Chapter

The One-Health Approach to Infectious Disease Outbreaks Control

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Abstract

Close contact between people, animals, plants, and their shared environment provides more disease transmission opportunities. Host characteristics, environmental conditions, and habitat disruption can provide new opportunities for disease to occur. These changes may lead to the spread of existing and new diseases. Bacteria, viruses, fungi, protozoans, sporozoans, worms, and others cause infectious diseases. Some of these diseases may be prone to explosive outbreaks and may constitute deadly epidemic threats that could rapidly reach pandemic proportions. Drugs and vaccines can successfully control many infectious diseases; however, this is challenged by the lack of facilities and resources. In all parts of the world, infectious disease is an essential constraint to increased human, animal, and environmental interactions. Identifying hot-spot and interventions for prevention while considering the heterogeneity of target diseases to places, population time, or situation is essential. Therefore, successful infectious disease control measures must be based on understanding disease transmission pathways, strengthening surveillance systems, and intervention. Application of the One Health method is a responsive approach to infectious disease control. Much of the One-Health based approach to managing an infectious disease has been utilized with a promising effect on controlling current outbreaks. More deliberate efforts should encourage understanding of disease determinants to analyze infectious disease issues through a One-Health lens. Only through the extensive participation of all related field stakeholders can One-Health truly reach its potential to mitigate infectious disease outbreaks. This chapter reviews utilization of the One Health approach to infectious disease outbreak control.

Keywords: virus, one health, infectious disease, outbreak, control

1. Introduction

Infectious disease remains responsible for a large part of the world's premature death and disability burden [1]. Bacteria, viruses, and protozoa, among other agents, cause infectious diseases to humans [2]. Usually, infected cases are present in numbers at an expected level, but an outbreak may occur every once in a while [3]. A new strain of the disease agent can significantly impact either the local or global levels [4]. For example, global pandemics of smallpox, cholera, and influenza periodically threatened populations before developing improved living conditions, especially in high-income countries [5]. To date, safe, effective, and affordable vaccines and the increasing availability of antibiotics have reduced the burden of many such diseases in high-income countries, though there is a lack of adequate control in many middle and low-income countries [5, 6].

Close contact between people, animals, plants, and their shared environment provides an increased risk of disease transmission [7]. Host characteristics, environmental conditions, and habitat disruption can provide new disease opportunities [6, 7]. These changes may lead to the spread of new or emerging diseases. For instance, viral diseases have become as common as emerging and re-emerging diseases [8]. They occur worldwide, in a variety of ecological settings [9]. Others are found only in limited ecologic and geographic foci. Over 60 percent of infectious diseases and 70 percent of humans' emerging infections are zoonotic, with two-thirds originating in wildlife or domestic animals [9, 10]. Notable examples of globally emerging and re-emerging infectious diseases include Ebola hemorrhagic fever, dengue, chikungunya, yellow fever, and other respiratory viral infections such as pandemic influenza H1N1 2009, SARS, Avian Influenza (H5N1) and (H7N9) [11, 12]. These diseases are prone to explosive outbreaks and constitute deadly epidemic threats that could rapidly reach pandemic proportions, affecting people's lives [13]. On the other hand, a global increase in antibiotic-resistant bacteria has resulted in pathogens resistant to most or essentially all of the available antimicrobials [14]. Problems facing scientists today include the emergence of diseases from the fast-changing human-animal ecosystems due to multiple factors [15]. Increasing human-environment interaction provides ingredients for outbreaks of infectious diseases [16].

In a world of increased frequency of interaction, animal food production for human consumption, increased use of transportation, and increased movement of people across national borders, these factors act as determinants for infectious diseases by directly or indirectly influencing the occurrence and distribution of infectious diseases [17]. Measures for successful disease control must be based on understanding disease transmission pathways, strengthening surveillance systems, and intervention [18, 19]. This is possible by the application of the One Health approach. Much of the One-Health based approach to managing outbreaks of infectious disease has been utilized with a promising effect to control current outbreaks. More deliberate efforts should encourage understanding of disease determinants to analyze infectious disease issues through a One-Health lens. Only through the extensive participation of all related field stakeholders can One-Health truly reach its potential to mitigate infectious disease outbreaks.

One Health is a collaborative, multisector, and transdisciplinary approach — working from local to global levels — to achieve optimal health outcomes by recognizing the interconnection between people, animals, plants, and their shared environment [20–23]. Therefore, One Health is an approach that recognizes that people's health is closely connected to animals' health and shared environment. One Health has become more important recently because many factors have changed interactions between the environment, people, animals, and plants [24].

Human populations continue to grow and expand. They increase close contact with wild and domestic animals, both livestock and pets [25]. Animals play an important role in lives, whether for food, fiber, livelihoods, travel, sport, education, or companionship [26].

Animals also share susceptibility to environmental hazards and some diseases, which can sometimes serve as early warning signs of potential human illness. For instance, birds often die of the West Nile virus before people in the same area get sick with West Nile virus infection [24–27].

The One Health issue includes a focus on zoonotic and vector-borne diseases, antimicrobial resistance, food safety, food security, environmental contamination, and other health threats shared by humans, the environment, and animals. Other fields such as chronic disease, mental health, injury, occupational health, and non-communicable diseases also benefit from a One Health approach involving collaboration across disciplines and sectors [28, 29].

One Health is gaining recognition globally as an effective way to fight health issues at the human-animal-environment interface, including zoonotic diseases.

The complexity of health and environmental challenges needs to be evaluated in an integrated and holistic manner to provide a more comprehensive understanding of problems and potential solutions [30, 31]. Concerted efforts in the paradigm shift from the silo-based health systems to the One Health approach is important [29–32]. Decision-makers for disease prevention and control should utilize the One Health approach to prepare for and prevent illness, hospitalization, death, and the economic burden experienced during disease epidemics. In any public health emergency, an early warning system to combat epidemics is usually immediately implemented. Response networks, e.g., the Global Outbreak Alert and Response Network (G.O.A.R.N.), collaborate with institutions and networks to pool their human and technical resources to fight outbreaks [33]. The critical decision to initiate disease response is often reactive and urgently needed in a rapidly changing environment with little or incomplete information available and biased [33, 34]. Traditional surveillance systems provide regular data updates. However, these systems are inherently retrospective and delayed, limiting their utility for real-time epidemic response [35].

Additionally, a silo-based health system deals with present conditions or those immediately expected [30–36]. The One Health approach could help fill these holes by controlling the utility, scale, and timing of counteraction techniques [36]. For example, scientists recognized the link between human and animal health and its threats to Ebola epidemics' welfare and economies. This resulted from the importance of collaborative and cross-disciplinary approaches for responding to emerging and resurging diseases, particularly the inclusion of a wildlife component for global disease prevention and control.

During infectious disease outbreaks, the coordination and communication of prevention strategies – such as vaccination and treatment – support the deployment and management of crucial public health resources [37]. However, earlier trial vaccines that are protective in animals and safe to humans are not useful because most existing beneficial trials are not standardized or validated. Patients' safety remains unknown because the resources are usually limited and not enough to conduct conclusive trials [38]. Testing the drugs in animals is challenged by the unavailability of facilities to conduct research. Specifically, there are not enough biosafety laboratories. A significant issue surrounding this and other potential disease preventive measures is ensuring the availability and affordability of any useful drugs and vaccines [39]. The One Health approach could bring together scientists, public health officials, and researchers from academia, industry, and government in an open project and develop tools to address specific disease prevention challenges [40]. The tool could be a program to predict disease trends while addressing specific needs by engaging decision-makers and researchers in real-world scenarios. For instance, a collaborative effort that focuses on geographic risk can provide greater insight into which geographic areas emergent pathogens may be circulating in but are undetected [41]. These predictive models allow for more strategic focusing of resources for monitoring the emergence and spread of threats [42]. Continuous surveillance of wildlife and domestic livestock in these limited areas for early detection of pathogens may yield faster and more economical results than spreading resources worldwide to detect pathogens [39–42]. Wildlife is a reservoir of an extraordinarily deep and diverse pool of novel microbial agents [43]. Even considering such overwhelming diversity, the actual numbers of microbial agents reported to infect humans and cause disease are probably many viral infections that remain undetected [44]. Continuous surveillance focusing on these few microbial agents for early detection of pathogens may yield faster and more economical results than spreading resources to all possible microbial agents to detect pathogens [43–45]. As a result, chance-based interceptions permit the utilization of information about the heterogeneity of hazard to target outbreak location to those spots, populaces, times, or circumstances where the danger of sickness is generally considerable and the probability of discovering high [46].

While the specific disease sources remain unknown, many pathogens are thought to be harbored in wild animals or the environment, with initial transmission to humans via contact with infected animal species or fomites, and later spread through human-to-human transmission [47]. The world-ecology provides habitats for diverse fauna [48]. Changes of the natural ecosystem because of social-cultural and environmental procedures have increased closeness between the human populace, domesticated animals, and wildlife, promoting increased contacts with the disease-causing microbe [49]. The One Health approach is expected to provide a good understanding of the drivers of spillover events from hot spot dwelling fauna to interfacing humans, which will enable disease prevention and control at the source while forecasting accuracy, visualization and communication, collaboration and partner engagement, state and local health department perspectives, pilot projects, and other issues at hand.

Using infectious disease outbreaks response as an example, we propose in this chapter utilization of the One Health concept approach, such as identifying spillover sources in both human and animal populations, designing comprehensive surveillance systems, and implementing an intervention approach to combat infectious disease outbreak.

2. Understanding disease transmission pathways

Complex interactions of humans with the biotic and abiotic components of the environment facilitate spillover events [3, 50]. Documenting how diseases occur is the key to understanding disease transmission pathways and different meanings attached to infectious diseases in different communities [34, 51]. This includes identifying potential sources and reservoirs of viruses in environmental, human, and animal systems.

Data collection is crucial to attaining preliminary information for the identification of sources of transmission. Numerous agencies publish data regarding clinical cases of human and animal disease, both spatially and temporally. These data can be collected and analyzed through integrated human-animal disease surveillance to assess infectious disease occurrence [51]. Additionally, spatial and temporal patterns, the likelihood of infectious disease in certain areas or periods, land use [52], human/livestock/wildlife population density [53], and other data may be collected and analyzed. Potential pathways can be prioritized to determine the most relevant regions [54]. A system of weight factors to perform prioritization using statistical models could be developed, such as the degree of human-animal interactions [55]. Regulation of environment and livestock waste could impact the importance of the potential pathways associated with human-animal ecosystem interactions.

3. Strengthening surveillance systems

Surveillance systems of the critical environmental reservoirs and pathways will allow for the early detection of outbreaks. It is essential to quickly identify critical times and critical locations for the onset of outbreaks by monitoring disease indicators such as the pathogen presence or burden in a particular community with associated risk factors. This can be achieved by the environment, livestock, wildlife, and human sampling [56]. Regular monitoring of critical reservoirs will identify peaks in presence or indicators related to early signals of disease outbreaks [57].

Traditional human and livestock disease detection and management systems are based on diagnostic analyses of clinical samples [58–60]. However, these systems fail to detect early warnings of public health threats at a broad population level and fail to predict outbreaks promptly [61]. An alternative to this could be using human-wildlife contaminated ecosystems such as community-based urine, fecal, and other samples to identify public, wildlife, or livestock health [62]. This kind of monitoring, together with unique sampling, allows early detection and prediction of outbreaks by understanding pathogens, including shedding rates, risks, and magnitudes, critical in disease surveillance [63]. Recently, raw sewage has been used to monitor the presence and abundance of COVID-19 in communities. An epidemiological tool developed and refined by environmental scientists over the last 20 years (Wastewater-Based Epidemiology — WBE) holds the potential to contain and mitigate Covid-19 outbreaks while also minimizing domino effects such as unnecessarily long stay-at-home policies that stress humans and economies alike. WBE measures chemical signatures in sewage, such as fragment biomarkers from the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), only by applying the type of clinical diagnostic testing to the collective signature of entire communities [64]. As such, it could rapidly establish Covid-19 infections across an entire community. The One Health surveillance model aims to identify risks before clinical cases are reported [65]. Mapping pandemic potential can facilitate data collection representative of at-risk regions followed by risk mitigations [66]. Microbial source tracking can be more complicated, especially in limited-resource areas, which necessitates determining the environment to sample. Specific population, shedding rate and natural degradation and comparison, and correlation with clinical data are vital tools for getting reliable information for strengthening surveillance systems [66–68].

Intervention approaches in the One Health approach involve utilizing feasible innovation technology for human and animal ecosystems management, medical and veterinary interventions to oversee diseases, and education of local communities and governments to change human behavior, practices, and policy based on relationships between the environments or human and animal health [69].

The first intervention for vaccine-preventable infectious diseases is wildlife animal vaccination and treatment strategies [70]. Disease preventive measures act as a barrier between human-animal disease transmissions. For example, encouraging the disinfection of clean water could remove pathogens from the community. Interventions to prevent pathogens shedding are among the possible management that requires multiple strategies for accomplishment [71, 72]. For instance, rabies prevention by oral vaccination of wildlife with live vaccines has proven a powerful tool to eliminate or control rabies in multiple countries in Europe and North America. In 2012–2013 U.S. Department of Agriculture's Animal and Plant Health Inspection Service through Wildlife Services program, conducted the field trial involving the distribution of new oral rabies live recombinant human adenovirus type 5 vector, expressing rabies virus glycoprotein (AdRG1.3) (Onrab) vaccine bait in five states [73]. Baits laden with oral rabies vaccines are essential for managing wildlife rabies to monitor human contacts and potential vaccine virus exposure. Continued surveillance like these is needed because of the potential for vaccine virus infection [74].

This approach and several others can be considered examples of the complementary policies for the permanent implementation of interventions. There is a need to regulate animal pathogen shedding in waste products, especially in rural areas and forest ecosystems, and other previously reported critical transmission pathways [75–77].

The modification of human behavior is also imperative to minimize the transmittance of infectious diseases and pathways in which interventions cannot be performed for cost, capability, or convenience [78–81]. One primary health behavior-changing method is educating medical, veterinarians, and environmental professionals in the One-Health approach [82]. It is also crucial to educate the public where people are vulnerable to disease transmission [83]. Especially in impoverished, high-risk areas, robust measures should be taken to educate the public on the critical pathways of transmission of viral disease [84–88].

4. Conclusions

This chapter advocate utilizing the One Health model as part of the solution to the ultimate control of infectious disease outbreaks. Disease transmission includes complex frameworks that incorporate associations between humans, animals, and the environment. These systems have spatial and temporal variations that require a deep understanding of the interaction and the processes within. The most significant advance in understanding disease transmission is identifying reservoirs and primary transmission pathways.

Traditional infectious disease control measures such as case management, vaccination, active surveillance, case identification and isolation, and strategic community engagement have helped contain outbreaks. However, many people still die, and more epidemics are anticipated in previously affected and new geographical areas; new control approaches, including One Health, are essential. Research on the role of wildlife in disease causation should be undertaken to improve the situation. Wildlife surveillance data on the biodiversity of animal interface found in the hot spot regions and the pathogen's activity in animals and humans should also be included in strategic interventions. Overall, infectious disease control's success requires a balance between medicine, veterinary science, bioscience, epidemiology, health systems, socioanthropology, and political science, to facilitate early detection and response to unusual events.

Moreover, documenting how diseases occur is the key to understanding disease transmission pathways and different meanings attached to infectious diseases in various communities. A multipronged approach with data and tracking systems' support is an equally important component in attaining national and global health security. The One-Health-based approach to managing an infectious disease has been utilized with a promising effect to control few current outbreaks; there has still more principally that needs to be grasped by the veterinary network. Increasingly purposeful endeavors ought to urge other professionals to examine infectious disease issues through a One-Health focal point. Only through the broad cooperation of all related field partners can One-Health arrive at its capability to control infectious diseases.

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