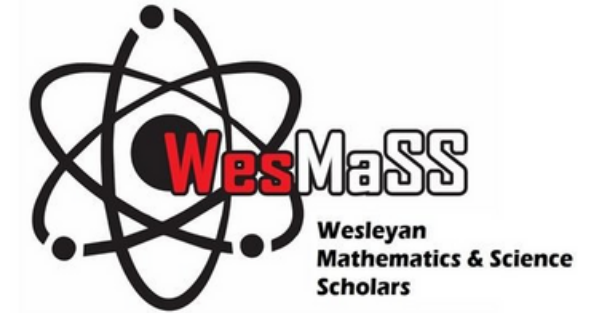




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PLAGUED BY OUR SUCCESS: CONTRIBUTIONS TO A BOOK PROJECT

Elizabeth Ouanemalay and Frederick Cohan
Department of Biology, Wesleyan University, Middletown, CT 06459



INTRODUCTION

Humans within the ecological world are notorious for their disturbance on environment - enough for geologists to deem the current epoch as The Age of Humans. Since the Industrial Revolution, our hunger for the world's natural resources have only exponentiated beyond agriculture, now desiring more food, land, transportation, energy and health care. In a world of scarcity, supply is unable to fulfill our demands, yet we continue to disrupt nature in a way that is both unsustainable and irreversible. Such actions are not without repercussions as mankind has consistently found itself plagued by one disease after another. Our research focuses on major human activities such as urbanization and deforestation, that have detrimentally altered the Earth's biome with the consequences of bringing us infectious diseases. Through our research, we aim to redirect the energy of our visceral fears of infection in a more productive manner that helps to mitigate the emergence of novel pathogens.

Technological innovations are crucial towards containment of these emerging infectious diseases. Current success at reducing the strain caused by infectious diseases can be attributed to technological advancements in vaccine development, antibiotic treatment, and secure access to sanitized water. However, these developments are not enough, especially in developing countries where outbreaks continue to run rampant due to inaccessibility to the health care and tools required to treat these diseases. Therefore, we are suggesting that controlling and limiting the spread of infectious diseases is not only an ecological concern, but a moral imperative as well. If the ultimate goal is eradicating current infectious diseases and restricting the number of future outbreaks, then our efforts must extend beyond individualism and instead merge into collective responsibility. We must financially invest in countries with poor health care infrastructures in order to reduce health inequities and acknowledge the necessary challenges that will come with this growing involvement.

My current research analyzes close calls with various outbreaks throughout the 21st century such as with SARS-1 and Ebola as a result of human consumerism and also the possible origins of our current COVID-19 pandemic. I am particularly interested in our current behavior when dealing with infectious diseases and the ethics behind limiting our carbon footprint and reducing the perils of emerging pathogens. Despite the evidence and number of close calls in regards to outbreaks, we have made little to no progress towards altering these hazardous behaviors which increase the risk of a zoonotic spillover. We still share our street with rats despite their ability to serve as reservoirs for infectious. We still continue to mishandle livestock by placing them in confined and unhygienic conditions despite such conditions amplifying virulent spillovers. We still continue to hunt deer and other animals without proper protective equipment, despite the potential hazard of injury.

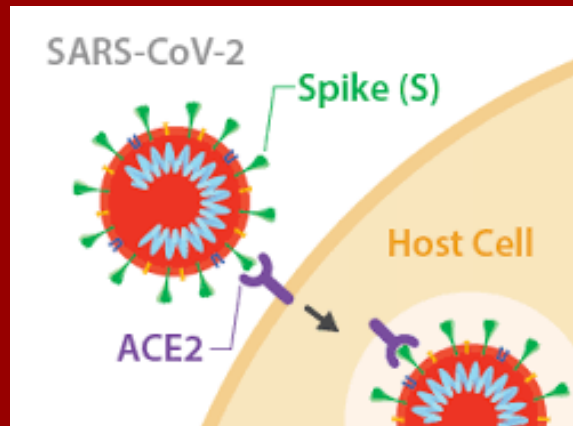


https://www.cifor.org/publications/reports/english2008/domains/reforming_bushmeat.htm

BUSHMEAT IN THE FOOD CHAIN

The dangers of bushmeat hunger linger long after the animal has been killed.

"Captive wild animals destined for the table are vulnerable to infections from other animals as they move through the food supply chain. This is seen most obviously in the case of SARS in 2002, when captive civets became infected with a bat's coronavirus at a live-animal market in Guangdong, and then passed on their new infection to their human handlers. A recent study shows that captive field rats in Vietnam steadily increase their likelihood of carrying coronaviruses as they move on the food supply chain from bushmeat hunters to restaurants (Huong et al. 2020). Contributing to increased infection rates are the constricted conditions in transit, plus the stressors of travel that may hinder the rats' immune response, making rats more susceptible to pathogens, as well as their likelihood of spilling over a pathogen to humans."



<https://www.sciencedirect.com/science/article/pii/S0950268820301201>
ORIGINS OF COVID-19

So many factors are believed to have been involved with the emergence of COVID-19.

"While uncertainties remain, the consensus among scientists is that the virus came to us as an accident of human disturbance of wild animals, where animals sold in a live-animal market became infected by a bat virus (Andersen et al. 2020). Nevertheless, remaining uncertainties have given rise to conspiracy theories that the virus emerged through nefarious actions of human actors (Metz 2020). Of particular interest here is the origin of the receptor-binding domain of the virus's spike protein. Conspiracy theories purport that the virus was modified either at the Wuhan Center for Disease Control (CDC) or the Wuhan Institute of Virology (WIH) to increase the binding of the virus to human ACE2.

As new information unfolds, such claims are increasingly laid to rest, especially those of the SARS-CoV-2 being the product of genetic modification. Genomic analysis of the SARS-CoV-2 has revealed that the receptor-binding domain (RBD) on this virus possesses a strong affinity not just to human ACE2 but also to the ACE2 of several other mammals, including pangolins (Andersen et al. 2020). Also, the binding of SARS-CoV-2 to human ACE2 is far from optimal and could have been improved if it were the product of genetic engineering (Andersen et al. 2020). Instead, the origin of SARS-CoV-2's RBD through recombination with the pangolin's virus appears to explain the origin of the RBD sequence most parsimoniously. The conspiracy theories are not needed to explain the origin of the virus."

REFERENCES

- Andersen, K. G., A. Rambaut, W. I. Lipkin, E. C. Holmes, and R. F. Garry. 2020. The proximal origin of SARS-CoV-2. *Nature Medicine* 26:450-452.
- Baize, S., D. Pannetier, L. Cestreich, T. Riegler, L. Koiragui, N. F. Magassouba, B. Soropogui, M. S. Sow, S. Keita, H. De Clerck, A. Tiffany, G. Dominguez, M. Loua, A. Traoré, M. Kolié, E. R. Malano, E. Heleze, A. Bocquin, S. Mely, H. Raoul, V. Caro, D. Cadar, M. Gabriel, M. Pahlmann, D. Tappin, J. Schmidt-Chanais, B. Impouma, A. K. Diallo, P. Formenty, M. Van Herp, and S. Günther. 2014. Emergence of Zaire Ebola Virus Disease in Guinea. *New England Journal of Medicine* 371:1418-1425.
- Brookshire, B. 2020. 5 reasons you might be seeing more wildlife during the COVID-19 pandemic. *Science News*.
- CDC. 2012. *Mycobacterium bovis* (Bovine Tuberculosis) in Humans.
- Chakrabarti, S., P. Singh, and T. Bruckner. 2020. Association of Poor Sanitation With Growth Measurements Among Children in India. *Jama network open* 3:e202791-e202791.
- Enserink, M. 2020. Coronavirus rips through Dutch mink farms, triggering culls. *Science* 368:1169.
- Hayman, D. T. S., M. Yu, O. Cramari, L.-F. Wang, R. Suu-Ire, J. L. N. Wood, and A. A. Cunningham. 2012. Ebola virus antibodies in fruit bats, Ghana, West Africa. *Emerging Infectious Diseases* 18:1207-1209.
- Hagenboom, M. 2014. Ebola is bushmeat behind the outbreak? *BBC News*.
- Huang, P. 2020. Dutch Minks Contrast COVID-19 - And Appare To Infect Humans. *Goats and Soda*.
- Huong, N. Q., N. T. Thanh Ngo, N. Van Long, B. D. Luu, A. Latane, M. Pruvot, N. T. Phuong, L. T. Vinh Quang, V. Van Hung, N. T. Lan, N. T. Hoa, P. Q. Minh, N. T. Diap, N. Tung, V. D. Ky, S. I. Robertson, H. B. Thuy, N. Van Long, M. Gilbert, L. Wickler, J. A. K. Mazer, C. K. Johnson, T. Goldstein, A. Tremou-Bravard, V. Ontiveros, D. O. Joly, C. Walzer, A. E. Fine, and S. H. Olson. 2020. Coronavirus testing indicates transmission risk increases along wildlife supply chains for human consumption in Viet Nam, 2015-2014. *bioRxiv* 2020.2016.2005.098590.
- Kuehn, R. 2019. Tuberculosis in Deer Hunters. *JAMA* 322:1757-1757.
- Kurpiers, L. A., B. Schulte-Herbruggen, I. Eptoe, and D. M. Reeder. 2015. Bushmeat and Emerging Infectious Diseases: Lessons from Africa. *Problematic Wildlife: A Cross-Disciplinary Approach*:507-551.
- Laporta, G. Z. 2014. Landscape fragmentation and Ebola outbreaks. *Mem Inst Oswaldo Cruz* 109:1038.
- McPhail, W. 2020. *Block Party*. The New Yorker.
- Metz, J. 2020. Origins of SARS-CoV-2.
- Padilla, M. 2020. C.D.C. Warns of 'Aggressive' Rats Searching for Food During Shutdowns. *New York Times*.
- Pigott, M. A., A. I. Miller, L. East, C. Morozoff, B. A. Han, F. M. Shearer, D. J. Weiss, O. J. Brady, M. U. G. Kraemer, C. L. Moyes, S. Bhatt, P. W. Gething, N. Golding, and S. I. Hay. 2016. Updates to the zoonotic risk map of Ebola virus disease in Africa. *PLoS One* 11:e016412.



THE LINK BETWEEN MINKS AND COVID

Research has shown that the current conditions of many livestock amplify the risk of zoonotic spillovers.

"A new casualty of Covid-19 is the mink industry in Europe, where minks are raised at high densities for their fur. The new human disease appears to have jumped from humans to farmed minks. In late April of 2020, beginning with two Dutch farms, and eventually spreading to 17 of the 125 farms in the Netherlands, minks have presented symptoms of respiratory disease, later confirmed to be positive for Covid-19. The virus was most likely transmitted to the minks from a sick farm worker. Similarly in Spain, a farm with nearly 100,000 minks was hosting an epidemic of Covid. Here 87% of animals tested positive. To contain the spread of the virus, the Dutch and Spanish governments culled infected herds (Enserink 2020). Given similarities in lung structure between minks, ferrets, and humans, such a transmission is not surprising.

If Covid-19 were to become established in mink farms, the virus could eventually move from minks to wild mammals. In this case, eradicating the virus would become much more complicated than just eliminating human cases (Huang 2020)."



RATS AMONG US

Anybody who lives in major city has probably encountered a rat or two out in the streets.

"Despite our best efforts to rid our cities of rodents, they are still with us. The recent Covid-19 lockdowns clearly revealed the abundance of urban rats to anyone looking to observe nature on sidewalks and alleys. Rats were desperate to find food during the lockdowns because their usual food supply in restaurant dumpsters had disappeared. At the same time, there were fewer of us on the streets to scare away the rats. This emboldened rats to venture out in broad daylight in search of food (Padilla 2020). Will McPhail's cartoon 'Block Party' celebrates the liberation of the urban rat during the pandemic lockdowns—rats are partying on a city street while humans peer down mournfully from their apartment windows, each in isolation (McPhail 2020). Rats may be easier to spot in the pandemic, but there has been no discernible uptick in their population (Brookshire 2020). More than just an eyesore, our continuing proximity to rats poses a significant peril to public health, even in the modern age."

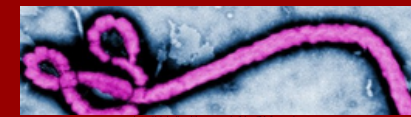


DANGERS OF DEER HUNTING

Deer hunting is a beloved American pastime that many do not realize, harbors the same hazards as bushmeat hunting.

"Cooking protects us from the most obvious danger of ingesting pathogens in our prey, but it does not protect us from a range of human errors in handling carcasses. Handling of animal carcasses can subtly abrade our skin, serving as a gateway for pathogens. Even if we are careful, our skin usually has tiny cuts anyway, so a novel pathogen can spill over from the prey to the human hunter or butcher. We can also become infected if we do not properly decontaminate frequently utilized surfaces and tools. Such concerns in America arise predominantly from the beloved pastime of deer hunting. In one recent case, three deer hunters in Michigan testing positive for tuberculosis after exposure to the bacterium *Mycobacterium bovis* from an infected deer, either through an injury in handling the deer from inhaling aerosols from the deer before it died (Kuehn 2019). *M. bovis* is a close relative of the pathogen that causes most of human tuberculosis, and largely infects domesticated cows and their wild relatives.

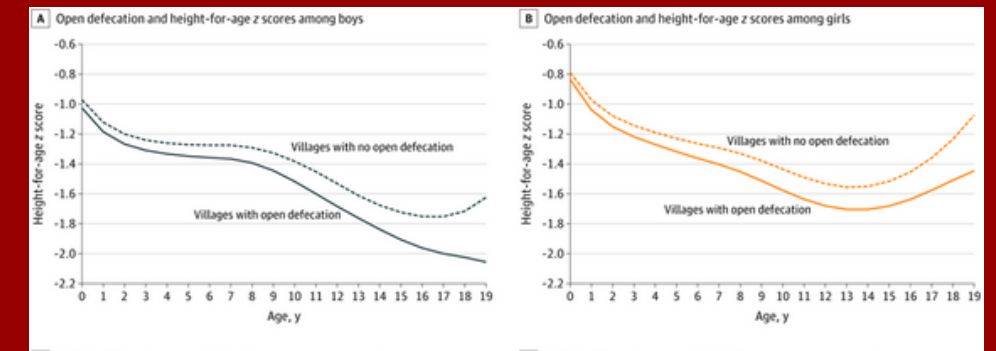
Most spillover events such as these do not pose a major threat to public health as many transgressing pathogens are neither novel to humanity nor incurable. In the case of *M. bovis*, one may even be latently infected and not realize it, as infection can be asymptomatic and does not always progress to tuberculosis (CDC 2012). Even if one were to be diagnosed with *M. bovis*, an amalgam of antibiotics is typically able to treat the disease (CDC 2012)."



EBOLA OUTBREAKS

The Ebola outbreak of 2014 was one that sent chills down the spines of epidemiologists due to how close it came to becoming a pandemic.

"The recent Ebola epidemic in West Africa infected nearly 50,000 people and killed over 11,000 in 2014. The epidemic began with a single spillover to a two-year-old child in the village of Meliandou in Guinea, West Africa (Baize et al. 2014). This Patient Zero hailed from a family of bushmeat hunters who had recently hunted two species of fruit bats believed to be reservoirs for the Ebola virus. Bushmeat hunting was therefore deemed a likely route of infection (Hogenbloom 2014, Kurpiers et al. 2015, Pigott et al. 2016). To this date, we are still unable to confirm the reservoir species for Ebola, but have strong reason to believe that fruit bats are a superior reservoir host. Presence of antibodies in large fractions of fruit bat populations in Western and Central Africa suggest that bats do not get seriously ill with Ebola Virus and are possibly asymptomatic carriers of infection (Hayman et al. 2012, Pigott et al. 2016). Since the first known Ebola cases in the 1970s, outbreaks have occurred with greater frequency and intensity (Kurpiers et al. 2015). Encroachment has blurred the territory distinguishing human and nonhuman animals, escalating transmission rates. Indeed, most Ebola outbreaks are associated with newly deforested land (Laporta 2014). We will return to the environmental disturbances that bring us Ebola in Chapter 2."



<https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2764400>

POOR SANITATION AND STUNTED GROWTH IN INDIA

India is one of the many developing countries which continue to lack steady access to sanitized water.

"Beyond short-term diarrhea, lack of proper sanitation may hold long-term detrimental health consequences for developing countries. In fact, poor sanitation and exposure to fecal pathogens during early childhood increase the risk of stunting growth. Research in India shows that exposure to waterborne pathogens from poor sanitation correlates with short stature (Chakrabarti et al. 2020)."

FUTURE DIRECTIONS

There are still many unknowns in the scientific world when dealing with the mechanisms of viruses and spillovers. Therefore, it is essential to closely monitor disease with the potential to become outbreaks and to quickly treat any cases as soon as they occur. Future research will focus on the ethical decisions of preventing infectious diseases.

We have come a long way thanks to current technological advances having greatly reduced the tragedies of infectious diseases in developed countries. However, the current procedures in place are not enough. Even with our current tools, many developing countries still lack the resources and infrastructure to prevent the emergence of novel pathogens. Most continue to be plagued by vector diseases like West Nile Virus, Ebola, Malaria, etc. that lack a vaccination.

We must look beyond our individual selves and instead adopt a communitarian view in our belief in science and desire to continue producing innovative tools. Innovation alone will be restricted if we solely rely on science, hence the importance of recognizing infectious disease research as a moral imperative. It is also crucial to recognize the influence of government in its ability to provide the financial support and resources towards reducing health inequities. Concepts drawn from Socialism of the Microbe will prove critical to the understanding and prevention of both current and future infectious diseases.

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