Emerging Viruses and Epidemics

What is a Viral Epidemic?

To understand the scope and importance of a viral epidemic, we first must expand upon what an epidemic is. The normal disease or infection prevalence in a geographic location is referred to as the **endemic level**. Endemic infections or diseases are typically always present in a population, whereas **sporadic** infections or diseases can emerge infrequently and unpredictably. When a pathology is considered **hyperendemic**, this means that the disease is seen consistently and in high levels1. An example of an endemic virus is dengue, which has become endemic in almost all of South America due to the rapid spread of the viral carrier, a species of mosquito called Ae. aegypti3. Simply, an **epidemic** indicates a rapid increase in the number of reported cases of a disease or infection in an area, far above what is considered endemic1. A viral epidemic, then, refers to a sudden increase in reported cases of a virus.

For example, in 1901 there was a smallpox epidemic in Boston that resulted in 1,500 reported cases and 270 deaths. Most recently, the CDC has declared that the Zika virus was a public health emergency due to its rapid expansion in North and South America after its original discovery in Uganda2. Though the term “viral epidemic” may spur thoughts of the Spanish Influenza or Smallpox outbreaks that killed or otherwise seriously affected millions, outbreaks do not have to reach these staggering numbers to be considered an epidemic. In fact, it is much more beneficial to declare a public health emergency and garner scientific interest before it reaches these disastrous levels.

What are Contributing Factors to Emerging Viruses?

There are many contributing factors to emerging viruses, some that are viral specific and many which are contributing to most emerging diseases. Most of the causes of emerging diseases, or in some cases reemerging diseases, are due to the high level of human movement due to globalization. As mentioned previously, it is natural for there to be endemic disease in any given geographical location. People who live in these areas may have a natural immunity built up due to past exposure or genetic defenses. However, due to an increase in global travel and exposure to new populations, people can go from a country with endemic West Nile to a country who isn’t, and effectively put the new population at risk of exposure. Furthermore, when people travel or people move commercial goods overseas, they could be carrying **vectors** of disease with them, like mosquitos. A vector is an organism that transmits a pathogen from one organism to another.

A tragic, but perhaps inevitable, example of this is the introduction of the mosquito species *Aedes albopictus* to the United States in 1985 due to a shipment of tires to Houston, TX4. Before the introduction of *Aedes albopictus*, the United States only had *Aedes aegypti*, which has the potential to spread many tropical viruses but can only live in warm environments and typically only feeds at dusk5. *Aedes albopictus* is not limited to warm climates and can survive in broader climates than *Ae. aegypti*, so it has successfully established itself in at least 32 states since its initial exposure to Houston in 19854,5. Additionally, this mosquito does not limit its feeding to just dusk and can bite animals and humans during the day as well. Prior to 1985, Americans didn’t have to worry about mosquito bites unless they were out when it was dark. The good news is that *Ae. albopictus* is much less likely to spread viruses because it feeds on animals and humans, but this demonstrates how easily a vector could be introduced in a population and quickly dominate the landscape.

Additionally, our long history of exposure to animals also contributes to the emergence of disease and potential establishment of an epidemic. Since humans started to domesticate animals for use in agriculture, we have made ourselves vulnerable to zoonoses. **Zoonoses** refers to diseases or pathogens that can be transmitted from animals to humans. When we work in close quarters with animals, whether that be for agricultural or companionship purposes, we expose ourselves to a plethora of diseases that are naturally found in animals. For example, some reptiles are known carriers of salmonella and if proper hygiene practices aren’t followed while interacting with a pet reptile, the handler could contract salmonella6. Salmonella is relatively mild, and, in most cases, symptoms resolve themselves rather quickly. In the next section of this chapter, we will cover emerging viruses from an animal that is not as mild as salmonella.

Another contributing factor to emerging viruses is the high rate of viral evolution. Many viruses are RNA viruses and so they utilize **RNA polymerase**. This is an enzyme that creates new RNA strands from template strands, **DNA polymerase** makes new DNA strands from template strands. The error rate of RNA polymerase is much higher than the error rate of DNA polymerase and this results in many more point mutations after RNA replication. This high propensity for mutation increases even more so when a virus is stressed, so when a virus establishes itself in a population and potentially reaches epidemic levels, the population may start to die off, gain natural immunity, or begin medical treatment. In these stressful situations, a virus could be gaining mutations at a rapid rate and may gain a beneficial mutation that can help it survive to continue infecting people.

Lastly, the anti-vaccine movement has been gaining momentum globally and vaccination rates are becoming lower and lower. For vaccines to work properly, they rely on a concept known as herd immunity. **Herd immunity** refers to collective immunity against a virus when 93% of a population is vaccinated, which means that even unvaccinated individuals will reap the benefits of the vaccine. In the U.S., New York has been hit with the worst case of measles since the 1990s, with 80% of those affected reporting being unvaccinated. The 20% of vaccinated people may have been vaccinated long ago and no longer had the beneficial effects from the vaccine but were protected under herd immunity7. Now that vaccination rates have dropped below the recommended 93%, even those who have been vaccinated previously are at risk.

Some Current Examples of Emerging Viruses

As mentioned previously, there are worse zoonotic diseases than salmonella that are now being reported in human populations. Smallpox was the first officially eradicated disease, and for good reason given its virulence. **Virulence** refers to how infectious an agent is and how severe the symptoms are. However, there are now reports of a similar virus termed monkeypox that can be transferred from animals to humans. The Gambian rat is one of the **natural hosts** of monkeypox, meaning that it shows little to no symptoms of the disease. However, the Gambian rat can transmit the virus to other animals and humans, causing similar symptoms to smallpox. Thankfully, the fatality rate of monkeypox is only estimated to be 1 to 10%, but when it first popped up it caused an immediate scare within world health organizations due to the similarity to smallpox8.

Though there are seemingly endless emerging viruses popping up naturally, another important category of emerging viruses are the ones being created in research labs. Most commonly, researchers are doing dual research on influenza strains. **Dual research** refers to research that has both scientific and weapons/bio warfare implications. A team of researchers sought out to recreate the strain of influenza that killed 50 million in 1918, and they were successful much to the horror of many in the community9. They accomplished this by using many fragments of the virus found from hospital samples and a corpse found in Alaska. Recently, scientists proved how easy it is to synthesize the Polio virus in a lab by using multiple oligo sequences and piecing the original sequence together10. **Oligos** are short DNA or RNA sequences that can be spliced together to make genes, and it is relatively easy for anyone with a laboratory background to do this. The synthesized Polio virus was found to be identical to the original Polio virus that has plagued human populations for decades before a vaccine was developed.

How do We Prevent Future Epidemics?

Prevention of future epidemics comes down to due diligence of epidemiologists and other infectious disease specialists to monitor and prevent the spread of emerging disease. This is complicated by poor access to healthcare and vaccines in impoverished regions, recent refusal to self-vaccinate or vaccinate children, and poor practices of quarantine or sterilization during global movement of people and animals. Once a virus emerges or reemerges and establishes itself in a population, there is not much that can be done but to focus attention on preventing new cases, treating or curing current cases, and containing the spread. Many countries have extremely relaxed policies surrounding quarantining newly arrived animals or screening newly arrived human populations, but Australia is a good example of national policies aiming to prevent newly introduced pathogens. They have implemented several detailed and thorough guidelines for what can be brought into their country and how it can be introduced11. While harsh, they have a policy of killing any and all stray cats due to their propensity to spread disease and decimate native animal populations, especially birds and rodents11. Adopting strict and careful policies such as these could markedly reduce zoonotic diseases, which attribute to many human infections.

Additionally, increasing the vaccination rate through mandatory vaccination policies and increased financial support in impoverished areas would greatly reduce incidences of disease. As mentioned previously, herd immunity must be at 93% to work properly, and as more and more individuals choose to not vaccinate, we will continue to see outbreaks of previously controlled viruses. Some U.S. states and other countries are choosing to mandate vaccines by law, while others such as Arizona are considering loosening their policies regarding mandatory vaccinations12. It is almost certain that we will continue to see emerging viruses and epidemics pop up worldwide, but the global response and action plan to combat this issue is yet to be decided on.

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