Pandemics: History and Prevention

This is a transcript of a lecture given in 2018 by Dr. Michael Greger, founder of nutritionfacts.org. It is eerily prophetic. The lecture video is on YouTube. What the World Health Organization predicted would happen, is happening!

The two greatest threats facing humanity, according to the United Nations are climate change and emerging infectious disease—particularly pandemic influenza. The current focus of pandemic discussions and debate understandably centers on what we in the public health community refer to as secondary prevention: mediating the impact of the next pandemic, an intervention analogous to mammography. Mammograms don't prevent cancer, but if caught early enough, for example, we may be able to decrease morbidity and mortality. And, the same with pandemic planning. But what of primary prevention, the possibility of preventing the emergence of pandemic viruses in the first place? Like cancer, the root cause is likely multifactorial, difficult to tease out, but a question worth exploring, nonetheless, and the question I'd like to address here today.

Let's go back a few years. 1981. Here in the United States, Ronald Reagan takes the oath. MTV starts broadcasting Indiana Jones, and Pacman mania is all the rage. In June, the CDC released a tiny bulletin. Five men in Los Angeles, it seems, were dying with a strange cluster of symptoms. From humble beginnings, AIDS has since killed 25 million people. Now, the spread of the AIDS virus has been facilitated by promiscuity, blood banking, IV drug use; but where did this virus come from in the first place? And, of course, AIDS is not our only new disease. There's SARS, Ebola, mad cow, bird flu… But from where do emerging diseases emerge? Well, let's go back a bit further, much further. Human beings have been on this earth for millions of years, yet throughout most of human evolution, there were no epidemic diseases.

No one ever got the measles, because measles didn't exist. No one got smallpox, no one got the flu, not even the common cold until about here—10,000 years ago. Medical anthropologists have identified three major periods of disease since the beginning of human evolution, and the first started just 10,000 years ago, with the domestication of animals. When we brought animals into the barnyard, they brought their diseases with them. When we domesticated cows and sheep, for example, we also domesticated their Rinderpest virus, which turned into human measles, now thought of as a relatively benign disease. Over the last 150 years, measles has killed 200 million people. And, in a sense, all those deaths can ultimately be traced back just a few hundred generations to the taming of the first cattle. Smallpox likely came from camel pox. We domesticated pigs, and got whooping cough. We domesticated chickens, and we got typhoid fever and Typhoid Mary, and domesticated ducks, and got influenza. Before the domestication of ducks, likely no one ever got the flu. Leprosy likely came from water buffalo, and the common cold from horses. How often did wild horses have the opportunity to sneeze into humanity's collective face until they were broken and bridled? Until then, the common cold was presumably only common to them.

In his Pulitzer Prize-winning book, *Guns, Germs and Steel*, Professor Diamond tried to explain why the diseases of the landing Europeans wiped out up to 95% of the native Americans, and not the other way around. Why didn't native American plagues kill the Europeans? Well, because there were no plagues. In his chapter, "Lethal Gift of Livestock," he explains how before the Europeans arrived, we had buffalo, but no domesticated buffalo; so, no measles. American camels were wiped out in the Pleistocene ice age; so, no smallpox. No pigs, and so no pertussis. No chicken, so no typhoid. So, while people were dying by the millions of killer scourges in Europe and Asia, none were dying with diseases in the so-called new world because there weren't essentially foreign animals to domesticate. There wasn't this spillover of animal disease.

The next great period of human disease started just a few hundred years ago with the Industrial Revolution of the 18th and 19th centuries, leading to an epidemic of the so-called diseases of civilization: diabetes, obesity, heart disease, cancer, etc. But by the mid-20th century, the age of infectious disease at least was thought to be over. We had penicillin, we conquered polio, eradicated smallpox. In fact, in 1968, the US Surgeon General declared

the war against infectious disease has been won. In 1975, the Dean of Yale School of Medicine pronounced that there were no new diseases to be discovered—except maybe lung cancer. But even Nobel laureates were seduced in the heady optimism of the time. One famous virologist wrote, in a 1962 textbook, "To write about infectious disease is almost to write about something that's passed into history. The most likely forecast of the future of infectious disease," he wrote, "is that it will be very dull."

But then, something changed. After decades of declining infectious disease mortality in the United States, the trend has reversed in recent decades. This is a graph from the CDC of infectious disease mortality over time, in the last 50 years or so. And as you can see, it starts declining. Declining, declining, declining, but then around 1975, it started to go back up. The number of Americans dying from infectious disease started to go back up. Starting around 1975, new diseases started to emerge and reemerge at a rate unheard of in the annals of medicine. More than 30 new diseases in 30 years—mostly newly discovered viruses. In fact, the whole concept of emerging infectious disease has gone from a mere curiosity in the field of medicine. Now it's an entire discipline, really moved to center stage.

We may soon be facing, according to the US Institute of Medicine, what they call a catastrophic storm of microbial threats. We are now smack dab in the third era of human disease, which seems to only have started about 30 years ago. Medical historians have called this time in which we live the Age of Emerging Plagues, almost all of which come from animals.

But we domesticated animals 10,000 years ago. What has changed in recent decades to bring us to this current situation? Well, we are changing the way animals live. Take Connecticut, for example, where in 1975, Lyme disease was first recognized. Since, spread across all 50 states affecting an estimated 100,000 Americans since its emergence. Lyme disease is caused by bacteria-infested deer ticks, but the primary host is actually not deer, but the white-footed mouse. The ticks themselves, not quite as cute really, but we've been sharing the woods with these fellows forever. What changed recently was suburbia. The black-legged ticks live on the white-footed mouse, kept at bay by woodland predators. But then, developers came in and chopped up America's woodlands into subdivisions, scaring away the foxes and bobcats, and now we have more mice, more ticks, and more disease. We are changing the way animals live. Going back a little farther, with the big cattle-producing nations fighting during the Second World War. What Argentina did, took advantage of the situation by dramatically expanding its beef industry at the expense of its rainforest. There we discovered the deadly human virus, or rather it discovered us, and the so-called hamburger-ization of the rainforest exposed hemorrhagic fever viruses all across the continent subsequently. Turning to the other side of the world, cutting into Africa's rainforests exposed a number of other hemorrhagic fever viruses, including Lassa virus, Rift Valley fever, and, of course, Ebola. Now the inroads into Africa's rainforest were logging roads cut by transnational timber corporations hacking deep into the rainforest, dragging along a hungry migrant workforce, which survived on bush meat: wild animals killed for food. Now this includes upwards of 26 different species of primates, including a number of endangered great ape species, gorillas, chimpanzees, who are shot, butchered, smoked, and sold as food. Now by cannibalizing our fellow primates, we may be exposing ourselves to viruses particularly fine-tuned to our own primate physiology. In fact, recent outbreaks of Ebola, for example, have been traced to the exposure to the bodies of infected great apes hunted for food. Now Ebola is one of our deadliest infections, but not efficiently spread, compared to a virus like HIV.

The leading theory as to the emergence of the AIDS virus is direct exposure to animal blood and secretions as a result of hunting, butchering, and the consumption of contaminated bush meat. Experts believe the most likely scenario is that HIV arose from humans sawing their way into the jungle, butchering chimpanzees for their flesh along the way. Now in many countries in Africa, the prevalence of HIV exceeds 25% of the adult population, leaving millions of orphan children in its wake. Someone butchered a chimp a few decades ago, and now 25 million people are dead. But wildlife has been hunted for thousands of years. Yes, but never before like this.
With the demand for wildlife meat outstripping local supplies, what countries have done is set up these intensive captive production farms, cramming wild animals in these cramped filthy cages, and then smuggling them around the world. This intensive commercial bush meat trade actually started in the live markets of Asia, particularly the

Guangdong province, a southern province surrounding Hong Kong, from which the current bird flu threat arose. The civet cat, a popular commodity in these Chinese animal markets. In addition to being raised for their flesh, they also produce the most expensive coffee in the world. So-called fox dung coffee is produced by feeding coffee beans to captive civets, and then—you guessed it— recovering the partially digested beans from their feces. A musk-like substance of buttery consistency secreted by the anal glands is said to give this coffee its distinctive favor. One might say this unique drink is good to the last dropping. I'm sorry. This animal was blamed for the SARS epidemic. Quoting from the medical Journal, *Lancet*, "A Culinary Choice In South China." "A culinary choice in South China led to a fatal infection in Hong Kong."

Subsequently, 8,000 cases of SARS. Nearly a thousand deaths, 30 countries, six continents. Maybe they should have just stuck to Starbucks. These live animal markets took a class of viruses, which in human medicine we had only known for causing the common cold, and seemed to turn them into a killer, SARS, which then spread around the world. Viruses can escape rainforests in animals, live or dead, as pets or as meat. In 2003, the exotic pet trade brought monkey pox from the jungles of West Africa to Wisconsin. Bird-smuggling may have actually been what brought West Nile virus to the Western Hemisphere. Here, it hits New York in '99, and has since spread across the country. Hundreds of human deaths, thousands of cases, all perhaps because of a single imported pet bird.
So, we are changing the way animals live, contributing to the emergence of these new diseases. But, you know, there's one way we have changed our relationship with animals that really out shadows all the rest. In response to this torrent of emerging and re-emerging infectious diseases, the world's three leading authorities got together for a joint consultation. The World Health Organization, the Food and Agriculture Organization of the United Nations, and the World Organization for Animal Health (the world's leading veterinary authority), got together to uncover the key underlying causes of this age of emerging plagues. They came up with four, four main risks––four main themes of risk factors for the emergence and spread of these new diseases. Yes, they talked about the exotic pet trade. They talked about bush meat, but number one on their list was this increasing demand for animal protein the world over. Yes, we domesticated animals 10,000 years ago, but never before like this—especially pigs and poultry.

Chickens used to peck around the barnyard, but now chickens raised for meat are typically warehoused in sheds containing tens of thousands of birds. About half of the egg-laying hens on this planet are now confined in what are called battery cages. These small barren wire enclosures extending down long rows and windowless sheds; can be up to a million birds on a single farm. About half of the pigs on the planet are now again crowded into these intensive confinement operations. You know, old MacDonald's farm has since been replaced by the new MacDonald's farm. These intensive systems represent the most profound alteration of the human-animal relationship in 10,000 years. And, no surprise, they are breeding grounds for disease.

A few snapshots. China, 2005, the largest pork-producing nation suffers an unprecedented outbreak of an emerging pig pathogen, strep suis, causing meningitis and deafness in people handling infected pork products. Hundreds of people infected, the deadliest strain on record. Why? Well, according to the World Health Organization, indeed it seems to be these intensive confinement conditions. The USDA elaborates, "All strep suis starts out harmless as natural gut flora, but then the immunosuppressive effect of stress, due to overcrowding, inadequate ventilation, causes the bug to go invasive, causing infections of the brain, blood, lungs, heart, and death." Starts out harmless, turns deadly. That's what these kinds of conditions seem to be able to do. This is not, arguably, how animals were meant to live.

Pig factories in Malaysia birthed the Nipah virus, one the deadliest of human infections: a contagious respiratory ailment killing 40% of those it infects, causing relapse and brain infections, propelling it onto the official U.S. list of bioterrorism agents. And again, according to one of the leaders of the field, it seems to be the way in which we now raise these animals. So, the three eras of human disease can be characterized perhaps as first, the diseases of domestication, then the diseases of industrialization, and of, finally, of land-use and agricultural intensification. We took natural herbivores like cows and sheep, turned them into carnivores and cannibals by feeding them slaughterhouse waste, blood, and manure, and then we took downed animals, too sick to even walk, fed them to people, and now we have mad cow disease. We feed antibiotics to farm animals by the truckload.

This is the total amount of antimicrobials used for all of human medicine every year. Now, contrast that with the amount we feed to farm animals, just to promote growth, or prevent disease, in such a stressful unhygienic environment. Millions of pounds a year, and now we have these multi-drug-resistant bacteria, and we as physicians are running out of good antibiotic options. Scientists at NYU traced the path of some of these "super bugs" starting, for example, with the mass feeding of the Cipro class of antibiotics to chickens, and then we—there is a fecal contamination of the carcass at slaughter. We buy chicken at the supermarket, polluted with fecal material, leading to longer and more severe human infections.

The CDC recently really cinched it. They spent a million dollars over a three-year period doing rectal swabs of newly admitted hospital patients. This is what they found. Essentially, they found zero growth of these antibiotic-resistant bacteria within the bodies of those that had zero contact with fresh or frozen poultry. But at least these so-called super bugs aren't effectively transmitted from one person to the other. With the seeming propensity of industrial animal agriculture to churn out these novel lethal human pathogens, what if these animal factories gave rise to a virus capable of a global pandemic of disease?

Let me put these new animal disease threats in perspective. SARS infected thousands of human beings, killed hundreds; Nipha infected hundreds, killed scores. Strep suis infected scores, killed dozens. Now AIDS has infected millions, but there's only one virus on the planet that can rapidly infect billions, and that's influenza. Influenza, the so-called last great plague of humankind, is the only known pathogen capable of truly global catastrophe these days. Unlike many other important diseases like malaria, which are largely confined at the equator, or a virus like HIV, which is only fluid-borne, the influenza virus is considered the only pathogen capable of literally infecting half of humanity within a matter of months.

Now in the 4,500 years that we as species have had influenza, since the first domestication of birds, influenza has always been one of our most contagious known diseases. But only since the emergence of this highly pathogenic, highly disease-causing strain, H5N1, has the influenza virus also emerged as one of our deadliest. H5N1, spreading out of Asia, 2004, 2005, 2006, and continuing to this day, has only killed about a hundred, a few hundred people. And not to minimize, each death is a terrible tragedy. But in a world in which millions of people continue to die of diseases like AIDS, tuberculosis, why is there so much concern about the so-called bird flu? Because it's happened before. Because the last time a bird flu virus adapted to human beings, it triggered the worst plague in human history: the influenza pandemic of 1918.

Modern flu strains tend to spare young healthy adults, but the 1918 virus killed people in the prime of life. In 1918, a quarter of all Americans fell ill. This is a chart of "Percent of Population Die." Humanity's greatest mass murderer eluded scientists for nearly a century, before a mass grave in Alaska was unearthed. Victims of the pandemic, frozen in the permafrost for 80 years, traces of virus in her lungs allowed scientists to piece together letter by letter the genetic code of the 1918 virus, solving perhaps the greatest medical detective story of all time. Humanity's greatest killer was bird flu. First civilian casualty in the U.S. was September 11th, ironically, 1918, and then, in a single month, this was week one, week two, week three, week four. And this is 1918 now. We're talking steam locomotives here. Scientists at the Imperial College of London ran a simulation to see how a pandemic might spread today in the UK. Scientists at Los Alamos ran a simulation through their supercomputers to see how a pandemic might spread in the day of commercial airline travel. Here, it hits LA in this simulation, and in a few weeks the entire country is blanketed. In 1918, between 50 and 100 million people lost their lives. A similar virus today could kill many, many more. What started out for millions as muscle aches and a fever ended days, or even hours, later, with many people bleeding from their eyes, from their nostrils, from their ears, into their lungs. Homeless orphans, their parents dead, wandered the empty streets. One agonized official in the stricken East sent an urgent warning West. "Hunt up your woodworkers and set them making coffins, then take your street laborers and set them to digging graves."

This is a clipping from *The New York Times*. At the time, victims of plague everywhere, great pyres of bodies consumed by the flames. Many victims strangled in their own bloody fluids. Their corpses, tinged blue from

suffocation, were said to have been stacked like cord wood outside of morgues, and cities ran out of coffins, so they dug mass graves. That bird flu-originating virus killed more people in 25 weeks than AIDS has killed in 25 years. No war, no plague, no famine has ever killed so many people, in so short a time, as the 1918 pandemic. Yet in 1918, the mortality rate of this disease was less than 5%. This estimate here, potentially tens of millions of people dead in the next pandemic, is based on that same 2 to 3% mortality rate. What the CDC is now calling a category 5 pandemic, around 2% mortality, around two million Americans dying. So that's 2%. Currently, H5N1 is officially killing over half of its human victims. Don't even seem to get a coin toss as to whether or not one lives through this disease. Dr. Robert Webster, the world's leading authority on bird flu: "If we go back to 1918, 2.5% of people died. How many people are dying with bird flu? 50%. We've never seen such an event since the time of the plagues."

Up to 60 million Americans come down with the flu every year. What if it suddenly turned deadly? That's what keeps everyone up at night: the possibility, however slight, that a virus like H5N1 could trigger a human pandemic. That'd be like combining one of the most contagious known diseases, influenza, with one of the deadliest, like crossing a disease like Ebola with the common cold.

Where did this virus come from? Well, the current dialog surrounding avian influenza speaks of a potential H5N1 pandemic as if it were a natural disaster—a hurricane, earthquake— of which we couldn't possibly have control. The reality, though, is that the next pandemic may be more of an unnatural disaster of our own making. In poultry, bird flu has gone from an exceedingly rare disease to one which now pops up every year. The number of outbreaks of highly pathogenic avian influenza in the first few years of this century have already exceeded the total number of outbreaks recorded for the entire 20th century. You'll note that these are five-year intervals. Well, in just the first five months of 2006, we were already up to here, without breaks, continuing to this day. If one looks at the number of birds involved, the escalation is even more dramatic. At this scale, not even a blip until the 1980s. Bird flu seems to be undergoing evolution, in fast forward. As one leading flu expert told science, "We've gone from a few snowflakes to an avalanche." And the increase in chicken outbreaks has gone hand in hand with increased transmission to humans.

A little over 10 years ago, essentially no known people—not a single person known to get sick directly from bird flu, but, since H5N1 arose in 1997, four other chicken flu viruses have affected people from Hong Kong to New York City. We can add another pink ring for the four cases in England and Wales last year. In the Netherlands outbreak, there's evidence from a government investigation of a thousand people infected, with symptomatic poultry workers passing the virus on to a whopping 59% of household family members. Human-to-human transmission at a rate of seasonal flu. So, ten years ago or a dozen years ago, essentially no one was getting infected with bird flu, and now there's been over 1,000 cases in continents around the world. Now the Netherlands outbreak—30 million chickens died, but only one person; one of the attending veterinarians tragically died, so the Netherlands virus was good at spreading, but not at killing.

H5N1 is kind of the opposite, right? H5N1 isn't even good at spreading from birds to people. Look, it's been around 10 years, over 10 years. Only a handful of people, a few hundred people, have become infected. And currently— certainly not good at spreading from person to person. But the human lethality of the strain is ferocious: over 10 times deadlier than the worst flu virus on record, that which triggered the pandemic of 1918. So what the Netherlands outbreak shows us is that this virus can evolve to go directly human to human. What H5N1 shows us is that this virus can evolve into an efficient human killer. If this trend is allowed to continue, our nightmare may one day be realized. The worst of both worlds, contagious and deadly. So, to slow down or stop this rapid recent emergence of highly pathogenic flu viruses, one must first ask well, what triggered this avalanche in the first place? What has changed in recent decades to bring this all upon us?

The emergence of H5N1 has been blamed on free-ranging flocks and wild birds. But people have been keeping chickens in backyards for thousands of years, and birds have been migrating for millions. Bird flu has been around forever. What turned bird flu into a killer? Well, the senior correspondent of "News Hour with Jim Lehrer" posed that question to Dr. Webster, the so-called godfather of flu research. "Was there something qualitatively different

about this last decade, made it possible for this disease to do something it's never done before? Some kind of changing conditions that suddenly lit a match to the tinder?" Webster replied. He said, "Farming practices have changed." He talks about growing up on a farm, but "now we put millions of chickens into a chicken factory, next door to a pig factory. And this virus has the opportunity to get in one of these chicken factories, and make billions and billions of these mutations continuously. And so what we've changed is the way we raise animals, and our interaction with those animals." And then, he talks about how the virus is escaping from the factories, infecting wild birds. He says that's what's changed. We've changed the way we raise animals. But we changed the way we raise animals by the billions.

The number of chickens we slaughter every day, spread wing to wing, would wrap more than twice around the world's equator. The big shift in the ecology of avian influenza has been the intensification of the global poultry sector. The developing world meat and egg consumption has exploded, leading to these industrial-scale commercial chicken facilities, arguably the perfect storm environment for the emergence and spread of these so-called "super strains" of influenza. In the early 1980s, nearly all the chickens in China were raised in tiny backyard outdoor flocks, but now there are 63,000 CAFOS in China—concentrated animal feeding operations— with a few of these so-called factory farms confining 10 million birds on a single farm. The World Health Organization blames the emergence of H5N1, SARS, Nipah virus, all these new deadly emerging Asian viruses, in part on what they call the overconsumption of animal products in this intensive animal agriculture.

The Food and Agriculture Organization of the United Nations starts out, "There seems to be an acceleration of human influenza problems in recent years." This is what they mean. This is from the World Health Organization. These are all the new influenza viruses infecting human beings over the last century or so. Now, turn your attention to just 1995 on. Seems to be kind of snowflakes to an avalanche in people, too; but why? Well, according to the world's leading agricultural authority, this is expected to largely relate to the intensification of poultry production, and possibly pig production as well. They elaborate in an internal FAO document, "Chicken to chicken spread, particularly where assisted by these intensive husbandry conditions, causes the virus to shift, adapt to a more severe highly pathogenic type of infection. Intensive production favors the rapid spread of the viruses in the so-called 'hotting up' of the virus from low pathogenicity to highly pathogenic types."

Factory farms, it seems, can be thought of as the incubators for the emergence of highly disease-causing strains of this virus. In this diagram here, they actually trace the path of a human pandemic, starting with increased demand for poultry products, and ending up with a virus capable of human-to-human transmission. The United Nations, in fact, has called on all governments to fight the role of what they call factory farming. Quoting from a UN press release, "Governments, local authorities, international agencies need to take a greatly increased role in combating the role of factory farming, which combined with these live bird markets provide ideal conditions for the virus to spread and mutate into a more dangerous form."

Let me show you how it works. All bird flu viruses start out harmless to both birds and people. Very important to understand. They start out harmless. Avian influenza has existed for millions of years as a harmless intestinal virus of aquatic birds like ducks, waterborne viruses. I said, well, how does a duck's intestinal bug end up in a human cough? Well, in people, the virus must make us sick in order to spread, must make us cough in order to shoot the virus from one person to the next. With the virus's natural reservoir, aquatic birds like ducks, the virus doesn't need to make the ducks sick in order to spread. In fact, it's in the virus's evolutionary best interest not to make the ducks sick as dead ducks don't fly very far. So, the virus silently multiplies, and the intestinal lining of the duck is secreted out into the pond water, is swallowed up by another duck, and the cycle continues, as it has for millions of years, and no one gets hurt. But if an infected duck is dragged to a live bird market, for example, crammed in cages high enough to spot virus-infected feces on land-based birds, terrestrial birds like chickens, well then, the virus has a problem. If the virus finds itself in the gut of a chicken, it no longer has the luxury of easy waterborne spread. Chickens aren't paddling around in the pond, so the virus must mutate or die.

Unfortunately for us, mutating is what influenza viruses seem to do best. So, in its natural reservoir it's been described as being in total evolutionary stasis, harmless, but when thrown into a new host, like land-based birds,

it quickly starts mutating, acquiring mutations to adapt to its new host. In the open air, it must resist dehydration, for example, and it may have to spread to different organs to find a new way to travel. The intestines ain't going to work anymore, and they may find the lungs and become an airborne pathogen, which is bad news for terrestrial mammals, such as ourselves. Goes into chickens as an aquatic virus, but may come out as the flu. In its new host, the more virulent, the more violent, this virus becomes, the quicker it may be able to overwhelm the immune system of its new host. But, if the virus becomes too deadly though, it may not spread as far. In an outdoor setting at least, if the virus kills its host too quickly, the animal may be dead before it has a chance to spread to too many others. So, in nature, there's kind of a natural limit on how virulent these viruses can get—or at least there was until now.

Enter intensive poultry production. When the next beak is just inch—inches—away, there may be no limit to how nasty these viruses can get. Evolutionary biologists believe that this is the key to the emergence of hyper-virulent, predator-type viruses like H5N1. Disease transmission from immobilized hosts. See, when you have a situation where the healthy cannot escape the disease, where the virus can knock you flat, and still transmit just because you're so crowded, then there may be no stopping rapidly-mutating viruses from becoming truly ferocious. And this may explain the virus of 1918, rising out of the trenches of World War I. There were these crowded troop transports; boxcars were labeled "8 horses or 40 men." So, when this harmless virus found itself in these kinds of conditions, it turned deadly. Millions forced together under cramped quarters; no escaping a sick comrade. This is thought to be where the virus of 1918 gained its virulence.

From the virus's point of view though, these same trench warfare conditions exist today. In every industrial chicken shed, every industrial egg operation, confined, crowded, stressed, but by the billions, not just millions. The industry is slowly waking up to this growing realization that viruses previously innocuous to natural host species have in all probability become more virulent by passing through these large commercial populations.
This from an industry journal. Starts out harmless, turns deadly. That's what these conditions may be able to do. This is not arguably how animals were meant to live. So how does the poultry industry feel about the possibility that its own animal factories may produce a virus capable of killing millions of people around the world? Well, the executive editor of "*Poultry*" magazine wrote an editorial on just that topic. She wrote, "The prospect of a virulent flu, to which we have absolutely no resistance is frightening. However, to me, the threat is much greater to the poultry industry. I'm not as worried about the U.S human population dying from bird flu as I am that there will be no chicken to eat." This is how the Department of Interior puts it. "Domesticated poultry is the necessary stepping stone to create a pandemic strain of influenza." Now we used to think pigs were an important link in this chain, so this—probably not a good idea. H5N1 found a way, it seems, not only to kill people directly, but seems to have gone full circle, reinfecting its natural hosts—migratory aquatic species—who could potentially fly this factory farm virus to continents around the world.

Now, unfortunately for us, there's some quirk of evolution. The respiratory tract of a chicken seems to bear striking resemblance to our own primate respiratory tract on a molecular level, on a virus receptor level. So as the virus gets better at infecting, killing chickens, the virus may be getting better at infecting and killing us. Virologist Earl Brown, specialist in the evolution of influenza viruses. "You have to say," Dr. Brown concluded, "again, this high-intensity chicken rearing, really the perfect environment for the evolution for generating virulent avian flu virus."

Now in contrast, there has never been a single recorded emergence of a highly pathogenic flu virus ever from an outdoor chicken flock. Never once has a dangerous deadly virus ever arisen that we know of in chickens kept outside. You can breed a deadly virus here. It can escape. In fact, backyard birds, free-ranging flocks, even wild birds, but that transition from harmless to deadly always seems to happen in these kind of conditions, because of the overcrowding. Remember, transmission from immobilized hosts, because of the sheer numbers. Because of the inadequate ventilation, the dankness helps keep the virus alive. Because of the stress crippling their immune systems. Because of the filth. The virus is in the feces that they're lying in, which, decomposing, releasing ammonia, burning their respiratory tracts, predisposing them to respiratory infection in the first place. And because there may be no sunlight. The UV rays and sunlight are actually quite effective in destroying the influenza

virus. 30 minutes of direct sunlight completely inactivates H5N1, but it can last for days in the shade, and weeks in moist manure.

So, you put all these factors together, and what you have is this kind of perfect storm environment for the emergence and spread of new super strains of influenza. But what about biosecurity? Don't we want all the birds confined indoors, away from waterfowl? I mean, does it matter? If these kinds of conditions can turn a harmless virus into a deadly virus, if the harmless virus can't get inside in the first place? Well, an FAO research report addressed this very question. They, in their evidence-based analysis, they looked at the best data set available: a massive survey of flocks in Thailand, in which over a million birds were tested for H5N1, in factory farms and backyard flocks. And what they expected to find was that backyard flocks would be at higher risk for infection, because they're just out there in the open. What they found was exactly the opposite. They found that backyard flocks are at significantly lower risk of infection, compared to commercial scale operations. Industrial quail and chicken operations were at least four times more likely to become infected than backyard flocks. So, not only may factory farms be the incubators for the original emergence of high-path strains, based on the best science available, they may also play a role in the spread, the subsequent spread of the virus as well—in part because of the massive inputs and outputs required for this industrial style of animal agriculture. Tons of feed and water go in. Tons of waste comes out. Tens of thousands of flies buzzing around. And, these high-volume ventilation fans blowing dust and waste out into the countryside, potentially contaminating the air, the soil, insects, rodents, transport. Industrial-style production can lead to industrial-style contamination of the environment.

Researchers at Johns Hopkins University School of Public Health looked back and realized that their conclusions were actually consistent with other high path outbreaks, whether in the Netherlands, Canada, Italy, other diseases. Factory farms are consistently at higher risk. They concluded that there's no empirical evidence to support this myth that backyard flocks are somehow the crux of the problem. And again, people have been raising birds in their backyards for about 4,000 years before this disease erupted out of control. On other factors, the studies have uncovered widespread disregard for biosecurity, even in developed countries. which claim to have the best biosecurity in the world. According to North Carolina University Poultry Health Management, high biosecurity is still wishful thinking in many areas of intensive poultry production.

A bird flu outbreak in Virginia in 2002 led to the deaths of four million birds. Found its way inside 200 factory farms, highlighting just how wishful the thinking is that industrial poultry populations are somehow completely protected against this kind of infection. Based on the rapid spread of avian influenza in Virginia recently, this decade, USDA poultry virologists conclude the obvious, that biosecurity on many farms is simply inadequate. Investigators from the University of Maryland surveyed chicken facilities throughout the Delaware, Maryland, and Virginia peninsula, perhaps the most concentrated density of chickens in the world, and concluded that U.S. chicken flocks were constantly at risk for infection, triggered by these poor biosecurity practices. But even if the industry had perfect compliance with these guidelines, even if everyone going in and out stepped in antiseptic foot baths, scrubbed their boots, washed their hands, even with perfect compliance, it likely would not be enough. We now know that H5N1 can be carried by flies. You cannot keep flies out of a poultry shed. See, H5N1 is a biosafety level 3+ pathogen. That means in a laboratory setting, this virus must only be handled in unique high containment buildings, specially engineered with airlocks, double-door access, shower in, shower out, all floors, walls, ceilings sealed and waterproofed. All electric outlets, phone cords, caulked, collared, sealed to prevent any air leaks. All surfaces decontaminated daily. All solid waste incinerated. That is how you're supposed to handle this virus. That's biosecurity. In contrast to this, the global industrial poultry industry seems to be breeding viruses like H5N1 at essentially biosafety level zero. So, the poultry industry may not only be playing with fire with no way to put it out, they may be fanning the flames, and firewalls to contain this virus do not yet exist.

Unfortunately, a leading USDA poultry virologist told an international gathering of bird flu scientists, "Unfortunately this level of biosecurity just doesn't exist in the United States," and doubts if it really exists anywhere in the world. And according to emeritus poultry professor, author of Handbook on Livestock Diseases, standards of biosecurity may actually be in decline in an attempt for the industry to cut costs. Now biosecurity

measures as they're currently practiced are certainly better than nothing, but may not be something we want to stake the lives of millions of people upon for the sake of cheaper chicken.

A pandemic caused by H5N1 or some comparable future bird flu virus has the capacity to trigger one of the greatest catastrophes of all time. So, to decrease the risk of generating increasingly dangerous bird flu viruses, the global poultry industry must reverse course, away from greater intensification by, for example, here, in the annals of New York Academy of Sciences, replacing these large industrial units with smaller farms with lower stock and densities of animals, which could potentially result in less stress, less disease susceptibility, less intense infectious contents, and lower infectious loads across the board.

In 2007, the Journal of the American Public Health Association published an editorial that went beyond just calling for de-intensification of the poultry industry. They questioned the prudence of raising so many chickens in the first place. In their editorial, "Chickens Come Home to Roost," it is curious that changing the way humans treat animals—most basically ceasing to eat them, or at the very least radically limiting the quantity of them that is eaten—is largely off the radar as a significant preventive measure. Such a change, if sufficiently adopted or enforced, however, even at this late stage, could still reduce the likelihood of the much-feared influenza pandemic. It would even more likely prevent unknown future diseases that, in the absence of the change, may result from farming animals intensively and killing them for food. Yet humanity does not even seem to consider this option. We don't tend to shore up the levees until after the disaster. Hopefully won't take a pandemic before we take these recommendations into account. The editorial concludes, "Those who consume animals not only harm those animals and endanger themselves, but they also threaten the well-being of future generations on this planet."
To switch avian images, it is time for humans to remove their heads from the sand, and recognize the risk to themselves that can arise from their maltreatment of other species. How we treat animals can have global public health implications. It's not surprising, then, that the American Public Health Association, the largest association of public health professionals in the world, has called for a moratorium on factory farms, urging all federal, state, and local authorities to impose a ban on the building of new intensive livestock operations to protect the health of the local communities in terms of air, water, land contamination, pollution. The prudence of this measure certainly grows with our increasing understanding of the role that these operations play in emerging infectious disease.

I'm often asked how the industry responds to this kind of sentiment from the scientific community? Well, last summer the United Nations released yet another report on the global health risks of intensive animal agriculture. Let me show you how U.S. agribusiness responded to this report. "*Feedstuffs*" is America's leading agribusiness publication, and, in an editorial, responded this way to the FAO research report. "FAO claims to use scientists to generate its reports, but I wonder if those scientists don't resemble a bearded guy living in a cave in Pakistan, who wants the U.S. on its knees?" All too typical of the kind of "you're with us or against us" industry attitude, unfortunately. Now, this is an extreme example.

There are those within industry who can take a step back and look at the longer-term view. Avian health expert and longtime industry insider, Ken Rudd, wrote a really candid article in *Poultry Digest* called "Poultry Reality Check Needed." Drawing on his 37 years' experience from within the poultry industry, he concluded with these prophetic words. He said, "Now is the time to decide. We can go on with business as usual, charging headlong towards lower costs, or we can begin making prudent moves necessary to restore balance between economics and long-range avian health. We can pay now, or we can pay later, but it should be known and it must be said one way or another, we will pay."

So, cutting down our consumption of chickens and fighting the role of factory farming, as the United Nations has called for, may indeed prevent the emergence of future viruses, but H5N1 has already been hatched, already spread and mutated into a more dangerous form, and now that is endemic in poultry populations across two continents, eradication is unlikely. Dr. Michael Osterholm is the director of the U.S. Center for Infectious Disease Research and Policy, an associate director within the Department of Homeland Security. He tried to describe what an H5N1 pandemic could look like in one of the U.S. leading public policy journals, called *Foreign Affairs*. He

asked policymakers to consider the devastation of the 2004 tsunami in South Asia. He said, “Duplicate the tsunami in every major urban center and rural community around the planet. Simultaneously add in the paralyzing fear and panic of contagion, and we begin to get some sense of the potential of pandemic influenza.” That’s what he thinks it could be like. A tsunami in every city, every town, everywhere people drowning in their own bodily fluids. Or, we could imagine Katrina. Imagine every city in New Orleans around the world at the same time, all perhaps because people insisted on eating cheaper chicken.

The next pandemic may be more of an unnatural disaster of our own making. A pandemic of “even moderate impact may result in the single biggest human disaster ever, far greater than AIDS, 9/11, all the wars of the 20th century, and the tsunami combined, has the potential to redirect world history, as the Black Death redirected European history in the 14th century.” Hopefully, the direction world history will take is away from raising birds by the billions under intensive confinement, so as to potentially lower our risk of us ever being in this precarious place ever again.

My intention today was just to focus on primary prevention, getting to the root cause, but with the unprecedented spread of this truly precedented virus, it is important that everyone be prepared for the next influenza pandemic. So let me just throw out some resources. The CDC has set up an excellent pandemic preparedness website: pandemicflu.gov. If you click across here, you will find pandemic preparedness checklists for businesses, schools, communities, faith-based groups, all the way down to individual and family preparation, which really focuses on getting everyone right now to stockpile weeks of essential supplies to shelter in place during a pandemic, isolating ourselves and our families in our homes until the danger passes. The U.S. Department of Homeland Security Is now using as a key planning assumption that the U.S. population may be directed to remain in their homes under self-quarantine for up to 90 days per wave of the pandemic, to support social distancing. Kind of like a snow emergency, where you’re just told to stay inside; don’t go out unless it’s an emergency. But instead of lasting a day or two, lasts weeks or even months. Everyone ready to stay in their homes for three months? If we have to go out to the corner store during a pandemic to buy toilet paper or something, we may be bringing back to our family more than just groceries.

Let me end with a quote from the World Health Organization, The Bottom Line. “The bottom line is that humans have to think about how they treat their animals, how they farm them, how they market them— basically the whole relationship between the animal kingdom and the human kingdom is coming under stress. In this age of emerging plagues, we now have billions of feathered and curly-tailed test tubes for viruses to incubate and mutate within billions more spins at pandemic roulette. Along with human culpability, though, comes hope. If changes in human behavior can cause new plagues, well then, changes in human behavior may prevent them in the future.” Thank you.