REVIEW ARTICLE

Perspectives of Emerging Zoonoses – Challenges and Opportunities

Muhammad Tariq Navid[1], Raheela Akhtar,[2] Muhammad Zeeshan Bhatti [1]

ABSTRACT

Zoonoses are infectious diseases that are linked with human and animals. During the last few decades, human-animal linkages and close associations have increased the threats of the zoonotic diseases up-to several times. The increasing demands of animal-based edible proteins have resulted in a higher rate of human-animal interaction. Moreover, human, animal and environmental factors have increased the threat of vector-borne and food-borne illnesses globally. In the present study, we have focused on vector-borne and food-borne diseases that are transmissible between human and animal species. We have highlighted a few opportunities through which we can reduce the chances of emerging zoonotic illnesses in developing countries such as Pakistan.

Key Words: *EmergingInfection,Human-AnimalInterface,One Health,Zoonoses.*

How to cite this: *Navid MT, Akhtar R, Bhatti MZ. Perspectives of Emerging Zoonoses – Challenges and Opportunities. Life and Science. 2020;1(4):169-173. doi:http://doi.org/10.37185/LnS.1.1.70*

The Emerging Zoonoses

1. Pathogen Context

Among the various health hazards, emerging zoonoses have the potential to induce human illnesses. The pathogens originated from animals, contribute to more than half of the total known pathogens.[1] About 75% of newly emerging infections are zoonotic. Since the last three decades, the emerging pathogens have been evolved alarmingly and the scientists correlated this increase with frequent contact of animals with human beings (Fig. 1).[2] The threat from zoonotic diseases potentially introduced a new concept of One Health (OH). The OH approach is defined by One Health Commission (OHC) as the collaborative efforts of multiple disciplines to obtain optimal health for people, animals and environment.[3] The emerging zoonoses are a threat posed by newly evolved pathogens that needs to be reinvestigated and detected, through a sustained network and following the OH principles. This strategy can help to prevent the globe from zoonotic disease pandemics.

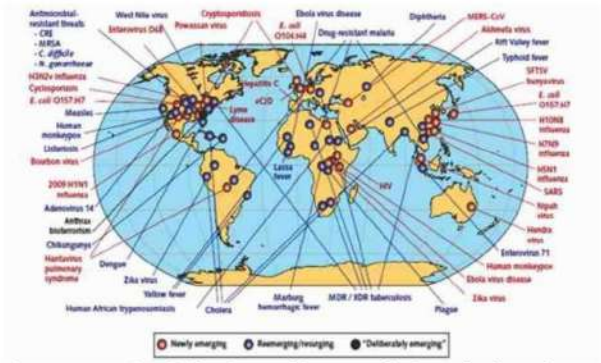

Fig 1: Emerging infectious diseases during the last few decades in various parts of the globe[2]

The emerging zoonoses are presumed due to the extensive use of bio-habitat which leads to altered biodiversity and its associated life practices. This introduces disruptions in the ecosystem and causes an alteration in disease transmission. The global toxification and pathogenic pollution has been increased due to various factors at human-animal-environmental interface which lead to serious concerns in health and biodiversity.[4] More than 700 mammals and avian species have been affected adversely due to climate change. The[5] zoonotic diseases affect one billion livestock producer along with 2.7 million human deaths annually. Only[6] six diseases (Ebola, Chikungunya, Lyme disease, HIV, Influenza, MERS-CoV) caused USD 800 billion loss

[1]*Department of Biological Sciences*
National University of Medical Sciences, Rawalpindi
[2]*Department of Pathology*
University of Veterinary and Animal Sciences, Lahore
Correspondence:
Dr. Muhammad Zeeshan Bhatti
Assistant Professor, Biological Sciences
National University of Medical Sciences, Rawalpindi
E-mail: zeeshan.bhatti@numspak.edu.pk

Funding Source: NIL; Conflict of Interest: NIL
Received: Sep 03, 2019; Revised: Apr 24, 2020
Accepted: Sep 10, 2020

during 1997-2009, while only avian influenza caused economic losses of USD 300 billion which is about 5% of global GDP.[7]

Since the expansion of human population, various factors have influenced the dynamics of zoonoses emergence. These factors are associated with humans, animals and their environment (Fig 2). The human factors are increase in population density, higher mobility, uncontrolled urbanization and increasing demand for animal protein. The animal factors are coupled with the intensive production system, increase in trade of animal and products, live animal markets and peri-urban production. The environmental factors are related with deforestation, climate change, human encroachment, habitat fragmentation and biodiversity loss.

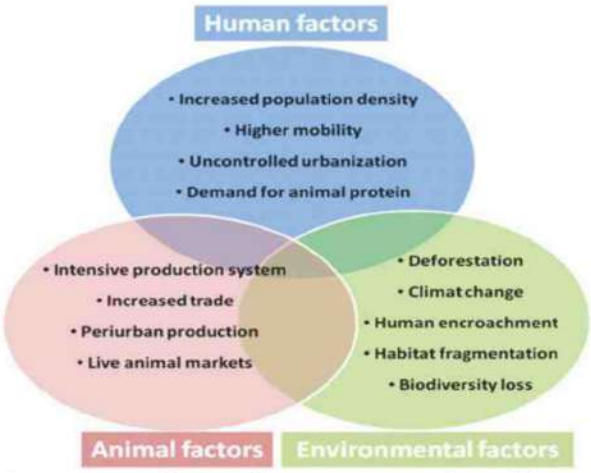

Fig 2: Factors affecting disease pattern and possibly playing a role in the emerging and re-emerging of infectious diseases in the globe

2. Vector-borne Zoonoses

Around 30% of the emerging zoonotic infections are vector-borne and connected with domestic and wild animal reservoirs. The vector-borne zoonoses are transmitted through ticks, mosquitoes, flies and many other arthropods. Extensive agricultural and livestock production has enhanced the house-hold interaction with the commodity that increased the chances of vector-borne infections. The higher incidence of novel and known arthropod based infections indicates human encroachments over animal natural habitats. These practices resulted in henipa viruses, Crimean Congo Hemorrhagic Fever virus, Middle East Respiratory Syndrome coronaviruses and bunya virus infections.[8,9,10] Eisen and colleagues shared a comprehensive review on ticks, their geographical distribution and opportunities for vector adoption in current times. About 40% of the emerging pathogens have been emerged during the last two decades.[11]

Mosquitoes are considered as one of the deadliest creatures. They act as a vector for various diseases that resulted in the deaths of millions of people each year (Table 1). The global incidence of dengue has multipliedthirty times in the last three decades, while malaria alone caused the deaths of 0.44 million people during 2015. The majority of mosquitoes like Aedes, Culex, and Anopheles induce various highly threatening diseases like Zika, Chikungunya, Dengue,

Table 1: Timeline for Zoonoses and Epidemics of the 21st Century

Year	Event	Comments	References
1999	West Nile virus arrives in New York	Poor state of preparedness of Public Health	Sejvar et al[12]
2001	West Nile hits Florida	Surprise at the ferocity of the epidemic (Originate from wild birds)	Paz et al[13]
2003	SARS pandemic	From wild animals (Canada , Korea, China hit primarily)	LeDuc et al[14]
	Monkeypox	Could it have been smallpox?	Yinka-Ogunleye et al [15]
	Mad Cow Disease	From cow meat in UK, Germany, Italy, Russia	Washer et al[16]
	West Nile impacts the Mid-West USA	Spread recorded as an epidemic from wild birds	Wimberly et al[17]
2004	H5N1 Avian Influenza explodes	Some human cases and deaths in China	Fasanmi et al [18]
2005-7	H5N1 Avian Influenza spreads to more countries in Asia (Panzootic)	Virus adapts to village poultry, ducks & wild birds. (Still persists; 31 fatalities recorded in Egypt in 2015)	Smallman-Raynor et al[19]
2010	H1N1 Swine flu spreads to human	H1N1 Triple reassortant, killed > 55,000	Chastagner et al[20]
2014	Ebola	From Monkeys in Africa	Rewar et al[21]
	H7N9 Avian Influenza outbreaks	From birds to human in China	Millman et al [22]
2014-15	MERS-CoV	From Camel to human in Middle East	Han et al[23]
2015-16	Zika outbreaks	Cases reported in Brazil that induces Public Health Emrg.	Osorio-de-Castro et al[24]
2017-18	H1N1 outbreaks	Cases reported in Punjab, Pakistan	Sherwani et al [25]
2019-20	SARS-CoV-2	Global pandemic of COVID-19	Andersen et al [26]

Others viral emergencies include Eastern Equine Encephalitis, Lassa, Nipah, Hendra, Rift Valley Fever, CCHF ,Chikungunya *etc.*

and Yellow fever. Global warming has introduced a variety of mosquitoes, having enhanced efficiency of viral replication while globalization has facilitated new pathways for the increase of vector-borne zoonoses.

3. Food-borne Zoonoses

Various zoonotic pathogens transmitted to human bodies through the consumption of contaminated food items and/or drinking water. The increase rate in urbanization and demand for readily available/frozen animal meat products have amplified the threat in developed countries. The development and preferences of human taste for bush meat have allowed direct contact with a potential reservoir of zoonotic pathogens.[27,28,29]

Moreover, the unhygienic procedures for meat processing, preservation and even meat consumption played an important role in the emergence of high impact zoonoses like SARS-CoV, ebolavirus, retroviruses, noroviruses, hepatitis A and E viruses. The high impacted food-borne bacterial pathogens are *campylobacter*, *salmonella*, pathogenic *Escherichia coli*, and toxins of *Staphylococcus aureus, Clostridium perfringens, Clostridium botulinum* and *Bacillus cereus. Parasite based food-borne illnesses are produced by Trichinella*, *Toxoplasma*, *Cryptosporidium*, and *Giardia.*[30] Most of the food-borne pathogens are normally inhabitant in the intestine of the animal and the risk for the emergence of disease is present, from farm till fork that needs a comprehensive strategy for prevention and control of the emergence throughout the food chain. Food-borne zoonotic illnesses are a global public health concern and need a coordinated approach to control. Usually viruses need living cells to live in and to replicate. Majority of food-borne viruses are highly infectious for human beings and spread diseases from person to person.[31] The reporting system for food-borne viral pathogens does not exist even in the advanced countries which highlights an utmost need of systemic surveillance program for such pathogens. Moreover, poor and insufficient detection mechanisms along with continuous evolution in viral genomes are increasing the disease burden throughout the globe.[32]

4. Possible role of RNA viruses in upcoming pandemics

The RNA viruses are a diversified group of emerging zoonotic pathogens that contain about 180 different species. The evolutionary nature of RNA viruses is uniquely important supplemented with the discovery of two new species each year.[33] There is wide range of host susceptibility among human, avian and mammalian hosts for these pathogens. This susceptibility helps in disease transmission and signifies a global challenge for disease control. As the RNA viruses rapidly adapt to a new species and transmit the disease this leads to a pandemic. Examples of RNA viruses include HIV, SARS, Hendra, Nipa, and MERS to name a few. Carrasco-Hernández and collaborators,[34] throughout different levels of complexity, cover the molecular mechanisms allowing RNA viruses to adapt to new host species and to develop resistance to specific pharmaceutical regimes.

5. Possible Solution for Emerging Zoonotic Diseases

5.1 Awareness

Zoonotic diseases are naturally transmitted between human and animal hosts. A study for the assessment of zoonotic diseases conducted from human and animal health workers in 2016 suggested that public health awareness campaigns and educating healthcare workers along with optimum diagnostic facilities are the key steps toward recognition and diagnosis of zoonotic diseases in the developing countries.[35] In Pakistan, the structural framework for the assessment and awareness for zoonotic diseases in health care sector is deficit. Such awareness, perceptions and practices are critically important to design an effective program for the improvement of diagnosis and treatment.

5.2 Early Pathogen Detection

One of the important segments of a zoonotic pathogen is established non-symptomatic or asymptomatic persistent infection. This status is relevant for intermittent reactivation and shedding of a pathogen into the environment. The clinical infection is quite different than comprehensive pathogen detection program must consider differential point for an persistent infection, it is necessary to understand the entire philosophy.[36] A appropriate diagnosis.

Other than the technical issues, highly specialized and well-equipped laboratory with highly trained staff is required at the national level. The biosafety and biosecurity is important for dealing with

zoonotic pathogens.[37] The strategies for internal collaboration between local and national laboratories according to the WHO guidelines and a quick response to Outbreak and Response Network may be needed all the time.

5.3. Effective Surveillance

"Surveillance for emerging diseases contributes to global security. If basic surveillance and laboratory capacities are compromised, will health authorities catch the next SARS [severe acute respiratory syndrome], or spot the emergence of a pandemic virus in time to warn the world and mitigate the damage?"—Dr. Margaret Chan

Director-General of the World Health Organization Address at the 23rd Forum on Global Issues. (March 18, 2009)

The rapid spreading of the emerging infectious and zoonotic diseases across the nations and contents urges an effective surveillance system. This surveillance program integrates detection of pathogens of human and animal origin which is a global requirement at the earliest possible time.

Currently, an effective, integrative, collaborative and nationally /internationally monitored surveillance program is deficit throughout the world (Fig 3). The public and private institutions across the countries and regions are committed to establish an effective surveillance program along with all relevant sectors *via* human health, animal health, natural resources, agriculture and education. This surveillance program will comprehensively meet the quality, multi-sectoral collaboration, its goals and objectives in a true sense under the guidelines of WHO and OIE.[38]

5.4. Integrated Diagnostics

The emerging zoonotic pathogens are a challenge to global health system. Although the novel sophisticated diagnostics assays have upgraded our capability to capture and respond to these pathogens more rapidly. These sophisticated techniques are based on the initial identification of such specific disease at local community level where the initial cases are reported from human and animal host. Most of the developing countries are at high risk of zoonotic diseases and are deficit with sufficient infrastructure and trained personnel to combat these public health threats. These countries are also unable to support advanced laboratory diagnosis.

Fig 3: The surveillance cycle for investigating infectious diseases

The advanced mechanism for such pathogen detection is based on various factors that include from a comprehensive understanding about local sociological and ecological factors for disease transmission, surveillance methodology at human-animal interface (One Health), community engagements, diagnostic facilities and trained laboratory workforce.[36] Both the human and animal health sector should share the information about the zoonotic diseases and should work together for the quick response towards control of these threats.

Conclusion

Animal transmitted human diseases have a potential threat to mankind. The evolutionary changes and adoption to the environment are modifying the zoonotic pathogens as stronger than ever before. These pathogens are directly or indirectly inducing health hazards through vector-borne and food-borne illnesses. Most of the pandemic outbreaks are induced by RNA viruses due to their multi-host adaptability. The current zoonotic threats may be reduced through the dissemination of awareness about the diseases, early pathogen detection, effective surveillance and integrating diagnosis. An integrated approach from the human and animal health sector is needed for the establishment of an effective zoonotic disease control program.

Acknowledgements

We are thankful to the National University of Medical Sciences for providing facilities to conduct this work.

REFERENCES

1. Bank W. People, pathogens, and our planet : Volume one : towards a one health approach for controlling zoonotic diseases (English). Washington, DC; 2010.

2. Paules CI, Eisinger RW, Marston HD, Fauci AS. What Recent History Has Taught Us About Responding to Emerging Infectious Disease Threats. Ann Intern Med. 2017; 167: 805-11.
3. Commission OH. Sharing responsibilities and coordinating global activities to address health risks at the animal-human-ecosystems interfaces. One Health Commission; 2010.
4. Aguirre AA. Biodiversity and Human Health. EcoHealth. 2009; 6: 153-6.
5. Pacifici M, Visconti P, Butchart SHM, Watson JEM, Cassola FM, Rondinini C. Species' traits influenced their response to recent climate change. Nature Climate Change. 2017; 7: 205-8.
6. Magwedere K, Hemberger MY, Hoffman LC, Dziva F. Zoonoses: a potential obstacle to the growing wildlife industry of Namibia. Infect Ecol Epidemiol. 2012; 2: 18365.
7. Bank W. People, pathogens and our planet : the economics of one health (English). World Bank; 2012.
8. Croser EL, Marsh GA. The changing face of the henipaviruses. Vet Microbiol. 2013; 167: 151-8.
9. Liu Q, He B, Huang SY, Wei F, Zhu XQ. Severe fever with thrombocytopenia syndrome, an emerging tick-borne zoonosis. The Lancet Infectious Diseases. 2014; 14: 763-72.
10. Wit Ed, Doremalen NV, Falzarano D, Munster VJ. SARS and MERS: recent insights into emerging coronaviruses. Nat Rev Microbiol. 2016; 14: 523-34.
11. Eisen RJ, Kugeler KJ, Eisen L, Beard CB, Paddock CD. Tick-Borne Zoonoses in the United States: Persistent and Emerging Threats to Human Health. ILAR J. 2017; 58: 319-35.
12. Sejvar JJ. West nile virus: an historical overview. Ochsner J. 2003; 5: 6-10.
13. Paz S. Climate change impacts on West Nile virus transmission in a global context. Philos Trans R Soc Lond B Biol Sci. 2015; 370: 20130561. LeDuc JW, Barry MA. SARS, the First Pandemic of the 21st Century 1. Emerging Infectious Diseases. 2004; 10: e26-e.
14. Yinka-Ogunleye A, Aruna O, Dalhat M, Ogoina D, McCollum A, Disu Y, et al. Outbreak of human monkeypox in Nigeria in 2017–18: a clinical and epidemiological report. The Lancet Infectious Diseases. 2019; 19: 872-9.
15. Washer P. Representations of mad cow disease. Social science & medicine. 2006; 62: 457-66.
16. Wimberly MC, Lamsal A, Giacomo P, Chuang TW. Regional variation of climatic influences on West Nile virus outbreaks in the United States. Am J Trop Med Hyg. 2014; 91: 677-84.
17. Fasanmi OG, Odetokun IA, Balogun FA, Fasina FO. Public health concerns of highly pathogenic avian influenza H5N1 endemicity in Africa. Vet World. 2017; 10: 1194-204.
18. Smallman-Raynor M, Cliff AD. The Geographical Spread of Avian Influenza A (H5N1): Panzootic Transmission (December 2003–May 2006), Pandemic Potential, and Implications. Annals of the Association of American Geographers. 2008; 98: 553-82.
19. Chastagner A, Herve S, Bonin E, Queguiner S, Hirchaud E, Henritzi D, et al. Spatiotemporal Distribution and Evolution of the A/H1N1 2009 Pandemic Influenza Virus in Pigs in France from 2009 to 2017: Identification of a Potential Swine-Specific Lineage. J Virol. 2018; 92: e00988-18.
20. Rewar S, Mirdha D. Transmission of ebola virus disease: an overview. Ann Glob Health. 2014; 80: 444-51.
21. Millman AJ, Havers F, Iuliano AD, Davis CT, Sar B, Sovann L, et al. Detecting Spread of Avian Influenza A(H7N9) Virus Beyond China. Emerg Infect Dis. 2015; 21: 741-9.
22. Han HJ, Yu H, Yu XJ. Evidence for zoonotic origins of Middle East respiratory syndrome coronavirus. J Gen Virol. 2016; 97: 274-80.
23. Osorio-de-Castro CGS, Miranda ES, Freitas CMD, Camargo KJD, Cranmer HH. The Zika Virus Outbreak in Brazil: Knowledge Gaps and Challenges for Risk Reduction. Am J Public alth. 2017; 107: 960-5.
24. Sherwani RAK. Awareness about swine flu/H1N1 influenza virus among the tertiary population of Lahore, Pakistan. J Pak Med Assoc. 2017; 67: 1596-9.
25. Andersen KG, Rambaut A, Lipkin WI, Holmes EC, Garry RF. The proximal origin of SARS-CoV-2. Nat Med. 2020; 26: 450-2.
26. Kamins AO, Restif O, Ntiamoa-Baidu Y, Suu-Ire R, Hayman DT, Cunningham AA, et al. Uncovering the fruit bat bushmeat commodity chain and the true extent of fruit bat hunting in Ghana, West Africa. Biol Conserv. 2011; 144: 3000-8.
27. Karesh WB, Noble E. The bushmeat trade: increased opportunities for transmission of zoonotic disease. Mt Sinai J Med. 2009; 76: 429-34.
28. Suwannarong K, Schuler S. Bat consumption in Thailand. Infect Ecol Epidemiol. 2016; 6: 29941.
29. Arie H. Food-borne zoonotic diseases EFSA2016 [Available from: https://www.efsa.europa.eu/en/topics/topic/food-borne-zoonotic-diseases.
30. de Wit MA, Koopmans MP, van Duynhoven YT. Risk factors for norovirus, Sapporo-like virus, and group A rotavirus gastroenteritis. Emerg Infect Dis. 2003; 9: 1563-70.
31. Le Guyader FS, Mittelholzer C, Haugarreau L, Hedlund KO, Alsterlund R, Pommepuy M, et al. Detection of noroviruses in raspberries associated with a gastroenteritis outbreak. Int J Food Microbiol. 2004; 97: 179-86.
32. Woolhouse MEJ, Brierley L. Epidemiological characteristics of human-infective RNA viruses. Sci Data. 2018; 5: 180017.
33. Carrasco-Hernandez R, Jácome R, López Vidal Y, Ponce de León S. Are RNA Viruses Candidate Agents for the Next Global Pandemic? A Review. ILAR Journal. 2017; 58: 343-58.
34. Zhang HL, Mnzava KW, Mitchell ST, Melubo ML, Kibona TJ, Cleaveland S, et al. Mixed Methods Survey of Zoonotic Disease Awareness and Practice among Animal and Human Healthcare Providers in Moshi, Tanzania. PLoS Negl Trop Dis. 2016; 10: e0004476.
35. Bird BH, Mazet JAK. Detection of Emerging Zoonotic Pathogens: An Integrated One Health Approach. Annu Rev Anim Biosci. 2018; 6: 121-39.
36. Burkle FM, Jr. Global Health Security Demands a Strong International Health Regulations Treaty and Leadership From a Highly Resourced World Health Organization. Disaster Med Public Health Prep. 2015; 9: 568-80.
37. Keusch GT, Pappaioanou M, Gonzalez MC, Scott KA, Tsai P. Sustaining global surveillance and response to emerging zoonotic diseases: Washington, D.C. : National Academies Press, c2009; 2009.