

A Call for One Health in Medical Education: How the COVID-19 Pandemic Underscores the Need to Integrate Human, Animal, and Environmental Health

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Abstract

During the early stages of the COVID-19 pandemic in 2020, the first author, then a fourth-year student at Harvard Medical School, was enrolled in a One Health clinical experience at Zoo New England where he was introduced to a transdisciplinary approach to integrate human, animal, and ecosystem health. Seeing the vast impact of the pandemic and knowing its roots as a zoonotic disease, he realized this approach was critical to his medical education and for preparation against future novel infectious diseases. Zoonotic diseases have been emerging into human populations with increasing frequency,

leading to public health emergencies such as Ebola, avian influenza, and SARS. The SARS-CoV-2 narrative, starting in bats and then mutating through an intermediate host into humans, is another striking example of the interconnectedness between human, animal, and ecosystem health that underlies these infections. Preventing future pandemics will require a transdisciplinary One Health approach, and physicians should be prepared to participate in these discussions while advocating for One Health initiatives for the benefit of their current and future patients. Integration

of One Health education into medical school curricula will also prepare future physicians for other complex and urgently important health issues such as climate change, antimicrobial resistance, and the impact of biodiversity loss. As the consequences of the COVID-19 pandemic persist, education in One Health must become a priority; it is essential to break down the conventional disciplinary silos of human medicine, veterinary medicine, environmental health, public health, and the social sciences, so that future health crises can be prevented and mitigated collaboratively.

I entered my One Health rotation at Zoo New England's Franklin Park Zoo in Boston excited for the opportunity to interact with zoo animal patients as part of a fascinating clinical experience, but I had not anticipated that, during my time as a student at Harvard Medical School (HMS), it would be my only exposure to an essential framework for understanding a global public health crisis.* This rotation was a unique, hands-on opportunity to learn about the interconnectedness of human, animal, and environmental well-being, which would prove extraordinarily relevant in March 2020.

Before my rotation was cut short due to the COVID-19 pandemic, every day at the zoo brought new and unique experiences. On my first day,

we conducted ultrasounds on a tapir and a pygmy hippo, checking each for pregnancy. Later in my time there, we performed a full physical and dental exam of a hyena. I did a double take looking at the abdominal radiograph, which showed large, sharp, mineral opacities throughout the abdomen. The lead vet looked over to a zoo keeper and asked when the hyena was last fed bones. Sure enough, bones had been on the hyena's menu the day before, confirming these opacities were indeed bone in the gastrointestinal tract, something I had not considered because of my bias toward human patients. But this foundation in comparative medicine was only to serve as the context for a broader understanding of the interrelatedness of health for all beings on the planet.

After spending mornings working with the veterinarians in their clinical practice, I spent afternoons diving into assigned readings and discussions with mentors about One Health. The One Health approach attempts to solve complex health problems by engaging professionals from many disciplines such as human, veterinary, and ecosystem

health, as well as the social sciences.¹ I learned that over the past 30 years, novel infectious diseases have been arising with increasing frequency, with the vast majority being zoonoses originating in animals. Ebola, highly pathogenic avian influenza, West Nile virus, Lyme disease, Nipah virus, and the coronavirus-induced Middle Eastern respiratory syndrome and SARS are striking examples of this trend.¹

As my 4-week rotation continued, it became increasingly clear to me how this unique clinical experience was linked to the COVID-19 pandemic I saw unfolding around me. Then, halfway through my month with the veterinarians at Zoo New England, the zoo was forced to close. HMS also halted student rotations due to the pandemic, ironically ending my only formal exposure to the One Health framework. As COVID-19 spread across the United States and altered every aspect of our lives, lessons about the emergence of zoonotic diseases with pandemic potential ceased to feel like distant history lessons or case studies from the other side of the world.

I had been following the SARS-CoV-2 story for a couple months, and it was increasingly clear that COVID-19

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Acad Med. 2021;96:951-953.

First published online March 23, 2021

doi: 10.1097/ACM.0000000000004072

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*This essay is written from the perspective of one author (M.P.D.), though both authors contributed to the contents and organization of the piece.

was going to have a major impact in the United States and Europe. Cases and deaths in Seattle were rising exponentially, heart-wrenching stories about ventilator shortages in Italy were surfacing, and there was increasing concern about new cases arising in New York City. By the time of this writing, there can be no doubts about the incalculable losses of life and disruptions to our daily routines which have been caused by COVID-19. But, sadly, all our responses to this pandemic have been reactive. Why are more zoonotic infections emerging now, and what can we do to prevent them or catch them earlier? I know now that a One Health approach will be critical to answering these questions.

The coronavirus story is a One Health story. Wildlife trafficking and alterations in land use are major threats to the Earth's biodiversity and have brought animal carriers of coronaviruses, most notably bats, increasingly into contact with humans and domestic animals.² The SARS outbreak nearly 2 decades ago was thought to have originated in horseshoe bats in the genus *Rhinolophus* and then spread to masked palm civets and 2 other wildlife species.³ These animals were being sold at a live animal market in the Guangdong Province of China. Coronaviruses are known to mutate, allowing for animal-to-human and human-to-human transmission.³ When there is increased interaction at the human-wildlife interface, there is also increased likelihood that these random mutations result in transmission to humans. Many of these viruses may be only a few mutations away from widespread human-to-human transmission.

SARS-CoV-2 is thought to have followed a similar path of emergence. Based on the best available evidence, the virus started in bats, then went through an intermediate host to a food market in Wuhan, China.⁴ The virus then mutated again, acquiring the ability to infect humans and subsequently beginning human-to-human spread.⁵ While virus mutations can be unpredictable, our responses do not need to be. Given the known reservoir of these potentially harmful viruses in bats, and the interactions of bats with other animals near the human-wildlife interface, a One Health approach would implement

measures to decrease the risk of future zoonotic diseases.^{6,7}

Such measures could involve the creation of systems that decrease the risks of transmission from the natural host. To achieve this, we must take into account the interfaces that the natural host has with humans or intermediate hosts, and how those interfaces are changing over time, including human expansions into bat habitats, or trafficking of bats and other wildlife for human consumption.² Public health messaging could also instruct people about behaviors to minimize risk. Risk of transmission from the intermediate host can be reduced by separating domestic animals and wildlife. Regular monitoring plus a rapid response to a possibly threatening virus could also prevent or limit disease spread.⁶

While prevention or risk mitigation efforts like those described above are typically led by ecologists or public health experts and not physicians, physicians should be equipped with core competencies such that we can understand, collaborate, and advocate for systemic change. We must be taught to appreciate health in the context of ecosystems and to understand the ways that physicians might lend their particular expertise as one discipline among many required for comprehensive solutions to complex global issues. The core competencies of One Health that should be required of medical trainees must include appropriate epidemic response, but these principles are generalizable to many other pressing issues of our day as well.⁸ Antibiotic resistance is a complex topic in which environmental or agricultural use of antibiotics can directly influence human health through water sources or food consumption.^{9,10} While stewardship of antibiotics is an important component of preventing multi-drug-resistant microbes, it will be insufficient without transdisciplinary interventions to combat resistance. Climate change will also have a profound impact on our patients. The effects will be direct, such as a higher number of people dying from extreme temperature and weather events.^{11,12} Even more important, water resources,^{13,14} global biodiversity,¹⁵ and food supply chains¹⁶ will likely all suffer, leading to untold effects on our planet and human populations. The long-term ramifications of the COVID-19 pandemic may be small

in comparison to these downstream effects of climate change unless we act soon.

Realizing the importance of One Health led me to reflect on why I had selected this experience in the first place, over numerous other potentially transformative and unique clinical and nonclinical rotations. I had registered for the elective a full year before SARS-CoV-2 was discovered, so although the pandemic deepened my interest, it was not the cause of it. My appreciation for the One Health approach goes back to my roots, growing up on a farm in rural Michigan, where our connectedness with land and animals is inevitable. As with most rural areas, our water comes from a well that is sensitive to groundwater contamination from pollutants. Adequate control of the white-tailed deer population is important to avoid motor vehicle accidents and promote crop growth, a balance that would not be needed if their natural predators such as bobcats, coyotes, and wolves had not been driven away from the area. For most of the 2018–2019 academic year I lived in Botswana, where cows roam around downtown in the capital, elephant-human interactions commonly lead to destruction of property and much-needed water sources in rural communities, and the desert climate would be among the first to severely suffer from rising global temperatures. Both of these contexts solidified for me the importance of integrating animal and ecosystem health into the biomedical model of medicine.

Throughout medical school, my peers and I learned from many disciplines outside traditional biomedical fields that are essential to our clinical practice and research. We learned epidemiology and other public health principles so our perspective would expand beyond the hospital or clinic. We covered social determinants of health because it is essential to understand systems of housing, racism, and poverty that often determine health outcomes: a sad reality which the COVID-19 pandemic has highlighted.^{17–19} We studied health policy, which informs structures and incentives behind our clinical practices. I regard each of these topics as an essential part of my medical education, and they have informed my own career path in profound ways.

My One Health elective with Zoo New England was another essential component of my medical education, as the COVID-19 pandemic has made abundantly clear. Although few trainees will share such a clinical experience, One Health education should be integrated into medical education curricula. This should start early, during the preclerkship curriculum. One Health educational modules could be led by professionals representing multiple fields to include human and veterinary medicine, public health, ecosystem health, ecology, social sciences, and so on, ideally bringing students together from the different disciplines to explore relevant case studies collaboratively. During clerkships, teaching should continue in One Health-informed social history taking; for example, urban heat islands, poor air quality, extreme weather or temperature events, vector-borne disease exposures, and animal interactions can all be related to providing the best care for patients in the short and long terms.²⁰ When possible, further clinical activities can be offered after clerkships to explore One Health via collaborations between medical schools, vet schools, zoos, and wildlife reservations or parks, similar to the transformative experience I had as a final-year medical student.

I will witness more zoonoses leading to epidemics or pandemics during my medical career, and the conventional disciplinary silos of human medicine, veterinary medicine, environmental health, public health, and the social sciences will not adequately prevent or respond to emerging diseases without cross-disciplinary training and collaboration. Education in One Health will be essential to equipping future physicians to advocate for a One Health approach and the preservation of biodiversity so that we can enact policy and public health interventions to prevent the next pandemic. One Health will also be critical to our understanding of other broad environmental and human health issues like climate change and antibiotic resistance, which are urgently important as well. As I enter my internship in

a hospital system slowly returning to normal following the first wave of COVID-19, I feel obligated to conduct my interviews with One Health in mind,²¹ to conduct One Health-informed research outside the traditional biomedical model, and to frequently discuss these themes with my colleagues and mentors. With COVID-19, countries around the globe can now only react to the pandemic because we are far beyond prevention or containment. If we truly believe in embracing prevention and addressing disease at its roots, we can no longer neglect integrating One Health into our medical education.

Acknowledgments: The authors would like to thank Zoo New England and Harvard Medical School for their support of this initiative and inspiring the writing of this work.

Funding/Support: None reported.

Other disclosures: None reported.

Ethical approval: Reported as not applicable.

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