine facility can produce more sewage than all but a small handful of the largest cities in the United States.¹⁵⁵

CAFOs heighten the risk of zoonotic disease in other ways as well. Overuse of antibiotics, which are fed prophylactically to livestock, drives the development of antibiotic resistant strains of bacteria and renders these same medicines ineffective for treating disease in humans.¹⁵⁶ Roughly 70% of medically important antibiotics used in the United States are fed to livestock.¹⁵⁷ In addition, animal agriculture reduces biodiversity and contributes substantially to climate change, which may serve as a threat multiplier for zoonotic outbreaks.¹⁵⁸ ¹⁵⁹ ¹⁶⁰

¹⁵². Native populations have a long and tragic history with infectious disease, in part as a result of new exposures to livestock. When Europeans traveled to the Americas during colonization, the mixing came with devastating results. Some estimate that more than 70% of indigenous people perished from disease following sustained European contact. One reason why Europeans proved to carry so many more pathogens than native people is because of their extensive history of close contact with livestock. Diseases that had spread through livestock production in Europe were brought to native populations with no such history or immunity against these zoonotic diseases. Simon L. Lewis and Mark A. Maslin, “How Disease and Conquest Carved a New Planetary Landscape,” The Atlantic, August 24, 2018, https://www.theatlantic.com/science/archive/2018/08/human-planet-migration-columbian-exchange/568423/.


¹⁵⁸. There are many reasons for this. For example, as a changing climate alters the landscape and natural systems, many species will become displaced and be forced to live in closer proximity to humans. Climate change drives new interactions, between different species of animals and between humans and animals, that can give rise to new outbreaks of disease. Some estimate that in the coming decades there will be up to 300,000 first encounters between species that normally do not interact, leading to about 15,000 spillover events where viruses enter new species. Ed Yong, “We Created the ‘Pandemicene’” The Atlantic, April 28, 2022, https://www.theatlantic.com/science/archive/2022/04/how-climate-change-impacts-pandemics/629699/.


Significant government resources are dedicated to protecting agricultural animals from zoonotic disease because of their economic value and importance to the food supply. Much of this effort is carried out by the USDA as well as state departments of agriculture. The U.S. livestock industry is regulated primarily at and following the point of slaughter. There is very little regulation of livestock animals before they reach the slaughterhouse including the ways in which producers and livestock interact, leaving open significant opportunities for zoonotic spillover.

CONSUMER MARKETS

In the following discussion, we examine 36 distinct consumer-facing animal markets, each with its own unique risk profile. This section of the report documents a range of U.S. animal markets—articulating the supply chains that support them, the regulation surrounding them, and evaluating the zoonotic risks that each may pose.

Zoonotic risk depends on a host of variables, many of which are difficult to measure. The market’s operations, supply chain, and oversight each shape the level of inherent risk and the level of risk mitigation. We define inherent risks to include those derived from the nature of the activities themselves, derived from factors such as the types of species involved, the number of animals housed together, the level of confinement, the health of the animals, the types of pathogens they may carry, the intensity of human exposure to animals, the length of the supply chains and methods of transport, as well as the scale of the industry in question. Risk mitigation, on the other hand, is determined by the guardrails put in place to prevent disease transmission. It is a function of factors such as preventative biosecurity measures, transparency and traceability of supply chains, as well as the level of regulatory oversight.
These variables and others affect the likelihood, severity, and scale of a potential zoonotic outbreak. For example, the danger of the pathogens that a particular species may carry shapes the zoonotic risks posed by commercializing that animal. Single-strand RNA viruses are often considered to be the most dangerous pathogens because of their so-called pandemic potential, driven by their dangerously high mutation rate. This group includes influenza viruses (such as H1N1 and H5N1), coronaviruses (such as SARS-CoV-1, SARS-CoV-2, and MERS-CoV), retroviruses (such as HIV-1), filoviruses (such as Ebola), paramyxoviruses (such as Nipah virus and measles), and flaviviruses (such as Zika and West Nile). Of these, epidemiologists are perhaps the most concerned about influenzas, which can mutate rapidly and carry fatality rates of up to 60%, though historically the mortality rate of dominant strains has been substantially lower.

### Pathogens of High Priority

<table>
<thead>
<tr>
<th>Primary Animal Carriers</th>
<th>Influenza Viruses</th>
<th>Coronaviruses</th>
<th>Retroviruses</th>
<th>Paramyxoviruses</th>
<th>Flaviviruses</th>
<th>Filoviruses</th>
<th>Lyssaviruses</th>
<th>Salmonella Bacteria</th>
<th>Brucella Bacteria</th>
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<td>Exotic Pet Trade</td>
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</tbody>
</table>


**Risk Factors**

For the Market Risks chart on the next page, we sought to evaluate the level of risk presented by conditions of each market based on research, interviews, and expert opinion. The chart maps 10 primary risk factors onto each of the markets examined in this report, which are organized here by general use categories. Note, however, that this set of risk factors is not exhaustive, nor is assessing risk a precise science. Each of the markets presented here is examined in greater detail in the pages that follow. Below are descriptions of how we evaluated the 10 primary risk factors used in the market risk grids displayed below and throughout the report.

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pathogen Danger</strong></td>
<td>How dangerous are the types of pathogens that might be present in the market given the species of animals they contain? Certain species of animals are known to harbor certain types of pathogens. The danger posed by a pathogen is a reflection of its virulence but also its “pandemic potential,” which reflects how likely the pathogen is to become highly transmissible and spread human-to-human on a large scale. Of greatest concern for pandemic risk are single-strand RNA viruses, such as coronaviruses and influenza viruses, which are infamous for their ability to spread and change rapidly to generate new forms.</td>
</tr>
<tr>
<td><strong>Intensity of Confinement</strong></td>
<td>How closely confined are animals housed in the market? Are they densely packed together with many others? Housing a large number of animals in a small space enables pathogens to transmit more effectively between the animals, while allowing more space between animals does the opposite. Close confinement also creates stress for the animals which can make them more susceptible to disease.</td>
</tr>
<tr>
<td><strong>Animal Health</strong></td>
<td>How healthy and well maintained are animals in the market? Do they receive adequate veterinary care? Animals who have poor health and welfare are more susceptible to disease.</td>
</tr>
<tr>
<td><strong>Mixing of Species</strong></td>
<td>How many species of animals are contained in the market? As different types of animal species interact, it presents additional opportunities for pathogens to spread between species. This can lead to the development of new forms of the pathogen or allow it additional opportunities to spill over into humans.</td>
</tr>
<tr>
<td><strong>Supply Chain</strong></td>
<td>How long is the supply chain that animals move through? What kinds of conditions are maintained during transport? Transporting animals many times across long distances over lengthy periods of time can increase opportunities for disease exposure and transmission, as can aggregating animals from multiple different sources.</td>
</tr>
<tr>
<td><strong>Biosecurity</strong></td>
<td>What measures are taken or not taken to reduce the likelihood of introducing new pathogens or allowing existing pathogens to spread between animals or between humans and animals? Biosecurity measures might include cleaning and sterilizing animal enclosures, wearing personal protective equipment, or quarantining new animals before they are introduced.</td>
</tr>
<tr>
<td><strong>Human Exposure</strong></td>
<td>How frequently and intensely do humans and animals interact in the market? Certain activities, such as slaughtering an animal or hand-feeding an animal, are more likely to expose humans to pathogens than other less intensive interactions, such as watching wildlife from a distance, where there is no direct contact between humans and animals. In addition, the magnitude of human exposure can increase where more humans interact with more animals, such as at an industrial farm that may contain tens of thousands of animals and dozens of workers together at a single site.</td>
</tr>
<tr>
<td><strong>Transparency</strong></td>
<td>Does the industry maintain visibility, transparency, and good records of operations? Is the industry open to the public and regulators? Are they clear and forthcoming about their practices? Greater transparency can provide additional layers of oversight that might reduce the use of dangerous practices and make it easier to trace the origins of a disease outbreak in order to contain its spread.</td>
</tr>
<tr>
<td><strong>Regulatory Oversight</strong></td>
<td>How effectively is the market regulated? Are there regulations in place to mitigate disease risk, and, if so, how well are these regulations enforced? Additional health and safety checks can reduce the danger of zoonotic spillover and better manage disease risk.</td>
</tr>
<tr>
<td><strong>Market Size</strong></td>
<td>How many animals are included in the market? Some markets are relatively small in scale, while others contain billions of animals. Greater numbers of animals (and human-animal interactions) means more opportunities for zoonotic transmission. The number of animals also affects the scale of any potential outbreak.</td>
</tr>
</tbody>
</table>
## Summary of Market Risks

<table>
<thead>
<tr>
<th>Pathogen Chavers</th>
<th>Animal Health</th>
<th>Animal Welfare</th>
<th>Supply Chain</th>
<th>Biocentrality</th>
<th>Human Exposure</th>
<th>Transparency</th>
<th>Regulatory Oversight</th>
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<td>Animals in Research</td>
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The Pet Trade
The pet trade includes a range of markets, each selling animals who are predominantly acquired for the purposes of living in or around the home as pets. Markets within this industry offer a wide variety of animal species, from traditional companion animals such as dogs and cats to exotic pets such as Burmese pythons and tiger cubs. Studies show that the largest proportion of wildlife from high-risk taxa brought into the United States are imported for commercial use, in particular, for the exotic pet trade. We divide the Pet Trade discussion into four consumer-facing markets: the exotic pet trade, pet stores, swap meets, and dog breeders, though in many cases their supply chains intermingle and overlap.

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165. Our estimates for each of the market sizes as illustrated at the beginning of each market group are based upon government agency reports and/or publicly available data from industry associations. Where exact figures were not available, we extrapolated numbers based upon relevant available information, such as, but not limited to, average operation sizes, average number of animals per operation, or average weight of relevant species in the market. Market size charts are not to scale from one market group to the next.


167. For example, a pet store may sell dogs which come from dog breeders or kittens born in a local home, and a swap meet may sell animals imported through the exotic pet trade.
1. Exotic Pet Trade

The United States is a dominant driver of the pet trade globally. Within the United States, the exotic pet trade includes hundreds of species and constitutes a large retail market, estimated to be worth as much as $15 billion annually. Roughly 14% of American households own one or more exotic animals, a category loosely defined to include any pet that is not a traditional companion animal (such as cats, dogs, or horses). These animals include species from lion cubs to monkeys, reptiles to tropical fish, and backyard fowl to exotic birds. Interest in exotic pets accelerated noticeably in the 1990s with the advent of reality TV shows such as Animal Planet’s “The Crocodile Hunter,” as well as popular live shows such as Siegfried and Roy. The exotic pet industry has continued to grow, spurred on by digital demand—in particular the growth of e-commerce sites, social media, and other entertainment platforms, many of which serve not only as a forum to display exotic animals but also as a venue to advertise their sale and connect with potential customers. The American exotic pet trade sources animals legally and illegally from the wild as well as from captive breeding facilities all over the world.

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171. For a closer examination between animal entertainment and demand for exotic pets, see The Conservation Game, directed by Michael Webber (Nightly Entertainment, 2021), https://www.theconservationgame.com/watch/.


176. Globally, the exotic pet trade is the number one driver of trade in live wildlife, with a large percentage of these animals being sourced directly from the wild. Lauren Harrington, et al., “Live Wild Animal Exports to Supply the Exotic Pet Trade: A Case Study from Togo Using Publicly Available Social Media Data,” Conservation Science and Practice 3, No. 7 (July 2021): https://doi.org/10.1111/csp2.430.
The illegal wildlife plays a key role in the sourcing of many types of animals in the exotic pet trade; the annual value of the illegal trade of exotic pets in the United States is estimated at $4.3 billion dollars.\textsuperscript{177} 178 Illegal trafficking operates under the radar but sometimes occurs in plain sight, for example, moving a sedated tiger cub across the border in a duffle bag or selling one in the parking lot of a large department store.\textsuperscript{179} 180 The illegal pet trade is diffuse and difficult to police but involves many of the same individuals who participate in the legal trade.\textsuperscript{181}

On the legal side, breeders—whether larger commercial wholesalers, individual hobbyists, or something in between—supply millions of animals for sale in the United States each year. Some sell directly to consumers through digital sales, auctions, or trade shows, while others sell to pet stores or dealers.

Many commercial wholesalers operate with minimal health standards. For example, a 2014 study examining a large international exotic animal wholesaler in Texas found that 80% of the more than 25,000 animals held at the facility were either injured, sick, or dead from disease and other causes attributable to poor conditions.\textsuperscript{182} These animals, representing more than 170 species including sloths, snakes, prairie dogs, frogs, and exotic rodents, suffered extremely high mortality rates. An estimated 6,100 individual animals died and were discarded each week on average, though many of these deaths were not recorded.\textsuperscript{183} The dealership had no disease testing protocols in place nor did they seek to establish the cause of death when animals died to identify potential disease outbreaks. Quarantine protocols at the dealership were also inconsistent, though many animals were brought in from abroad and captured from the wild while others were shipped out from the facility to dealers and consumers across the country.\textsuperscript{184}

Zoos also can play a role in facilitating the exotic pet trade. When the young animals grow and no longer attract visitors for photo opportunities and the like, they sometimes are sold into the pet trade,
usually at auction or through online sales. Exotic pet auctions take place all over the United States with a large number in Texas and Ohio. At the Mid Ohio Alternative Animal and Bird Sale in Mt. Hope, Ohio, over 100 species are available for sale at what is considered one of the largest exotic animal auctions in the country. At exotic animal auctions, animals from across the region are brought to a single location to be auctioned off to the highest bidder, although, today, many of these events also take place virtually with online bidders. Auctions include a wide range of species: kangaroos, pythons, primates, zebras, bobcats, sloths, turkeys, camels, water buffalo, and others. These animals are often bought to be kept as pets, to be used in captive hunting operations, or to become breeding stock. During and after the auction, animals of many species are confined in small spaces next to one another, stressed and, often, in poor condition. Many major auctions, particularly those dealing in large animals, require health papers for consignments. Other auctions, however, especially those held online, do not require health inspections. Reports of the Mt. Hope Auction indicate that purchasers—even those buying rare and dangerous exotic animals—are not required to provide their name or address, making it extremely difficult for health officials to trace back the origins of a zoonotic outbreak should one occur.

Digitally-enabled captive wildlife transactions are also growing. Consumers acquire exotic pets both legally and illegally through online marketplaces, pet stores, exotic pet auctions, and swap meets. In recent years, because many pet stores, auctions, breeders, and distributors have begun providing online direct-to-consumer channels, animals of all kinds are now visible and available for purchase from anywhere in the country.

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191. Personal interview with retired Ohio police officer and expert on exotic pets and large cats, May 18, 2021.
192. The 2010 documentary The Elephant in the Living Room offers unique footage of the magnitude of species offered at these exotic pet auctions, the bleak conditions these animals are kept in, and their popularity. The Elephant in the Living Room, 2010, Director Michael Webber, http://www.theelephantinthelivingroom.com.
193. Swap meets are places where people buy, sell, or trade animals, usually in an open-air, flea-market-style setting. Swap meets usually exist out of the public and regulatory eye, and can be venues for both legal animal sales and illegal transactions. For more information, see our discussion on Swap Meets.
In many cases, the journey of an exotic animal, such as a lemur or a big cat, can be long and winding, bouncing from a zoo to an auction to a private home and back again. Many of these animals ultimately die of illness or are killed or euthanized, while some end up at sanctuaries or are illegally exported.\textsuperscript{194, 195}

Keeping wild animals as pets creates substantial risk for zoonotic spillover, as 60\%–75\% of recently emerging zoonotic pathogens have come from wildlife.\textsuperscript{196} Wild animals imported to supply the exotic pet trade are often sourced from areas of high biodiversity, which are often also hotspots of emerging infectious diseases. Given that these animals live alongside people as pets, and typically undergo no health screenings prior to entering the country, they present a particularly acute risk of

\textsuperscript{194} The term “big cats” is used to describe any large member of the cat family, species such as lions, tigers, leopards, jaguars, snow leopards, clouded leopards, cheetahs, and cougars.


zoonotic transmission and of introducing foreign zoonoses into the United States.197

The exotic pet trade is problematic from a public health standpoint because it brings high-risk species of wildlife into American homes, paving the way for close human-animal interactions that serve as potential flashpoints for spillover of zoonotic disease. For example, in 2003, an outbreak of mpox, a disease from the same family of virus as smallpox, swept across much of the Midwest and infected 72 people who came in contact with pet prairie dogs.198 199

Some zoonoses carried by pets are relatively common. For example, studies have shown that at least 50%–90% of snakes, turtles, and lizards are carriers of Salmonella; across the United States, these animals are handled and held by individuals, often children, with few sanitary precautions.200 201 202 203 Other diseases are rare but can be quite deadly.

For example, though primates represent a small percentage of the total number of exotic pets in the United States, they pose a unique risk to humans due to the genetic similarity between our species and theirs. Yellow fever, Ebola, dengue, viral hepatitis, and disease caused by poxviruses are all potentially deadly if transmitted from primates to humans.204 In addition, past research has found that 80%–90% of macaque monkeys, one of the most popular primate species kept as pets in the United States, are infected with herpes B—a virus that can result in severe brain damage or death in humans.205 Monkeys have also been shown to transmit bacterial zoonotic diseases to humans including tuberculosis and others.206

Disease risks are often amplified by owners who are unaware of the unique medical, nutritional, behavioral, psychological, physical, and sanitary needs of these exotic animals. Poor husbandry can lead to suboptimal physical health, mental distress, and can create an environment ripe for zoonotic transmission. Furthermore, keeping exotic animals as pets in the home or in close confinement to humans allows for intimate human-animal interactions that facilitate the spread of disease through airborne particles, direct contact with the animal, saliva, blood, or waste, as well as through insects and other vectors. Even petting animals and being licked or cut/scratched by them can transmit deadly diseases such as mpox, hantavirus, hepatitis, tularemia, and salmonellosis.

While the exotic pet trade is vast in scale, it is also largely invisible. Many of the transactions happen online or out of public view, as exotic pet auctions and swap meets typically do not allow cameras. Sales frequently take place without adequate record-keeping. The exotic pet industry has proven highly resistant to regulation and benefits from lack of visibility; exotic pets themselves are kept indoors or out of sight—in attics, backyard sheds, or basements. Yet, the catalog of species and associated diseases involved in the trade is seemingly endless. As a result, law enforcement, doctors, and other first responders are generally unfamiliar and ill-equipped to deal with many of these foreign or uncommon diseases (which may prove particularly difficult to diagnose in patients with no history of travel).

Regulatory oversight of the exotic pet trade in the United States is limited. Most federal regulation is concerned primarily with animals protected by the Endangered Species Act (ESA) or by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), although these species constitute only a small fraction of the animals commonly kept as exotic pets. The Animal Welfare Act requires breeders, wholesalers, dealers, transporters, and sellers of exotic and wild animals to be licensed but only provides limited oversight and does not apply to small operations with fewer than five breeding females, or fewer than nine small exotic pets. Moreover, the AWA’s provisions have little direct impact on disease risk, and the Act exempts broad categories of animals—including reptiles, amphibians, birds, and “pocket pets,” such as ferrets, sugar gliders, hamsters, hedgehogs, mice, rats, prairie dogs, flying squirrels, chinchillas, and others who are capable of carrying zoonotic disease.
Without effective national oversight, states are left to create their own laws to regulate the exotic pet industry. Most states impose laws pertaining to the ownership of certain exotic animals, although their restrictions vary widely. Three states (Alabama, North Carolina, and Wisconsin) still impose no regulation of the private ownership of exotic animals.214 Other states may restrict and ban ownership by species, require licensing, require a certificate of veterinary inspection, or simply require proof of adequate housing.215 216 217 218 219 220 There is wide variation from one state to the next in terms of which animals are regulated and in what ways, creating a patchwork of regulatory oversight. In some cases, the same species may be owned legally in some parts of the country but not others.221 By and large, when regulations do exist, they are primarily concerned with animals deemed to present a physical threat to public safety, for example, big cats and venomous snakes. However, regulators rarely factor disease risk into this calculus, despite the fact that it has the potential to cause far greater harm than claws or fangs.

2. Pet Stores

Pet stores in the United States sell a variety of domestic animals, such as dogs and cats, but also dozens of species of exotic animals including rodents, amphibians, reptiles, fish, birds, and many others. The pet trade is a large industry in the United States—with 67% of U.S. households, or about 85 million families, owning a traditional pet such as a dog or cat, and 18 million households owning one or more exotic pets.222 223 Exotic pets sold in pet stores come from a variety of sources, both foreign and domestic. The type and size of producer also varies widely. For example, bird breeders range from “backyard breeders” or hobbyists with just a few birds to huge wholesale facilities where thousands of exotic birds are bred.

Ninety percent of the puppies sold in pet stores are originally sourced from large scale commercial breeders, sometimes known as puppy mills.224 These animals commonly carry health

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220. Certain loopholes in USDA regulation allows some operators to circumvent state laws. A USDA OIG report found that 70% of exhibitors with four or fewer exotics, in fact, did not qualify as “exhibitors,” but instead obtained the USDA license in order to overcome state and local laws that prevent private ownership of exotic. “Controls Over APHIS Licensing of Animal Exhibitors,” USDA Office of Inspector General, Audit Report 33601-10-Ch, June 2010, https://www.usda.gov/sites/default/files/33601-10-CH.pdf
problems and may have weakened immune systems. For example, in January 2018, the CDC was called in to contain the spread of a string of multidrug-resistant *campylobacter* infections that sickened 118 individuals, including 29 pet store employees across 18 states, and that was spread by diseased pet store puppies.

![Disease Risk Associated with Pet Stores](image)

Very little is known about the animals entering pet stores—physically, medically, or behaviorally. Rarely do pet stores provide customers with information about the source of their animals, the animals' medical history, or other relevant background. Indeed, in many cases, pet stores themselves may lack access to this information. Pet stores may source their animals from a dozen or more different suppliers within the country and abroad, making record keeping more difficult. Because of this, pet stores also act as a potential locus for disease with large numbers of animals coming together in one place, bringing with them whatever pathogens they may have encountered along the supply chain.

Once inside a pet store, animals are usually housed in small enclosures with or close to many other animals of the same species and often in close proximity to other species. These conditions can easily result in disease transmission within and across different animal species. Typically, animals sold in pet stores have not been thoroughly vetted for disease. This is especially true for low-cost animals where providing veterinary care may not make economic sense for the seller.

These risk factors are coupled with close human-animal interactions, involving both pet store employees as well as customers. Customers, and in particular children, often hold and touch animals, frequently interacting with different species throughout a single visit. Visiting pet stores sometimes serves as a form of leisure activity, with families visiting to observe and handle the animals, even without any intention of purchasing a pet. These conditions culminate in a substantial risk of zoonotic spillover, particularly where proper sanitation is not employed. A sick animal in a pet shop can potentially transmit a pathogen to other animals within the shop, and ultimately to a large, broadly dispersed set of visitors. For example, a single rabid kitten for sale at one U.S. pet shop exposed 665 people to the disease, requiring

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all of them to receive prophylactic rabies treatment, costing taxpayers over $1 million dollars.229

The wide catalog of species in pet stores presents a diverse range of disease risks. Exotic animals such as parrots, ferrets, chinchillas, hedgehogs, and turtles can each harbor a unique range of zoonotic pathogens, especially if raised in unsanitary conditions.230,231,232 Parrots, for example, may carry avian influenza as well as psittacosis.233 Reptiles most often carry bacterial pathogens such as Salmonella.234 The CDC estimates that roughly 7% of salmonella cases in the United States are associated with the handling of reptiles and as many as 50%–90% of snakes, turtles, and lizards carry Salmonella.235,236 Frogs and toads are also frequent carriers.237 The high rates of bacterial disease in reptiles and amphibians may be linked to poor care and suboptimal living conditions. Studies have found that poor treatment of these animals and stress may lead to metabolic imbalances, low immunity, and poor hygiene, all of which contribute to the risk of transmission of this and other pathogens.238 In addition, Salmonella outbreaks have originated from shipments of frozen feeder mice, which are sold to feed carnivorous pets, with some shipments infecting customers across 21 states.239 A wide range of other zoonotic diseases has been reported from pet stores including lymphocytic choriomeningitis (transmitted from hamsters), leptospirosis (transmitted from mice), tularemia (transmitted from rabbits), mpxo (transmitted from prairie dogs), and toxocariasis (transmitted from dogs).240,241

Pet stores could play an important role in educating customers about the risk of zoonotic disease, as they are often the initial touchpoint where customers receive information about their new pet. However, in most cases, pet stores do not provide meaningful information related to zoonotic risks, risk mitigation, and proper animal handapnedy.

Further, pet store employees themselves are rarely trained about the risks of zoonotic disease and some are unaware altogether that disease can spread from animals to humans.242,243


241. In 2022 hamsters in a pet store in Hong Kong were found to transmit SARS-CoV-2 to humans. Smriti Mallapaty, “How Sneezing Hamsters Sparked a COVID Outbreak in Hong Kong,” National, February 4, 2022, doi: https://doi.org/10.1038/s41598-022-00322-0.


243. One study based in the United Kingdom found that 36% of pet store employees were not aware that disease can be transmitted from animals to humans. While COVID-19 may have increased awareness among the public of the zoonotic risks posed by handling animals, there are no more recent studies available at the present time. Kate Halsby, Amanda Walsh, Colin Campbell, Kirsty Hewitt, & Dilys Morgan, “Healthy Animals, Healthy People: Zoonosis Risk from Animal Contact in Pet Shops, a Systematic Review of the Literature,” PLoS ONE 9, No. 2: e89309 (February 26, 2014). https://doi.org/10.1371/journal.pone.0089309.
Retail pet shops are exempt from the Animal Welfare Act and remain largely unregulated. As a result, states serve as the primary regulators of retail pet stores, with wide variation in laws from one state to the next. Fewer than half of U.S. states require pet stores to obtain a license. Apart from the initial licensing, there is very little opportunity for inspection. Only 21 states require proper housing and regular cleaning for animals in pet stores. A majority of states, 34, do not require that pet stores provide any veterinary care for their animals.

Very few state laws, if any, aim to address zoonotic disease risk from pet store animals.

3. Swap Meets

Swap meets are large markets, typically outdoors, where a range of animal species both wild and domestic can be bought or sold. In contrast to live animal markets where animals are purchased solely to slaughter and eat, animals at swap meets are usually obtained to be kept as pets, though many animals at swap meets are purchased to be eaten. Swap meets are similar in style to flea markets, with a variety of vendors often each selling many types of animals. The meets are particularly common in the Midwest and South, sometimes taking place in indoor arenas. One of the largest swap meets in the country takes place in Canton, Texas and hosts thousands of sales booths spanning several acres and attracting up to 500,000 shoppers per weekend.

Animals commonly sold at swap meets include domestic animals such as rabbits, geese, ducks, chickens, goats, ponies, pigs, kittens, and puppies as well as a wide range of exotic animals including parrots, snakes, spiders, and hedgehogs. These animals come from both legal and illegal and domestic and international sources. Because of the lack of government oversight, swap meets serve as a preferred outlet for illegally smuggled exotic animals, such as rare tortoises from Asia and parrots from Mexico.

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244. The Animal Welfare Act defines a retail pet store to mean a location where the seller, buyer, and the animal available for sale (for the purpose of being a pet) are physically present. Those who sell animals for pets where the buyer is not physically present must obtain an AWA license and are monitored by the USDA. “Animal Welfare; Retail Pet Stores and Licensing Exemptions,” USDA Animal and Plant Health Inspection Service, 9 CFR Parts 1 and 2 101 (2013): 57227-57250.


247. Five states (California, Maine, Maryland, Washington, and Illinois) and hundreds of cities have moved to ban retail pet store sales of dogs and cats sourced from breeders. These laws were driven in part by concerns about the health of animals sourced from commercial breeding facilities. In addition to these bans, many states employ “puppy lemon laws” to protect consumers’ financial investment when purchasing an animal who is likely to have health issues. However, these laws do not protect consumers from exposure to diseases that their new pet may carry.


Swap meets are also a convenient platform for large scale commercial dog breeders who want to avoid regulation and increase profit margins by selling dogs directly to consumers in informal, often unregulated settings. Animals at swap meets are regularly sold without record. During the 2003 mpox outbreak, for example, CDC agents were unable to track down more than 100 of the infected prairie dogs who had been sold through swap meets, where both buyers and sellers operate largely anonymously and transactions occur with little or no documentation. Investigators ran into similar headwinds during a 2015 multi-state outbreak of salmonella caused by contact with turtles. This outbreak infected 143 people (hospitalizing 32%), including a patient who had purchased turtles illegally at a swap meet in Alabama. Fewer than half of infected patients were able to identify whom they had purchased their animals from, and public health investigators were not able to trace these animals back to their original supplier.

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Anatomy of an Outbreak: Mpox Virus

Gambian rats carrying the mpox virus are shipped from Ghana to US pet traders

Ghana

Import shipment arrives in Texas

Texas

Shipment clears customs with or without being visually inspected by a Fish and Wildlife Service officer

Shipment goes from Texas importer to distributors in 6 states

MN NJ TX IA WI IL

Illinois

Gambian rats are stored alongside 200 prairie dogs at an Illinois distributor

Infected prairie dogs are shipped to 6 states

Infected prairie dogs are sold at swap meets and pet stores

Virus jumps to humans infecting pet owners and sellers

Wir IL KS MO OH IN

Illinois

Virus jumps species to prairie dogs

Virus jumps species to humans

Across the United States

Virus continues to jump species to humans in 6 other states

The CDC is only able to locate 93 of 200 infected prairie dogs. The remaining 107 were sold without record

Scientists fear the virus will spread to native wildlife, establishing a permanent reservoir in the US

A 3 year old child is admitted to the hospital with a high fever, swollen eyes, and skin lesions

26% of infected children are hospitalized as disease spreads
Animals sold at swap meets often are transported and housed in cramped, unsanitary conditions. Each swap meet has its own set of restrictions and regulations set by the meet’s organizer, and as a result, the types of animals sold and the conditions of their care vary greatly among markets. Generally though, conditions are wanting. Animals can be kept outside in extremely warm temperatures with little to no water. Cages are sometimes stacked above and on top of one another during sale and transport such that excrement or other fluids from one cage may leak into another below. The animals themselves are often unvaccinated, and many never have been examined by a veterinarian. Because of these conditions, swap meets present a clear risk not only for spreading disease among animals, but also for transmitting those same diseases to humans. Different species are held in close proximity to one another, creating additional pathways (and potential intermediate hosts) through which a virus may infect humans. This zoonotic risk is exacerbated by the fact that many swap meet attendees touch, hold, or examine animals as a form of entertainment without the intention of buying.

Swap meets are not well documented and operate largely out of sight of the general public. Many swap meet organizers ban photography and video recording. These venues often will remove journalists when identified. This lack of transparency with respect to the general public, as well as a lack of visibility among regulators and law enforcement, make swap meets more dangerous. And while swap meets can function as important centers for trade in rural communities, live animal trade and a lack of regulatory oversight leave them open to disease risk, fostering conditions and practices that are dangerous to both animal and human health. Even where regulations do exist, they are rarely enforced and tend to set only minimal standards of care, with little or no thought to zoonotic risk. Some states have restrictions against selling animals in public places, but these laws do not apply to swap meets, which usually are held on private property.

4. Dog Breeders

Forty percent of U.S. households own a dog. Collectively, in 2022, Americans spent an estimated $56 billion caring for these 77 million pets. Dogs are sourced from both small-scale and large commercial breeders, as well as animal shelters and rescue groups. In addition, the USDA estimates that approximately 1.1 million dogs are imported into the United States each year. The USDA fostered the creation of the dog breeding industry after World War II, though today, public funding is required to manage millions of unwanted animals.

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258. As of June 2021 the CDC issued a temporary suspension of the importation of dogs from 113 countries considered to be high risk for importing dog rabies. These countries include Turkey, China, Brazil, Peru, Jordan, Lebanon, and Saudi Arabia. Though only four cases of rabies have been found in imported dogs since 2016, exemptions to this suspension are limited and are said to be only approved for those bringing in three or fewer dogs.
259. This large-scale commercial breeding of dogs became popular after World War II when the USDA promoted these operations as a form of job creation in reaction to crop failures in the Midwestern United States. Hoping to adopt a more lucrative business model, as outlined by the government, many farmers converted chicken coops and rabbit hutches into housing for puppies whom they would sell to pet stores. “Puppy Mills Then and Now,” Humane Society of the United States, 2012, https://www.humanesociety.org/sites/default/files/docs/report-puppy-mills-then-now.pdf.
In 2019, there were approximately 150,000 dog breeders in the United States producing over 2.4 million puppies annually and generating close to $2 billion in annual revenue. Of these breeders, only 2,400 are licensed and subject to inspection by the USDA. The market is highly decentralized with large commercial breeding operations (commonly referred to as puppy mills) that can house up to 1,000 dogs at one end of the spectrum and small-scale backyard breeders on the other. Backyard breeders generally have no more than five breeding females, though many maintain four or fewer to avoid USDA oversight.

It is estimated that 90% of puppies sold in pet stores are sourced from large-scale commercial breeders or “puppy mills.” These operations also feed online retail sales, which have gained popularity in recent years. Additionally, commercial breeders may offer their unsold dogs at auctions, with the two largest auctions taking place in Missouri. Each of these three value chains supplied by commercial breeders—pet stores, online sales, and auctions—is marked by a lack of transparency as are the facilities themselves. They are generally located in remote warehouses and not accessible to the public, maintaining a very scant digital footprint and public record.

There are about 14,000 animal shelters and rescue groups in the United States to care for and manage stray, unowned, or unwanted animals. Many shelters are publicly funded, though the dog breeding industry fuels much of the shelters’ animal intake. Approximately 25% of the 1.5 million dogs

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**Disease Risk Associated with Dog Breeders**

<table>
<thead>
<tr>
<th>Pathogens Danger</th>
<th>Intensity of Confinement</th>
<th>Animal Health</th>
<th>Making of Species</th>
<th>Supply Chain</th>
<th>Biosecurity</th>
<th>Human Exposure</th>
<th>Transparency</th>
<th>Regulatory Oversight</th>
<th>Market Scale</th>
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<td>Low</td>
<td>Negligible</td>
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<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
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Many of the same qualities that make these facilities frequent targets of criticism by animal welfare groups also make them susceptible to zoonotic disease: poor sanitation, limited air flow, excess waste, overcrowded conditions, poor animal health and welfare, and a lack of veterinary oversight.

entering animal shelters in 2021 were purebred animals, likely bred by breeders. The physical setup of breeding operations creates risk for zoonotic disease transmission along the supply chain. This is perhaps most true in large-scale commercial operations that tend to employ more intense forms of confinement, similar to those used in industrial agriculture. Many of the same qualities that make these facilities frequent targets of criticism by animal welfare groups also make them susceptible to zoonotic disease: poor sanitation, limited air flow, excess waste, overcrowded conditions, poor animal health and welfare, and a lack of veterinary oversight. Recent demand for “designer breeds,” such as goldendoodles, has augmented these concerns by reducing genetic diversity through intensive breeding of specific gene pools. USDA records also suggest that breeders will sometimes carry out veterinary procedures themselves without medical training. These practices can include removing an animal’s tail by twisting, ear cropping with scissors, or “de-barking” a dog by mangling its vocal chords. Some commercial breeding operations may also improperly dispose of dead animals.

However, zoonotic risk is not limited to commercial breeders. Though hobby and backyard breeders often offer better living conditions, their dogs are usually bred and raised in the home or in close proximity to humans as well as other pets, creating additional opportunities for zoonotic transmission.

Pathogens transmissible from dogs to humans include bacteria, such as *Campylobacter*, *Girdia*, *Salmonella* and (less commonly in the United States) viruses such as rabies virus. In addition, imported dogs can also carry canine brucellosis and other vector-borne diseases such as ehrlichiosis, babesiosis, and leishmaniasis. Though many of the above are deadly to dogs, there have been limited human fatalities in the United States resulting from canine zoonotic transmission. The relatively low risk of zoonoses associated with these traditional pets likely stems from their basic biology, prolonged history living with humans, as well as more sophisticated veterinary knowledge and animal care practices.

Most regulation surrounding dog breeders relates to husbandry or licensing standards rather than systems of sale. At the federal level, USDA APHIS enforces the Animal Welfare Act (AWA) and requires licenses for those who breed more than four female dogs or cats for retail sale. However, enforcement of the AWA is lacking. These deficiencies on the part of the USDA stem in part from data reliability issues that make tracking inspections and violations difficult. Often, there is no consistent follow-up to complaints, leading to breeders operating illegally without a license or oversight. A 2021 investigation by USDA’s Office of Inspector General (OIG) found that the USDA has not been able to adequately inspect and enforce AWA standards. And since the USDA removed its animal care policy manual from its website in 2018, breeders no longer have easy access to guidelines and requirements.

Furthermore, the USDA’s reach is limited, as it does not regulate most breeders who sell directly to the public on site. There are a range of state laws governing breeding standards including how old puppies must be before they can be sold. California, Maryland, Maine, Washington, Illinois, and over 400 local municipalities have passed bans on the sale of dogs from breeders through retail pet stores.
Hunting, Fishing, and Trapping
Hunting, fishing, and trapping take place on both public and private lands inside the United States. Most animals involved are native, free-roaming wildlife; however, they can also include captive native wildlife (such as fenced-in antelope or deer) and captive exotics (such as Arabian oryx). Both hunting and fishing can occur across the spectrum of captivity. Some activities such as trapping are executed primarily for commercial reasons while others, such as captive hunting (hunting game in confined areas), are undertaken for recreation or entertainment. Similarly, some animals are consumed and others are killed for trophies. This section includes discussions of hunting and trapping, captive hunting, and commercial and recreational fishing markets.

### Number of Animals in Hunting, Fishing, and Trapping

- **Commercial and Recreational Fishing**: 3.4 billion animals
- **Hunting and Trapping**: 104 million animals
- **Commercial Upland Game Bird Production**: 40 million animals
- **Captive Hunting**: 1 million animals

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**CONSUMER MARKETS | HUNTING, FISHING, AND TRAPPING**
5. Hunting and Trapping

As a whole, the hunting and trapping industry is valued at just under $1 billion. An estimated 3.5% of Americans, 11.5 million people, take part in hunts each year. Of this group, nine out of 10 hunters are male; most are middle- to high-income, and 97% are white. A wide range of species is hunted and trapped in the United States, including bison, elk, rabbits, bears, raccoons, pheasants, groundhogs, coyotes, foxes, snakes, and alligators, with deer and duck hunting being the most popular. Only 16%–35% of hunters hunt primarily for food; the rest do so predominantly for trophies or entertainment. Still, hunters bring home over 815 million pounds of wild venison meat (also known as “game,” “wild meat,” or “bushmeat”) each year and more than a billion pounds of meat in total.

Hunting occurs on both private and public lands. Roughly 40% of U.S. land is publicly owned and managed by the Department of Interior along with the states. Of these areas, roughly three-quarters are open for hunting, including 220 million acres of federal land managed by the Bureau of Land Management. Most Americans, though, choose to hunt on private land. Commercial operations, such as private hunting ranches, offer a more concentrated supply of animals and associated services.

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283. This percentage is less than half of what it was 50 years ago, and this decline is expected to continue. Nathan Rott, “Decline In Hunters Threatens How U.S. Pays For Conservation,” NPR, March 18, 2018, https://www.npr.org/2018/03/20/593001800/decline-in-hunters-threatens-how-u-s-pays-for-conservation.


such as lodging, meals, and guided hunts, which can cost thousands of dollars per day.296

In the United States, most hunters kill animals with guns or bows. Sometimes dogs are also used. Hunters often field dress the animals at the site of the kill, a process that includes removing the animal’s organs, which helps to lighten and cool the carcass in order to preserve the meat and reduce bacterial growth, while also making it easier to transport. However, field dressing, which requires close contact with blood, saliva and other bodily fluids as well as entrails presents significant opportunities for disease exposure. This is particularly true in cases where hunters do not use gloves while handling the carcass, but even when they do, transmission can occur in other ways or through cuts which are common. For example, the CDC identified a previously unknown parapoxvirus in deer hunters from Virginia who nicked their fingers with a knife while field-dressing a white-tailed deer.297 The kinds of intensive pathogen exposures that occur during this process make hunters “more likely to become infected with uncommon zoonotic infectious diseases.”298

Where field dressing is not allowed and the aforementioned commercial operations are not assisting, the hunter must drag the dead animal out through sheer force if it is not possible to drive a motor vehicle to the site. Sometimes this is done with the help of a team, a game cart, or a strap-on winch.299 Many hunters bring the carcass home and butcher the animal themselves into meat-sized portions, providing meat at a relatively low cost. Others employ local butchers to prepare the meat. Private game reserves, which require a fee or membership dues, often supply these services on property or have established partnerships with local butchers and tanners.

The trapping industry consists of individuals who trap animals for their fur, commonly called “pelts.” Trapping spans a wide range of species, including animals such as red squirrels, bobcats, rabbits, mink, raccoons, mountain lions, skunks, otters, beavers, badgers, opossums, coyotes, and red foxes.300 Traps also capture “non-target” species such as moose, eagles, cats, and dogs, as well as endangered animals and, occasionally, humans.301 Trap types vary from snare traps to body gripping traps to steel-jawed leghold traps. While some are designed to kill the animal, others, such as steel-jawed leghold traps, are meant only to restrain them until the trapper returns or the animal succumbs to injury or dehydration.302

This style of trap may present the greatest risk of disease transmission as trappers come into close contact with weak and injured live animals. The number one consumer in the world of leghold traps is the U.S. government.303 State-published leg-hold trapping manuals suggest methods of killing such as beating the animals to death or standing on their chests to suffocate them.304

Wildlife Services, a division of the USDA, has killed roughly 35 million wild animals in the last decade, largely in the name of protecting livestock, crops, and big game.305 This agency operates in relative obscurity, with limited oversight from Congress or the American public.306 Wildlife Services relies on trapping, shooting, poisoning, and the use of explosives to kill the animals such as foxes, owls, black bears, badgers, mountain lions, and raccoons in large numbers.307 308 309 310 311 312

One common tool used by Wildlife Services is the leg-hold trap. These traps are banned in over 80 countries from Norway to China, while the U.S. government remains the largest consumer of leghold traps in the world.312 314 Leg-hold traps are not intended to be lethal but instead clamp onto an animal and hold them alive until the trapper returns or the animal dies of dehydration, starvation, exposure, or blood loss. This mechanism exposes personnel to wounded wild animals and their bodily fluids, which can carry zoonotic pathogens.315 In addition, the indiscriminate nature of trapping means that Wildlife Services frequently captures non-target species. In cases where the non-target animal is still alive, operators may be exposed to risk while releasing injured animals.

Continued on next page.

307. Wildlife Services has also received citations from the EPA for violating laws on the use of pesticides, including some for placing explosive devices that release sodium cyanide, known as M-44s or “cytotoxic bombs,” within 50 feet of walking paths or roadways. The division is reported to use 17 different poisons, including Sodium Cyanide which is used in M-44 spring-propelled cartridges. (Wildlife Serves employs the use of roughly 30,000 M-44s per year.) It is estimated that for every one target animal that is killed, two additional non-target animals are killed. Since 1987, at least 18 employees and several members of the public have been exposed to cyanide from triggered spring loaded traps, while an estimated 1,100 dogs have been killed by M-44s from 2000-2012. Jeremy Tobias, “The Secretive Government Agency Planting ‘Cyanide Bombs’ Across the US,” The Guardian, June 26, 2020, https://www.theguardian.com/environment/2020/jun/26/cyanide-bombs-wildlife-services-idaho.
Disposing of millions of wildlife carcasses a year also poses a significant zoonotic risk. While Agency guidelines require the use of gloves when handling carcasses, they do not require masks or other forms of PPE.236 Several aspects of the disposal process leave open opportunities for disease transmission from wildlife to humans. For example, manuals instruct operators to begin by “lightly touch[ing] the cornea of the animal’s eye” to ensure that it is dead.237 The USDA seems aware of the risks created, providing Wildlife Service employees with a Physician’s Alert Card which “identifies a number of the more significant zoonotic diseases that personnel are likely to encounter.”238

According to agency policy, “furs, animal parts, or edible meat may be donated, salvaged, sold or transferred.”239 Agency directives require that, “attempts should be made to donate edible animals to charitable institutions, public agencies, handicapped or senior citizens, or other needy individuals/groups,” though at the same time noting, “WS personnel are not authorized to certify any edible wild meat as disease free.”240 Except in rare cases, no disease testing is performed on carcasses.

Apart from those used for rendering and human consumption, carcasses are generally disposed of by being “discarded or buried on the property where they were killed or recovered, or deposited on another cooperators’ property.”241 Casual surface burial and other techniques employed can allow pathogens to linger in the environment and potentially seep into groundwater supplies or infect scavenging animals.242 This is of particular concern with respect to prion diseases and others which can persist in the environment for months or years.243 Wildlife Services receives roughly $120 million in federal funding, about twice the total amount allocated to enforcing wildlife laws and regulating wildlife trade.244 245 246 247

Roughly four to seven million animals are killed by trappers in the United States each year—more than in any other country in the world.248 Individual fur trappers usually handle the full production process of trapping, killing, skinning, processing, and selling the animal. Some trappers sell their animal products to garment manufacturers, often overseas in Asia, while some keep the pelts for personal use.

Private trappers can also sell their pelts as well as skulls, various body parts, and full carcasses to larger fur auctions, often sponsored by private commercial dealers, some of which hold auctions across as many as 25 states. Hundreds or thousands of such items are displayed at large in-person


324. In addition, the agency is also paid by private parties who contract with wildlife services to remove wildlife from their land. Because Wildlife Services is not subject to the same laws that govern private citizens, this process allows individuals to circumvent environmental laws. In some cases, the federal government spends millions of dollars to preserve endangered species and, at the same time, gives Wildlife Services license to kill these same animals. Rachel Bale, “This Government Program’s Job Is to Kill Wildlife,” National Geographic, February 12, 2016, https://www.nationalgeographic.com/animals/article/101210-Wildlife-Services-predator-control-livestock-trapping-hunting.


329. The United States, Canada, and Russia are the three largest nations in terms of trapping. However, the precise number of animals taken through trapping each year is not known as no official estimates exist. Unlike Canada, which publishes government data on trapping, the U.S. federal government and many states do not require trappers to report how many animals they kill. Such data deficiencies make regulating the practice all the more difficult and threaten conservation efforts. “Trapping and Penning,” Animal Welfare Institute, accessed May 23, 2022, https://awionline.org/content/trapping-and-penning.
auctions, such as the Western States Fur Auction, in Livingston Montana, where purchasers can peruse piles of animal parts and pelts laid out on tables. Online fur auctions serve as another outlet for sales. Using an online platform, bidders and sellers can purchase and prepare for sale any pelts or carcasses of animals such as foxes, mountain lions, bears, beavers, martins, bobcats, muskrats, otters and coyotes. However, most of the zoonotic risk associated with the trapping industry lies earlier on in the supply chain when animals are killed, cleaned, and skinned, before being shipped through the mail or delivered to auction. 

Pathogens can be contracted from live or recently deceased animals. Both hunting and trapping require direct human contact with wild animals who were recently killed or injured. This contact can include direct exposure to bodily fluids such as blood, cerebrospinal fluid, and saliva. There are a number of discrete potential animal-human touch points along the hunting and trapping process, such as being bitten or scratched by an animal caught in a trap or handling fresh carcasses, each of which creates manifold opportunities for zoonotic transmission. These risks may be augmented by the timing of hunting seasons, which often occur during seasonal migrations, a time when healthy animals may come into contact with weak or diseased animals.

In addition, hunters sometimes install wildlife feeders to attract and concentrate animals in artificially high numbers, further creating the conditions that can facilitate disease spread between animals.

Studies have shown that many hunters are uninformed about zoonotic risks and take few precautions to mitigate them. For example, only 16% of duck hunters wear gloves when handling and defeathering dead birds. Yet, wild aquatic birds, the natural reservoirs for avian influenza, have transmitted low pathogenic strains of virus to hunters. If more deadly high pathogenic strains of the virus were introduced in North America, the risk for human exposure to the virus through hunting could be substantial.

Dozens of other zoonoses are present in hunted species throughout the United States including rabies viral disease,
Tuberculosis, for example, is present in certain populations of white-tail deer and elk in the North Central United States, while brucellosis is found in elk and bison in the greater Yellowstone area of Montana, Wyoming, and Idaho. More recently, the USDA found evidence of SARS-CoV-2 in free-roaming white-tailed deer and mink. Further research found 30% of captive and wild deer tested in Iowa in 2020 to carry SARS-CoV-2, with some groups showing infection rates of over 80%.

Another concern is Chronic Wasting Disease (CWD), a prion disease similar to mad cow disease that is 100% fatal in animals and cannot be removed by cooking. Though CWD has not been found in humans, there is some evidence suggesting that it could be transmissible or become transmissible in the future. Studies have shown CWD can infect non-human primates who eat meat from CWD-infected animals, raising concerns that there could be risks to hunters from consuming or handling CWD-infected animals. Furthermore, deer infected with CWD do not always show any visible symptoms of disease. Because of this risk, the CDC recommends testing in areas where CWD is present before consuming the meat. As of 2020, the FDA and the USDA consider meat from CWD-positive animals to be unsuitable for human or animal consumption. Though there is no federal testing system in place, some states such as Colorado have moved to fill this gap.

The USDA found evidence of SARS-CoV-2 in free-roaming white-tailed deer and mink.

352 Another growing activity in the United States is “shed hunting” or the collection of antlers, shed annually by adult male elk, moose, and deer. Velvet antlers, as they are called during their soft growth period, later ossify and the animals use trees to scrape off their velvet coating. Shed hunters collect found antlers left behind by animals, but they also sometimes harvest the antlers, or connected antlers and skull plates, from dead animals (or live ones in captive breeding facilities). In the process, they may be exposed to blood or other cerebrospinal fluids that can carry pathogens like CWD. (This is of particular concern when interacting with the animal’s brain and skull.) Shed hunts are particularly popular in Wyoming where antler pairs are known to sell as high as $1,500 and dead mounts (parts of a dead animal assembled in a natural position giving them a life-like appearance), many times more. In addition to supporting domestic demand, the United States now exports nearly three million dollars’ worth of antler products, primarily to Asia. Abe Streep, “The Great American Antler Boom” The New Yorker, March 7, 2022, https://www.newyorker.com/magazine/2022/03/14/the-great-american-antler-boom.
**WINTER ELK FEEDING PROGRAMS**

Five states have implemented state-sponsored winter feeding programs to increase elk populations for hunting and limit elk grazing on land used for livestock production. Wyoming alone spends roughly $2 million annually to feed some 22,000 elk across 22 feeding stations in the western part of the state where much of the species’ historical range has been supplanted by cattle ranching. Elk at these feeding grounds are tightly packed together with up to 5,000 animals per acre in some cases. While many pathogens do not cause disease in humans, artificially aggregating wildlife in densities not found in nature allows pathogens opportunities to move rapidly through a host population with the potential to acquire beneficial mutations and generate more dangerous forms along the way. After finding that the presence of brucellosis antibodies was 13 times higher in feedground elk than elk that did not frequent the feedgrounds, the Wyoming Game and Fish Department’s report concluded, “These data support the contention that feedgrounds increase the probability of disease transmission.”

State policymakers nevertheless continue the practice despite warnings that feedgrounds might rapidly spread new disease like CWD, which has the potential to decimate wildlife populations as it may remain infectious and bioavailable in the environment for more than two years. CWD was detected for the first time in feedground elk in Wyoming in 2020.

Apart from federally protected species, hunting and trapping are regulated entirely at the state level. State departments of wildlife oversee 630 million acres of public lands and establish rules for hunting and fishing. Roughly 50,000 people are employed by state wildlife agencies, compared to just 8,000 federal employees at FWS.

**INDIGENOUS PRACTICES**

Hunting and trapping is an important part of many indigenous practices in the United States, making these individuals particularly susceptible to zoonoses present in native wildlife. Tens of thousands of Indigenous Alaskans, for example, rely heavily on a diet of wild animals, such as caribou, seals, and fish. Animals are also used for shelter, fuel, clothing, tools, and transportation as well as handicrafts made from their parts. The Endangered Species Act and the Marine Mammal Protection Act generally exempt Indigenous Alaskan subsistence hunting from their prohibitions. Tribes have worked, sometimes unsuccessfully, with federal, state, and local governments to preserve habitat and prevent overhunting and overfishing. Under existing treaties, Native Americans generally possess exclusive rights to hunt and fish across the 55 million acres of Federal Indian trust land and treaty-reserved areas.


361. Alaska Statute §16.05.940.


363. Exemptions extend to animals used for handicrafts and other purposes apart from food. Handicrafts made under these exemptions may be sold, so long as they are substantially altered. However, these exemptions have been exploited on occasion. In 2007, for example, a member of the Aleut community pled guilty to selling seal penises commercially for use in traditional Asian medicine. “Alaskan Man Pleads Guilty to Sale of Seal Penises,” Alaska Statute §16.05.940.


Each state department of wildlife is overseen by commissions (or boards) that set agency policy. However, many states reserve a number of seats—often a majority of seats—on these commissions for consumptive users (hunters, trappers, and fishermen), while other states go so far as to prohibit any non-consumptive user from serving on the commission. For example, Mississippi law states, “All of the Commissioners shall be an active outdoorsman holding a resident hunting or fishing license in at least five (5) of the ten (10) years preceding appointment.” Estimates suggest that roughly 75% of commission seats nationwide are held by consumptive users, though hunters, for example, make up just 3%–4% of Americans. Among the general public, non-consumptive activities such as wildlife watching are far more popular. However, without representation on state wildlife boards, these perspectives are marginalized and rarely reflected in policy-making, resulting in a value gap between the public and regulators. Because of the success of ballot measures, which have historically carried broad public support, limiting certain types of hunting and hunting methods, some states have moved to further insulate the industry from public opinion by adding additional procedural hurdles that either stop ballot measures from taking effect or to prevent hunting and trapping from being regulated through public initiatives altogether.

State wildlife agencies are funded in part by tax revenue from the sale of hunting equipment. They also both issue and are funded by the sale of hunting licenses, which in some states account for 60% of their annual budget. Unlike other administrative agencies, such as departments of public health, this structure ensures that regulators are financially dependent on those whom they regulate. In some states, wildlife agencies receive no general funding, meaning they are almost wholly reliant on the “sale” of wildlife. The result is something more akin to a traditional private-sector business model whereby state agencies, responsible for issuing the licenses, spend time and money marketing to recruit new hunters and provide industry supporting programs, such as training, game

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367. These boards often control budget, rule-making, and leadership decisions as well. They range in size from four to nineteen members, typically appointed by the governor.
368. Consumptive uses are those in which the animal is killed. By contrast, non-consumptive uses, such as wildlife watching, are those wildlife related activities that do not involve lethal measures. Bruce Rocheleau, Wildlife Politics, New York: Cambridge University Press, 2017.
farming, and state-sponsored bounties on carnivores. Because of this structure, states have little incentive to impose sanitary or public health related regulations on hunters that may negatively affect license sales.

There is some evidence that these incentives trickle down to color scientific recommendations as well. For example, scientists working for state wildlife agencies were three times more likely to recommend removing protections for grizzly bears than independent scientists employed at universities. The study’s authors noted that, “Scientists who work for governmental agencies can face strong ‘top down’ pressure from within their organizations... to reach particular decisions.” These forces culminate in a regulatory system that is strongly predisposed in favor of consumptive wildlife activities, while doing relatively little to support non-game species. This approach can undermine ecosystem health and biodiversity, which heightens the risk of zoonotic disease.

States require hunters and trappers to obtain licenses to hunt on public or private land. However, there are broad exceptions to this rule. Various other restrictions apply that dictate when, where, and how wildlife can be killed.

STATE-SPONSORED BOUNTY PROGRAMS

State-sponsored bounty programs exist across much of the country in order to secure additional funding for state wildlife agencies. Predator reduction leads to overpopulation of prey species which, in turn, drives the sale of more hunting licenses and increased bag limits. However, these programs also incentivize direct contact with dead or injured animals through the hunting and trapping process. In order to collect the financial reward, hunters must kill and transport some portion of the carcass to redeem for payment—a scalp, or foot, or tail. This process sometimes requires contact with blood and entrails of species types that are high-risk carriers of zoonotic disease and may also lead to improper disposal of the remainder of the carcass. Recent bounty programs include Idaho’s wolf bounty that paid $1,000 per dead animal or Utah’s program that paid $50 per coyote scalp; in a single year, the Utah program paid out more than $500,000 for 11,000 coyotes. South Dakota compensates hunters for killing a wide range of species that may prey on the eggs of waterfowl in order to increase bird populations for hunting. Here, hunters can be compensated for killing raccoons, striped skunks, badgers, opossums, and red foxes. In the last two years of this program, 4,300 people participated and killed 81,000 animals, many of them rabies vector species.
how, and how many animals may be killed. Most states require hunting education courses; these courses focus on firearm safety and other principles, but say little about disease risks. Vanishingly few state regulations governing hunting are grounded in public health. For example, states do not impose sanitary requirements on hunters, such as requiring the use of gloves, other personal protective equipment (PPE), or hand washing when handling dead animals, and do not typically regulate the disposal of carcasses.

Trapping is noticeably less regulated than hunting. Only 21 states require licensees to complete trapper education courses, and even fewer regulate how trappers kill live animals caught in their traps. Fewer than half of the states set quotas for trappers, and just 13 states require trappers to report the number of animals they harvest. As a result, no sound data exists as to the number of animals processed through this industry and little is known about the zoonotic risk these interactions carry.

6. Captive Hunting

Captive hunting, sometimes colloquially known as “canned hunting,” is a form of a commercial hunting operation that takes place on fenced private lands in the United States where animals are hunted for a fee. Unlike traditional hunting, captive hunting facilities (sometimes also called “hunting preserves”) guarantee success while eschewing principles of “fair chase.” Captive hunting may involve native species such as white-tailed deer and elk as well as non-native exotics spanning over 130 different species such as antelope, zebra, oryx, wildebeests, and buffalo.

No sound data exists as to the number of animals processed through this industry and little is known about the zoonotic risk these interactions carry.
Most animals on captive hunting reservations are bred on-site or purchased directly from exotic animal breeders (sometimes known as “game ranches”) while others are obtained through exotic animal auctions. Zoos, disposing of surplus animals, can also serve as a source. Likewise, unwanted animals from the exotic pet trade are sometimes used to stock these hunting facilities. A small set of animals is imported for this purpose as well, further complicating the supply chain. It is estimated that there are over 1,000 exotic hunting operations in the United States, with most of these located in Texas, where some four million acres are devoted to exotic animal ranches and reserves. Hunts happen both during the day and at night. Sometimes animals are shot on foot but also from roaming SUVs, ATVs, or hunting towers equipped with pool tables, poker, and alcohol as well as with motion sensors to alert patrons to the presence of an animal.

Captive hunting operations allow for the mixing of a wide range of species from different continents that would never encounter one another in nature. This interspecies contact may offer pathogens additional opportunities to spread among species and provide them new pathways to reach humans. Other conditions of captive hunting facilities also lend themselves to zoonotic transmission. For example, animals are artificially concentrated in large numbers, with both native and non-native species confined in fenced areas sharing the same feeding stations and water sources. Veterinary care is provided infrequently. The lack of biosecurity among different species of captive wildlife, between free-roaming wild animals and captive ones, and between hunters and the animals they kill each increase the risk of disease transmission.

Captive hunting presents zoonotic risks at a variety of animal-human touch points along the supply chain. White-tailed deer, one of the most common species on captive hunting operations, are often bred or artificially inseminated in pens at captive breeding facilities where both CWD and SARS-CoV-2 have been found. Animals are handled during the transport process as they are moved from a breeding facility to hunting ranch; sometimes they are sedated before being loaded onto a cattle trailer. Once on the hunting grounds, some animals become tame enough for people to hand feed or pet.

Pathways for Pathogen Transmission on a Captive Hunting Facility

Feed and water stations concentrate animals and enable disease spread

Permeable boundaries allow for disease spread to and from native wildlife

Pathogens spread as the hunters interact with the carcass in the field and as it is processed for trophies and human consumption

Captive markets | Hunting, Fishing, and Trapping

Animal Markets and Zoonotic Disease in the United States
Certain species, such as camels and giraffes, for example, are sometimes used by facilities for entertainment or as mascots, rather than for killing.\textsuperscript{399} Animals are typically shot with either a gun or a bow and arrow; the latter presents additional risks, as animals more often die of exsanguination (loss of blood) allowing for increased risk of disease transmission.\textsuperscript{400} And after the kill, the patron or ranch operators will field dress the animal (removing internal organs at the kill site) and transfer the carcass to a butcher or taxidermist. Many animals are processed for human consumption. In some cases, this processing may happen at local butcher shops alongside other domestic species, using the same equipment. Each of these steps in production presents opportunities for the spread of pathogens through direct contact or indirect contact, causing diseases such as tuberculosis, brucellosis, sarcoptic mange, papillomavirus, and CWD.\textsuperscript{401,402}

\textbf{TAXIDERMISTS}

Taxidermy is a surprisingly large industry in the United States that operates mostly outside of the public eye. There are over 3,200 taxidermy businesses generating roughly $700 million in annual revenue.\textsuperscript{403} Taxidermists provide a service for hire for hunters looking to turn their kills into trophies. Some taxidermists also source animals to create their own mounts for sale, sometimes from pet stores, breeders, zoos, online sellers, wildlife rehabilitation centers, veterinary offices, or as roadkill. The first step in traditional taxidermy is removing the skin from the animal, so that it can be salted and preserved. In some cases, the remainder of the animal is then discarded in favor of an artificial mold. In other cases, particularly with birds, the skull and body cavities are emptied out to be filled with clay or wire framing.\textsuperscript{404} It is not uncommon for taxidermists to accidentally cut themselves during either process. The nature of these interactions—whether they are carried out by the taxidermist or in preparation for taxidermy by the hunter in the field—carries risk in terms of the potential for disease transfer.\textsuperscript{405} Some, but not all of this risk, can be mitigated by freezing the carcass. Roughly half of states require taxidermists to obtain a license.\textsuperscript{406} Licenses often cost as little as $6 and do not require training.\textsuperscript{407,408}

\textsuperscript{402} Though CWD has not been shown to infect people, its management is still a top concern in conservation medicine today.
\textsuperscript{405} A taxidermist and his wife were among those infected when a new strain of SARS-CoV-2 apparently jumped from mink to humans on Michigan fur farms. There is also the possibility that the virus spilled over into other nearby animal species. It is not clear whether the individual obtained the virus from community spread through human populations or from interacting with dead wildlife, such as deer, who had been infected with the disease. However, this individual had no known connection to the fur farms where the outbreak first occurred. Emily Anthes, “The Michigan Mink Mystery: How Did an Interspecies Outbreak Unfold?” The New York Times, May 22, 2022, https://www.nytimes.com/2022/05/22/health/coronavirus-mink-michigan-spillover.html.
\textsuperscript{407} Some states, including Montana and Texas, require taxidermists to keep a record of the animals they accept for mounting. However, not all taxidermists keep accurate or complete records. Some on occasion will falsify records in order to handle illegally poached animals. Stephen L. Eliason, “Trophy Poaching: A Routine Activities Perspective,” Deviant Behavior 33, No. 1, (2012): 72-87, DOI: 10.1080/01639652.2010.548289.
No federal law meaningfully regulates the captive hunting industry. States are left to regulate as much or as little as they choose. Many states, in particular those states with high numbers of captive hunting operations, allow them to operate with minimal oversight and impose few regulations. Where regulations do exist, even fewer are grounded in public health. Some states like Texas, which is home to a majority of the nation’s captive hunting operations, incentivize the practice by providing subsidies or tax benefits for the industry. In Texas, wildlife stocked for private hunting are classified by the state as “livestock,” which shields them from regulations that might otherwise apply to wildlife. At the same time, they are not subject to public health regulations that govern traditional livestock production, despite the fact that some of these animals are processed for human consumption and may pose a greater risk of zoonotic disease than domestic livestock. This regulatory scheme allows captive hunting facilities to operate in a twilight zone as neither livestock nor wildlife, in some cases, escaping regulation altogether.

7. Commercial Upland Game Bird Production

There are over 40 million birds produced at over 3,000 commercial upland game bird facilities each year in the United States. In total, they comprise an industry valued at $1.6 billion.

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409. The Animal Welfare Act does not apply to game preserves, hunting preserves, and captive hunts. Some of the species on these ranches like the scimitar-horned oryx are threatened, endangered, or even extinct in the wild in the countries where they are or were native. But many species of exotic hoofstock on captive hunting ranches can be hunted legally because most are not in the list of Endangered Species, which focuses primarily on the protection of U.S. native species. For those species that are listed under the Endangered Species Act, the Fish and Wildlife Service allows ranches to hunt and kill certain animals that are federally designated as threatened or endangered species if the hunting preserves take certain steps. For example, one captive hunting preserve received an exception by donating 10 percent of its hunting proceeds to conservation programs. Manny Fernandez, “Blood and Beauty on a Texas Exotic-Game Ranch,” The New York Times, Oct 19, 2017, https://www.nytimes.com/2017/10/19/us/exotic-hunting-texas-ranch.html.

410. The problem of classification is complicated—Is the activity “hunting” if the animals are captive bred and owned? On the other hand, is it “agriculture” if the animals are killed for entertainment?


412. This regulatory scheme allows captive hunting facilities to operate in a twilight zone as neither livestock nor wildlife, in some cases, escaping regulation altogether.


Ninety percent of birds produced in these facilities are sold for hunting on public or private land or for gun-dog training, where they are released, shot, and recovered by hunting dogs. Some are also sold to live bird markets where consumers select animals for slaughter onsite and consumption. Others are processed onsite at production facilities for sale as food to restaurants or supermarkets or kept as breeders in pens for the next year’s production cycle. In most of these supply chains, the animals are ultimately consumed by people.

Birds produced at upland commercial game facilities include a mix of both native and non-native species of wildlife, most commonly the Pharaoh Coturnix Quail, the Bobwhite Quail, the Chukar Partridge, the Ring-necked Pheasant, and the Northern Mallard Duck. Other more ornamental breeds such as the Hungarian Partridge are also becoming increasingly popular. Almost all commercial upland game bird production facilities are single-location operations and are either partially or fully vertically integrated where birds are bred, hatched, brooded, and grown to maturity at the same facility. The breeding and sales cycle is cyclical: chick hatching, in indoor cages similar to those used in conventional poultry operations, happens from mid-March to mid-August. The birds are then transferred outside in late summer to lower-density, large netted pens to grow and adapt to living outside. Birds are sold for live release from autumn to winter to match the optimal hunting months of different regions around the country. Though the largest facilities produce up to 300,000 game birds each year, the size of farms vary greatly with most holding under 1,000 birds at any one time.
Some portion of game birds raised at these commercial upland game bird facilities are sold to public entities, and specifically to states that wish to release them on public hunting grounds and sell permits to hunters to kill them. This practice is especially common in states like New Jersey and Connecticut, for example, which wish to create and maintain hunting markets for birds such as Ring-necked pheasants, who are neither native nor adapted species in the area, unable to survive naturally in the wild. Connecticut purchases over 20,000 pheasants a year from commercial breeding facilities for release, transporting the animals to state-owned hunting grounds and setting them free from cages just a few days before hunting season begins to minimize losses from predation. In Connecticut, an estimated 50%–60% of the birds which are released are killed by hunters each year. Some states, like Montana, instead elect to reimburse land owners for raising and releasing pheasants to increase the population for hunting.

Other states have taken direct control of the process. The state of Wisconsin maintains its own state-run pheasant farms, which it uses to stock public lands at the start of hunting season. Pennsylvania too operates four game farms and distributes about 200,000 ring-necked pheasants annually.

Many of the 40 million commercial upland game birds produced through this industry are consumed without undergoing the health or safety checks required of other meat production. Hunters are free to eat the animals they kill, and states do not require health screening of animals bred and sold for this purpose. So while regulations require that a Bobwhite quail, sold by a game bird producer to a live animal food market, undergo health and safety checks before the animal can be eaten by customers, that same quail, if sold to a hunting preserve, could be released, shot, and eaten, and no regulations would apply.

Zoonotic risk is present at game bird farms wherever producers and animals interact. Producers collect eggs, sort and move chicks by hand, and handle birds regularly from the time they are embryos to the moment they are

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426. The economics of this practice may be profitable for the state. For example, in Connecticut, it costs the state approximately $14 per bird to buy, and licenses to hunt these birds are $47. Bag limits in the state are two per day and 10 per season. Robert Miller, “From the Game Birds We Pay to Bring to CT to the Turkeys That Roam the State,” CTInsider, October 30, 2021, https://www.ctinsider.com/columnist/article/Robert-Miller-From-the-game-birds-we-pay-to-16572899.php.


432. New Jersey, which had long farmed its own pheasants, has recently moved to purchasing animals from private producers; however, state employees still sow seeds each spring to ensure that pheasants have adequate food and plant cover in the fall when they are released for hunting. “Pheasant and Quail Stocking,” NJ Fish and Wildlife, last updated January 12, 2023, https://dep.nj.gov/nfw/hunting/stocking/.
corralled and boxed for sale or release. Producers who slaughter and process birds onsite usually do so manually with a knife. Animals also die in the breeding process, and producers walk the pens frequently to collect and remove dead birds. When an animal becomes sick or injured, other birds will often attack it and sometimes consume it. Cannibalism has the potential to accelerate disease spread within captive game bird populations and remains an ongoing problem for producers.

Most often, production occurs in remote rural locations away from human settlement, which makes them more insulated but also requires that birds be transported long distances to customers of up to 1,000 miles increasing the opportunity for disease spread during transport. These rural locations allow significant crossover with native wildlife. Concerns regarding avian influenza and other wild-borne diseases are especially acute during the middle and later stages of production when the birds are kept outside, where they may come into contact with wild birds or their saliva or droppings, as well as small carnivores and rodents. The seasonal migrations of wild birds that occur each fall amplify this risk and expose captive flocks to any diseases these wild birds may carry, in particular where captive operations are situated in close proximity to water and wetlands that attract migratory waterfowl.

Production facilities are susceptible to pathogens spread by wild birds but also have the potential to introduce disease to wild populations both during the production process, and later, when the birds are ultimately released.

There are, however, certain structural protections present in commercial upland game production operations that help mitigate the risk of disease spread. Because they are usually single sites and personnel, equipment, and vehicles are not shared between farms, there is less risk of disease transfer between two or more producers. Customers often source birds from a single production facility; however, there is typically no regular quarantine process for the hunting ranches and other operations that receive birds, which increases the risk of introducing disease.

Though the market for game birds is much smaller both in terms of overall volume and production scale than conventional poultry, it has proven to be a potential flashpoint for the spread of avian influenza—one that could serve as a conduit to introduce influenza strains circulating in wild birds to humans or to poultry. Between 1980 and 2017, there were 23 documented avian influenza outbreaks at commercial upland game bird facilities. Of these 23 outbreaks, more than 90% occurred during the


436. Many producers hand-fit blinders or hoods on the birds to reduce the impact of these behaviors, which are more common among birds held in close confinement. Ralph A. Ernst, Allen E. Woodard, Pran Vohra, and Carol Cardona, “Raising Game Birds,” University of California Division of Agriculture and Natural Resources, Publication 8155, 2007, https://anrcatalog.ucanr.edu/pdf/8155.pdf.


mature bird production stage in the summer and fall when the birds are outside and exposed to native wildlife. Studies have documented other risk factors as well. For example, 70% of avian influenza outbreaks occurred at upland game bird production facilities that either had connections to live bird markets or raised ducks on site.

More recently, in 2022, avian influenza again spread to commercial upland game farms across the United States. Since H5N1 avian flu was first documented in North America in 2022, 16 commercial upland game farms from New York to Texas to Idaho have reported outbreaks of the virus. These outbreaks predictably follow the movements of wild birds. In October 2022, for example, as wild birds migrated south through the Central Flyway, highly pathogenic avian influenza infected a production facility in Nebraska that contained 159,000 game birds, all of whom were culled after the disease was found.

In most states, game bird production is governed by the state’s Department of Fish and Game, which establishes and enforces rules and regulations for the management of wildlife. In part because these agencies often both support and are supported by the hunting industry, regulation is typically loose and producer-friendly, especially with respect to native species and certain established exotic species. As a result, outside of a license, which can usually be obtained simply by showing proof of land ownership, payment of a fee, and agreement to self-report production volumes, commercial upland game producers remain largely unregulated in most states. Apart from this production license, producers are usually not subjected to additional oversight, nor are many of the birds they sell, in particular, those animals sold for hunting and later consumed. Birds produced on commercial upland game farms, while not otherwise regulated by the USDA, are nonetheless compensated by the Agency in the event of a disease outbreak, such as H5N1. At the same time, these animals are not subject to USDA


449. Game birds are not covered by the Poultry Products Inspection Act. The USDA does offer voluntary inspections on a pay-for-service basis. “What animals are inspected by the United States Department of Agriculture?” AskUSDA, March 24, 2023, https://ask.usda.gov/w/article/What-animals-are-inspected-by-USDA.

regulations that govern most traditional poultry or livestock processing. The Poultry Product Inspections Act (PPIA) requires inspection for ducks and geese processed for slaughter for human consumption, but does not overseer other wild game species or wild game that are sold initially for non-consumption uses such as live release and hunting dog training, but that are ultimately consumed by people.  

### 8. Commercial and recreational fishing

Both commercial and recreational fishing are large industries in the United States. Commercial fishing, which generally refers to the fishing and harvesting of wild fish and shellfish, is a $9.7 billion disaggregated market with over 65,000 commercial fishing operators. Although commercial fishing is quite a large industry in the United States, with over 9.7 billion pounds caught each year, the country imports over 80% of the fish consumed domestically. Recreational fishing, by contrast, is undertaken on an individual scale either as a leisure activity or for food. It is the nation’s second most popular outdoor activity after jogging, with nearly 1 in 7 Americans fishing at least once a year. In 2018, these recreational fishermen caught an estimated 956 million fish, with 64% released back into the water.

### Disease Risk Associated with Commercial and Recreational Fishing

<table>
<thead>
<tr>
<th>Pathogen Danger</th>
<th>Intensity of Contact</th>
<th>Animal Health</th>
<th>Mixing of Species</th>
<th>Supply Chain</th>
<th>Biosecurity</th>
<th>Human Exposure</th>
<th>Transparency</th>
<th>Regulatory Oversight</th>
<th>Market Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Negligible</td>
<td></td>
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</table>

Commercial and recreational fishing in the United States is regulated at both the federal and state level. At the federal level, the FDA is responsible for ensuring that the country’s fish supply is safe, sanitary, and properly labeled. The National Marine Fisheries Service (NMFS), which sits under the Department of Commerce, regulates commercial and recreational marine fisheries while FWS regulates freshwater fishing. FWS also oversees the National Fish Hatchery System, which is a network of 70 hatcheries that breed fish for release in lakes and rivers across the United States to buttress wild populations declining from habitat loss and overfishing. State agencies also carry out stocking

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456. “Seafood,” US Food and Drug Administration, last updated April 17, 2023, [https://www.fda.gov/food/resources-you-food/seafood](https://www.fda.gov/food/resources-you-food/seafood).


458. The Magnuson–Stevens Fishery Conservation and Management Act of 1976 is the primary law governing fishing activities and it seeks to avoid overfishing to increase long-term economic and social benefits. Other relevant laws include the American Fisheries Act, the Aquaculture Act (which promotes and supports aquaculture) and the Lacey Act (which responds to illegal trade of fish). “Rules and Regulations,” National Oceanic and Atmospheric Administration, accessed May 31, 2023, [https://www.fisheries.noaa.gov/rules-and-regulations#fisheries](https://www.fisheries.noaa.gov/rules-and-regulations#fisheries).
operations. In total, an estimated 3.6 billion hatchery-raised fish are released in the United States annually—almost ten for every American citizen.\(^{459,460}\) State and local governments generally regulate most fishing activities through permits, tags, or licenses.

Though aquatic species generally pose a lower risk of zoonoses than terrestrial animals, the handling, killing, gutting or processing of fish, as well as the use of smaller fish for bait, creates opportunities for disease transmission.\(^{461}\) Most zoonoses carried by fish are bacterial pathogens including *Salmonella*, *Mycobacterium*, *Erysipelothrix*, *Campylobacter*, *Aeromonas*, *Vibrio*, *Edwardsiella*, *Escherichia*, *Klebsiella*, and *Streptococcus iniae*.\(^{462}\) While disease transmission can occur through contact with live or dead fish, humans most commonly acquire fish-borne parasitic zoonoses through the consumption of infected raw, undercooked, or inadequately preserved fish.\(^{463,464,465}\)

In the United States, from 1973 to 2006, approximately 180 outbreaks from seafood caused more than 4,000 illnesses, 160 hospitalizations, and 11 deaths.\(^{466}\)

\(^{459}\) Releasing hatchery-raised fish or eggs into wild waters can sometimes risk spreading disease to native wildlife or undermining ecosystem balance. For example, one study found that stocking efforts in the Pacific Northwest led to disease spread that increased amphibian embryo mortality by 15%. M. Anders Halverson, “Stocking Trends: A Quantitative Review of Governmental Fish Stocking in the United States, 1931 to 2004,” *Fisheries Magazine* 33, No. 2 (February 2008): 69-75, https://doi.org/10.1577/f1548-8446-33.2.69.


Large-Scale Production for Food and Fiber
This category includes animal production industries that raise millions of animals a year through formalized systems of production for food, fur, and other uses. Industrial animal agriculture, by far the biggest of all animal markets, produces over 10 billion animals a year in the United States. Also contained in this section are the related markets of livestock auctions and live animal food markets. Large-scale production of non-traditional livestock and of wildlife is also discussed, including big game farming, fur farming, and aquaculture.

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9. Big Game Farming

Big game farming in the United States typically takes place on large private ranches where captive wild animals are raised primarily for meat, as well as for other by-products, breeding stock, hunting, or aesthetic value. The United States has seen growing demand for ungulate meat, which is sometimes perceived as healthier or more natural. Species commonly farmed on these ranches include deer, elk, deer, bison, and yaks. The total direct economic impact of deer, elk and other cervid farming is estimated at over $890 million.468 Major markets for bison, elk, and other big game meat producers often include wholesalers, restaurants, custom meat shops, and direct to consumers through mail-order or on-farm sales.469 Animals are selectively bred for consumptive use and kept in pens on feed and forage until they reach their desired market weights. Typically, they are provided some amount of veterinary care but disease remains a primary concern.470 The USDA reports that 61% of deaths among captive bison herds are the result of poor health or disease.471

In part because big game species are not domesticated, transport presents additional stress for the animals and difficulty for producers.472 Slaughter is often carried out at smaller facilities that may process fewer than a hundred animals a day. The Humane Methods of Slaughter Act does not apply to big game species.473 These animals are often killed by gunshot without stunning. The meat is often custom cut, vacuum packed, frozen, and shipped according to the buyer’s specifications.474 475 Some of these farms also produce by-products such as hides or leather. One of the more sought-after by-products is elk antlers, which are sold for decoration, as dog toys, or for medicinal purposes.

### Disease Risk Associated with Big Game Fishing

<table>
<thead>
<tr>
<th>Disease Risk</th>
<th>Animal Health</th>
<th>Animal Welfare</th>
<th>Biosecurity</th>
<th>Human Exposure</th>
<th>Transparency</th>
<th>Regulatory Oversight</th>
<th>Market Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pathogen Risk</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Intensity of Containment</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Animal Health</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Mating of Species</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Supply Chain</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Biosecurity</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Human Exposure</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Transparency</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
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<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Regulatory Oversight</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Market Scale</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
</tbody>
</table>

469. Others provide animals for captive hunting operations.
In some cases, newly sprouted antlers are cut off of sedated immobilized elk, a process that can expose human handlers to contact with blood from velvet antlers.\textsuperscript{476, 477, 478}

Tuberculosis and brucellosis are two significant zoonoses found in farm-raised bison, deer, and elk. But, due in part to a 2015 federal eradication program in cattle and captive deer, these diseases are fairly uncommon in the United States.\textsuperscript{479} More recently (as noted above) farmed deer have been found to carry SARS-CoV-2. Researchers found that 30\% of captive and wild deer tested in Iowa in 2020 carried SARS-CoV-2, with one herd having infection rates over 80\%.\textsuperscript{480} USDA research in early 2020 showed that although deer did not show symptoms, they can transmit the disease.\textsuperscript{481} At the time of this writing, deer appear to be spreading the disease back to humans.\textsuperscript{482}

Big game farming also has the potential to spread disease to free-roaming wildlife or domestic livestock as well as to humans who interact with the animals along the supply chain. Enclosures are highly permeable, allowing for fence-line transmission of disease between captive animals and native wildlife.\textsuperscript{483} The dominant disease of concern in this respect is CWD, which has been reported in 29 states and is considered endemic in some, including Colorado, Wyoming, and Nebraska.\textsuperscript{484} In certain areas, roughly 10\% of free-roaming deer carry the disease.\textsuperscript{485} However, in captive ranches, the incidence can be significantly higher. The CDC reports that, on some big game ranches, 79\% of deer tested positive for CWD.\textsuperscript{486}

Though CWD has not presently been shown to infect people, its management is a top priority in conservation medicine today, and there is some concern that CWD could infect humans, as studies have shown the disease is transmissible to other primates.\textsuperscript{487, 488} As a result, there may be risk to people who consume meat from a CWD-infected animal, particularly because cooking does not destroy the prion that causes CWD.\textsuperscript{489}


\textsuperscript{481} Escape can also occur, particularly in the case of deer and other animals known to jump fences.

\textsuperscript{482} “Chronic Wasting Disease: Occurrence,” Centers for Disease Control and Prevention, last updated April 17, 2023, https://www.cdc.gov/prions/cwd/occurrence.html.


\textsuperscript{484} “Chronic Wasting Disease: Occurrence,” Centers for Disease Control and Prevention, last updated April 17, 2023, https://www.cdc.gov/prions/cwd/occurrence.html.


\textsuperscript{487} In laboratory settings, CWD has been shown to infect species of non-human primates who were fed meat from CWD-infected animals. It may also have potential to change forms to become more transmissible. Osterholm, Michael et al. “Chronic Wasting Disease in Cervids: Implications for Prion Transmission To Humans and Other Animals,” mBio, Vol. 10, Issue 4, https://doi.org/10.1128/mBio.01091-19.

Except for the regulations regarding interstate transport of animals, there is no federal oversight of big game farming. While the USDA regulates slaughter of “amenable species”—defined as cattle, sheep, swine, goats, equines, and domesticated birds—under the Federal Meat Inspection Act and the Poultry Products Inspection Act, big game species fall outside this regulation. At the federal level, inspection of non-amenable species, such as deer, elk, bison, rabbits, quail, and others, is performed only on a voluntary basis through the USDA.  

In order to sell the meat commercially for consumption, however, producers must process animals in a facility that is either USDA approved or licensed under a parallel state inspection system. The ratio of each varies by species, but with respect to bison, for example, roughly 85% of those commercially processed were slaughtered in federally approved facilities in 2016 (with the remaining amount slaughtered in state inspected facilities), as doing so allowed their meat to be sold interstate without navigating a patchwork state accreditation system. Still, some game farmers have found other ways to reduce regulation or circumvent inspection laws, such as allowing customers to butcher the animal themselves. 

Regulatory authority for big game farming is assigned differently in different states, such that a species may be considered wildlife in one state and domestic livestock in another. As a result, regulation of a particular species varies drastically from one state to the next, as does enforcement. Some states require big game farms to be permitted and inspected, while others do not. There is also no cohesive system of health certificates, import permits, and testing requirements for moving animals from one state to another. In recent years, however, due to the threat of CWD, there has been a proliferation of laws regulating interstate transport of deer and other cervids. Over half of states now participate in the USDA’s voluntary CWD herd certification program. The USDA has also authorized indemnification payments to compensate producers for culling of diseased herds.

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491. Unlike the slaughter of amenable species, voluntary inspections are paid for by the producer rather than taxpayers. FSIS inspectors perform ante-mortem visual inspections of herds, as well as post-mortem visual inspections of the animal and its entrails. However, many diseases cannot be diagnosed by looking at an animal’s physical appearance alone. 9 C.F.R. § 352.


493. Many states do not offer their own state licensing system and instead rely on the federal system.


499. 9 C.F.R. § 55.
10. Fur Farming

Fur farming in the United States includes the practice of selecting, breeding, and raising fur-bearing mammals, such as mink, fox, rabbit, coyote, chinchilla, and raccoon, for their skins, known as “pelts.” Minks and foxes are two of the most common species on fur farms, with minks greatly outnumbering foxes. There are approximately 275 mink operations in 23 states which, in aggregate, produce about 3 million pelts annually, at a value of more than $300 million. Some of these pelts are sold together in large lots at auctions to domestic buyers or internationally, through in-person or online sales.

Species on fur farms, especially minks and foxes, have been selectively bred over many generations for a range of desired characteristics, including color, size, quality of fur, and growth rate. The living conditions on farms can cause poor welfare and stress. Mink, who are usually housed in small wire cages averaging 1’x1’x3’, are themselves more than a foot long and have little room to move around. These cages are placed in deep rows, where the animals live side by side. Feces and urine fall through the wire mesh, preventing their fur from being dirtied, but causing further stress to the animals, who have a sensitive sense of smell and difficulty moving on an unstable wire floor. Runoff from manure leaks poses a threat to soil and water quality, which, in turn, can negatively impact nearby farmed and wild animals.

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502. These farmed species are in addition to a range of species that are trapped from the wild, for example, bobcats, coyotes, beavers, lynx, sables, raccoons, foxes, mink, mountain lions, otters, and weasels.
504. It should be noted that rising concerns in the United States over animal welfare in these fur farms have led to a decreased demand for fur products year-over-year since 2016. It is expected that the outbreak of COVID-19 in U.S. fur farms in 2020 will cause the industry decline to continue though prices may rise with reduced stock. “Mink,” United States Department of Agriculture, Economics, Statistics and Market Information System, last updated July 18, 2022, https://usda.library.cornell.edu/concern/publications/2227mp65f.
As a result of their living conditions, fur-farmed animals can develop behavioral disorders and suffer compromised immune systems, making them more susceptible to disease. Fur farms kill and process animals on site, using gas, blunt force trauma, or electrocution. After the pelts are removed by skinning, the carcasses are sometimes processed for oil or fertilizer. Disposal of carcasses can present secondary disease risks. In responding to outbreaks of COVID-19 among farm-raised mink, public health officials noted, “After we went onto these farms and saw what they considered to be composting, which really were just piled-up mink, we made the decision... to just have these buried at landfills,” in order to limit the likelihood of the virus spreading further.

The threat of disease spread is high in fur farms where animals with low levels of genetic diversity are held in high densities and in poor conditions with no regulatory oversight. Biosecurity on fur farms is limited—often they are open-air and processors may or may not wear gloves or other PPE when interacting with live animals or carcasses. Disease risk is amplified too by the types of species involved. Most animals raised for fur are small carnivores, who present higher disease risk than other orders of mammals and may pose a greater risk of transferring zoonoses to humans.

Cognitively complex and communicative, mink are known to escape regularly, allowing pathogens to be transmitted to native wildlife, including other mink, and potentially allowing viruses to establish a permanent natural reservoir in these wild populations. Documented disease outbreaks in U.S. fur farms have included influenza, toxoplasmosis, canine distemper, Aleutian mink disease parvovirus (ADV), and COVID-19. In total, 18 mink farms across four states experienced outbreaks of COVID-19. The CDC waited several months after confirming that mink may have spread COVID-19 to farmworkers in Michigan before releasing this information publicly.

In total, 18 mink farms across four states experienced outbreaks of COVID-19.
Countries like Denmark moved quickly to contain COVID-19 outbreaks on fur farms, culling 17 million mink to prevent the virus’s spread, while the United States chose not to require cullings.\footnote{“Denmark to Cull Up to 17 Million Mink Amid Coronavirus Fears,” BBC News, November 5, 2020, https://www.bbc.com/news/world-europe-54818615.} Of the 250 escaped minks that the USDA and CDC captured around one Utah farm, one-third were infected with SARS-CoV-2.\footnote{Sonia Shah, “Animals That Infect Humans Are Scary. It’s Worse When We Infect Them Back,” The New York Times, January 19, 2022, https://www.nytimes.com/2022/01/19/magazine/spillback-animal-disease.html.} Some of these minks are thought to have contracted COVID-19 after being exposed by infected workers, a process called reverse zoonosis, whereby disease passes from humans to other animals.\footnote{Prior to this, SARS-CoV-2 infection has not been documented in any other intensively farmed species, suggesting that mustelids may exhibit a higher susceptibility to the virus. Mustelids are fur-bearing carnivores that inhabit terrestrial and aquatic regions throughout the world, except Australia, Antarctica, and most oceanic islands. Examples include badgers, otters, ferrets and martens. Costanza Mane, Rania Gollakner, and Ilaria Capua, “Could Mustelids Spur COVID-19 Into a Panzootic?” Veterinaria italiana 56, (2020): doi: 10.12834/VetIt.2375.13627.1.} Mink are also one of the only known species to have passed COVID-19 back to humans. This cycle of a virus spilling over from humans to animals and then back again risks creating new and more dangerous forms of existing human pathogens.

There is no federal regulation that governs the treatment, health, housing conditions, or slaughter of animals raised on fur farms.\footnote{Regulations instead focus on labeling practices and other forms of consumer protection.} The AWA exempts domesticated fur-bearing animals as “farm animals,” leaving fur farms outside of the purview and inspection of the USDA APHIS.\footnote{They are also exempt from the Human Methods of Slaughter Act as non-amenable species. Other federal laws that may be tangentially implicated include the ESA, the Lacey Act, and the Humane Methods of Slaughter Act (“HMSA”). However, most species that are bred for fur farming are not endangered, and both the HMSA and the AWA exempt fur-farmed animals, leaving them effectively unregulated.} Fur farms are not licensed by federal wildlife authorities, either. As a result, fur farms fall into a regulatory void. In many states, neither agricultural nor wildlife agencies regulate fur farms at all. A handful require operators to obtain a license, but in others, public health authorities may not know how many fur farms exist in a state or where they are located, leading to delayed response times and significant exposure when a disease outbreak occurs. When COVID-19 spread through mink farms in Wisconsin, the Wisconsin State Veterinarian had to ask an industry trade group, the Fur Commission USA, how to reach the farmers and how many there were.\footnote{In a letter published in the Lancet, virologists studying the zoonotic threat posed by fur farms and their risk of mink farming creating new natural reservoirs of disease by spreading viruses to native wildlife noted, “[T]here is currently no global overview of the location of such farms, and no mandatory surveillance programme. In view of our observations, that is urgently needed.” Marion Koopmans, “SARS-CoV-2 and the Human-Animal Interface: Outbreaks on Mink Farms,” The Lancet Infectious Diseases 21, No. 1 (January 2020): 18-19, https://doi.org/10.1016/S1473-3099(20)30592-9.}

Because of carve-outs in federal legislation and minimal state regulation, fur farms are largely self-regulated. Fur Commission USA, the largest industry trade association, offers voluntary guidelines for producers seeking its certification label.
However, its recommendations carry no force of law.\textsuperscript{527} As a result, although the fur farming industry presents a significant zoonotic disease threat, combining high-risk species and high-risk practices, it remains almost entirely unregulated.\textsuperscript{528,529} Finally, because fur-bearing animals are not considered livestock, producers are not eligible for indemnity payments from the USDA if their animals are culled because of a disease outbreak.\textsuperscript{530} As a result, producers have little incentive to report disease outbreaks for fear of financial losses.

### 11. Industrial Animal Agriculture

Livestock carry many pathogens that are transmissible to humans. Research suggests that eight of the 10 mammalian species who share the highest number of viruses with humans are domestic species including pigs, cattle, sheep, and goats.\textsuperscript{531} The largest concentrations of these animals are found in food production.

#### Disease Risk Associated with Industrial Animal Agriculture

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Intensity of Confinement</th>
<th>Animal Health</th>
<th>Mixing of Species</th>
<th>Supply Chain</th>
<th>Biodiversity</th>
<th>Human Exposure</th>
<th>Transparency</th>
<th>Regulatory Oversight</th>
<th>Market Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Negligible</td>
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</table>

In the United States, chickens, cows, and pigs are the dominant forms of livestock. Small independent farms have all but given way to large, consolidated production facilities. Ninety-eight percent of livestock in the United States live on large-scale facilities known as CAFOs (“concentrated animal feeding operations”), colloquially called “factory farms.”\textsuperscript{532,533} CAFOs are officially defined by the USDA as operations that house more than 2,500 swine, 1,000 head of beef cattle (raised for meat), 700 dairy cows (raised for milk), 125,000 broiler chickens (raised for meat), or 82,000 laying hens or pullets (raised for eggs).\textsuperscript{534,535}


\textsuperscript{528} A U.S. House bill was introduced in July 2021 to ban the farming of mink in the United States in an effort to control disease spread; however, the bill was not enacted. “Minks are Superspreaders Act,” H.R. 4310, 117th Congress, 2021-2022, https://www.congress.gov/bill/117th-congress/house-bill/4310/text?r=1&s=1.


\textsuperscript{530} Casey Barton Behravesh (Captain, U.S. Public Health Service; Director, One Health Office), email message to Janet Blair and Leah Gilbert, October 8, 2020, https://www.documentcloud.org/documents/21562819-cdc_foia_pg_1893-1901suicide-prevention?responsive=1&title=1.


\textsuperscript{532} CAFOs are regulated under the National Pollutant Discharge Elimination System (NPDES) of the EPA. “Animal Feeding Operations (AFOs),” United States Environmental Protection Agency, accessed May 31, 2023, https://www.epa.gov/nodes/animal-feeding-operations-afos.


\textsuperscript{535} To avoid increased regulation, some operations deliberately stay just under these number thresholds.
LIVESTOCK SUBSIDIES

CAFOs are heavily subsidized by taxpayer funding. Each year the United States spends an estimated $38 billion to subsidize meat and dairy producers. In addition, the USDA overspends $557 million in “checkoff funding” spent on advertising campaigns to promote the consumption of meat and dairy, compared to just $51 million spent to promote fruits and vegetables. As subsidies have increased, consumer prices have fallen to artificial lows. For example, when adjusting to account for inflation, a pound of chicken cost $6.89 in 1950 but less than $2.00/lb in 2022. Some studies estimate the true cost passed on to taxpayers of each fast food burger, which retails for $4.49 on average, is between $2.90 – $7.00. Still, major meat conglomerates are the primary beneficiaries of these subsidies. The current industry model implemented by the major processors—including Tyson, JBS, and Cargill—puts the majority of the risk on contract farmers, while taking steps to insulate themselves from risk in the event of a disease outbreak or poor yield.

536. Farm subsidies date back to the 1920s when price disparities and price volatility after World War I led to extreme hardships in the agricultural economy. Subsidies have continued and grown ever since despite stabilization in pricing.


543. In the contract farming model, the chicken farmer will bear responsibility for the capital cost of the facility, yet the poultry themselves are provided and owned by the corporate producers who also oversee transport of the animals. The farmer is paid by quality of output. If a flock dies or does not reach premium weights, the farmer does not get compensated at the rate expected. With a weak flock, a farmer often struggles to pay off the mortgage on the facility. Under such a system, in the event of a disease outbreak, producers tend to blame the contract farmers/growers, who assume virtually all of the risk under this model.
The Environmental Protection Agency (EPA) estimates that there are over 19,000 CAFOs in the United States, with more than 430,000 similar but smaller operations known as AFOs (“animal feeding operations”). In aggregate, CAFOs in the United States produce over 9.4 billion chickens, 200 million turkeys, 125 million pigs, 380 million laying hens, and over 34 million beef and milking cows annually. Industrial meat markets are vertically integrated and highly consolidated. The four largest producers control 82% of the U.S. beef market, 66% of the U.S. pork market, and 54% of chicken processing. Industrial animal agriculture facilities are spread across the country, but found most

Number of Animals Slaughtered Annually at USDA-Licensed Facilities

- 9,429,687,000
- 125,314,000
- 379,000,000
- 34,690,900

The Environmental Protection Agency (EPA) estimates that there are over 19,000 CAFOs in the United States, with more than 430,000 similar but smaller operations known as AFOs (“animal feeding operations”). Industrial animal agriculture facilities are spread across the country, but found most


often in rural and low income areas, leading to inequitable health and environmental burdens for these communities.\textsuperscript{555} Intensive animal production poses large-scale threats to public health, despite some of the strictest biosecurity measures of any animal industry.\textsuperscript{556} Access to these facilities is tightly controlled. However, sealing them off and keeping animals entirely indoors can reduce the frequency but increase the magnitude of disease outbreaks.

In CAFOs, hundreds of thousands or millions of animals can be held together in intense confinement with limited air flow, making these facilities ripe for pathogen transmission among animals as well as between animals and workers. Systems of production vary by use and by species. Pigs and chickens are kept entirely indoors in long enclosed warehouses. Beef cows begin their life on pasture before being transported to feedlots where they are housed outside in large numbers until they reach their slaughter weight of 1,100 lbs.\textsuperscript{557} Dairy cows are kept under a different system and held predominantly indoors, where they go through cycles of artificial insemination, pregnancy, calf removal, and milking.\textsuperscript{558}

\begin{quote}
\textbf{FOIE GRAS}

\textit{While in the United States, foie gras production usually happens on a smaller scale than many other forms of intensive farming, operations may house tens of thousands of animals. Hudson Valley Foie Gras, one of the largest producers, produces 7,000 ducks per week, with each employee responsible for force-feeding roughly 500 birds per day.}\textsuperscript{559} Foie gras is typically produced through the process of force-feeding male ducks or geese a high-fat diet to enlarge their liver (up to ten times the normal size) and increase the fat content of their liver. During the force-feeding process, known as gavage, producers hold open the animal’s mouth, and hold their head still while they insert a metal or plastic tube down the animal’s throat through which they deliver a large amount of corn. Mortality rates are high, as many animals die from ruptured organs during the gavage process. This process takes place twice or three times a day for a period of two to three weeks before the animals are slaughtered.

Foie gras production allows for significant disease exposure given the intensity of the physical contact between the animals and producers during the force-feeding and the likelihood that producers may come into contact with saliva or other fluids. Because ducks are potential reservoirs for avian influenza, the close interaction is particularly concerning; elsewhere, in France, foie gras production facilities have documented outbreaks of avian influenza.\textsuperscript{560}
\end{quote}

The American livestock production system strives to deliver meat that is both uniform and inexpensive. Industrial producers seek to maximize efficiency in every aspect of production, such that animals cycle through facilities as quickly as possible and are slaughtered as soon as they reach

\begin{itemize}
\item 556. This is more true of some species than others and varies by stage of production. For example, feedlots present far greater opportunities for contact with wildlife than an indoor poultry facility.
\item 557. The cow-calf industry focuses on earlier-maturing cattle, while the feeding industry’s goal is to produce cattle at ever-increasing weights. The vast majority—97%—of cattle are fattened, or “finished,” with com-based diets at feedlots that are concentrated in the Great Plains but are also located in parts of the Corn Belt, Southwest, and Pacific Northwest. Troy Marshall, “Cow-Calf vs. Feedlot,” Beef, August 26, 2011, https://www.beefmagazine.com/business/troy-marshall/0826-cowcalf-feedlot.
\end{itemize}
sufficient size. This cycle takes about two months for chickens, six months for pigs, and 20 months for cattle.\textsuperscript{561}

This pursuit of efficiency often means raising as many animals as possible in as little space as possible. Poultry barns often stretch 600 feet in length and house animals at high densities.\textsuperscript{562} A single broiler chicken facility may hold more than five million birds, roughly the same human population as Colorado and more than most U.S. states. At the same time, an egg-laying hen in a so-called battery cage, for example, is allocated only a nine-by-nine inch square of floorspace, an area smaller than a sheet of paper.\textsuperscript{563} Rapid breeding and growth necessitate the use of large amounts of resources. A single sow may give birth to 36 piglets a year, each of which is later fed six to 10 pounds of corn and soybeans per day.\textsuperscript{564} CAFOs increase their efficiency by purpose-breeding animals and eliminating those which are not desired or productive, macerating 200-300 million male chicks born into the egg industry each year.\textsuperscript{565} CAFOs also produce roughly 500 million tons of sewage a year, which is often held in open tubs known as “manure lagoons” or spread, untreated, on crop land.\textsuperscript{566} A single hog facility can produce more sewage per year than the city of Philadelphia.\textsuperscript{567}

As the size and stocking density of animal production facilities increase, so too does the likelihood of a potential outbreak.\textsuperscript{568} The vast scale of these operations and density of animals make them extremely conducive to disease transmission between animals, as does the lack of airflow.

\textsuperscript{565} Using or disposing of this many animals safely can create environmental and public health challenges. Many are fed into other industries such as pet food production. Michael Brice-Saddler, “France Says It’s Poultry Industry Will Stop Shredding Male Chicks Alive by 2022,” The Washington Post, Jan. 29, 2020; Meaghan Wray, “Germany, France Push to End Male Chick ‘Shredding’ in European Union,” Global News, Jan. 16, 2020.
Concentrating animals in numbers and in closed environments seldom seen in nature can also give pathogens opportunities to rapidly evolve and generate new forms.

At a small-scale farm, using less intensive forms of production, disease may impact some animals but not all of them, while in a CAFO, pathogens may infect virtually every animal.\(^570\) Concentrating animals in numbers and in closed environments seldom seen in nature can also give pathogens opportunities to rapidly evolve and generate new forms.\(^571\)

Most animals held in CAFOs lack the genetic diversity that can act as a natural buffer for disease.\(^572\) As the USDA’s Agricultural Research Service explained, “The U.S. currently has the largest, most genetically homogeneous and, thus potentially, the most disease-susceptible population of food animals in the history of mankind... The emergence of a new disease or a slight shift in the epidemiology of an existing disease could lead to immediate and disastrous results...”\(^573\) Like storing tanks of gasoline next to a fire, holding such vast numbers of genetically similar animals can also amplify zoonotic risks posed by other forms of animal industries. The geographic overlap between pig and poultry production is of particular concern, because the interplay between the two species heightens the risk of human influenza outbreak.

Generally speaking, animals in CAFOs have low levels of welfare and high levels of stress, which can reduce their ability to fight infection.\(^574\) As a result of this stress, animals engage in behaviors such as self-mutilation or cannibalism which may also increase the risk of transmission by creating open wounds, dispersing blood and other bodily fluids.\(^575\) Conditions in these facilities can be unsanitary, as live and dead animals are stored together along with their waste in enclosed rooms where the air is thick with ammonia. (Roughly 12,700 Americans die due to air pollution from livestock production each year, with ammonia particles from waste the dominant driver.\(^576\))

While this system of animal production has become increasingly mechanized, there are still several aspects of the production process that are performed by hand, all of which facilitate opportunities for disease transmission. In the pig industry, for example, semen collection and artificial insemination of sows are carried out manually, with or without gloves, allowing for direct contact with the animal as well as bodily fluids.\(^577\) Similarly, tail docking, castration, earmarking, and teeth clipping—all of which are standard industry practice and generally not carried...
out by veterinarians or under anesthetic—can lead to contact with blood, saliva, or fecal matter as well as scratching or biting by animals seeking to escape. Runts, young piglets who are smaller than their siblings, are sometimes killed by hand. Each of these facets of the production process presents opportunities for zoonotic transmission to humans as well as disease spread within captive populations while similar high-risk touchpoints occur throughout cattle and poultry production as well. But, for producers, simply standing inside facilities that hold thousands of animals creates a risk in particular for pathogens that are transmitted through respiratory droplets and for airborne pathogens, just as standing in an amphitheater of infected persons would allow significant opportunities for exposure. Studies estimate that swine workers have a 30 times greater risk of zoonotic influenza infection than the general public. In some studies, the connection is even more pronounced. For example, research from the University of Iowa found a 54-fold increase in H1N1 influenza risk among those with exposure to pigs. Furthermore, even their non-swine-exposed spouses were at 28 times greater risk compared to individuals with no connection to the swine industry. However, despite this increased risk, livestock workers are not mentioned in annual influenza vaccine recommendations nor are they included on priority access lists for pandemic influenza vaccines.

Disease spread can occur anywhere along the chain of production. Both cows and pigs typically move through three different facilities before being transported to a fourth for slaughter. Under the current system, chickens may change hands up to five times, from farm flocks, wholesale dealers, poultry auctions, and retail markets before reaching the end-point consumer.

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By transporting diseased animals, vehicles have also delivered and contributed to the spread of pathogens, occasionally resulting in outbreaks, and each movement has potential to introduce and spread new disease as animals are aggregated in greater numbers along the chain of production.\(^{588}\) Vertical integration in the poultry industry is common, such that a truck owned or other equipment used by a large producer may visit multiple facilities in one day, potentially spreading pathogens from one to another.\(^{589}\)

Animals are transported by truck for slaughter at one of the more than 800 federally inspected livestock slaughter plants in the United States.\(^{590}\) According to an analysis of USDA data, roughly 20,000,000 chickens, 330,000 pigs, and 166,000 cows die during transport to slaughterhouses each year.\(^{591}\) With animals dying from a range of different causes, including heat stress, cold, illness, and trauma, it may be difficult to assess which deaths are due to disease and to identify potential outbreaks. Once at the processing facility, workers stun the animal, and then hang the animal upside down, cut their throats, and process the parts into different cuts of meat.\(^{592}\) This meat is then shipped to wholesalers, restaurants, retailers, and consumers.\(^{593}\)\(^{594}\)

Much of U.S. meat production is shipped for export to China, Japan, and Hong Kong, as well as to Mexico and Canada.\(^{595}\) Roughly 17% of U.S. poultry, 13% of U.S. beef, and 27% of U.S. pork is consumed outside the country.\(^{596}\)\(^{597}\)\(^{598}\) While these export markets carry commercial value more than $20 billion in total, they also carry significant costs.\(^{599}\) Producing hundreds of millions of additional animals for export overseas means taking on additional zoonotic risks. At the same time, the United

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\(^{591}\) This figure includes animals who die upon arrival at the facility prior to slaughter. Many more animals—another 800,000 pigs, for example—arrive unable to walk. Sophie Kevany, "More than 20 million farm animals die on way to abattoir in the US each year," The Guardian, June 15, 2022, [https://www.theguardian.com/environment/2022/jun/15/more-than-20-million-farm-animals-die-on-way-to-abattoir-in-us-every-year](https://www.theguardian.com/environment/2022/jun/15/more-than-20-million-farm-animals-die-on-way-to-abattoir-in-us-every-year).

\(^{592}\) Poultry are hung before stunning takes place.


States also imports poultry, beef, and pork products in addition to live animals.

When particular diseases are detected in livestock, veterinarians are required to report them to state health officials, who relay those reports to the USDA. After an outbreak is confirmed, USDA’s APHIS prepares a containment plan with steps that often include destroying animals who are infected or may have been exposed. Producers are compensated by USDA indemnification payments for the loss of culled animals. However, when mass cullings of herds or flocks take place, safe disposal of such a large number of carcasses can present environmental challenges and secondary disease risks.

Of all of the pathogens examined in this report, influenzas are perceived by experts to be the most dangerous because of their pandemic potential, driven by their ability to re assort, mutate, and spread through droplets in the air. Wild aquatic birds are the natural reservoirs of avian influenzas and transmit the viruses to domestic poultry, who can then turn low-pathogenic strains to highly pathogenic strains, potentially spreading them to other species. Both chicken and hog facilities are particularly susceptible to viral influenzas, with hogs acting as a potential bridge species capable of passing avian influenza to humans and spawning new forms of disease. While recent prior outbreaks of avian influenza in humans have been rare and mostly limited to poultry workers, mortality was severe ranging from 30%–60%.

Estimates project an influenza A pandemic could infect 30% of the world’s population in a matter of months.

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Several strains of influenza including H1N1, H1N2, H3N2, H5N1, and H7N9 have been circulating in U.S. pig and poultry facilities in recent years. The impact of these diseases on both human and animal health is substantial. The 2009 H1N1 “swine flu” epidemic is estimated to have hospitalized over 900,000 Americans—who presented with symptoms of fever, chills, and vomiting—in one of the largest disease outbreaks of recent record. The virus, though it carried a relatively mild mortality rate compared to other strains, demonstrated the speed with which a novel influenza virus could travel through the United States, infecting over 60 million Americans in the first 12 months after emerging from a commercial hog farm. This outbreak has been linked to prior influenza strains found on North Carolina farms and elsewhere, demonstrating the difficulty of permanently eradicating these types of viruses. Spatiotemporal analysis of outbreak patterns during the 2009 epidemic showed increased risk in areas with high numbers of hog production facilities, suggesting that animals in these facilities acted as amplifier reservoirs while the virus circulated in both pigs and humans.

Since 2010, the USDA has tested over 120,000 samples from 33,000 swine for the presence of Influenza A Virus in swine (IAV-S). During this period, over 10,000 samples were positive for IAV-S. Prior research from Iowa, the nation’s largest swine producing state, demonstrated higher prevalence of Influenza A Virus in swine (IAV-S). During this period, over 10,000 samples were positive for IAV-S. This outbreak has been linked to prior influenza strains found on North Carolina farms and elsewhere, demonstrating the difficulty of permanently eradicating these types of viruses. Spatiotemporal analysis of outbreak patterns during the 2009 epidemic showed increased risk in areas with high numbers of hog production facilities, suggesting that animals in these facilities acted as amplifier reservoirs while the virus circulated in both pigs and humans.

613. Many large-scale outbreaks occurred prior to this as well. For example, in 1983, avian influenza was identified in 448 flocks in Pennsylvania and Virginia and 17 million birds were destroyed to protect from further spread. Gerald Fichtner, “The Pennsylvania/Virginia Experience in Eradication of Avian Influenza (H5N2),” Avian Diseases 47 (2003): 33-38, http://www.ijsr.org/issue/3298724.
that the same was true of their spouses. Communities in areas surrounding CAFOs may themselves act as a springboard for viral influenza outbreaks; often such communities are poor and rural.

Prior to 2022, the largest avian influenza outbreak of record occurred in 2014 and 2015, resulting in the loss of more than 50 million birds, most of them commercial laying hens, at a cost of $3.3 billion. A few years later in 2017, a different influenza virus infected a Tyson farm in Tennessee. Despite killing 73,000 birds at that facility to contain the virus, the same strain was later found in commercial poultry flocks in neighboring Alabama, Kentucky, and Georgia. In early 2022, another avian influenza outbreak (H5N1) marched across the Midwest, reaching 29 states and led to the culling of more than 35 million birds in just three months. By 2023, the outbreak spread to poultry in 47 states with over 58 million birds dead. It has also infected more than a dozen different species of mammals from harbor seals in Maine to bottlenose dolphins in Florida to Kodiak bears in the Aleutian Islands of Alaska. The CDC reported the first human case in the United States in April 2022. The virus jumped species to infect a man in Colorado who was assisting with depopulating diseased flocks. As of the time of this writing, however, there is no evidence of person-to-person spread inside the United States, though in some cases the virus appears to have obtained qualities that make it more transmissible to mammals, reigniting fears that H5N1 could spark a human pandemic.

As of the time of this writing, however, there is no evidence of person-to-person spread inside the United States, though in some cases the virus appears to have obtained qualities that make it more transmissible to mammals, reigniting fears that H5N1 could spark a human pandemic.

626. The USDA has established agreements with growers to compensate them for culled flocks. The 2002 outbreak was estimated to cost taxpayers close to $120 million. The culling and disposal of flocks from the 2015 outbreak is estimated to have cost $1 billion. Ali Khan and William Patrick, The Next Pandemic: On the Front Lines Against Humankind’s Gravest Dangers (New York: Perseus Books, 2016).
In addition to influenza viruses, CAFOs can be the source of more common forms of illness. Roughly 320,000 people in the United States suffer from salmonella infections resulting from the consumption of chicken and turkey. Industrial animal agriculture has also been associated with a wide range of outbreaks such as hepatitis E virus, bovine tuberculosis, brucellosis, mad cow, Q fever, Escherichia coli O157:H7, Streptococcus suis, livestock-associated methicillin-resistant Staphylococcus aureus, and Cryptosporidium parvum in farm animals. Even when disease outbreaks in livestock do not spread to humans, their scale and economic impact can be substantial.

### ANTIBIOTIC RESISTANCE

Antibiotic-resistant bacteria, strains of bacteria that cannot be treated through the use of antibiotics, present a significant and growing threat to public health. Antibiotic resistance occurs when bacteria adapt and continue to grow in the face of medications that once prevented them from spreading; this process is driven by overuse and improper use of antibiotics. Each year, in the United States, over 13 million pounds of medically significant antibiotics, approximately 65% of the total sales volume, are sold for use in farm animals.

Antibiotics, generally intended to treat infections in humans, are instead fed prophylactically to livestock to prevent disease in densely-packed, high-volume production operations. In 2017, the FDA prohibited the use of medically significant antibiotics for the purpose of growth promotion in livestock. However, this has done little to stem the overuse as producers continue using large quantities of such drugs prophylactically to similar ends. They are sometimes administered indiscriminately to whole herds of animals in feed or in water. A third of antibiotics approved for use in agriculture can be administered for excessively long or undefined periods of time. Such applications contribute to overuse and drive the development of antibiotic resistance.

Antibiotic-resistant bacteria can enter the human body when people eat contaminated meat or animal products. They can also spread from fans in livestock houses or from manure spread on fields as fertilizer, washing down into lakes and rivers. Past studies have found that 71% of pork chops at supermarkets in the United States carried antibiotic-resistant bacteria, 79% of ground turkey, 36% of chicken breasts, and 62% of ground beef.

Continued on next page.
ANTIBIOTIC RESISTANCE (Continued)

Each year, at least 23,000 Americans die and some 2 million are sickened by antibiotic-resistant bacterial infections resulting from exposure to such tainted meat, at a cost to the healthcare system of over $2 billion.\(^{643, 644, 645, 646}\)

Even so, very little is known about antibiotic use in the livestock industry. Neither the USDA nor the FDA nor the CDC tracks or monitors antibiotic use.\(^{647}\) Data is extremely scarce. When outbreaks do occur, agency response is limited by both a lack of political will and by an industry that is resistant to regulation of antibiotic use.

When 192 people became seriously ill after eating pork contaminated with an antibiotic-resistant strain of salmonella at a pig roast in Washington, for example, public health investigators from the CDC and the USDA were blocked by farm owners and industry groups from inspecting farms where the outbreak began.\(^{648, 649}\) Without access to the production facilities that raise animals and administer these antibiotics, public officials cannot trace outbreaks back to their source, initiate recalls, or advise on safer practices. As a result, health officials lack even the most basic information about on-farm use of antibiotics and the prevalence of antibiotic-resistant pathogens at such facilities.\(^{650}\) In an interview with The New York Times, a former chief veterinarian at the USDA’s Food Safety and Inspection Service stated that the pork industry regularly blocked the release of information regarding antibiotic use, noting, “When it comes to power, no one dares to stand up to the pork industry, not even the U.S. government.”\(^{651}\)

Apart from direct transmission of pathogens, overuse of antibiotics in CAFOs also presents serious risks to public health. Antibiotic drugs are fed to animals to prevent and treat illness, often caused by poor living conditions, as well as to stimulate their growth.\(^{652}\) While federal law sets maximum allowable levels of drug residue for meat sold for human consumption, it does relatively little to curb the overuse of medically significant antibiotics in animal agriculture.\(^{653}\) This overuse, in turn, encourages the development of antibiotic-resistant pathogens, such that the livestock industry not only creates zoonotic disease exposure but also undermines the human health system’s ability to treat some of those same diseases.\(^{654}\)

Antibiotic drugs are fed to animals to prevent and treat illness, often caused by poor living conditions, as well as to stimulate their growth.


645. Livestock employees and their families are at the greatest risk of antibiotic-resistant infection. Studies have found that workers at hog facilities were six times more likely to carry multidrug-resistant staph infections (including “MRSA”) than the general public, while their children were twice as likely as other children to carry these same diseases. Shylo E. Wardyn, Brett M. Forshey, Sarah A. Farina, et al., “Swine Farming Is a Risk Factor for Infection With and High Prevalence of Carriage of Multidrug-Resistant Staphylococcus aureus,” Clinical Infectious Diseases 61, No. 1, (July 2015): 59–66, https://doi.org/10.1093/cid/civ234.


647. The FDA collects sales data on antibiotics but does not collect data related to use. Because of this, it is unknown exactly what is being used, at what rate, and for what purpose. USDA APHIS has done a handful of self-reported surveys, but these are done infrequently and only at the species level.


652. While there have been federal restrictions imposed to curb the latter, it is still common practice, with little means to distinguish between these dual motivations.

653. 21 C.F.R. § 556.

CAFOs can also drive environmental damage that undermines public health and presents broad risks of disease transmission. Dangerous pathogens can be released through waste and other forms of pollution that affect groundwater and neighboring populations. In 2019, the Iowa Department of Natural Resources announced that more than half of the state’s rivers, lakes, and wetlands failed to meet required water quality standards due, in large part, to pollution from the state’s overwhelming number of industrial farms.

At the federal level, CAFOs are regulated and monitored by EPA and USDA APHIS, an agency that enforces legislation related to biosecurity measures, slaughtering protocols, and food safety regulations. The USDA’s Food Safety and Inspection Services Division (FSIS) and the FDA share responsibility for ensuring that livestock animal products are safe for human consumption. The USDA is also responsible for inspecting imported live livestock at the border to prevent foreign animal diseases from entering into the U.S. food system. FSIS inspectors conduct pre and post-mortem visual inspections of animals at slaughter. Some but not all communicable diseases can be diagnosed by visual inspection alone. Animals who exhibit outward symptoms of specific diseases, such as tuberculosis, are separated from the rest of the herd. However, removing animals on an individual basis for displaying symptoms of infectious disease overlooks the fact that other members of the herd have also been exposed to the infected animal. In addition, the brevity of these inspections may severely limit their effectiveness, as each FSIS inspector must inspect more than 600 animals per hour, nearly 25,000 animals per week. These concerns may become more pressing as line speeds at processing plants continue to accelerate. At poultry plants, chickens are killed and processed at speeds of up to 175 birds per minute. Assessing an animal’s health status at these speeds is extremely challenging and expecting inspectors to sustain these rates of inspection over an extended period of time may be unrealistic.

655. The EPA estimates that livestock account for 49% of all agricultural greenhouse gas emissions; however, this estimate does not include the emissions from growing crops that are used to feed livestock. Together, livestock and livestock feed account for almost 80% of all agricultural greenhouse gas emissions in the United States. Livestock production is also the single greatest contributor to methane emissions, a super pollutant that is 80 times more potent than CO2 over a 20 year time horizon. “Greenhouse Gas Emissions Inventory Data Explorer 1990-2021,” last updated April 20, 2023, https://cfpub.epa.gov/ghgdata/inventoryexplorer/#agriculture/entiresector/aliasa/category/ali.


663. For comparison, imagine, for example, a doctor, who has three patients flash before her eyes for one second, and then disappear. The doctor can neither touch nor test them, but has only this third of a second to assess them for diseases, including asymptomatic ones.
At present, there is no universal disease testing of livestock in the United States. The USDA does, however, operate specific sampling and certification programs for particular diseases at the population level. APHIS has a sampling program for livestock, while FSIS has a sampling program for raw meats.\textsuperscript{664, 665}

Oversight of factory farms themselves is limited. Regulators may lack basic information about how many operations exist and where.\textsuperscript{666} Surveying aerial photographs in 2017, Iowa’s Department of Natural Resources found 4,200 previously unknown facilities in Iowa alone, a state with 80 million farm animals and just three million people.\textsuperscript{667} Prior attempts by the Environmental Protection Agency to inventory and locate factory farms were abandoned following a string of lawsuits from the livestock industry.\textsuperscript{668}

An overwhelming majority of the regulation governing large-scale animal agriculture applies only to the last stages of production—slaughter, processing, and cold storage.\textsuperscript{669, 670} As a result, greater risks for zoonotic spread may occur upstream in the supply chain. For the vast majority of an animal’s life, until they are loaded for transport to slaughter, there are virtually no laws governing their living conditions, welfare, or treatment. CAFOs are not physically inspected, and the USDA maintains that it does not have

\begin{itemize}
  \item \textsuperscript{666} This may be especially true of animal feeding operations (“AFOs”) that fall just below the numbers thresholds required to meet the definition of a “CAFO.”
\end{itemize}
authority to carry out on-site inspections of these facilities. Livestock handling is functionally exempt from state animal cruelty laws and there is little else governing human-animal interactions at these facilities.

Many industrial animal agricultural operations do, however, have higher levels of biosecurity than other industries. Access to these facilities is tightly controlled. Sealing off these operations and keeping animals entirely indoors can reduce the frequency but increase the magnitude of disease outbreaks. Intense biosecurity goes hand-in-hand with a lack of transparency at these facilities that are closed to the public, journalists, and regulators, such that much of what is known of conditions in CAFOs comes through private undercover investigations or whistleblowers. Still, the ongoing H5N1 influenza outbreaks demonstrate that even with strict biosecurity protections in place and advanced warning about impending disease, many producers are still unable to prevent infection.

12. Livestock Auctions

In livestock auctions, domestic animals are consigned for sale to bidders through public auction. Approximately 10.4 million livestock animals are sold annually through online or physical auctions, representing an annual revenue of close to $6.2 billion. Livestock commonly sold at these auctions include cattle, pigs, sheep, goats, horses, donkeys, and mules. In person auctions typically take place in large barns and consist of livestock offered for sale by many different farms. Animals are presented in the auction ring, offered either individually or as lots, weighed, and sold to the highest bidder. Online auctions (including live webcams of physical auctions) have increased in number in the last five years, dramatically expanding the audience reach.
Livestock auctions can broadly be broken into two categories: “productive markets” and “cull markets.” In the former, animals are sold for their productive value, i.e., their value while alive, while in the latter, animals are sold for their value at slaughter. Animals presented at auctions come from many different places, sometimes travel long distances for sale, and often include less-valued, young, old, or sickly animals sold at discounted prices. Some die in transport or at the auction site. These animals come to one centralized location where they are held in close quarters with other such animals before being sold, and subsequently dispersed to other farms where they may bring any pathogens they carry back to infect existing herds (or to slaughterhouses).

Several aspects of livestock auctions facilitate transmission of zoonotic disease through close contact between humans and animals. Before the auction begins, attendees (often including children) are welcomed back to touch and inspect the animals in their holding pens. Direct interactions with

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679. Animals sold at cull auctions often include young cattle, pigs, sheep, goats, and birds bred specifically for slaughter as well as “spent” animals who were once valued for their reproductive capacity but who have been deemed economically inefficient. These animals are typically either transported directly to slaughterhouses or moved to a feedlot or farm to be fattened before slaughter. Kathryn Gillespie, *The Cow with Ear Tag #1389* (Chicago: University of Chicago Press, 2018), 94.


live animals, such as these, can and have given rise to zoonotic transmission. Moreover, because auctions are generally held on a weekly basis, with limited biosecurity, pathogens may survive week to week and infect the next round of animals held in the same physical structures of the auction house. In some cases, auctions take place daily. A certificate of veterinary inspection is often required at larger auctions but may be overlooked at smaller ones or those that source animals exclusively from within the state. Inclusion of animals who may have been exposed to wildlife heightens the disease risk, as it increases the risk of introducing pathogens endemic to wild animals that have potential to mix and propagate among farmed animals. Bringing animals from a variety of sources as well as a variety of species and holding them together as they wait allows pathogens to spread from one animal to the next, as does bringing each into a central ring for sale where pathogens may linger in the wood shavings or dirt floor. Further opportunities for transmission arise when infected animals sold at auction are loaded up and transported back to farms where they may spread disease to workers or other livestock. In addition, if buyers slaughter the animals they purchase from auction for personal consumption, they generally may do so themselves on their own property with no licensing or inspection requirements.

Despite the disease risks inherent in livestock auctions, there is often a lack of sanitation and transparency. Journalists and photographers are sometimes not allowed to document certain portions—sometimes any portions—of the auction. Additionally, lack of recordkeeping means that it may be very difficult to trace and control a disease outbreak sourced from a livestock auction. Salmonella, E. Coli, and Coxiella burnetii (the pathogen that causes Q fever) are some of the bacterial risks at livestock auctions; the effects of these may be mild but can be life-threatening. Other common zoonotic diseases found in and around livestock auctions include brucellosis, influenza, leptospirosis, and psittacosis. Livestock auctions are very lightly regulated. The USDA does require a certified veterinary inspection for all livestock transported interstate, however, and some states have additional inspection and identification requirements to help prevent disease spread across state

References:

lines, though there is little oversight of intrastate sale of animals. Regulation is largely left to state and local discretion, and enforcement is inconsistent. Where health inspections do occur, the quantity of animals sold and the rapidity required of those inspections often allow only cursory appraisals. Some states have imposed minimal welfare regulations, for example, requiring that animals sold for slaughter are killed within five days of sale. These measures, however, do little to address disease risk.

13. Live Animal Markets

Live animal markets in the United States are typically retail food markets where animals are stored alive and sold to consumers for the purpose of human consumption. Animals in some cases may be sold alive but are more often freshly killed and butchered on site. Species sold at these markets include poultry (predominantly chickens, ducks, and quails, and less frequently pigeons, squabs, geese, turkeys, guinea fowls, peacocks, partridges, and pheasants), mammals (predominantly rabbits, pigs, calves, sheep, and goats), fishes, and other aquatic animals (predominantly frogs, turtles, and crustaceans). Many live animal markets sell only poultry, though they typically offer a wide variety of bird species. In New York City, roughly one-quarter of these markets also slaughter large livestock.

Hundreds of such markets operate across the United States, some of which may sell and process thousands of animals per week. The USDA estimates that more than 25 million birds of different species pass through 130 known live bird markets in the Northeast alone each year.
Live animal markets generally sell to individual households for personal consumption. Market clientele are culturally diverse, though often predominately made up of members from Asian-American, Latinx, Jewish, and Muslim communities. These markets are considered to be particularly important to immigrant communities for cultural and religious reasons such as obtaining animals that were slaughtered in a particular way. This is especially true in the New York City boroughs which are home to over 80 live animal markets.

Many characteristics of live animal markets make them especially vulnerable to outbreaks of zoonotic disease. Generally, animals are kept at high densities under poor conditions. While the proximity of animals to one another facilitates contagion, limited air flow and hygiene can also promote pathogen spread. These conditions also induce stress, which may cause animals to shed viruses at higher levels or make them more susceptible to infection. With birds packed densely in stacked cages, feces, urine, and blood travel downward from one cage to the next. Some live animal markets in the United States tend to be cleaned and disinfected irregularly and insufficiently. The wooden chopping blocks that are used for slaughter and butchering are of particular concern in facilitating disease spread. Disposal also presents risks, with reports of gutted carcasses and blood being improperly discarded, sometimes left in public spaces in open trash cans.

The movements of the animals into and within live animal markets are another relevant factor in disease transmission. Producers sell to wholesale dealers and haulers who bring the animals to live animal markets and sell them to shop owners. Animals may come from a variety of sources, including CAFOs. For example, in Pennsylvania, live animal markets acquired poultry from an average of almost 30 different sources. Often, there is significant carryover of animals from one day to the next, with some animals remaining on site for weeks, allowing pathogens to persist despite any regular cleaning.

With birds packed densely in stacked cages, feces, urine, and blood travel downward from one cage to the next.

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Religious slaughter and animal sacrifice take many forms in the United States. The most common forms of religious slaughter are Halal and Kosher, which delimit rules for Muslim and Jewish consumers of certain food products, including meat. Halal and Kosher slaughter in some cases operate on a smaller scale than most meat-processing in the United States. Halal and Kosher slaughterhouses generally source their animals from the same places as the rest of the industry, although they may rely more on livestock auctions and live animal food markets, which can increase the likelihood of disease transmission. Because these specialized slaughter facilities may be located proximate to the communities they serve, and individual consumers may be allowed in very close proximity to the live animals, their ability to transmit zoonotic disease is further heightened. Some of these religious activities are enabled through exemptions in the Poultry Products Inspection Act (PPIA) as well as FSIS Directives and the Humane Methods of Slaughter Act.

Within the United States, sacrificial slaughter is most commonly practiced under the auspices of Judaism, Islam, and the Afro-Caribbean religions of Santeria and Palo Mayombe. While many forms of sacrificial slaughter pose heightened zoonotic disease risk due to a lack of biosecurity and oversight, perhaps the most significant risk comes from the Jewish practice of Kaporos (Kapparot), which occurs at a larger scale than other events.

Each year in New York City alone, Kaporos practitioners sacrifice an estimated 60,000 chickens in public streets over the course of a few days before the onset of Yom Kippur. Practitioners are expected to directly handle the birds before and during slaughter. The quantity of those interactions, as well as the resultant biofluids such as blood and excrement that can contaminate public streets, make this form of sacrificial slaughter particularly high-risk for public health.

In the Islamic tradition, the most common form of sacrificial slaughter occurs during Eid al-Adha, an important Islamic holiday observed by slaughtering an animal, usually a goat, a sheep, a cow, or a camel. In Minnesota, for example, hundreds of Muslim observers travel to farms where practitioners can select from pens the animal that they would like to sacrifice. Customers at these farms sometimes perform the sacrificial killing themselves or sometimes with the assistance of an employee.

Victoria de Martigny / We Animals Media
Daily introduction of new animals into this environment provides optimal conditions to introduce new infectious diseases such as influenza. Even when markets are deep cleaned, disinfected, left empty for days, and repopulated with animals from closely monitored sources, however, disease has been found to return to markets within a matter of weeks. Moreover, the very act of cleaning can diffuse pathogens into the environment via sewage and waterways, enabling pathogens to spread beyond market walls if done improperly.

These high-risk conditions common across live animal markets can be exacerbated by several other factors. For example, many live animal markets sell a diversity of species including birds, mammals, reptiles, fish, and amphibians. As a result, live animal markets bring together pathogens from different taxonomic origins and provide them an ideal venue to mix and mutate. Some of these markets also sell animals alive for consumers to take home and kill themselves, enabling pathogens to spread and move beyond the confines of a market and creating concerns as to where and how the slaughter is taking place. This threat is also present when unsold animals from live animal food markets are sent back to nearby farms. Even when animals are no longer present, transport trucks that ferry empty crates back and forth to farms have been found to carry disease.

The dominant disease risk from live poultry markets is influenza. Live bird markets are particularly high-risk in this respect because they often combine waterfowl—the natural reservoirs of influenza—with chickens and other poultry who can become infected and potentially spread the virus to other animals and humans. While industrial production facilities raise only one species, live bird markets mix many, and in doing so, they threaten to create versions of the virus that can be introduced back to industrial poultry producers. For example, live poultry markets have been implicated in past outbreaks of H5N2, which led to the culling of 17 million chickens at a cost of $400 million. In 2004, another outbreak of H5N2 occurred in Texas after a


The creation of “new viruses,” that had not been documented in those markets before. Given the potential risks that live bird markets pose in terms of igniting outbreaks among poultry, some producers are determined to eliminate these operations for fear that they may jeopardize the poultry industry writ large and endanger public health. The risk of influenza transmission to humans is particularly acute in markets that contain both pigs and poultry, two important carriers of influenza viruses.

A detailed study of pigs in two live animal food markets in Minneapolis found high rates of influenza viruses not just in and on the animals themselves, but in the air and on surfaces throughout the market. At these markets, which brought in between 80-200 new pigs per week, 47% of the pigs were found to carry influenza virus at the time they were slaughtered. Fifty-three percent of air samples taken from above the pig holding pen also tested positive for the virus. In addition, 47% of the railings and bars of the pen indicated the presence of influenza. The virus was also found on door knobs, on the faucet, and in the sink. The study also found strong evidence indicating that the virus spilled over in the markets from pigs to humans. Sixty-five of influenza. The virus was also found on door knobs, on the faucet, and in the sink.

The study also noticed or diagnosed. Many of the infected workers did not exhibit symptoms, suggesting that these kinds of infections may often spread asymptomatically without being noticed or diagnosed.

The authors note that “employees were frequently being exposed to a variety of IAVs present in the air,” but importantly, the pigs were also exposed to human-origin influenza viruses through close interspecies contact at the markets, allowing for possible transmission in both directions. Only one of the 17 employees who participated in the study had been vaccinated against seasonal influenza.

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These results, and others like them, highlight the danger of zoonotic spillover at live animal food markets in the United States. But they also demonstrate how the ways in which these markets operate can amplify the risk and showcase the ability of influenza viruses to generate new and potentially dangerous forms.

Currently most of the regulation of live animal poultry markets—including inspection and licensing—is carried out at the state level.\textsuperscript{745} The USDA only regulates the sale of cows, sheep, pigs, and goats at live markets.\textsuperscript{746} The USDA has published voluntary guidelines, however, for preventing avian influenza in live bird markets and all states currently employ these guidelines, which include monthly testing for avian influenza viruses of randomly selected flock members.\textsuperscript{747, 748} With these guidelines in place since 2003, the presence of H5 or H7 strains in New York live bird markets fell dramatically from 60%–80% of those tested in the early 2000s to none in 2019.\textsuperscript{749, 750} Prior to these guidelines, studies found that less than 2% of live bird markets followed recommended biosecurity and handling practices.\textsuperscript{751} Despite these improvements, disease risks remain.\textsuperscript{752, 753} In the first four months of 2023, there were six outbreaks of H5N1 at live bird markets in the United States, occurring in New York, Florida, and Virginia.\textsuperscript{754} Many of these markets were located in densely urban areas and contained up to 1,400 birds.\textsuperscript{755}

The process of selling live animals for on-demand slaughter came under increased scrutiny in the United States during the COVID-19 pandemic due to potential connections between the virus and the Huanan Seafood Market, a live animal market in China. In light of public health concerns, Utah banned live bird markets in 2020, and during the same year, New York extended a four-year moratorium on live animal markets within 1,500 feet of residential buildings.\textsuperscript{756, 757, 758}

758. Stricter bills have been introduced in New York, Rhode Island, and California, but nothing has yet passed into law.
14. Aquaculture

Aquaculture, the practice of farming of aquatic animals in captive or controlled aquatic environments, is a $2.7 billion annual market, encompassing 4,100 fish farms in the United States. The process often attempts to insulate the fish from predators, pests, and disease to increase yield rates. Fish raised for human consumption, including catfish, perch, salmon, hybrid striped bass, tilapia, and trout account for approximately 60% of the aquaculture market with ornamental fish, such as koi and tropical fish, baitfish, and sportfish making up most of the rest. The majority of U.S. production focuses on freshwater species. Freshwater crawfish, shrimp, and mollusk species such as oysters, clams, and mussels are also produced in large numbers. Yet, despite this significant market size, the United States remains a relatively minor player in the global aquaculture industry overall, ranking 17th in total production.

Aquaculture is regulated at both the federal and state level. The EPA is responsible for wastewater permitting across all industries, while the FDA covers food safety regulations. State and local governments generally oversee permitting or licensing at the community level. Permits often deal with zoning, building, water use, and waste discharge. Laws and regulations governing aquaculture vary among different states and can also vary considerably between geographic locations within a state. The majority of applicable controls have an environmental focus, while relatively few address public health. There are a number of zoonotic diseases present in farmed fishing operations; however, the overall risk posed to humans from aquaculture is relatively low. There have been reports of fish handlers contracting bacteria such as *Vibrio vulnificus*, *Streptococcus iniae*, and *Edwardsiella tarda*. More often, people are infected through the consumption of raw or undercooked fish containing Salmonella or parasites such as trematode, cestode, and nematode parasites. As sushi and raw fish products have become more popular in recent years, illnesses caused by these parasites have increased accordingly.
Given the risk that disease outbreak poses to farmed fish producers, even without regulatory mandates, some have chosen to reduce disease risk by investing in vaccines, probiotics, higher-quality diets, limited culture density, and antibiotics, all of which may help to prevent disease in controlled environments.\textsuperscript{767}

However, use of antibiotics in aquaculture also poses the same risks of creating antibiotic resistant strains of bacteria as with terrestrial species.\textsuperscript{768}


A number of small-scale animal farming industries operate throughout the United States raising wild or domestic animals from a spectrum of different species. The list of specialized farming markets examined below is not exhaustive, but rather it is intended to provide a sample of how such systems of production operate. Producers range from backyard breeders and hobbyists to more established commercial operators. Some enterprises included in this section raise animals predominantly for meat, while others generate a particular product such as skins, wool, fur, milk, guano, or urine. Although the scale of these operations can appear marginal in comparison to others examined in this report, even small operations can carry significant public health risks, and the trajectory of a disease may be the same whether spillover occurs at a CAFO or a camel farm.

### Number of Animals in Specialized Farming and Production

- **Backyard Poultry Production**, 18.4 million animals
- **Bat Guano Harvesting**, 15 million animals
- **Turtle Farming**, 3.4 million animals
- **Rabbit Farming**, 853,000 animals
- **Crocodilian Farming**, 350,000 animals
- **Guinea Pig Farming**, 341,000 animals
- **Alpaca and Llama Farming**, 300,000 animals
- **Ferret Farming**, 100,000 animals
- **Ostrich and Emu Farming**, 16,000 animals
- **Camel Farming**, 3,000 animals
- **Coyote and Fox Urine Production**, 3,000 animals
15. Alpaca and Llama Farming

Alpacas and llamas are two species of Camelidae kept primarily for wool production, though some are also kept as pets or livestock guardians. They are raised in outdoor pens, usually with a small shelter—a barn or three-sided lean-to. Animals are shorn at least once a year. There are over 260,000 alpacas across the United States with the largest number in Ohio, Washington, Oregon, New York, Colorado, and California. In the last Census of Agriculture report of 2017 (published every five years), there were fewer than 40,000 llamas in the United States, down from almost 145,000 llamas in 2002.

Risk of disease spread from alpacas and llamas is greatest at fairs, exhibitions, auctions, and other trade shows. In the United Kingdom, tuberculosis, cryptosporidiosis, and sarcoptic mange are known diseases to have been transmitted from camels to humans. However, there have not been widespread reports of these diseases on U.S. farms. Alpacas and llamas also can carry viruses such as rotavirus, foot and mouth disease, West Nile virus, and bacteria such as *Streptococcus zooepidemicus*, *Salmonella*, *Leptospira*, and *Streptococcus equi* (commonly known as “alpaca fever”).

Perhaps of greater concern, in 2012, alpacas in Saudi Arabia were shown to be carriers of MERS-CoV (the pathogen that causes Middle East Respiratory Syndrome), though the virus is primarily found in camels. MERS-CoV is a coronavirus that is 35% fatal in humans and highly contagious.

Although, to date, MERS-CoV has not been found in alpacas outside the Arabian Peninsula, there is concern that alpacas and other camelids could provide a foothold for the virus if it were introduced to North America. While current case reports of alpaca and llama-transmitted diseases are relatively rare, owners usually do have close contact with these animals, whether they are bred for wool or kept as pets. Alpaca and llamas are often treated as livestock and only lightly regulated. Importing camelids into

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the United States requires a USDA import permit. Some states also require a certificate of veterinary health inspection prior to moving animals into the state.

16. Backyard Poultry Production

Small-scale bird breeding, also often known as “backyard bird keeping,” is growing in popularity especially in urban and suburban areas in the United States. Roughly 13 million American households (1 in 10) raise backyard poultry, and 93% of major U.S. cities allow for urban poultry raising in some capacity. Birds are housed in a residential setting, some in the backyard of a home in a purpose-built bird coop consisting of a contained area, nesting boxes, and perches, while others are left to roam the premises freely and roost in trees. In some cases, birds have regular access to human living areas. A vast range of bird species are raised as backyard poultry, including chickens, ducks, geese, peafowl (peacocks), guinea fowl, pigeons, and turkeys. These birds are raised primarily for consumption of eggs and meat, although they may also be used as pets, as showbirds, or as sources of fertilizer or feathers. Husbandry conditions vary greatly among breeders. Some backyard poultry owners operate intensively managed and highly elaborate systems for breeding and raising birds, keeping detailed records of their genetics and production. Others leave the birds, more or less, to fend for themselves. Only 3% of backyard flocks receive veterinary care, with larger operations being the most likely to employ veterinary assistance.

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Disease Risk Associated with Backyard Poultry Production


777. See, for example, Wash. Admin. Code § 16-54-105.


Birds are sourced from feed stores, hatcheries, auctions, swap meets, breeders, friends or relatives, and online sales, where chicks cost only about $4 each and can be shipped via U.S. mail. The animals are transported in boxes, cages, and paper bags before being introduced to their new flocks. There is a large amount of turnover within the backyard poultry industry—36% of operators add new birds each year, while 18% sell or give away animals. The movement of animals within the industry and from various suppliers creates opportunities for pathogens to spread and access new healthy flocks. One important node in the supply chain are animal feed stores, which serve as a central hub of the backyard poultry industry, providing both supplies and information for customers on questions about husbandry. However, these businesses can also play an important role in disease transmission as they often carry live animals for sale and, potentially, pathogens brought by customers and suppliers from dozens of different locations. Those who raise backyard poultry often sell excess eggs, advertising through word-of-mouth, yard signs, and farmers markets. When birds die, they may be disposed of in household trash, composted, buried, or burned. The disposal process for manure and dead animals can pose additional zoonotic risks.

Unlike industrial poultry producers, backyard bird operations impose few if any biosecurity measures. Half or more of the birds have contact with wildlife—including waterfowl, the natural reservoirs for avian influenza. In addition, many owners raise multiple species of birds or other animals. Sixteen percent of operators also raise pigs, for example, a species that can serve as a mixing vessel for influenza viruses and may transmit them to humans. Sanitation practices are often overlooked in this more casual setting, making dangerous interactions between humans, wildlife, and captive birds all the more likely.

Part of the disease risk posed by small-scale bird production is derived from the human dimension of these practices. Backyard breeders, more so than commercial breeders, have limited knowledge of disease risks and may be less likely to employ protective measures as a result. Many do not take basic precautions such as wearing gloves or washing hands after handling the animals.

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Fifty percent of owners surveyed were unaware that live birds may pose a disease risk. Unlike commercial production, some backyard chickens are treated as pets, allowing increased human-animal contact, particularly with children. Wide differences in facilities, husbandry practices, and owner cooperation may present additional challenges to responding to disease outbreaks. All of these conditions persist amidst a regulatory backdrop that does little to mitigate such risks.

Backyard bird breeders, defined as any operation with fewer than 1,000 birds, are exempt from USDA slaughter inspection. Twenty-seven states also exempt these operations and impose no additional legal requirements for slaughter. The remaining 23 states do impose additional requirements for slaughter of poultry for human consumption.

At the local level, backyard poultry is allowed in all but 11 of the 150 largest U.S. cities. In those jurisdictions that regulate the industry, most do so only with respect to flock size and the location of coops or noise levels. Roughly one-third require operators to receive a permit. Less than 10% of cities impose policies to govern the disposal of dead birds, and only a handful regulate slaughter. Local ordinances governing backyard poultry operators are difficult to enforce and often lack a public health objective, leading to significant gaps in safety, though flocks may carry a host of pathogens from *Salmonella*, *Campylobacter*, and *E. coli* to Newcastle Disease and avian influenza.

The backyard poultry industry provides a common and well-worn route of *Salmonella* transmission. Chickens, ducks, geese, turkey, and other live poultry can carry *Salmonella* bacteria in their guts, as well as in their droppings and on their feathers, feet, and beaks. These germs then spread through the environment, contaminating coops, feed and water dishes, surrounding soil, and ultimately, processing of the birds and disposal of carcasses also increases these risks. These problems persist after the birds are processed. For example, 60% of individuals rinsing raw poultry for consumption leave bacteria in their sinks. "Washing Raw Poultry: Our Science, Your Choice," USDA, August 20, 2019, https://www.usda.gov/media/press-releases/2019/08/20/washing-raw-poultry-our-science-your-choice.

795 Processing of the birds and disposal of carcasses also increases these risks. These problems persist after the birds are processed. For example, 60% of individuals rinsing raw poultry for consumption leave bacteria in their sinks. “Washing Raw Poultry: Our Science, Your Choice,” USDA, August 20, 2019, https://www.usda.gov/media/press-releases/2019/08/20/washing-raw-poultry-our-science-your-choice.


805 In many cases, the infected birds appear healthy.
residential homes. In a 2013 outbreak, which infected 356 people across 39 dates with a hospitalization rate of 26% percent, 95% of infected persons reported purchasing live poultry from agricultural feed stores. Roughly 60% of ill persons were children under 10 years of age. That same year another outbreak spread across 30 states and was ultimately traced back to a single hatchery that supplied 95% of infected persons with mail-order chicks. The scale and breadth of hatchery distribution systems allows pathogens to be disseminated widely across the United States. Salmonellosis outbreaks continue to occur on an annual basis and backyard poultry remain a persistent source of infection. In 2019 and 2020, the CDC reported that 2,856 people across all 50 states were infected as a result of contact with backyard birds. Roughly a third of infected patients were hospitalized and nearly a quarter of those infected were children under the age of five.

Backyard flocks have been linked to other disease outbreaks as well. Virulent Newcastle disease, caused by Newcastle disease virus, a paramyxovirus that, the USDA notes, “is so virulent that many birds and poultry die without showing any clinical signs,” decimated backyard flocks in 2003 and caused subsequent outbreaks in 2018–2020. Three million birds were culled to contain this outbreak, costing taxpayers $161 million in indemnification payments with industry losses estimated at $5 billion, as hundreds of backyard flocks were infected alongside commercial producers. While Newcastle disease virus has thus far only caused rare and mild effects in humans, it may carry significant zoonotic potential. Like Nipah virus and Hendra virus, Newcastle disease virus belongs to the family of paramyxoviruses which carry the highest cross-species transmission rates of all RNA viruses.

Backyard poultry have also been affected by the current avian influenza outbreak, which, at the time of this writing, has reached 507 backyard flocks along with 325 commercial suppliers, leaving a total

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814. Only one known human death caused by Newcastle disease has occurred in the United States. However, presentations of lethal disease in a range of other species including pigs and mink demonstrate the virus’s adaptability to a wide range of host species. Scott J. Goebel, Jill Taylor, Bradd C. Barr, Timothy E. Kiehn, et al., “Isolation of Avian Paramyxovirus 1 From a Patient With a Lethal Case of Pneumonia,” Journal Of Virology 81, No. 22 (November 15, 2007): https://doi.org/10.1128/JVI.01406-07.


widely throughout the Midwest has been shown to cross species barriers and infect humans in the past. As one study notes, “Influenza A/H5N1, in particular, has repeatedly caused human infections associated with high mortality,” while another study calls it “an especially notorious strain... which has a mortality rate [in humans] of approximately 60%.” In these cases, infected persons are generally limited to poultry workers or bird owners who come into close contact with infected animals.

Pathways for Human Infection with Influenza Viruses

Influenza viruses can spread from wild birds to humans through various industries and intermediate hosts. Influenza viruses are considered the most likely kind of viruses to cause a future pandemic.

However, the real danger of outbreaks like this one derives from the risk that such a virus might mutate and gain the ability to spread person-to-person. Prior research has found that only a small number of changes to H5N1’s viral genome would be required to allow such airborne transmission between mammals. Given the ability of influenza to reassort and rapidly evolve, the longer an outbreak among animals persists, the greater the danger that a human pandemic influenza strain can emerge.

17. Bat Guano Harvesting

Guano is the excrement of seabirds and bats. It is used as a fertilizer due to its high content of nitrogen, phosphate, and potassium—key nutrients for plant growth. Bat guano has also been used in the United States for gun powder and other explosive materials. Guano is collected from caves

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inhabited by free-roaming bats in a model more akin to beekeeping than traditional forms of farming that involve captive animals. Bracken Cave near San Antonio, Texas supports more than 15 million Mexican free-tailed bats and is the largest bat maternal nesting colony in the world. Recent measurements estimate the current depth of guano in Bracken Cave to be between 75 and 100 feet in the 117-foot-tall cave. Purveyors harvest up to 50 tons of guano annually from Bracken cave alone. Workers in the cave shovel guano into air compressor-filled sacks and in one day can pull out 200 bags, or roughly 8,800 pounds, of guano. Similar caves are found around the United States, including in Oklahoma, California, Tennessee, and Maryland.

Many bacterial, fungal, and viral pathogens have been identified in bat guano. Bats are believed to be a reservoir for many viruses, including SARS-related coronaviruses. There has been at least one reported instance in China of bat-human disease transmission during the process of guano harvesting, in which six men fell ill with a severe respiratory disease. However, there have been no such reports in the United States. Bats are believed to be reservoir species for Nipah virus (NiV), Ebola virus (EBOV), Rabies virus, MERS coronavirus (MERS-CoV), as well as others and carry the fungus that causes histoplasmosis in humans. Of 105 outbreaks in the United States from 1938–2013 of histoplasmosis, bats or their droppings were present in

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**Disease Risk Associated with Bat Guano Harvesting**

<table>
<thead>
<tr>
<th>Pathogen Danger</th>
<th>Intensity of Containment</th>
<th>Animal Health</th>
<th>Mixing of Species</th>
<th>Supply Chain</th>
<th>Biosafety</th>
<th>Human Exposure</th>
<th>Transparency</th>
<th>Regulatory Oversight</th>
<th>Market Scale</th>
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<td>High</td>
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826. A maternal colony refers to a temporary colony consisting of pregnant females and their offspring. The colony usually stays together for the birthing, nursing, and weaning of their offspring.


23% of the outbreak settings. Bat guano can also contain bacterial pathogens including *Pasteurella*, *Salmonella*, *Shigella*, *Escherichia*, *Klebsiella*, *Proteus*, *Yersinia*, *Hafnia*, *Serratia*, *Staphylococcus*, and *Campylobacter*.\(^{839}\)

Entering caves to harvest bat guano presents a serious risk of zoonotic transmission both through the guano itself and through close contact with the bats that produce it. Elsewhere in the world, even activities such as mining, whereby humans may enter bat habitat for other reasons, have given rise to deadly zoonotic outbreaks.\(^{840}\) There are state and local guidelines as well as CDC guidelines for handling bats, but there are no known regulations in the United States governing bat guano farming.\(^{842}\)

### 18. Camel Farming

Camel farming in the United States is a small but growing market, especially among the Amish and Mennonite communities. There are approximately 3,000 farmed camels in the United States. Camel milk is marketed as an alternative milk source for those with allergies to cow’s milk.\(^{846}\) The same FDA regulations that govern cows milk also apply to camel milk: the milk must be pasteurized or aseptically processed before being sold to consumers across state lines.\(^{847}\) Raw milk from both camels and cows can carry bacterial pathogens such as *Campylobacter*, *Brucella*, *E. coli*, *Listeria*, and *Salmonella*. Because of this zoonotic risk, the FDA does not allow the interstate sale of raw milk. However, many producers offer raw milk for sale locally, and currently, 31 states allow for the sale of raw milk, which in particular carries a greater risk of brucellosis than pasteurized milk. Studies have shown that states that legalize raw milk sales experienced greater numbers of disease outbreaks related to milk consumption.\(^{848}\)

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845. Human development in bat habitat can augment risk. For example, residential developments have been built as close as a half mile from the Bracken Cave in Texas, leading to increased human contact with bats and bat guano.


Middle East respiratory syndrome (MERS), caused by MERS-CoV and initially identified in the Arabian Gulf in 2012, is the camel-borne virus of greatest concern. Although MERS-CoV has not been found in camels in the United States thus far, there is concern that camels could become infected if MERS-CoV were introduced to the region.

19. Coyote and Fox Urine Production

Coyotes and foxes, as well as other animals, are farmed in the United States for their urine. The urine, with its ammonia-like scent, is used both as a repellent by gardeners and those who wish to ward off small mammals and deer, but also as an attractant for hunters and trappers who use the urine as a lure to attract wild coyotes and foxes or cover their own scent. The urine is sold commercially, but there is very little information about, and virtually no monitoring of, coyote or fox urine farming. The market landscape is similarly murky. In 2006, a large 10-facility operation in Maine was believed to supply 90% of the coyote urine market in the United States. This is the only market data available and the facility owner did not respond to inquiries from the authors of this report.

The sale of urine for use as a pesticide or as a mask or lure is regulated by the EPA. While these laws govern the processing of the end product, the amount of oversight regarding the urine
production process is not clear and little is known about the associated risks. One of the leading sellers in the United States of coyote urine pellets suggests that the animals are not touched during the collection process. Instead, animals are kept in enclosed cages with permeable or slanted floors such that when they eliminate urine, the waste is collected below into drains. Presumably, such a process would result in the collection of other fluids and solids as well. There is concern that both keeping these animals in close confinement and handling runoff from their enclosures could present risk of pathogen transmission. More information and transparency is needed in order to better understand these possible risks and how to best mitigate them.

20. Crocodilian Farming

Alligators, caimans, gharials, and crocodiles are known collectively as “crocodilians.” While their meat is sometimes sold as a by-product, these animals are raised primarily for high-quality leather made from their belly skin, which is sold for use by the fashion industry within the United States and around the world. For this reason, care is taken during rearing to minimize damage to the belly skin from the surfaces of their enclosures. The density at which crocodiles are maintained is reduced as they grow larger, which helps to reduce interactions between individuals (in order to protect their skin from damage by others) and to promote growth. The American alligator is the crocodilian species most commonly raised for commercial purposes in the United States. As of 2014, there were approximately 37 alligator production facilities spread across four states: Louisiana, Florida, Georgia, and Texas. These farms in aggregate produced slightly more than 350,000 hides, with a total value of hides and meat exceeding $85 million. Louisiana and Florida farms account for more than 98 percent of the production. In addition to skin and meat products, some alligators are used in alligator wrestling events, which are held in at least 13 venues around the state of Florida. These wrestling events are usually promoted on social media and serve as a tourist attraction.

Alligator farming is regulated at both the federal and state level. FWS continues to protect the American alligator under the Endangered Species Act (ESA) classification as threatened due to similarity of appearance to other protected species such as crocodiles and caimans. Individual state agencies regulate both wild harvest and farm production activities through license requirements. Louisiana has housing requirements for the alligators (i.e., secured premises, clean water, controlled temperature) as well as slaughter requirements (performed only in a manner that causes a rapid loss of consciousness and death). In addition, all alligator farms are subject to inspection by the Louisiana Department of Wildlife and Fisheries (LDWF). The LDFW also tracks the size and number of alligators slaughtered. Florida has similar requirements and oversight departments.

Crocodilians can become infected with zoonotic viruses from insects, such as West Nile virus, and can transmit these viruses via scratches or wounds, blood, fecal or oral transmission, and possibly through contact with contaminated water. In the last 20 years, there have been outbreaks of infection with West Nile virus in both human populations and in farmed American alligators in Georgia, Louisiana, and Florida, with documented cases of alligator-to-human transmission. Research suggests that alligators may serve as important carriers and amplifying hosts of the West Nile virus.

Microbiology research on human wounds caused by alligator bites is limited.

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878. Alligators are known to cause serious or fatal injuries to humans, especially when stressed, for example, due to poor living conditions or forced interaction with humans. Casey Riordan, Jennifer Jacquet, and Becca Franks, “Investigating the Welfare and Conservation Implications of Alligator Wrestling for American Alligators (Alligator mississippiensis),” PLoS ONE 15, No. 11 (November 13, 2020): https://doi.org/10.1371/journal.pone.0242106.
zoonotic bacteria such as the *Citrobacter* and *Salmonella* have been found in wounds.\(^879\) Crocodilians can also carry herpesvirus and poxvirus, as well as a range of bacterial agents, making hygiene practices particularly important for handlers.\(^880\) \(^881\) Though crocodilians can and have transmitted pathogens to other species including humans, the risk of such transmission is relatively low and the industry, on the whole, is better regulated than most other forms of wildlife farming.

### 21. Ferret Farming

Ferrets are popular pets, with over 500,000 ferrets kept by owners in the United States.\(^882\) Ferrets are small carnivores, which can sometimes act aggressively toward humans and may pose a threat to wildlife if not properly contained.\(^883\) In part because of these concerns, states such as California and Hawaii as well as cities including New York City and Washington, D.C. have banned ownership of ferrets.\(^884\) There are relatively few U.S. ferret breeders and most are small operations.\(^885\) There is also a set of larger commercial ferret wholesalers, led by Marshall Farms in New York, which sells to pet dealers throughout the United States and abroad.\(^886\)

**Ferrets can transmit zoonoses to humans and present a higher risk of disease relative to other common pets.**

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**Additional Resources:**


humans. Pseudomonas luteola, a bacterial infection causing respiratory disease and abscess formation, Hepatitis E, and rabies are other examples of zoonotic diseases that have been reported in ferrets in the United States. Ferrets can also carry other bacteria such as Campylobacter and Salmonella and parasites such as Giardia and Cryptosporidia in their intestinal tract and spread them to people who clean their cages and litter boxes. Ferrets are regulated entirely at the state level with wide variation among states. Some states impose no regulation at all, while roughly fifteen other states require rabies vaccination and four require permits for possession or sale.

22. Guinea Pig Farming

Guinea pigs are farmed in the United States to supply the pet trade, research laboratories, and exotic meat markets. The animals are regulated differently depending on their use designation. Guinea pig meat is more commonly consumed in South America where it is known as “cuy” or “cavy.” However, it is also available in the United States in both grocery stores and restaurants, particularly those in Latin American communities in California, Florida, New Jersey, and New York. Guinea pigs can be quite profitable as a farmed animal, as they require much less room than traditional livestock and they reproduce extremely quickly. They are typically kept in a hutch or pen with wire siding and straw bedding. Animals are housed together with many others and enclosures are usually placed next to one another. Producers may raise 1,000 or more animals at a time. Because of the close confinement and sheer number of animals housed together, these operations have the potential to spread pathogens quickly among animals. USDA records indicate that these facilities do not always provide adequate welfare, with some facilities lacking sanitation while others were cleaned only once a year. Sick or dead animals may be stored alongside live ones and, given the sheer number of animals kept at larger production operations, go unnoticed.

In the United States, guinea pig is considered an exotic meat. This designation carries regulatory implications. As a “non-amenable species,” guinea pig meat is not subject to USDA inspection and falls instead under the jurisdiction of the FDA.\[897\] However, where guinea pigs are considered pets or raised for research purposes, the USDA does have jurisdiction under the Animal Welfare Act. Breeders who derive over $500 in gross income from the sale of guinea pigs in any calendar year are generally required to have a USDA license.\[898\] Yet, many breeders do not obtain a license, in part because USDA APHIS does not closely monitor this industry.\[899\]

Guinea pigs have not been associated with severe disease outbreaks in the United States; however, they have been linked to multistate outbreaks of salmonellosis contracted from animals sold at pet stores.\[900\] Lymphocytic Choriomeningitis Virus (LCMV) and Leptospirosis can be transmitted from guinea pigs to humans, though cases are extremely rare.\[901\] These diseases are usually transmitted to humans through contact with infected feces or urine.

### 23. Rabbit Farming

Rabbits in the United States are raised for meat, wool, fur, and breeding stock as well as for sale as pets and for laboratory use. Youth programs such as 4-H often raise rabbits, and the animals are common classroom pets. There are over 4,000 rabbit farms in the United States that sell approximately 500,000 rabbits each year.\[904\] Rabbit meat was a popular choice in the United States before the increase of beef consumption in the 1960s; however, rabbit meat has experienced a slight rebound in recent years.

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897. Some states such as California prohibit the selling of any animal carcass for food that is commonly kept as a pet, but these laws have not yet been tested with respect to guinea pigs.


Rabbits are kept in wire cages called “hutches” which are usually stacked at least two rows deep. Rabbits can start breeding as early as six or seven months of age. Given their relatively quick breeding cycle and large litter sizes (up to 12), one doe can be expected to wean up to 60 rabbits a year.\textsuperscript{905} When slaughtered on site at a rabbit farm, the rabbits are killed either by dislocating the neck or with a forceful blow to the skull behind the ears. To prepare a rabbit for consumption, the animal is hung by its back legs and bled by cutting off the head.\textsuperscript{906}

Because rabbits sold for meat are classified as “non-amenable species,” they are exempt from USDA regulations governing slaughter of livestock.\textsuperscript{907} As a result, producers generally need only comply with state or local health codes to sell within their state, though the FDA regulates interstate sales.\textsuperscript{908,909} Most states require a license to process rabbits for human consumption, though some provide licenses without regular physical inspection of facilities.\textsuperscript{910} By contrast, rabbits raised for pets or research are governed by the USDA under the Animal Welfare Act whereby the facilities are subject to physical inspection.

When disease occurs in rabbit farms, it is often attributable in part to poor care and management.\textsuperscript{911} Pathogens can spread quickly given the number of animals, level of confinement, and limited air flow. Depending on husbandry practices, there also may be potential opportunities for crossover between wild and domestic rabbits. It is not uncommon for rabbits to be raised along with other species, increasing possible sources for disease exposure. Rabbits can transmit pathogens through bites and scratches (such as pasteurellosis), skin-to-skin contact (such as ringworm), contact or accidental ingestion of fecal material from infected animals (such as cryptosporidiosis), and through

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aerosolization and inhalation of pathogens in contaminated soil (such as mycobacteriosis). Tularemia or “rabbit fever” is one disease of particular concern that can cause a range of symptoms from ulcers to pneumonia and can be fatal in humans if not diagnosed. Tularemia is highly contagious—so much so that the CDC considers it a potential target for bioweapon producers. It has been reported in every state except Hawaii. The United States sees roughly 200 human cases a year, mostly from wild rabbits. However, this number could increase exponentially if large populations of captive rabbits were to become infected.

24. Ratites: Ostrich and Emu Farming

Weighing up to 450 pounds and standing up to eight feet tall, the ostrich is the world’s largest bird, followed by the emu. Both are members of a diverse group of flightless birds known as ratites. Ostrich and emu farming regained popularity in the 1990s as a way to diversify farming opportunities, particularly in the eastern United States. These operations produce meat, eggs, oils, and other products. According to the 2017 Census of Agriculture, there are 212 ostrich farms and 1,535 emu farms in the United States, with most of these birds in Texas and California. Since 2001, ratites have been subject to the requirements of the Poultry Products Inspection Act (PPIA), but farms slaughtering fewer than 1,000 birds per year and selling within the state are exempt from PPIA inspection requirements. However, in order to sell ratite meat across state lines, birds must be slaughtered in a federally inspected meat processing plant.

There is a lack of data regarding diseases carried by ostriches and emus, and many tests commonly performed on poultry remain unvalidated for use on this unique group of birds. However, avian influenza viruses (AIVs) have been found in emus on farms in Texas and California. While that has not

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yet been the case for ostriches in the United States, there are numerous reports of AIV in ostriches in Europe, Asia, and Africa.921 922

25. Turtle Farming

Turtles have been raised in the United States as pets, for food, and for traditional medicine. In 1975, the FDA banned interstate trade of small turtles under four inches in length to help prevent the spread of salmonellosis, with exceptions to allow farmers to sell turtles within the country for educational, scientific, exhibition purposes, and for export.923 924 This restriction remains in place, though exports and sales of larger turtles continue, many of whom also carry Salmonella.925 926 The United States exported an estimated 17 million turtles from 2012 to 2016 (of which 16 million went through Louisiana).927 While there is limited data as to the animals’ origins, it is likely that many came from captive farms. Historically, the majority of U.S. turtle exports were shipped to Asia for human consumption; today, exports are down nearly 70% from a decade prior, mostly due to a decrease in prices of domestic turtle hatchlings in Asia.928

Most turtle farming takes place in the southeastern United States, with Louisiana leading all states in production volumes. There are reports of live soft-shelled turtles being offered for sale in food markets in many states including California, Louisiana, Florida, Pennsylvania, Minnesota, and New York, while turtle soup remains a fixture on menus across the Southeast.929 930 931

Very little has been published on methods of turtle farming in the United States; however, one study of a Louisiana farm outlines the process. The farm used artificial ponds enclosed by sand
beaches stocked with turtles at a high density of 12,500 turtles per hectare (equivalent to about two and a half football fields) or more than eight turtles per square foot. As turtle eggs are deposited in the sand, workers remove them to be incubated indoors. Farms may sell both hatchlings and yearlings. Hatchlings (newborn turtles) are exported or sold illegally in the United States, often through unmonitored websites. Other young turtles are moved to indoor ponds for a year, whereupon they are large enough to be sold legally through the domestic pet market. A turtle farm may sell about 325,000 new hatchlings and 55,000 yearlings annually.

People can pick up pathogens from turtles by touching them, their water, supplies, or areas where they live; turtles can appear healthy but still carry disease. The most common zoonotic disease found in turtles is salmonellosis, which is often present on turtle skin as well as the surface of their shell. Human infection occurs through direct contact with turtles or their droppings, infected tank water, or habitat. Transmission from turtles is common. For example, in 2020, the CDC reported that 26 people across 14 states were infected in one such outbreak of salmonellosis obtained from pet store turtles. Though many reptiles carry Salmonella, turtles are perhaps the most likely to be handled by small children, for whom the infection can be more severe.

Animal Markets and Zoonotic Disease in the United States
A number of animals in the United States are bred and maintained for human entertainment or for research purposes. The use of animals in entertainment takes a myriad of forms from circuses and rodeos, to zoos and marine parks, to activities such as livestock fairs and animal races, and other hands-on experiences with animals. In recent years, social media has been flooded with photos and videos of animals creating new genres of content and new forms of demand. Direct human-animal interaction is a hallmark of many of the industries that use animals as entertainment, including aquarium touch tanks, drive-through petting zoos, bull riding, and dolphin encounters. In this section, we discuss a range of markets where people pay a fee to interact with animals, observe animals, exhibit animals, or compete with animals. In addition, we examine the use of animals in research, where animals are employed to advance other human goals.
26. Roadside Zoos

Roadside zoos are collections of animals held in confinement for display to paying visitors. Roadside zoos do not meet the same animal care standards as zoos accredited by AZA (Association of Zoos and Aquariums). Animals at roadside zoos are often held in cages or small makeshift enclosures. Tigers, for example, may be held on a concrete slab with a kiddy pool, while younger animals might be kept in a dog crate. Many if not most roadside zoos allow for direct contact between animals and the public. Visitors pay to touch, feed, or play with the animals, in particular baby animals. These activities are especially popular with children, who may take fewer sanitary precautions to mitigate zoonotic risk. Unlike sanctuaries, roadside zoos may breed and sell animals for commercial purposes.

Thousands of these operations dot the American countryside, where many advertise on billboards to attract passing motorists. Today some take the form of traveling exhibitions where operators bring animals to fairs, parties, and promotional events. The precise number of roadside zoos is not known as many may operate informally without a license. While historically these facilities were stocked with farm animals and native wildlife, many roadside zoos today supply a wide range of exotic species for entertainment. In 2020, roadside zoos were thrust into the spotlight with the premiere of the Netflix series, Tiger King, which focused on one such establishment that was involved in the cub petting industry and big cat trade more generally. In light of growing public concern about such practices, many roadside zoos have become increasingly wary of negative publicity, with some going so far as to prohibit recording and require visitors to sign non-disclosure agreements prior to entry.


940. The two can be difficult to distinguish, and some roadside zoos present themselves as sanctuaries.

Roadside zoos combine a myriad of risk factors making them ripe environments for zoonotic transmission. These operations are often marked by substandard animal care, including poor nutrition, health, and housing, all of which lead to chronic stress, weaker immune systems, and an increased likelihood of disease. Multiple species held in close confinement further augments the risk. At the same time, roadside zoos offer the opportunity for intimate human-animal interactions, the kind that give rise to disease transmission, in a landscape that is both lacking in sanitation and largely devoid of regulation.

Disease exposure at roadside zoos can occur anytime there is direct contact between animals and the public, for example, through touching, holding, or feeding an animal, as well as by being licked, bitten, or scratched.\textsuperscript{942} In addition, indirect transmission can also occur through inhaling airborne pathogens or interacting with pathogens in the animal’s food, water, or environment.\textsuperscript{943} In such cases, a child might infect herself by picking up contaminated hay in an animal’s pen then touching her face, for example.\textsuperscript{944} Roadside petting zoos have been linked to numerous zoonotic outbreaks in the United States, including bacterial infections caused by \textit{Escherichia coli}, \textit{Salmonella}, \textit{Coxiella burnetii}, \textit{Cryptosporidium}, \textit{Giardia}, \textit{Campylobacter}, and a variety of viruses, as well as fungal infections.\textsuperscript{945, 946} Exposure to \textit{E. coli}, for example, can cause bloody diarrhea, anemia, or neurological impairments such as seizures or strokes, and children have been hospitalized and died as a result of such exposure at roadside zoos.\textsuperscript{947}

The risk of disease spread is fueled in part by the number of visitors that each animal might interact with daily as well as the frequency with which animals move through these operations. For instance, one bear cub, who was infected with rabies, was used in a roadside zoo and was found to have interacted with 400 people across 10 states in the one month before he died.\textsuperscript{948} These risks are amplified by the fact that many of

\textsuperscript{942} For example, the Austin Aquarium, a for-profit zoo in Texas which allows guests to touch and interact with animals, has received several citations from the USDA after children were bitten while handling primates, including lemurs, as well as a kinkajou. A pending complaint, filed with the Federal Trade Commission, alleges that over the course of a four month investigation there were 34 incidents in which guests or employees were bitten, scratched, or injured. “People for the Ethical Treatment of Animals, Petitioner v. Austin Aquarium, LLC, Respondent,” Complaint to the Federal Trade Commission, December 5, 2022, https://www.peta.org/wp-content/uploads/2022/12/2022-12-05-federal-trade-commission-austin-aquarium-complaint.pdf.


\textsuperscript{946} “Compendium of Measures to Prevent Disease Associated with Animals in Public Settings,” CDC MMWR, 2009, https://www.cdc.gov/mmwr/preview/mmwrhtml/mmwrhtml/sr5805a1.htm.


the operators and animal handlers who staff roadside zoos are inexperienced and uninformed about disease risk and animal husbandry.\textsuperscript{949} The Animal Welfare Act is the only piece of federal legislation aimed at regulating animal exhibitors.\textsuperscript{950} However, the law protects only a fraction of the species displayed at roadside zoos, exempting large categories of reptiles, amphibians, fish, birds, and invertebrates.\textsuperscript{951, 952} In addition, the Act only includes specific requirements for certain species but not others, while the Act’s general requirements are considered minimal.\textsuperscript{953} Compliance with the AWA is limited at best. Historically, as many as 60\% of USDA inspections found violations that resulted in citations—violations that are reported on a USDA inspection report.\textsuperscript{954} If a violation is particularly serious and/or it has not been remedied within 90 days, an official warning letter will be issued. If the violations are still not remedied, fines and a loss of license can result.\textsuperscript{955} Fines by the USDA under the Animal Welfare Act generally amount to no more than a few thousand dollars, however, and often do not serve as any practical deterrent. The Office of the Inspector General of the USDA has found that the USDA frequently issues penalties on the low end of the acceptable range as prescribed and has stated: “Dealers and other facilities had little incentive to comply with AWA because monetary penalties were, in some cases, arbitrarily reduced and were often so low that violators regarded them as a cost of business.”\textsuperscript{956} Many roadside zoos charge $50 or more for visitors to take photos with exotic animals and hundreds more for “play sessions” and other hands-on experiences. A single tiger cub may bring in $3,000 a day or more in profit, enough to make any fines from inspections trivial.\textsuperscript{957}


\textsuperscript{950} In recent years, the Endangered Species Act has been applied to certain captive species of conservation concern.


\textsuperscript{952} In 2000, the Congress directed the USDA to include birds, not bred for research, within the scope of the AWA and to promulgate rules to this effect. However, twenty years later, the agency has yet to do so, though this may soon change with a 2020 court order. Case No. 1:18-cv-01138 (TNM) American Anti-Vivisection Society v USDA, Filed May 26, 2020, https://thebrooksinstitute.org/sites/default/files/article/2020-06/AAVS%20Order%20-%202020-06-08%20Digest%20Issue%2030%20p%20304.pdf.


In addition, Animal Welfare Act enforcement has steeply declined beginning in 2015.\textsuperscript{958} In the years since, enforcement actions have fallen by 90%.\textsuperscript{959} Under a new strategic guidance, the USDA sought to prioritize commercial interests of animal enterprises and “minimize costs” associated with violations of the law.\textsuperscript{960} Some inspectors have suggested that, in recent years, they were directed to overlook non-compliance and avoid issuing citations.\textsuperscript{961} The change in directives culminated in what one former USDA assistant director dubbed “a systematic dismantling of [the] animal welfare inspection process and enforcement.”\textsuperscript{962}

### Animal Welfare Act: Enforcement Trends Since 2015

- **Enforcement Actions Decline by 90%**
- **Warnings Drop by 99%**
- **18% of Inspectors Resign in 12 Months**

#### 27. Livestock Fairs

State and county fairs as well as other forms of animal exhibitions such as “jackpot” shows are held across the country, often during the summer months and most commonly in the Midwest.\textsuperscript{963} The Minnesota State Fair, for example, draws more than 2,000,000 visitors annually, more than 35% of the state’s population.\textsuperscript{964} While fairs offer a range of activities from carnival games to vegetable growing contests, the presence of livestock animals is a hallmark of these events.\textsuperscript{965} Most fairs feature the exhibition of livestock often in contests, displays, and petting zoos.

#### Disease Risk Associated with Livestock Fairs

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<tr>
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<td>Medium</td>
<td>Low</td>
<td>Negligible</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>

\textsuperscript{958} Enforcement rates have increased some since their low point in 2016, but it is still meaningfully uninforced.


\textsuperscript{963} A jackpot show is one in which the entry fees are used to pay the judges, award cash prizes, and cover other show costs.


\textsuperscript{965} Some animals are touched only by their handlers, while others are available to the public or used in hands-on demonstrations, such as milking a cow.
Agricultural fairs can create an ideal environment for disease spread, with hundreds or thousands of animals brought together from different owners across the state. Still, the majority of exhibitors report that they do not disinfect pens or shared equipment that their animals use when attending these shows.966 Fairs allow pathogens opportunities to move from livestock to humans through close interaction with visitors, owners, and various youth groups who raise animals for the fair, such as 4-H or Future Farmers of America. Fairs are almost never limited to one species of animal, which presents additional opportunities for the spread of viruses. Perhaps the most dangerous of these combinations is poultry and swine, as pigs are susceptible to many forms of avian influenza and provide an ideal mixing vessel for the creation of novel strains of influenza virus.967 Over the last decade, following the 2009 H1N1 swine flu epidemic, the United States has recorded the highest number of swine-origin influenza infections of any country in the world.968 The vast majority of these infections occurred in youth swine exhibitors at state and county fairs.969 Roughly 18% of swine at county fairs test positive for influenza A.970

These findings are particularly troubling because influenza A is a single-strand RNA virus that carries “pandemic potential,” in that it may have the ability to spread easily from person to person.971 Outbreaks of such viruses through agricultural fairs may disproportionately affect children. Take, for example, the H3N2v strain, which spread across hundreds of people in 10 states with suspected person-to-person transmission: 93% of those infected had contact with swine at an agricultural fair and the median patient age was just seven years old.972 This outbreak led to scores of hospitalizations and, in one instance, death. Still, animal fairs remain largely unregulated—exempt from federal regulation including the Animal Welfare Act.973 After a fair, some animals go home or are sent to auction, while many others continue to another fair as part of a larger circuit, as infection rates build throughout the season.974

28. Petting Zoos

Other types of animal fairs, such as petting zoos, are usually geared toward children. Petting zoos are enclosures containing tame animals often including species such as sheep, goats, pigs, alpacas, ducks, chicken, and ponies for individuals to touch, interact with, and feed. Some petting zoos also include a wide range of exotic species. Typically, food pellets are sold for patrons to hand-feed to the animals. Petting zoos may be part of a larger fair or formal zoo, but many are standalone or traveling operations.
Petting zoos can be fertile grounds for zoonotic disease transmission, particularly of bacterial infections caused by *E. coli*, *Salmonella*, *Cryptosporidium*, *Giardia*, and *Campylobacter.* Most commonly, transmission occurs through the fecal/oral route as children become infected either through contact with the animals themselves, with the animal’s environment, or other contaminated surfaces. Past studies have shown a correlation between children falling down or sitting on the ground in petting zoos and zoonotic illness. Similarly, *E.coli* can sometimes be found on shoes, strollers, toys, and pacifiers after visiting a petting zoo, while other pathogens may remain in the environment for months or even years.

Several risk factors increase the likelihood of disease transmission at petting zoos. Animals are more likely to shed higher levels of pathogens due to stress caused by transportation, confinement, and handling. Housing multiple animals and multiple species together in a small space allows pathogens to spread more easily, particularly among young animals with limited immune systems.

Human behavior at petting zoos also amplifies zoonotic risk. For example, one study found that 74% of visitors had direct contact with animals while 87% had contact with contaminated surfaces in animal enclosures. In addition, 49% of visitors touched their face and 22% ate or drank while in the animal area. However, afterwards, just over a third of visitors washed or sanitized their hands. These statistics are particularly troubling because, in the same study, 63% of environmental samples taken at six different petting zoo sites involved in the study tested positive for *Salmonella*, and 6% were positive for *E. coli*. The CDC cautions that children under five and pregnant women are at highest risk for serious infections and should follow strict precautions if attending petting zoos.

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However, beyond these suggested guidelines for visitors, regulation surrounding petting zoos is lax. The CDC notes that “no federal laws exist that address this public health issue” and found that of the 44 states that responded to a national survey, “none had laws to control exposure of humans to pathogens at venues where the public has access to farm animals.” While bacterial infections commonly found at petting zoos pose serious, sometimes fatal, health risks to visitors, they do not carry “pandemic potential” and are unlikely to spread easily person to person.

29. Rodeos

Rodeos, another form of animal-based entertainment, typically include some combination of bull riding, bronco riding, steer wrestling, calf roping, and team roping done for sport and prize money. They can be stand alone events or put on as part of a larger state or country fair. Animals traditionally used in rodeos include cows and horses as well as other livestock. Rodeos are most common in the American West and Southwest. The largest rodeo in the world takes place annually in Houston, Texas and attracts more than two million visitors over the course of the 20-day annual event. More than 600 smaller events take place in the United States each year, including the Angola Prison Rodeo where the inmates participate in a number of different competitions including trying to capture a poker chip tied to a bull. Rodeos have been criticized by some as cruel; still, they remain a cultural tradition in many parts of the United States.

Disease Risk Associated with Rodeos

<table>
<thead>
<tr>
<th>Pathogen Danger</th>
<th>Intensity of Confinement</th>
<th>Animal Health</th>
<th>Mixing of Species</th>
<th>Supply Chain</th>
<th>Biosecurity</th>
<th>Human Exposure</th>
<th>Transparency</th>
<th>Regulatory Oversight</th>
<th>Market Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
</tr>
</tbody>
</table>

984. Though petting zoos are required to be licensed under the AWA, many temporary exhibits operate without one.
Rodeo animals carry a range of bacterial, fungal, and viral diseases. For example, feral pigs, which are often chased and tackled in rodeo events, have been shown to carry Brucellosis, Leptospirosis, Salmonellosis, tularemia, influenza A, and vesicular stomatitis, all of which are transmissible to humans. Zoonotic transmission can occur when rodeo participants come into contact with animals’ blood or other fluids, either during competitions, where injuries are common, or while animals are prepared for transport to slaughter. However, much of the zoonotic risk from these events stems from a lack of sanitation. Visitors may touch and interact with a range of livestock species without washing their hands. Often finger food such as hot dogs or cotton candy is sold near animal petting stations. Children, particularly young children, who may put their hands in their mouth, are at greatest risk.

The federal government does not regulate rodeos. While the Animal Welfare Act generally covers livestock used for entertainment, the law specifically exempts rodeos and exhibitions of agricultural animals. States have been reluctant to regulate rodeos for either human or animal protection in part because of their cultural status.

30. Animal Fighting

Though animal fighting is illegal in the United States, it is estimated that tens of thousands of people are still actively involved in the practice. The most common forms of fighting involve dogs, roosters (known as cockfighting), and, less commonly, pigs. The USDA notes that “a substantial component of backyard poultry is made up by the gamefowl (cockfighting) industry” estimating that nationally this industry may comprise some eight to 24 million birds, though assessing the true size of the industry is extremely difficult given its illicit nature. Online connections have made it easier for fighters to share information about fights while avoiding law enforcement.

Animal fights are formal or informal events where two or more animals are trained or driven to attack one another at the behest of their owners. Oftentimes, the fights last until one animal is dead or unable to continue. Animal fighting in the United States is largely limited to dogs and roosters, but sometimes pigs are also included in fights. In a “hog-dog fight,” one or more dogs are provoked to fight

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a wild boar or pig. It is suggested that hog-dog fights regularly occur in 10 southern states. In the case of cockfighting, steel razor blades or “gaffs” are tied to the birds’ legs to make the fights more lethal. Cockfighting is particularly prevalent in the Appalachian communities as well as Hispanic communities from California to Texas and across the South. Cockfighting is also prevalent in Hawaii. Many individuals involved in fighting breed and maintain a stock of animals at their residence.

Dog fighting and cockfighting have both been outlawed in all 50 states as well as at the federal level. However, legal loopholes and enforcement challenges continue to undermine these laws’ effectiveness. Due to the clandestine nature of the activity, these events are notoriously difficult to monitor, as they often occur on large tracts of private land. Though animal fighting is a relatively small market, it may convey significant zoonotic risk to those individuals involved in the practice because they are directly exposed to blood and other fluids. Participants regularly handle injured animals or animal carcasses and, without proper sanitation, could easily become infected with any pathogens that the animal carried. Cockfighting operations in particular may allow for the transmission of avian influenza and other highly contagious diseases. These concerns are augmented by a distinct lack of veterinary care and transparency. It was not until the 2002-2003 outbreak of Newcastle disease that the cockfighting industry and its movements came to be better understood by regulators. At the time, the industry was estimated to be worth $50 million in California alone and used a sophisticated system to transport birds illegally despite the state and federal quarantines in place.


997. The cockfighting season operates primarily from Thanksgiving through July.

998. Hal Herzog, Some We Love, Some We Hate, Some We Eat (New York: HarperCollins, 2010).


1001. Hal Herzog, Some We Love, Some We Hate, Some We Eat (New York: HarperCollins, 2010).


1003. These laws are difficult to enforce for a number of reasons. First, simply owning a large number of animals (such as roosters) is not a crime. And to obtain convictions in such cases, offenders must be caught in the act of fighting or have similarly strong evidence tying them to the crime itself. Fights often occur in clandestine locations that are not visible to the public or accessible to law enforcement without a warrant. In the case of cockfighting especially, fights often occur in rural remote areas on large tracts of private land making it difficult to monitor and nearly impossible to enforce the laws without inside information.


1007. Dogs rescued during dogfight investigations have been found to carry a broad range of parasites (including Babesia gibsoni and heartworm), in part because they lacked access to veterinary care; however, these particular parasitic diseases are not zoonotic in nature. S.H. Cannon, J.K. Levy, S.K. Kirk, P.C. Crawford, et al., “Infectious Diseases in Dogs Rescued During Dogfighting Investigations,” Veterinary Journal 211 (May 2016): 64–69, https://doi.org/10.1016/j.tvjl.2016.02.012.

31. Animal Racing

Horse and greyhound racing were once popular events in the United States, though both have experienced a significant decline in recent years. There are approximately 100 horse racetracks of varying size across the United States. These racetracks generate over $3 billion in revenue annually and employ over 16,000 people. This figure, however, does not include the roughly $11 billion wagered on horse races each year. An estimated 1.3 million horses are kept for racing, though not all of these animals make it to the track. Somewhere around 1,000 of these horses die annually from race-related activities.

Greyhound racing, by comparison, is a dramatically smaller industry with only 2,000 dogs racing at four tracks in 2020.

Horses may live for up to 30 years, but they typically race for no more than four. This excess supply of horses, who can no longer compete, has meant that horses bred for the racing industry are sometimes slaughtered for human or animal consumption. Though the use of horses for meat production is, for all practical purposes, illegal in the United States, operators circumvent the ban by shipping the horses out of the country to Canada or Mexico for slaughter.

Horses sold at livestock auctions in the United States sometimes end up at slaughter, and certain auctions are organized for the purpose of selling horses to buyers who drive the horses in trailers to Canada or Mexico where such slaughter is legal. It is estimated that from 2008 to 2018 an average of about 130,000 horses were exported annually for meat production.

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Disease Risk Associated with Animal Racing

<table>
<thead>
<tr>
<th>Pathogens Present</th>
<th>Vaccination of Animals</th>
<th>Animal Health</th>
<th>Mixing of Species</th>
<th>Supply Chain</th>
<th>Biosecurity</th>
<th>Human Exposure</th>
<th>Transparency</th>
<th>Regulatory Oversight</th>
<th>Market Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Yes</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Medium</td>
<td>No</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Low</td>
<td>No</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Negligible</td>
<td>No</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

It is estimated that from 2008 to 2018 an average of about 130,000 horses were exported annually for meat production.

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1012. In April and May 2023, 12 horses died at Churchill Downs in Kentucky, including two the week of the Kentucky Derby. Investigators are still trying to determine the causes of these deaths, but many believe trainers are incentivized (by purse winnings, betting protocols, etc) to race unhealthy horses, which may have had some impact on these deaths. Joe Drape, “Churchill Downs to Cease Racing as It Investigates Deaths of Horses,” The New York Times, June 2, 2023, https://www.nytimes.com/2023/06/02/sports/horse-racing/churchill-downs-deaths-horseracing.html.
1015. All meat products processed for sale across state lines must be inspected by the USDA, and a congressional ban on USDA funding for horse meat inspections was one of the primary reasons that all remaining horse slaughter facilities closed after 2011. The ban has since been lifted, but there have been no new requests for inspections. Phil Derfler, “Setting the Record Straight on Congress’ Lifting of the Ban on Horse Slaughter,” USDA Food Safety and Inspection Service, February 21, 2017, https://www.usda.gov/media/blog/2011/12/03/setting-record-straight-congress-lifting-ban-horse-slaughter.
While the horseracing industry has given rise to zoonotic outbreaks overseas, in particular Hendra virus, which caused the death of horse owners, trainers, and veterinarians in Australia, the zoonotic risk from animal racing is relatively low.\textsuperscript{1017} \textsuperscript{1018} Horses can be vectors for zoonotic diseases such as glanders, rabies, brucellosis, and leptospirosis.\textsuperscript{1019} \textsuperscript{1020} Still, these diseases require close contact, making veterinarians, trainers, jockeys, and stable hands the most at-risk groups for equine-human transmission.\textsuperscript{1021}

Historically, neither horse nor dog racing were federally regulated.\textsuperscript{1022} But in 2020, Congress passed the Horseracing Integrity and Safety Act, a law that primarily targets doping on the part of the horse racing industry. Seven states have banned all betting on horse races (both in person and online), and 42 states have outlawed greyhound racing.\textsuperscript{1023} \textsuperscript{1024}

32. Animals in Circuses

Animals in circuses are trained to perform tricks or stunts for paying audiences. After Ringling Brothers closed in 2017, many other circuses followed suit, as states and major cities took steps to ban the use of certain animal training tools and wild animals, in particular elephants, in traveling acts.\textsuperscript{1025} \textsuperscript{1026} There are still circuses in business today that travel around the United States with captive wildlife.\textsuperscript{1027}

Disease Risk Associated with Animals in Circuses

- Pathogens: High
- Intensity of Confinement: Medium
- Animal Health: High
- Mixing of Species: Medium
- Supply Chain: Low
- Biosecurity: Negligible
- Human Exposure: Negligible
- Transparency: Negligible
- Regulatory Oversight: Negligible
- Market Scale: Negligible

1025. These bans are enacted by prohibiting the use of bullhooks, a long pole with a sharp hook on the end that circuses rely on to control and punish elephants. “Bans on Circuses,” FOUR PAWS in US, accessed May 31, 2023, https://www.four-paws.us/campaigns-topics/topics/wild-animals/worldwide-circus-bans.
Circuses have frequently given rise to animal-induced injuries, but the risk level of zoonotic transmission is relatively low, particularly given how few circuses involving animals exist today. Still, there is risk. Circuses frequently include multiple species and entail close animal interaction with trainers. The transport process may also carry risks. Pathogens such as Tuberculosis (TB) have been transmitted from circus elephants to humans.

USDA APHIS regulates circuses under the Animal Welfare Act. However, apart from USDA inspections that happen on an irregular basis (though mandated at least once a year), circuses operate with little federal oversight. As of May 2023, on the local level, over 150 jurisdictions across 37 states had imposed full or partial bans on using wild animals in circuses.

33. Animals in Film and Media

Animal use in movies, television, and advertisements have become increasingly commonplace in recent years. Species both wild and domestic are kept for the purpose of performing. While the relative zoonotic risk posed by animals used in film is limited due to the industry’s small size, owners and trainers, who often live and work closely with the animals, may still have significant disease exposure, in particular those who interact with multiple species or high-risk species.

Of larger scale and concern is the growing space of social media, where content involving animals is an immensely popular genre. Posts involving animals have been found to have higher levels of engagement, driving “likes” and, ultimately, demand for animals through other types of animal markets, in particular the exotic pet trade. Social media can also foster misperceptions about animals and encourage human-animal interactions that may be dangerous and carry zoonotic risks. Videos of wildlife and exotic animals touching, licking, biting, and playing with humans are commonplace on many of
these forums and serve to normalize these types of interactions among the general public. Whole industries cater to serve this demand. For example, staged wildlife photography operations allow customers to select an animal to photograph from a menu of options. Handlers bring the animal from its cage to a large enclosure where customers can photograph the animal as if it was in the wild, sometimes paying hundreds of dollars for a single session with species such as clouded leopards or mountain lions.

Social media sites such as Facebook, TikTok, and YouTube have committed to removing flagged content that violates platform guidelines, which could be construed to include content such as misleading animal videos or depictions linked to the illegal wildlife trade. However, none have gone so far as to enforce bans on such content and any monitoring that does occur has historically been ad hoc and arbitrary. Technology that can effectively scan and identify problematic content is already in use in other fields.

While no federal or state guidelines specifically target the use of animals in film, several laws, including the Animal Welfare Act and the Endangered Species Act at the federal level as well as state cruelty laws, apply to various extents. The industry-based American Humane Association has guidelines to protect animals in film, but adherence to these guidelines is purely voluntary and their effectiveness has been questioned as the majority of harmful animal-human interactions may occur offscreen during training.

34. Large Zoos and Aquariums

Large zoos and aquariums are found throughout the United States and marked by the presence of permanent enclosures with a wide variety of species types held for public viewing. Just under 240 of these facilities are accredited by the Association of Zoos and Aquariums (AZA). Combined, they attract 200 million visitors annually. However, a far greater number of institutions, such as Niabi Zoo in Illinois, the shopping mall aquarium chain SeaQuest, and Salisbury Zoo in Maryland, are not accredited by the AZA.

### References


Many zoos that do not meet the qualifications for AZA accreditation will obtain a certification from the Zoological Association of America (ZAA) or another organization with less demanding standards. Non-AZA accredited zoos outnumber accredited AZA zoos almost 10 to one.\textsuperscript{1042,1043} Despite the similarity in name between the Association of Zoos and Aquariums (AZA) and the Zoological Association of America (ZAA), which confuses many members of the public, the AZA differs markedly from the ZAA in that it imposes far stricter guidelines for safety as well as animal care.\textsuperscript{1044} Because the Animal Welfare Act is the only federal law governing most zoo animals, voluntary membership and accreditation programs like the Association of Zoos and Aquariums are used to fill this regulatory gap. Other accreditation programs like the ZAA have been criticized for offering no more than a rubber stamp, intended to lend legitimacy to its members while requiring very little of them.\textsuperscript{1045,1046}

Zoos source the vast majority of their animals from other zoos and captive breeders. Animals may be transported or housed with other animals of the same or different species, and throughout their lives, interact closely with their human keepers. Zookeepers are responsible for a range of animal care activities from feeding to cleaning cages to handling and transporting animals, each of which offer opportunities for zoonotic disease transmission. In addition, animals may interact with other species of captive wildlife as well as free-roaming animals such as wild birds. Zookeepers, equipment, and other resources may be shared among different species and exhibitions, increasing the potential for interspecies spread. Unwanted zoo animals are sometimes sold to other zoos or sold to private individuals, captive hunting ranches, or are, on occasion, killed.\textsuperscript{1047,1048,1049,1050}

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|c|}
\hline
\textbf{Pathogen Risk} & \textbf{Infectivity of Containment} & \textbf{Animal Health} & \textbf{Mingling of Species} & \textbf{Supply Chain} \\
\hline
High & High & High & High & High \\
\hline
Medium & Medium & Medium & Medium & Medium \\
\hline
Low & Low & Low & Low & Low \\
\hline
Negligible & Negligible & Negligible & Negligible & Negligible \\
\hline
\end{tabular}
\caption{Disease Risk Associated with Large Zoos and Aquariums}
\end{table}

\textsuperscript{1044. “AZA vs ZAA,” Big Cat Rescue, March 11, 2022, https://biocatrescue.org/aza-vs-zaa/.}
\textsuperscript{1046. “AZA vs ZAA,” Big Cat Rescue, March 11, 2022, https://biocatrescue.org/aza-vs-zaa/.}
\textsuperscript{1047. The Conservation Game, directed by Michael Webber (Nightfly Entertainment, 2021), https://www.theconservationgame.com/watch/.}
While the range of potential zoonotic diseases that may be carried by zoo animals is seemingly infinite, the overall risk of transmission is relatively low at institutions accredited by the Association of Zoos and Aquariums, and largely limited to zookeepers, as long as the public is not allowed to interact with the animals directly.\footnote{Still, outbreaks do occur. For example, eight zookeepers and volunteers became infected with tuberculosis from elephants in one such event at the Oregon Zoo. Lynne Terry, “Oregon Zoo Staff Infected by Tuberculosis After Exposure to Infected Elephants,” The Oregonian, January 8, 2016, https://www.oregonlive.com/health/2016/01/officials_identify_tuberculosis.html.}

Zoos that are not accredited by the Association of Zoos and Aquariums, however, (including facilities that are accredited by the Zoological Association of America), present a significantly higher risk of transmission because they often allow direct interaction between the public and animals, generally have poorer conditions and animal care, and offer more limited veterinary oversight.\footnote{These risks may be amplified by improper disposal of deceased animals, with reports of zookeepers killing animals through improper methods such as drowning and disposing of animals in open garbage bins. Justin Jouvenal, “Mauling, Escapes and Abuse: 6 Small Zoos, 80 Sick or Dead Animals,” The Washington Post, September 18, 2015, https://www.washingtonpost.com/local/crime/mauling-escapes-and-abuse-6-small-zoos-80-sick-or-dead-animals/2015/09/18/dff46f10-2581-11e5-b77f-ebf3a3156983_story.html.}

Many Zoological Association of America facilities have logged dozens of Animal Welfare Act violations without losing their associated accreditation.\footnote{In addition, ZAA facilities, unlike AZA zoos, support private ownership of exotic animals.}

Indeed, there is no record of any Zoological Association of America institution ever losing this accreditation for any reason.\footnote{Rebecca L. Jodidio, “The Animal Welfare Act is Lacking: how to Update the Federal Statute to Improve Zoo Animal Welfare,” Golden Gate University Environmental Law Journal 12, No. 1 (July 2020): https://digitalcommons.law.ggu.edu/cgi/viewcontent.cgi?article=1155&context=gguelj.}

Recent outbreaks of COVID-19 among captive guerillas, snow leopards, and other zoo animals make clear the risk of reverse zoonotic transmission (from humans to animals) at zoo facilities. Transmitting a virus from humans to animals can allow it opportunities to change and develop new forms that may then be transmitted back to humans. This risk may be particularly great in zoos where humans interact closely with a vast range of different wildlife species over prolonged periods of time.\footnote{Alissa Widman Neese, “Scoop: Zoo Seeks New Accreditation, But Not Without Critics,” Axios Columbus, April 18, 2022, https://www.axios.com/local/columbus/2022/04/18/columbus-zoo-seeks-new-accreditation-zaa-criticism.html.}

35. Marine Animal Parks

Marine animal parks are commercial operations where aquatic species including marine mammals such as dolphins, beluga whales, seals, and sea lions are kept and displayed to the public through exhibits and shows.\footnote{See https://seaworld.com, https://www.sealifeparkhawaii.com, https://marineland.net, https://discoverycove.com/orlando, https://www.sixflags.com/discoverykingdom, accessed May 4, 2021.} SeaWorld, SeaLife Park Hawaii, Marineland of Florida, Discovery Cove, Miami Seaquarium, and Six Flags Discovery are examples of major marine animal parks in the United States.\footnote{Marine mammal parks are different from marine parks, which include natural reserves and marine wildlife sanctuaries such as coral reefs.}

Other marine parks such as the Dolphin Research Center employ captive ocean pens to the

Transmitting a virus from humans to animals can allow it opportunities to change and develop new forms that may then be transmitted back to humans.
same effect. Activities at these parks often include petting marine animals in touch tanks, ‘feed the dolphins’ exhibits where visitors purchase squid to feed to dolphins by hand, as well as other ‘encounter’-style activities that allow visitors to touch and swim with sea lions or dolphins.

<table>
<thead>
<tr>
<th>Pathogen Diversity</th>
<th>Intensity of Confinement</th>
<th>Animal Health</th>
<th>Mixing of Species</th>
<th>Supply Chain</th>
<th>Biodiversity</th>
<th>Human Exposure</th>
<th>Transparency</th>
<th>Regulatory Oversight</th>
<th>Market Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

Disease Risk Associated with Marine Animal Parks

Stress and poor conditions undermine animal health, weakening their immune systems and increasing mortality rates. Records show that a quarter of the sea lions, seals, dolphins, and whales kept in U.S. marine parks die before they reach the age of one; half die before they reach age seven. However, while these facilities may raise serious animal welfare concerns, especially with regard to marine mammals, zoonotic disease risk at marine animal parks is relatively low and generally limited to localized skin infections. In some cases, touch tanks and infected water can facilitate the spread of pathogens. More dangerous infections can also occur including brucellosis, tuberculosis, calicivirus, and influenza A. Employees who work at these facilities are typically at the greatest risk.

For example, roughly 11% of marine mammal workers report having contracted a bacterial infection, colloquially known as “seal finger.”

The Marine Mammal Protection Act allows dolphins and other marine animals to be captured from the wild for public display with certain conditions. National Oceanic and Atmospheric Administration (NOAA), the administrative agency that enforces the Marine Mammal Protection Act, issues permits for wild capture of marine mammals but does not require marine

animal parks to obtain a permit in order to operate. As a result, the only on-site regulation of marine animal parks themselves is carried out by the USDA via the Animal Welfare Act.

36. Animals in Research

Millions of animals are imported to U.S. laboratories every year to be used for one of three purposes: biomedical research (testing drugs and vaccines), testing consumer products (primarily cosmetics and cleaners), and education (medical and veterinary learning exercises). Millions more are bred domestically for these same purposes. Some of the species most commonly used in research include mice, rats, rabbits, pigs, guinea pigs, hamsters, dogs, and non-human primates.

Disease Risk Associated with Animals in Research

In 2018, the USDA reported that 780,070 animals were used in research facilities in the United States. However, this figure reflects only those species covered by the Animal Welfare Act. Mice, rats, fish, amphibians, reptiles, cephalopods, birds, and other animals are not included in this number. Studies suggest that between 93%-99% of the animals used in research are excluded from the protections of the AWA, which regulates only a small fraction of the estimated 11 million animals housed in research facilities around the United States. While historically sourcing animals for research purposes has been a matter of public concern, today most

Between 93%-99% of the animals used in research are excluded from the protections of the AWA.

1079. This estimate of 11 million includes only vertebrate animals. Other research offers a more conservative estimate. For example, if numbers reported from the EU are representative of US practices as well, 93% of research is conducted on species not counted under the Animal Welfare Act, the total number of vertebrates used in research in the United States would be approximately 11 million. “2019 Report on the Statistics on the Use of Animals for Scientific Purposes in the Member States of the European Union in 2015-2017,” Report from the Commission to the European Parliament and the Council, May 2, 2020, https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1581689520921&uri=CELEX:52020DC0016.
research animals that fall under USDA oversight are bred or sourced by licensed dealers as mandated by the AWA rather than through random source providers.\textsuperscript{1080, 1081} However, this does not extend to the majority of research animals, who are excluded from the Act’s coverage. In addition to the AWA, animals used in federally funded research may be subject to additional oversight from the National Institute of Health (NIH).

Perhaps in part due to the fact that animals are often kept in isolation and in part due to self-imposed protocols, instances of zoonotic disease outbreaks among animals appear quite rare in research facilities. However, the importation of wild species in particular carries exposure risk. For example, in a well-known incident from 1989, 100 monkeys who were imported by the Hazelton Research Products facility in Reston, Virginia carried a new strain of Ebola virus and infected several research workers at the facility.\textsuperscript{1082}

Additionally, several biosecurity labs in the United States carry out research focused on infectious disease wherein animals are deliberately infected or exposed to dangerous pathogens. Some of these studies have led to exposure among laboratory workers who then risk spreading these diseases to the general public.\textsuperscript{1083} The CDC requires safety protocols commensurate with pathogen risk as labs are rated from biosecurity level one to biosecurity level four (BSL-1 to BSL-4). Many of the most dangerous zoonotic pathogens may only be handled at one of a handful of BSL-4 facilities in the United States. Perhaps the most controversial type of research study is “gain of function research,” which seeks to better understand how pathogens, often animal pathogens, could be altered and made to adapt and acquire new capacities such as becoming more virulent, more transmissible, or better able to infect new hosts, often for the purposes of defending against them.\textsuperscript{1084}

Research animal transactions are regulated primarily at the federal level, but more often, they are managed through voluntary standards. The USDA administers the Animal Welfare Act’s registration requirements.\textsuperscript{1085} The USDA is also required to annually inspect each of the 1,100 or more research facilities in the United States for basic standards of veterinary care and animal husbandry including proper housing, treatment, food, and water. However, recent Freedom of Information Act filings show that since at least 2019, the USDA has

\begin{itemize}
\item \textsuperscript{1081} Arianna Pittman, “Pet Stores Aren’t the Only Issue—How Research Labs Also Fuel the Commercial Breeding Industry,” \textit{One Green Planet}, April 2021, \url{https://www.onegreenplanet.org/animalsandnature/research-labs-fuel-commercial-breeding-industry/}.
\item \textsuperscript{1082} This strain of Ebola virus, unlike prior strains, proved non-pathogenic in humans. These same monkeys were also infected with Simian hemorrhagic fever virus. P.B. Jahrling, T.W. Geisbert, E.D. Johnson, C.J. Peters, et al., “Preliminary Report: Isolation of Ebola Virus from Monkeys Imported to USA” \textit{The Lancet} 335, No. 8688 (1990): 502, \url{https://doi.org/10.1016/0140-6736(90)90737-P}.
\item \textsuperscript{1085} Research facilities are required to be registered but not licensed under the AWA. This is a critical distinction from other types of AWA-regulated facilities, with significant repercussions including that the USDA cannot take away their ability to operate. “Apply for a License or Registration,” USDA Animal and Plant Health Inspection Service, last updated April 13, 2023, \url{https://www.aphis.usda.gov/aphis/ourfocus/animalwelfare/apply/licensing-and-registration-application-packets}.
\end{itemize}
been pursuing a confidential policy of not fully inspecting certain facilities, deferring that work instead to a private organization, AAALAC International, despite the agency’s public assurances that all facilities were personally inspected by USDA inspectors. Voluntary guidelines or certification are offered by the Improved Standards for Laboratory Animals Act, a 1985 amendment of the Animal Welfare Act, the Public Health Service (PHS) Policy on the Humane Care and Use of Laboratory Animals, and the industry guiding principles of the 3 R’s—replace, reduce, and refine—that have long been a mantra to guide responsible use in animal testing. With the exception of AWA registration and regulation, however, all of these guidelines are voluntary for many research institutions.

Research animal suppliers are required to be licensed, unlike research facilities themselves, which must only be registered. Competition among research animal suppliers has pushed the industry to become more commercialized in recent years. In order to maintain their contracts with research labs, breeders typically subscribe to heightened veterinary, housing, and general care protocols, all of which may reduce the likelihood of disease, but this is not true across the board. For example, one chinchilla breeding facility supplying animals to research labs was recently cited for more than 100 alleged animal welfare violations between 2013 and 2017. More than 80 of these violations were driven by the lack of veterinary care supplied to sick and injured animals, as well as extremely poor living conditions, all of which foster disease transmission.

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1089. Research facilities that received Public Health Service funds must follow the Public Health Service Policy on Humane Care and Use of Laboratory Animals, and establish an Institutional Animal Care and Use Committee to review and approve all proposed research. “Regulation of Animal Research,” in Science, Medicine, and Animals (Washington DC: National Academies Press, 2004).
1092. A chinchilla is a small South American rodent often used to study hearing loss.
POLICY THEMES AND CHALLENGES

In the above sections we seek to analyze the risks presented by animal markets in the United States, though there are many variables involved and estimating these risks is not a precise science. In this section, we turn to the question of how the regulatory system manages or fails to manage those risks. In doing so, we move from the specific to the general to describe the regulatory landscape writ large.

Over the course of our research, we observed patterns and problems that characterize the U.S. policy response to animal markets, some of which are highlighted below in greater depth. Often these issues affect more than one of the markets mentioned above and speak to the role of institutional actors such as federal and state agencies. Taken together, they reveal the lack of a coordinated approach to addressing zoonotic disease. These challenges culminate in a system in which regulation is not always proportional to risk. The resultant landscape is one of confusion and legal gray areas, marked by underregulation and, in some cases, outright regulatory voids.

Disease risk in the United States could be radically reduced through policies that are based on a clear understanding of the markets as detailed in this study, through laws and regulations that are proportionate to risk, and through adequate implementation and enforcement. The following discussion is meant to lay the groundwork for such change by documenting the pitfalls and challenges that characterize the current U.S. regulatory response. Shining a light on these blindspots is a first step toward addressing them.

These policy challenges are loosely organized into three categories: Foundation, Design, and Function. “Foundational” challenges are those inherent to the subject matter that make the space particularly hard to regulate. By contrast, “Design” is used to describe challenges that arise from institutional, legislative, or regulatory design. Finally, “Function” captures challenges stemming from application—in particular, the ways in which agencies operate and how regulation is carried out.
POLICY THEMES AND CHALLENGES

It should be noted that these are not bright line categories—they often bleed into one another, as any such categorization is artificial and inherently messy. As a result, several of the themes identified below straddle the line between two or more of these categories. By and large, those challenges that touch upon multiple categories are among the stickiest problems and the most difficult to address.

Foundation

This group of insights describe unique foundational challenges that make the space particularly hard to regulate. They seek to answer questions such as: What makes animals and disease different from other regulatory subjects? What about those differences makes regulation more challenging?

Artificial Classifications and Assignments

Animals are often classified into artificially defined categories such as “wildlife,” “livestock,” or “companion animals” based on human use. Generally speaking, regulatory responsibility for each type of animal is divided along similar lines. The USDA primarily governs species considered “livestock” while FWS oversees “wildlife,” for example. However, these categories are inherently arbitrary and anthropocentric. They say more about humans than they do about animals. Furthermore, they oversimplify the wide spectrum of species and animal use. As a result, these classifications carry little meaning from a biological perspective as pathogens transcend these boundaries, passing easily from one category of animal to the next. To apply these same classifications to disease (treating them as “livestock diseases” or “wildlife diseases,” for example) belies a fundamental misunderstanding of the way pathogens operate and hinders our ability to contain them.1094

Too often, the result is a fractured response whereby different agencies apply incomplete strategies and narrowly circumscribe their own role in disease prevention. For example, the USDA may see some “wildlife diseases” as irrelevant or outside its responsibility, despite the fact that many such diseases may spread from “wildlife” to “livestock.” One research study documenting this paradox found that although the USDA regulators and state department of agriculture officials interviewed for the study regarded “wildlife” as the dominant source of most zoonotic diseases impacting humans and livestock, they had no working relationship with state or federal wildlife agencies. The author noted, “The gap between these two worlds seemed even wider than the gap between [livestock] and public health.”1095

Furthermore, classifications of animals are not uniform or consistent between jurisdictions. The regulatory status of animals can vary from one state to the next. In the case of the exotic pet trade, captive hunting, or big game farming, for example, species are treated differently across state lines such that the same animal may fall under the department of agriculture in one state and the department of wildlife in another and be completely unregulated in the next. These discrepancies, both with respect to what activities are regulated and

by whom, result in confusion within and across states, and undermine the effectiveness of the regulatory system as a whole. These problems are exacerbated by the fact that wild animals, and indeed pathogens themselves, do not respect human borders.

**Interconnectedness and Interplay Between Industries**

To further complicate matters, many animals change use as they move through multiple markets across intermixed supply chains. A change in use is often accompanied by a change in legal status. For example, a kangaroo at a zoo may be sold directly to a captive hunting operation and in the process change legal status from captive wildlife to livestock.

These transitions complicate regulatory enforcement and carry public health implications as well. A single animal may change hands dozens of times across multiple states and sellers with little or no documentation, while at the same time changing legal status. Should a disease outbreak occur, officials have no clear means of containment or traceable records to follow. For example, during the 2003 mpox outbreak, the CDC was able to locate less than half of the animals from the infected shipment of prairie dogs that spawned the outbreak. More than a hundred disappeared without record, presumably sold to families through swap meets, pet stores, and flea market sales. This movement can occur even within supply chains that appear self-contained. For instance, one interviewee discussed obtaining a Japanese snow macaque through the exotic pet trade that was branded with a tattoo indicating that the primate had previously been used in research.

In addition, legal and illegal trade in animals are often intertwined. There are many instances in which the same actors engage in both legal and illegal sales. For example, swap meet vendors may trade in legal species inside the venue and, at the same time, traffic in protected ones outside in the parking lot. The interconnectedness of animal supply chains makes regulating them more difficult. The legal status of the animal is not fixed but instead can be in flux as the animal moves through different markets, leading to regulation that varies over time and across the value chain.

In addition, the interplay between different forms of animal industry can heighten the risk of zoonotic disease emergence. For example, geographic proximity between poultry and swine production may increase the risk of generating a form of influenza virus that can infect humans. Pigs, who are susceptible to both avian and human influenza strains, can serve as mixing vessels to create new viruses—combining avian, human, and swine influenza viruses—or by taking avian viruses “allow them to adapt and efficiently infect mammals.”

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1097. Personal interview with retired Ohio police officer and expert on exotic pets and large cats, May 18, 2021.

1098. Alternatively, in some cases, selling the same animal intrastate may be legal while selling that animal interstate is not.


keeping 100,000 chickens can allow for significant cross contamination between the two groups of animals, as can transporting animals to and from facilities.\textsuperscript{1101} The high-volume fans needed to ventilate pig and poultry facilities can add to this risk, spreading particles and pathogens in both directions.\textsuperscript{1102} Over the last 60 years, production of both pigs and poultry has become increasingly clustered, concentrating in regions of the Midwest and Southeast and overlapping in areas like Iowa and North Carolina.\textsuperscript{1103, 1104} In these places, each form of production makes the other more dangerous. One study done in Minnesota, for example, found that turkey farms within 2 kilometers of pig facilities had eight times higher odds of influenza infection than farms that were located between 4-6 kilometers from the nearest pig facility.\textsuperscript{1105} And while USDA factsheets warn, “Do not raise pigs and domestic fowl on the same premises,” many producers do just that.\textsuperscript{1106, 1107} Though both USDA and CDC are well versed in the risks, neither imposes any regulation to separate pig and poultry operations in order to prevent the creation of new influenza viruses.

However, the interplay between different animal industries can amplify risk in other ways as well. For example, pathogens can spread as animals produced in one industry are used to feed animals in another. In an outbreak of influenza outbreak among 15,000 mink held on a Midwestern fur farm, researchers determined that the animals likely became infected when they were fed raw or partially-cooked turkey meat from birds who were carrying the virus.\textsuperscript{1108} However, laboratory analysis suggested that the strain the mink were infected with originated in swine—likely moving from a pig facility to infect nearby turkeys before the birds were slaughtered and fed to captive mink.\textsuperscript{1109} In this way, the connections and movement between different forms of animal use can increase the risk of disease spread and spillover.

\section*{Invisibility of Animal Markets}

Policymakers cannot regulate what they cannot see. Yet some of the highest-risk animal markets in the United States are largely invisible to

\begin{itemize}
\item \textsuperscript{1105} Cesar A. Corzo, Marie Gramer, Dale Lauer, Peter R. Davies, “Prevalence and Risk Factors for H1N1 and H3N2 Influenza A Virus Infections in Minnesota Turkey Premises,” Avian Diseases 56, No. 3 (2012): 488-493, \url{https://doi.org/10.1637/10037-121211-Req.1}.
\item \textsuperscript{1107} For example, a farm in Ohio raising both turkeys and pigs in buildings just twelve meters apart saw two influenza outbreaks affecting both species in consecutive years. Cesar A. Corzo, Marie Gramer, Dale Lauer and Peter R. Davies, "Prevalence and Risk Factors for H1N1 and H3N2 Influenza A Virus Infections in Minnesota Turkey Premises," Avian Diseases 56, No. 3 (2012): 488-493, \url{https://doi.org/10.1637/10037-121211-Req.1}.
\end{itemize}
the general public, regulators, or, in some cases, both. Evidence-based policy and decision-making must be grounded in data, but right now agencies lack even basic information about where, how, and why human-animal interactions are driving zoonotic risk. Agency representatives we spoke to sometimes expressed surprise to learn about the existence, extent, or practices of some of the less-visible markets cataloged here. “I am most concerned with those in-between spaces,” one CDC official told us—in particular, non-traditional farmed species. “So many of these areas fall into potential gaps in current regulation.”1110

Niche industries such as ferret farming, coyote urine production, and other forms of captive wildlife breeding operate almost completely out of sight apart from a small network of participating individuals, but these industries too may carry serious risk.

Even large markets can go mostly unnoticed by regulators. Exotic pets, for example, are sometimes known as the “animals in our basements” because they are typically held outside the view of neighbors, policymakers, and law enforcement, but together these animals constitute a $15 billion dollar industry comprising an estimated 113 million animals.1111 1112 States lack basic information about how many and what kinds of animals are held inside their borders. When COVID-19 outbreaks ravaged Wisconsin fur farms and elsewhere, in Michigan, spilled back from mink to infect humans, state public health officials had to ask for help from a fur industry trade group to find out how many farms there were in Wisconsin and where they were located. The state had no access to this information nor any means to contact operators.1113 1114 1115 1116 There is virtually no data or monitoring of the exotic pet trade, fur farming, or many other high-risk animal markets.

And yet, some of these unregulated, unseen industries are among the most dangerous. Mink farms spawned the creation of new variants of SARS-CoV-2, infecting mink farmers and threatening new outbreaks.1117 In addition, in 2022, 50,000 mink at a fur farm in Spain were destroyed after the animals became infected with H5N1 influenza, setting off fears of a new human pandemic.1118 And although entering a poultry facility, for example, often requires visitors and workers to wear a full Tyvek suit, mask, booties, and to “shower in”

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1110. Member of National Center for Emerging and Zoonotic Infectious Diseases, CDC, background interview, September 1, 2021.
and “out” of the facility, mink farms generally take no such precautions and lack even basic biosecurity measures.\footnote{1119}{1120} In researching a piece on viral spillback of disease from humans to animals, a reporter for the \textit{New York Times} interviewed mink workers in 2021, who were wearing no masks and flip-flops, standing between “ridges of mink waste” with animals in “rows of wire cages stacked waist high.”\footnote{1121} But because fur farms fall in a regulatory blindspot, neither the USDA nor USFWS tracks these operations—both claiming that these captive wildlife farms fall outside their jurisdiction.

Many industries—from livestock auctions, to swap meets, to roadside zoos—have taken steps to maintain some level of secrecy by limiting access to journalists, prohibiting photography, and, in the case of industrial animal agriculture, lobbying to criminalize such actions.\footnote{1122} This lack of visibility and lack of transparency limits public reporting and fosters the type of closed environment that allows disease to prosper. It also inhibits scientific research and disease monitoring. However, often, authorities are largely reliant on these same industries to self-report when a disease outbreak occurs. Many producers, we were told, are “less than enthusiastic” about reporting disease, while some attempt to shun regulators altogether.\footnote{1123} Public records requests reveal that, in the wake of COVID-19 outbreaks on Utah mink farms, for example, the State Department of Public Health was denied access to the infected fur farms while attempting to carry out testing in an effort to contain the spread.\footnote{1124} Similarly, Fur Commission USA, the industry’s largest trade group, issued warnings to its members not to allow reporters or researchers near their mink sheds, going so far as to circulate photographs of a \textit{New York Times} reporter’s rental car and license plate.\footnote{1125}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{mink_farm}
\caption{Mink farm in Aabybro, Denmark.}
\end{figure}

\textbf{Many industries—from livestock auctions, to swap meets, to roadside zoos—have taken steps to maintain some level of secrecy by limiting access to journalists, prohibiting photography, and, in the case of industrial animal agriculture, lobbying to criminalize such actions.}
Complex Drivers of Disease

Human behavior drives disease emergence. While animals are reservoirs of zoonotic pathogens, these pathogens more often than not spill over as a result of human action. Some of these actions involve direct use of animals, while others are indirect drivers of disease emergence. Both types of causes must be addressed in order to prevent spillover, yet each poses unique regulatory challenges.

Industries have been built around the commodification of animals with little regard for zoonotic risk. Millions of foxes, mink, bobcats, and chinchillas are raised and processed each year to supply fur to the fashion industry. White tailed deer are bred in similar numbers in captive facilities to stock hunting ranches across the South. Meanwhile, live animal imports flow freely across the border from abroad, while at the same time, we harvest and kill millions of animals to ship back overseas. This unnatural mixing can give rise to new diseases, opening new doors for pathogens that might never have existed without our help—creating networks and channels through which disease can spread from animals to humans and back again. As it stands today, a significant portion of the American economy has been founded on the use and production of animals, and for that reason, this use remains a cultural blindspot. However, without proper guardrails in place, these same activities may threaten the lives of those whose livelihoods they support, as well as the population writ large.

While much of our risk could be reduced by better regulation of animal use, other drivers of disease emergence and reemergence are more complex and difficult to regulate. Large-scale trends such as deforestation, urban expansion, climate change, and habitat destruction heighten the risk of infectious disease. From cutting down old growth forests to make room for residential development or filling wetlands to make more pastureland for cattle, our continued erosion of wild spaces has brought us uncomfortably close to displaced wild animals who harbor diseases that can jump to humans. It has also paved the way for increased interactions between domestic animals and wildlife, as well as between native and invasive ones. Just as healthy animals are less susceptible to disease, research has shown that healthy, intact ecosystems spawn fewer disease outbreaks than degraded ones. Furthermore, biodiversity dilutes disease risk, acting as a natural buffer to the spread of pathogens. As the health of ecosystems suffer and more wild species are lost, we place ourselves at greater risk of zoonotic spillover. Actions that harm environmental health are likely to put human health in jeopardy as well.

Although better regulation of animal use is an important first step to reducing zoonotic risk, equally important is acknowledging these underlying drivers of disease emergence. No single piece of legislation is likely to be able to speak to each of these vast regulatory challenges. Instead, these problems demand deliberate, steady effort, working to protect and restore fragile ecosystems, while at the same time addressing the root causes of habitat loss.

**Design**

This group of insights describe problems stemming from institutional, legislative, and regulatory design. They respond to the question: What are the structural issues that undermine regulation and prevent agencies from operating effectively?

**Government as a Market Participant**

While many animal markets exist entirely within the private sector, there are several for which the government acts not simply as a regulator, but as an active participant, creating and benefitting from the market itself. In these cases, state-sponsored activities may contribute to disease spread.

In the public market of hunting and trapping, state departments of fish and game are reliant on the sale of hunting licenses, and, by proxy, the sale of wildlife, to fund their own agencies. These incentives may allow disease risk to be overlooked in favor of revenue, for example, in the case of state-run feeding grounds for elk. Here, in an attempt to keep population numbers high and protect hunting revenue, Wyoming has created artificial environments of 800 or more animals per acre, in which diseases like brucellosis are found at thirteen times normal levels.

In instances like these, the government abandons its role as an impartial regulator and moves from a referee on the sidelines to a player in the game.

Government-owned and operated wildlife farms produce hundreds of thousands of game birds to be released on public lands for hunting each fall. While some of these species are neither native nor adapted, and, in fact, damaging to local ecosystems that these agencies were created to protect, there is strong consumer demand for hunting these birds. As one state agency put it, “We raise pheasants because people like to hunt them.” However, this production process increases the risk of diseases including avian influenza, with documented H5N1 outbreaks at 16 game bird farms in the last year alone.

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1133. In other cases, the state acts as a buyer, purchasing wild birds from breeding farms for $13 or $14 each while also selling permits to the hunters who will shoot and, later, eat them. Robert Miller, “From the Game Birds We Pay to Bring to CT to the Turkeys That Roam the State,” CT Insider, October 30, 2021, https://www.ctinsider.com/columnist/article/Robert-Miller-From-the-game-birds-we-pay-to-16572899.php.


State-sponsored bounty programs and predator eradication programs are other methods used by state agencies to increase revenue from hunting licenses. Yet, each of these interactions carries an inherent risk of disease. For example, to collect certain bounties, an individual not only must kill and interact with a dead or dying wild animal, but that person must also manually remove the animal’s scalp with a knife, exposing them to blood, saliva, and cerebrospinal fluid from the animal’s brain.

While in some cases the government intervenes to protect its own interests, in other cases, policy is inspired by a desire to cater to powerful industry groups or voter blocks. In particular, both federal and state agencies go to extreme lengths to support animal agriculture. Direct assistance in the form of $40 billion in annual subsidies is coupled with programs like the Bureau of Land Management’s Horse Adoption Program. This program seeks to eliminate competition for livestock, who graze on public lands at below market rates, by removing wild horses and providing subsidies for those who adopt horses from the program. In addition, the federal government sponsors the direct killing of over one million animals a year through the use of traps, poisons, and other means carried out by USDA’s Wildlife Services to eliminate predators such as mountain lions who may prey on livestock, as well as animals who may compete with livestock for forage or other resources.

Deep cultural roots as well as aggressive lobbying may help explain government-sponsored involvement and participation in protecting some of the animal markets discussed here. Many of these activities, on their face, may not otherwise seem justified. Conflicts of interest corrupt and undermine objective regulation across wide swaths of animal industry, making the public more vulnerable to disease.

Funding Not Proportional to Risk

More people died in one day in 2020 from COVID-19 complications than from the attacks of September 11th. Yet the FY2023 defense budget released by President Biden appropriated only $468 million for pandemic preparedness compared to $773 billion allocated for defense. On a percentage...
basis, spending on pandemic preparedness amounts to less than 1/10th of 1% of the total defense spending.\footnote{\textcite{LloydJ.~Austin,~"The~Department~of~Defense~Releases~the~President’s~Fiscal~Year~2022~Defense~Budget,~"~US~Department~of~Defense,~May~28,~2021,~https://www.defense.gov/Newsroom/Releases/ReleaseArticle/2638711/the-department-of-defense-releases-the-presidents-fiscal-year-2022-defense-budget/}} Public health remains chronically underfunded despite the human costs associated with a pandemic as well as the economic toll of disease. This lack of funding belies a misunderstanding or mis-accounting of modern risks, including bioterrorism. As a result, government response is limited to less cost-effective, band-aid style measures rather than preventative solutions. Many research reports estimate the present value of zoonotic disease prevention costs for 10 years to be only about 2% of the costs of the COVID-19 pandemic.\footnote{\textcite{Andrew~Dobson,~Stuart~Pimm,~Lee~Hannah,~Les~Kaufman,~et~al.,~"Ecology~and~Economics~for~Pandemic~Prevention,~"~Science~369,~No.~6502~(July~2020):~379-381,~DOI:~10.1126/science.abc3189.}}

Inspection and testing of both captive wildlife and livestock are severely limited by a lack of personnel and resources. For example, USDA employs 7,800 FSIS inspectors tasked with overseeing commercial slaughter at 6,800 federally inspected plants, with the goal of preventing diseased animals from entering the food supply.\footnote{\textcite{"Don’t~Let~Your~Outdoor~Meal~Become~a~Feast~for~Bacteria,~"~USDA~Food~Safety~and~Inspection~Service,~accessed~May~24,~2023,~https://www.fsis.usda.gov/}} In 2022, more than 9.9 billion animals were slaughtered at these federally inspected plants.\footnote{\textcite{"Slaughter~Inspection~101,~"~USDA~Food~Safety~and~Inspection~Service,~last~updated~August~9,~2013,~https://www.fsis.usda.gov/food-safety/safe-food-handling-and-preparation/food-safety-basics/slaughter-inspection-101.}} Assuming every inspector works full time, 52 weeks a year, each inspector is responsible for inspecting more than 1.2 million animals a year—nearly 25,000 per week, over 600 an hour.\footnote{\textcite{Note~that~because~both~a~pre-mortem~and~a~post-mortem~inspection~are~required,~each~inspector~must~carry~out~on~average~2.4~million~inspections~per~year~(nearly~50,000~per~week~and~over~1,200~per~hour).}}\footnote{\textcite{"Livestock~Slaughter~Annual~Summary,~"~USDA~Economics,~Statistics,~and~Market~Information~System,~April~29,~2023,~https://usda.library.cornell.edu/concern/publications/r207p32d.}} These rates may not be realistic nor sustainable. The broad mismatch between the scale of animal production and the number of USDA personnel tasked with overseeing slaughter suggests that more resources are needed to ensure the safety of the production process. In addition, the USDA does not inspect the hundreds of thousands of industrial animal production facilities that grow and supply animals to these processing plants, leaving open significant opportunities for disease exposure prior to animals reaching the slaughterhouse.

Additional funding for research is also needed to better understand the disease risks posed both by industries inside the United States and abroad. However, as is often the case, who provides the money matters. Within the livestock industry, for example, observers have noted, “Even the best scientists seem loath to say anything against the industry... With the decline in public research funding, it’s industrial animal agriculture that pays for virtually all the animal sciences research going on at land-grant universities today.”\footnote{\textcite{Charles~W.~Schmidt,~"Swine~CAFOs~&~Novel~H1N1~Flu:~Separating~Facts~from~Fears,~"~Environmental~Health~Perspectives~117,~No.~9~(September~2009):~A394-A401,~https://doi.org/10.1289/ehp.117-a394.}} As a result, most research focuses on how to enhance profitability of production rather than examining its potential risks to human health, ecosystems, or other problems.\footnote{\textcite{"Putting~Meat~on~the~Table:~Industrial~Farm~Animal~Production~in~America,~"~The~Pew~Charitable~Trusts~and~Johns~Hopkins~Bloomberg~School~of~Public~Health,~April~29,~2008,~https://www.pewtrusts.org/-/media/legacy/uploadedfiles/php/content_level_pages/reports/pcafipfinalpdf.pdf.}}
Lack of Public Health Purpose

Rarely is regulation governing animal markets implemented to serve a public health purpose. Instead, laws are created for other reasons, such as to protect endangered species or set bag limits for hunting. Such laws are imperfect instruments to combat disease transmission. Without specific legislative intent to prevent disease, existing laws are ineffective and limited tools to mitigate risk. They leave open gaps, while at the same time, instilling a false sense of security among the public.

The live animal import market is a good example. Many, and in some cases most, live animals enter the United States without being tested, physically inspected, or monitored for disease. A report by the Government Accountability Office concluded to Congress that “[t]he statutory and regulatory framework for live animal imports has gaps that could allow the introduction of diseases into the United States.” These findings echoed those of the National Academy of Sciences, which determined that a “patchwork of federal policies and agencies with limited or ill-defined jurisdiction” resulted in “a lack of coordinated federal oversight” leaving “a significant gap in preventing and rapidly detecting emergent diseases.” These failings are largely a reflection of the fact that the primary responsibility of FWS in overseeing wildlife imports is ensuring that endangered species are not brought into the country without proper documentation. Their focus is on determining the animal’s conservation status, which is what FWS inspectors are trained to do. Whether that animal is healthy or exhibits symptoms of disease is not their concern. A dead or dying wild animal with visible signs of disease may still be cleared by FWS for import, so long as the animal was not among a handful of protected species.

As the number one importer of live animals and wildlife in the world, the United States bears a substantial risk of importing dangerous zoonotic diseases. However, the United States lacks a comprehensive system to screen imports for disease and has limited ability to share data between agencies. Though the United States has invested vast resources in border protection, it does relatively little to keep zoonotic diseases from moving freely into its territories. Much of this failure can be attributed to the fact that disease control among captive animals is not a priority for FWS and is not included in the agency’s mandate.

1154. Personal interview with former U.S. FWS inspector, interview done on background, June 10, 2021.
The same is true in many other areas as well. The Animal Welfare Act, the primary piece of legislation governing animals in entertainment, animals in research, exotic animal breeders, zoos, auctions, commercial dog breeders, and online animal retailers, says very little about disease.\textsuperscript{1157} The word “disease” appears only a handful of times in the 242 pages of the Act and accompanying USDA regulations, while the phrase “zoonotic disease” is not mentioned at all.\textsuperscript{1158} Though some of the Act’s requirements may have secondary effects that reduce disease risk, without a guiding public health purpose, current regulation is largely ineffective at identifying and containing disease.

**Overlapping and Underlapping Jurisdiction**

A number of animal markets operate in regulatory gaps or legal gray areas. These gaps exist both among federal agencies (or state agencies) and between the federal and state levels. Markets that often fall into administrative cracks include fur farming, the exotic pet trade, captive hunting, big game farming, and backyard bird breeding. Troublespots arise when animals do not fit neatly into the predefined categories of “wildlife,” “livestock,” or “companion animals.” For example, a state may require vaccinations for dogs and cats, but fail to account for non-traditional pets such as prairie dogs or chimpanzees.\textsuperscript{1159} These problems are exacerbated when animals we associate with one of these categories operate as part of another—dogs who are raised as livestock by large-scale commercial breeders or white-tailed deer who are bred in captivity to supply captive hunting options. For this reason, one area of the spectrum that remains chronically under-regulated is wildlife in captivity. Without regulation, industries can operate in any manner they choose. However, conditions and practices that maximize profit—high stocking densities, limited vet care, poor facilities, inhumane handling—are also those that tend to maximize risk of zoonotic disease.

Regulatory voids are surrounded by legal gray areas where agencies are unsure of their own responsibilities and enforcement powers, as well as those of other agencies.
powers, as well as those of other agencies. Industries may benefit from this confusion and the associated lack of oversight. And, in some cases, whether it be captive hunting in Texas or elk and bison farming in the Midwest, there is a reluctance on the part of regulators to clear up confusion or mandate consistency across states when there are economic incentives not to do so. This manifests in a general unwillingness to take any actions that may be deemed as unfriendly to industry.

Where responsibility is shared between the federal and state level, states fill these gaps unevenly. For example, the federal Poultry Product Inspections Act (PPIA) provides exceptions that leave the regulation of smaller bird producers (1,000 birds or less) to the states. Some states, such as California, have taken up this charge and extended the federal guidelines to fill this gap. However, many other states have chosen not to extend the Act’s health and safety guidelines or lack the necessary resources to enforce such regulation, which can lead to significant regulatory holes around these smaller operations.

While the problems associated with underlapping jurisdiction are accessible and apparent, on the other end of the spectrum, similar issues may arise where agencies share competing jurisdiction. Involvement across multiple agencies and levels of government can muddy the waters and lead to a diffusion of responsibility among the relevant agencies and a lack of coordination between the parties involved. Often in these cases, regulators are unsure of their own duties and the duties of others, while at the same time are hesitant to infringe upon the domain of other agencies. Having everyone regulate runs the risk of no one regulating fully.

Live-animal food markets present one example where regulation is shared among local, state, and federal regulators. The patchwork of rules and interplay between agencies leads to confusion on all sides and a lack of consistency. One *New York Times* article noted that “the rules [governing live-animal food markets] are so confusing that officials at the Food Safety and Inspection Service of the United States Department of Agriculture initially told a reporter that their agency had nothing to do with live-animal markets” before later recognizing that they were responsible for overseeing the slaughter of certain types of animals at these markets. This confusion on the part of regulators is echoed by live market operators who may skirt the rules in some cases simply because they do not understand them.

1161. Personal interview with California Department of Food and Agriculture Animal Health and Food Safety Services state veterinarian, May 27, 2021.
In some cases, there is a mismatch between which agencies have the knowledge to regulate risk and which have the authority or the on-the-ground capabilities to carry out regulation effectively. The situation at the border presents one example: The CDC has scientific expertise related to diseases. USDA APHIS has the ability to test animals, the veterinary staff to do so, and quarantine facilities needed to hold animals.\(^{1163}\) However, FWS, the “boots on the ground” agency tasked with reviewing most import shipments of live wild animals, has neither the knowledge of CDC nor the capacity of APHIS.\(^{1164}\) As a result, they do not have the resources to assess risk nor the ability to detain diseased shipments. FWS inspectors are provided only minimal disease training, and the agency lacks quarantine facilities.\(^{1165}\) As a result, “wildlife are imported daily with little or no health monitoring, increasing the likelihood that zoonotic or animal diseases will enter the United States.”\(^{1166}\) Some of this omission is not for lack of wanting—FWS inspectors have expressed a willingness to do more to address disease risk. However, at present, the agency has neither the ability to test and examine incoming wildlife for disease nor the authority to initiate disease testing on its own.\(^{1167}\)

### Function

This group of insights describes issues that arise from the functioning of agencies and the application of regulation. They address questions such as: What limits the effectiveness of administrative actors? What pitfalls do agencies fall into that compromise and hinder their ability to implement their regulations?

### Response is Limited and Reactionary

Too often, agencies act only when circumstances force their hand. As a general rule, there are very few comprehensive risk analyses in place to identify zoonotic threats and address them proactively. Instead, regulators at both the state and federal level too often wait until an outbreak has occurred, focusing exclusively on containment. While some disease threats are novel, for many others, there is already sufficient information and motivation to take preventive measures now and stop future outbreaks—or in the case of imports,
to prevent known diseases from establishing a foothold inside the United States. The introduction of monkeypox to the United States provides an illustration of why prospective policy is needed. It is described in a 2010 report by the Government Accountability Office, a non-partisan legislative branch agency that conducts audits, investigations, information gathering, and evaluations on behalf of Congress:

Since the 1970s it has been well known that monkeypox, a zoonotic disease, was endemic to Africa. However, according to CDC officials, CDC did not have a process to conduct a risk assessment on the potential movement of monkeypox to the United States. Furthermore, they said, if such a risk assessment process had been in place, CDC might have restricted the importation of certain animals from Africa. After a 2003 outbreak of monkeypox in the United States, which sickened over 70 people, CDC restricted the importation of African rodents and other animals that may carry the monkeypox virus. However, CDC still allows the importation of rodents from countries outside of Africa, and these imported rodents are not subject to examination to determine whether they may be carrying zoonotic disease… For example, mice, rats, and gerbils are not screened for zoonotic diseases, but the animal family that includes these animals has been found to harbor 21 zoonotic diseases.1168

The GAO report, commissioned by Congress, concluded that, “CDC generally reacts only when a zoonotic disease problem arises” and that “CDC’s regulations are limited to specific species and regions and do not comprehensively prevent the importation of animals that are known to present a high risk of zoonotic diseases.”1169 By contrast, a more forward-looking policy might establish a comprehensive system for evaluating zoonotic risk and make prospective, real-time decisions as to whether to allow imports of a given species from a particular region. Imports might be pre-screened for disease prior to entering the country rather than waiting for those same diseases to establish themselves in the United States after they arrive. From an economic perspective, these public health risks should often outweigh the potential harm to a handful of animal importers. Even where imperfect knowledge exists, a cautious approach to protecting public health may be preferable to a “wait-and-see-style” of policymaking.

While proactive approaches require additional work and administrative capital, in the long run, they may save costs and lives. For example, in response to the ongoing H5N1 outbreak the government has been reluctant to require vaccination among poultry flocks, but instead has paid more than $150

At present, policymakers are often reluctant to address future risk and narrowly circumscribe responses while ignoring related issues. For example, in 2011, the governor of Ohio refused to adopt regulations that would have limited the ownership of dangerous exotic animals.1172 Six months later, in what came to be known as the “the Zanesville Exotic Massacre,” forty-nine exotic animals, including tigers, lions, baboons, and bears were slaughtered by law enforcement after their owner released them from their cages.1173 1174 Among these animals was a macaque monkey thought to be carrying Herpes B virus, which is 67% fatal in humans.1175 1176 The incident led to stricter exotic pet laws in Ohio but nowhere else in the country.

It is essential to move beyond what has happened in order to proactively address and prevent what could happen. To do this, policymakers must first take a comprehensive and holistic view of risk and sustain this focus long enough to affect meaningful change.1177

**Inter and Intra-Agency Siloing**

Poor interagency communication and the siloing of information, particularly among the USDA, FWS, CDC, and CBP, undermine regulation and enforcement. Every agency has their own culture, protocols, information systems, and institutionalized thinking about how to handle disease.1178 Each of these characteristics can act as a barrier to effective interagency cooperation, limiting the flow of information. For example, officials from both FWS and the CDC indicated that, to their knowledge, the LEMIS data, which describes wildlife entering the country and is collected by FWS, has not been shared with the CDC. However, the information described by the data—namely what types of wild animals are entering the country, where they came from, where they are going, and, by implication, what diseases they may carry—appears quite

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relevant to the CDC’s larger mission of protecting public health. As another example, CBP has developed a web-based portal for exchanging trade information among federal agencies, yet neither FWS nor the USDA has full operational access to this platform, preventing the sharing of information on live animal shipments as well as tracking of violations.1179 These types of informational silos exist not only at the regulatory level but at the scientific level as well. Each agency we spoke to including FWS, USDA, and USGS has their own pathology lab but few, if any, protocols or conduits for sharing scientific findings.

Poor interagency communication, in some cases, may also be a result of agency competition. When lobbying for limited funds, few regulators want to cede control to another agency, even when that agency may be better equipped to address the problem at hand. With no single coordinating entity, fiefdoms persist, agencies become politicized, and their effectiveness is marginalized. Some of these problems could be remedied by realigning incentives to encourage or require information sharing. Yet, this is unlikely to occur without mandates and infrastructure in place to do so.

We also observed siloing within individual regulatory agencies. Different departments within these larger agencies hold competing functions and may not always share information laterally with other teams. For example, scientists—biologists, pathologists, and others—may operate quite independently from those drafting regulations within that same administrative agency, resulting in regulations that do not always reflect the best available science or even the agency’s own findings.

Incentives Control When Regulation Does Not

Where self-interest and public interest point in opposite directions, oversight is needed to ensure that producers follow best practices. In the absence of such regulation, misaligned incentives often enhance risks to public health.

The USDA’s indemnification program compensates producers for animals lost to disease or culled to contain disease spread. However, while the program covers traditional livestock and a handful of additional species like deer, no payments are made to fur farms or other operations raising non-compensated species. Producers in those industries have little incentive to report infectious disease outbreaks at their facilities. Rather than losing some of their animals to disease, they could be asked or required to cull all of their animals without compensation. In addition, reputational harm, both to them as individuals and to the industry as a whole, may weigh heavily against reporting, especially where powerful trade groups discourage it. Instead of requiring these industries to undergo monitoring, testing, or inspection to ensure that disease is reported, the USDA largely leaves them to their own devices.1180 The present structure makes the public vulnerable and keeps regulators largely in the dark.

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1180. Veterinarians are required to report positive diagnosis of certain notifiable diseases to animal health officials. However, it is ultimately the producer’s choice whether to hire a veterinarian to examine sick animals. Many do not. In addition, very few vets will treat captive-farmed wildlife, as these animals fall outside the expertise of both small animal vets, who treat companion animals, and large animal vets, who treat traditional livestock.
In the absence of regulation, incentives to maximize profit may create conditions conducive to disease spread. For example, an importer shipping animals in improper containers may know that although many animals will die in transit, these losses will be outweighed by the benefits of cheaper shipping materials. Similarly, a contract farmer knows that meat producers pay by the pound, so the health of the animals is of less consequence than their weight. A pet store owner may realize that paying for vet care for animals sold for $6 each will never make financial sense, even if, now and again, a whole display case of animals is lost to disease. In these circumstances, regulation can be effective at realigning incentives to ensure public health is not written off by producers as a negative externality.

Educational Deficiencies and Lack of Preparedness

Policymakers, law enforcement, medical staff, and the public in general, tend to be undereducated when it comes to zoonotic disease. Outside of foodborne illness, current regulations do little to alert the public to potential risk. When a child enters a petting zoo, for example, there are no required signs to alert parents about potential disease risk. That child may go on to touch the animals, pick up feed or hay from the animals’ environment, and afterwards, eat food without first stopping to properly wash their hands. Similarly, customers at captive hunting operations reported that ranch operators made no mention of disease risk or sanitation practices before sending them out to kill and retrieve exotic animals. The same is often true at pet stores where customers purchase animals with little or no understanding of the disease risks those animals may carry. Risk disclosures are required in the restaurant industry where menus alert consumers to the risk of foodborne illness and bathroom signs urge employees to wash their hands before returning to work. Imposing a similar strategy at pet stores, animal auctions, fairs, and other public venues where humans and animals interact may go a long way toward reducing transmission. As it stands, many Americans believe that because an activity is legal, it must be safe or because an animal is offered for sale, they must have been checked for disease. However, this is simply not the case.

While a handful of zoonotic pathogens such as Zika virus and SARS-CoV-2 capture the public consciousness, most are not well known. First responders and medical personnel are not always equipped to handle or diagnose novel or lesser known diseases, in particular those associated with non-native species such as exotic pets. In the Midwest mpox outbreak (referenced above), for example, the index patient, a three-year old girl from Wisconsin, was not diagnosed. Her spherical skin lesions and

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1181. In the example of the escaped macaque monkey (referenced above) who was thought to be carrying Herpes B, one officer explained to the authors of this report the predicament faced by police, whose only law enforcement training directed him to shoot the animal, even though he feared that doing so in this case may risk dispersing blood and potentially contaminated bodily tissue.
other symptoms were written off as an anomaly, until weeks later when her mother and dozens of other patients began falling sick. Hers was the first case of mpox in the Western hemisphere, and emergency room doctors seldom search for rare foreign diseases in patients with no history of travel. Nor did the family who purchased the infected prairie dog realize that the animal could make them sick. Public education, in this respect, would be beneficial at every level from lawmakers to agency staff to the public to enforcement officials on the front line carrying regulations out.

### Inequities in Disease Risk

There is a heightened level of zoonotic disease risk among underserved and poor populations. This increased risk is driven by proximity to animals through the course of employment, the location of animal markets themselves, and human settlement patterns. At present, policy does little to address these inequities.

Workers from poor and underserved communities supply labor for many of the animal markets examined here and accordingly may be more likely to be affected by zoonoses. Studies have shown, for example, a higher prevalence of influenza viruses among those with occupational exposure to pigs, but the same is also true of their families, and in some cases, the communities themselves that surround hog operations. By contrast, wealthier Americans tend not to hold hands-on jobs that involve direct contact with animals. In industries such as food production, for example, a large percentage of slaughterhouse and meat-packing workers are low-income people of color, including workers from Mexico and other parts of Latin America. While these individuals are disproportionately exposed to disease risks inherent in animal operations, at the same time, they tend to be less likely to report risks or to seek out preventative or post-incident healthcare. Outreach efforts and public education campaigns may also be less effective in targeting these populations.

The geographic location of animal markets also puts some individuals at higher risk than others. CAFOs are more likely to be located in low-income communities. In Eastern North Carolina, where industrial swine facilities dominate the landscape and stand side-by-side with, in some cases within a few

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1188. Further, an unknown percentage of full-time and part-time workers in these large operations are undocumented persons, who may be less likely to report illness or hazardous working conditions, and unable to seek medical care or to miss work in the event that they are sick.
1191. By and large, wealthier communities exist in more desirable locations that include higher elevations where there is less standing water and more bug protection, as well as more insulation from animal-based operations.
Poverty and population density have been found to be predictive of disease risk in the United States. hundred yards of, residential homes, research has documented the presence of swine fecal bacteria on the exterior walls of homes and inside them, on kitchen countertops and cereal boxes.\textsuperscript{1192, 1193} Proximity to animal production makes these populations more susceptible to the disease risks and can facilitate the transmission of airborne viruses or bacteria such as \textit{Coxiella burnetii}.\textsuperscript{1194} Similarly, live animal food markets, which pose high and well-known risks of zoonotic disease transmission, are predominantly found in low-income, minority, and immigrant communities.\textsuperscript{1195}

Housing distribution patterns can also amplify the risk of zoonotic disease among vulnerable populations. For instance, homes in low-lying areas with more standing water may put residents at higher risk for vector-borne diseases transmitted by mosquitoes from other animals to humans including West Nile fever, dengue, La Crosse encephalitis, chikungunya, and Zika.\textsuperscript{1196} Poverty and population density have been found to be predictive of disease risk in the United States.\textsuperscript{1197} Little is being done at a policy level to mitigate these disparate effects.

However, the additional risks and challenges faced by these disadvantaged groups increase the danger to all members of the public. How long would it take to recognize the emergence of a novel virus circulating among workers at an industrial swine facility? The answer may depend on a number of variables tied to the socioeconomic position of the infected workers. It may take longer, for example, if those workers live in a rural community with limited access to healthcare, longer if English is their second language, or if they delay seeking treatment because they lack health insurance or avoid medical care altogether because they fear immigration consequences.\textsuperscript{1198, 1199} It may also take longer if these workers feel unable to report their illness to a supervisor or longer if they cannot miss work for fear of losing their jobs, meanwhile continuing to spread the virus to other employees. These delays can mean the difference between containment and outbreak, as pathogens move from livestock workers to the public at large. In this way, an unequal system may also be an unsafe one.


CONCLUSION

Animal use in the United States occurs on a vast scale for a wide array of purposes. Much of this use takes place outside of public view and rarely garners the attention of lawmakers. Still, just as animal use is everywhere, zoonotic risk is everywhere too—with pathogens circulating unseen but all around us.

While risk cannot be eliminated, it can be reduced, in many ways that would scarcely be felt by the public at large. There are vast opportunities for reducing risk that would not require significant behavioral change. Most Americans have never attended an animal swap meet where kangaroos can be bought alongside ferrets and chickens. Many do not frequent drive-through zoos where they hand-feed alfalfa pellets to crowds of deer, ostrich, zebra, and elk. Most of us have never bought anything at an exotic animal auction or a captive hunting operation where we aimed to kill exotic species and native ones, raised in breeding facilities. Most of our coats are not made of foxes and mink, nor do we use bat guano to fertilize our lawns. Few of us raise camels in our backyards or drink their unpasteurized milk. We do not receive shipments of wild animals, captured overseas, for resale. We rarely compete in livestock shows. In fact, most Americans do not kill our own food or buy it from a market where we select which living animal we want to eat. Still, we are all exposed to risks from each one of these operations. No matter how fringe the activity may seem, its risk weighs on all of us and spreads far beyond just those individuals involved. How many COVID-19 patients ever visited the city of Wuhan?

Surveying this landscape of low-hanging fruit, lawmakers and regulators should consider whether each practice justifies the risk it poses. For activities that present great risk but relatively little value,
economic or otherwise, the answer may simply be, “no.” For other practices, the cost-benefit analysis will pose a more difficult question. And for others still, where the practice is deemed too valuable to lose, we must regulate to reduce risk wherever possible. At present, we are not doing enough. The United States has no comprehensive strategy in place to address the threat of zoonotic disease. There are serious regulatory deficiencies across almost every animal industry. Large information gaps exist, and disease can seep between these cracks.

Some similarities may be found in an analogy to homeland security. The attacks of September 11th ushered in a new era of national defense. The impact from the attack was felt in the hearts and throats of the nation at large. For many Americans, COVID-19 did for infectious disease what 9/11 did for terrorism—making real a threat which, just moments before, had felt theoretical and far away. At the time of this writing, scientists continue to debate the precise origins of the virus but there is no question as to the impact it has had. Indeed, few aspects of daily life in the United States remain untouched.

The events of 9/11 forced us to re-examine risk and risk response. The failure of the intelligence community to prevent the attacks was deemed, in part, a function of its fractured nature: its gaps, lack of information sharing, and poor interagency coordination. In response, George W. Bush pulled 22 separate agencies and departments together to forge a new integrated cabinet level agency. The Department of Homeland Security was born of the specific goal of creating and carrying out a comprehensive strategy to safeguard the country against terrorism. We face a similar crossroads today with preventing pandemic-level disease. Our systems are not designed to prioritize disease detection, our institutions are siloed from one another, and wide regulatory gaps exist through which pathogens can spillover and spread. The status quo is not sufficient, and, as with terrorism, the stakes are too high for the problem to be ignored.

In 2003, a year after the Department of Homeland Security began, the department started a new initiative aimed at addressing the growing threat of bioterrorism. This BioWatch program routinely collects air samples from above thirty or more major metropolitan areas in the United States and analyzes the samples for the presence of biological weapons. In particular, operators test the samples for what the CDC refers to as “Category A Agents.” Category A Agents are considered pathogens of highest risk to national security because of the likelihood they may be used in a bioterrorist attack. Seven of the nine pathogens listed under Category A are zoonotic in origin, including anthrax, Ebola, Marburg virus, plague, and tularemia.

The purpose of the BioWatch program is to facilitate early detection of a bioterrorist attack by monitoring for the presence of dangerous pathogens. Yet, at the same time, the government does not conduct disease testing of animals known to be vectors of these same deadly pathogens. Commonsense policymaking urges us to do the easy thing first. While we collect samples in the sky to detect traces of biological agents, we may be unknowingly importing these pathogens in far greater numbers, sending them on to animal distributors and pet stores and ultimately into American homes and children’s bedrooms. So, while a deadly disease outbreak may be the work of anti-American terrorist

groups or hostile foreign powers, it may also stem from random chance—a source far more likely and, perhaps, more frightening. We consider the first case bioterrorism; the second, business-as-usual.

In the wake of COVID-19, we no longer have to imagine what a large-scale infectious disease outbreak would look like in the United States. Still, COVID-19 fatality rates in the U.S. hovered just under 2% for most of the early pandemic. What if, instead of this coronavirus disease, it had been another such as SARS, a cousin to COVID-19, with a mortality rate of 14%, or MERS, a disease caused by another member of the viral family, that is 32% fatal? What if one-third of the people you know who have contracted COVID-19 died of the disease? COVID-19 disproportionately affected elderly persons and those with weakened immune response. For other viruses, younger healthy persons are at greater risk.\footnote{G. Dennis Shanks and John F. Brundage, “Pathogenic Responses among Young Adults during the 1918 Influenza Pandemic,” Emerg Infect Dis. 18, No. 2 (February 2012): 201-207, doi: 10.3201/eid1802.102042.}

What if instead of sweeping through nursing homes, the virus swept through elementary schools, taking lives that had only just begun? There is a quiet consensus within the scientific community that the next pandemic may be far worse than what we have just experienced. Such an event may also happen sooner than we think, as outbreaks become increasingly common.\footnote{Katherine F. Smith, Michael Goldberg, Samantha Rosenthal, Lynn Carlson, et al., “Global Rise in Human Infectious Disease Outbreaks,” Journal of the Royal Society Interface 11, No. 101 (December 2014): https://doi.org/10.1098/rsif.2014.0950.}

Still, there is reason to be hopeful. We have the capability today to radically reduce our risk—to lock the cockpit door.

Along with this capability comes great responsibility and moral obligation to do so. This is the sober challenge we are left with.
GLOSSARY OF KEY TERMS

Animal
Any member of the biological kingdom of living things, Animalia—though the term refers most often to vertebrate members of the phylum Chordata. “Animal” may refer to any species of mammal, bird, reptile, amphibian, fish, crustacean, arachnid, or insect. This term includes both domestic animals, such as companion animals and livestock, as well as wildlife. For the purposes of this paper, we exclude humans from this category and instead use the term to refer to non-human animals. We use pronouns typically associated with humans (such as “he/she/they” and “who/whom”) when referring to animals rather than pronouns associated with inanimate objects (such as “it” or “that”).

Animal Market
Markets where animals or animal products are bought, traded, sold, or exchanged. These products may include living animals, dead animals, meat, animal parts, milk, eggs, fur, skins, leather, bones, and other lightly-processed goods derived from animal origins.

Captive Breeding
The process of breeding and raising wild-caught or otherwise non-domesticated species in enclosed, human-controlled spaces such as zoos or fur farms for the purposes of conservation, education, entertainment, food, meat, fur or other animal products.

Domestic Animals
Animals who have been selectively bred and genetically adapted over generations in service of human interests. “Domestic animals” are genetically distinct from their wild ancestors or cousins, and may have undergone physiological changes during the process of domestication in particular where humans bred the animals for specific traits or purposes. “Domestic animal” may refer to any species of livestock as well as companion animals such as horses, house cats, and dogs.

Exotic Pet
An animal held as a pet that belongs to a species other than those domesticated species commonly kept for companionship (such as cat, dogs, and horses), including, for example, ferrets, fowl, hedgehogs, chimpanzees, and so forth.

Live Animal Market
Areas or storefronts where animals are held alive and slaughtered on-site and on-demand for customers, most often for food.

Livestock
Domestic animals raised in captivity for agricultural purposes, including both consumption and labor.

Pathogen
A microorganism such as a virus, bacterium, fungus, or parasite that can cause disease. Pathogens may be transmitted in a number of ways, such as direct and indirect contact, droplet spread, and airborne transmission.

Spillover
An event in which a virus or other pathogen from animals jumps the species barrier to infect humans.

Reverse Zoonosis
A disease that is transmissible from humans to animals through a process known as reverse zoonotic disease transmission.

Wildlife
Animals who have not been domesticated. “Wildlife” often refers to animals, native or invasive, who generally live in the wild and are part of an ecosystem. The term “wildlife” may describe animals who are wild-born and wild-captured, as well as those bred and raised and farmed in captivity where the species, as a whole, has not undergone the process of domestication. (For example, an exotic pet may be considered “tame” in that the individual animal has become acclimated to humans; however, unless the species has been domesticated, the animal would still be considered “wildlife” in captivity.)

Zoonotic Disease
Infectious disease that occurs through the transmission of a pathogen between animals and humans. “Zoonotic disease” refers to a condition, often a constellation of symptoms, that arises from infection with a virus or other type of bacterial, fungal, prion, parasitic, or protozoan pathogen. Most commonly, zoonotic disease is transmitted through direct contact, indirect contact, droplet spread, vertical transmission, or through food, water, or vector borne infection. Pathogens that cause zoonotic disease in humans can often spread from one animal to another animal of the same or different species.