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Pandemics and biodiversity: A review

Sunita Saklani[1], Nitesh Kumar[2]
[1] Department of Zoology, Govt. College Sujanpur Tihra, Himachal Pradesh, India
[2] Department of Bio Sciences, Himachal Pradesh University, Summer Hill Shimla, Himachal Pradesh, India

Abstract
Pandemics have a long history throughout the centuries and most of them not only result in the fatality and also undermine the social and economic set up of a society. Pandemics are always linked with biodiversity since most of the pandemics are of zoonotic origin and the majority of these are caused by viruses like Influenza (H1N1, H2N2, H3N2), MERS, Ebola and most familiar present-day. The main cause of these outbreaks is the imbalance caused by humans in Nature. A rich level of biodiversity can overcome the menace of the outbreak of pandemics. Hence, by taking the lessons from the present and past pandemics, human as a global community need to take steps to mitigate the risk of future pandemics.

Keywords: biodiversity; influenza; pandemics; viruses

Introduction

In this modern era, where human advances in every field are taking giant leap the emerging and re-emerging of various communicable disease health threats, and its transmission is an ever- evolving subject. If we look at the history of emerging or re-emerging infectious disease pandemics globally, then we can easily conclude that on an average it happened in every decade. However, now, the trend is changing, and it is quite evident that-, the frequency between pandemics seems to be disturbingly shorter. Transmission of pathogens that causes acute respiratory diseases/infections which were better illustrated by Severe Acute Respiratory Syndrome (SARS) in 2003, Influenza A H1N5 (bird flu) in 2007, H1N1 (swine flu) in 2009, Middle East Respiratory Syndrome (MERS) in 2012, Ebola in 2014 and in present- most common example is Coronavirus disease 2019 (COVID-19) (Rewar & Rewar, 2015; Maurice, 2016; Qiu *et al*., 2016) [23, 16, 21].

If we look at terms often used for infectious disease, they are mistakenly used interchangeably even by medical experts. This is because the definition of each term is like liquid and it changes with the diseases which become more or less prevalent over the times. (Harris, 2000; Morens *et al*., 2009) [1, 9].

Definitions are as follows

- AN EPIDEMIC is a disease that affects a large number of people within a community, population, or region.
- A PANDEMIC is an epidemic that's spread over multiple countries or continents.
- ENDEMIC is something that belongs to a particular people or country.
- AN OUTBREAK is a greater-than-anticipated increase in the number of endemic cases.

So, Pandemic is an epidemic that travels with higher enormity in terms of geographical area, number of cases and days of suffering resulting in deaths. But what's the difference between endemic and epidemic? Endemic, are the diseases which have a constant presence in a specific location as malaria is endemic to parts of Africa, whereas on the other hand, an epidemic is often localised to a region, but the number of cases infected in that particular region is significantly higher than the normal. For example, when SARS cov2 or COVID-19 was reported, it was limited to Wuhan (China) at that time it was an epidemic. Afterwards, its geographical spread turned it into a pandemic. The human population have suffered from many pandemics throughout history be it the earlier form of smallpox or tuberculosis or various flu or the recent incidence of HIV/AIDS or H1N1 or SARS cov1&2. All these have created catastrophic damage in different forms.

Pandemics

The literal meaning of pandemic is "pan" meaning all and "demos" meaning population which apply to the rapid spread of transmissible diseases. So, pandemics are large scale outbreak of new infectious diseases globally, which affect the substantial number of population and destroy economic and social set up of the countries. It is primarily used to indicate the rate of spread of disease and the distance of its spread (Last, 1988) [14].

The first known use of the word pandemic was found in 1666, referred to "a *Pandemick*, or *Endemick*, or rather a *Vernacular* Disease (a disease mainly dominating in a Countrey) (Harvey, 1666) [10]. Afterwards in 1828, epidemiologist and lexicographer Noah Webster in his first edition of *Webster's Dictionary* listed epidemic and pandemic as synonym (Webster, 1828) [32]. In late 19th and early 20th- century influenza pandemics may have temporarily systemise the use of word pandemic, but due occurrences of large-scale non-influenza infections and chronic and lifestyle- associated diseases it gradually loses its exactness and it thereby returned to a status similar to its later one i.e. denoting almost anything that increased in and appeared to spread within or among groups of people. Moreover, with better control on major pandemic diseases as cholera, plague, smallpox and tuberculosis etc. the term "pandemic" became closely associated with ancient time diseases, rather than present time diseases (Moren *et al*., 2009) [19].

In the past 5-6 decades, the origin of 335 emerging infectious diseases was reported globally. Most recent epidemics are primarily zoonotic originating in wildlife populations. Bacterial pathogens have also increasingly of concern due to antibiotic resistance especially in the developing world (Jones *et al*., 2008; Allen *et al*., 2015) [13, 2]. But still many medical texts have not even defined the term pandemic. Thus, the distinction between the words "pandemic, " and "epidemic, " is regularly blurred and often used interchangeably in various social and medical contexts. Hence there is a natural to and fro between them, as treatments become available and measures for control are put in place or as flare-ups occur and disease begins to spread.

It is very difficult to analyse diffusion patterns of pandemics, as it depends upon various factors which include place-specific public health responses, social interactions among people, travel patterns within cities and across countries, the natural and built environments, and characteristics of the pathogens themselves

Characteristics features of Pandemic

There are various widely accepted definitions of the pandemic and this term refers to the numbers of diseases having different etiology and epidemiologic features (Moren *et al*., 2009) [19] It is more appropriate to consider those features in pandemics which are invariable and present in most the diseases. The Characteristic important features of the pandemics are: Wide geographical Extension, Involvement of large population, Novelty, Contagiousness, Severity etc.

- Wide Spread Extension of the disease- Term pandemic refers almost to every disease which spread to a large geographical area. Example- SARAS cov-2 novel corona virus disease or COVID-19 spread over 213 countries around the world and the whole world in the grip of this new Pandemic, SARS cov-1 (Severe Acute Respiratory Syndrome) in 2003 affected 26 countries, Swine flu pandemic caused by H1N1 in2009, HIV pandemic in 1981 and Spanish flu pandemics in 1918 etc.
- Involvement of a large number of population- Pandemics always involves a large number of population. As SARAS cov-2 virus infected 8,406,195 peoples and causalities are 451,387 around the globe till 17 June 2020, these figures are expected to rise remarkably in the near future. SARAS cov-1 outbreak of 2003 infected about 10,000 people and 2009 swine flu pandemic involve 491,382 cases. The largest number of the population infected by any pandemic till date is 1918 Spanish flu, which has about 500 million cases and was deadliest Pandemic (Taubenberger *et al*., 2006; Johnson, 2002) [2].
- Novelty- Pandemics are usually new diseases or at least it is caused by new strains of existing pathogens and the vast majority of the population have no immune protection against it which allow it to become a global outbreak. Pandemics are uncommon but some of them may repeatedly occur i.e. cholera, tuberculosis and influenza with an antigenic shift etc.
- Contagiousness- Contagious diseases are those diseases which spread from one person to another person through direct or indirect contact. Direct contact includes touching an infected person bearing the infections whereas indirect contacts are touching a contaminated object, inhaling droplets of coughing and sneezing droplets of an infected person. Most of the pandemics are contagiously transmitted from person to person.
- Severity- Generally severity of any diseases not considered as criteria to include it in pandemics (Shope, 1958) [25]. But it mostly applied to deadly or fatal disease which causes large number of causalities. Examples are Spanish flu, Black Death, HIV/ AIDS and SARAS. Sometimes diseases which cause mild severity may be called as Pandemic, when they exhibit widespread and recurrent spread; an example is AHC (Acute Hemorrhagic Conjunctivitis) of 1981.

World Profile of Pandemics

According to WHO, 137 million people living in urban areas simply not able to get safe drinking water and over 600 million lack basic sanitation facilities. The UN predicts that the urban population across the globe will double to over six billion by 2050 and this increase in density will be more prominent in Low and Middle-income countries. As the rate of transmission of respiratory and faecal-oral pathogens like Mycobacterium tuberculosis, influenza, cholera, rotavirus, hel-minths etc is related to population density. So we easily sense the health havoc (Alirol *et al*., 2010) [1]

Overpopulation, poverty and malnutrition are the primary factors which contribute to the severity and extension of any epidemic and Pandemic and in the present scenario if we link these factors with global warming, environmental degradation, habitat destruction, and increased human/host/reservoir interaction than the range and gravity of any future pandemic will be exponential. So especially in Low and Middle-income countries these conditions can serve as the breeding grounds for future Pandemics. For example, in Metro Manila, the most densely populated city in the world, approximately six million people live in slums with no piped water or toilets. (Alirol *et al*., 2010: Allen *et al*., 2015) [1, 2].

Pandemics have a heavy socio-economic impact, contributing significantly to enduring poverty in certain countries or in some specific geographic regions. The World Bank estimated that the economic burden of main zoonotic origin diseases from 1997-2009 amounted to US$80 billion over these past12 years (World Bank, 2012). Recent outbreaks of COVID-19 Pandemic, around the world are so catastrophic that, it drastically hit the countries GDPs of developed and developing world, so we have renewed interest in the study of its roll-out, in the properties of Pandemic and to have a view to lessening their impacts. Some of the Pandemic which spread havoc around the world are discussed below.

- Spanish flu- In history, Influenza pandemics are recurring events with negligible predictability and severe consequences on societies worldwide. The "Spanish Influenza" (1918) was the most devastating, with a mortality toll of 20 to 50 million globally. The H1N1 family member of influenza virus was responsible for its emergence in the early months of 1918. The second and severe wave of the disease spread all across the world, leaving no major human settlements untouched during the autumn of 1918. If we count the total toll in terms of mortality the focal point

was India, with an estimated deaths of 10 to 20 million (Johnson, 2002; Mayor, 2000) [2, 17].

- Avian influenza- In 1997, an avian influenza A virus of subtype H5N1was first reported in Hong Kong SAR, China. The primary risk factor for a human to be infected with H5N1 infection is direct contact or exposure to infected poultry. However, the virus remains challenging to transmit to humans its widespread re-emergence found in 2003-2004, which results in millions of poultry infections and over four hundred human cases. Presently, the virus is now entrenched in domestic birds in several countries, so controlling H5N1 among poultry is essential in reducing the risk of human and reducing the risk of any outbreak (WHO, 2017) [33].
- Influenza A- In early 2009, a new A (H1N1) pdm09 virus subtype of zoonotic origin was first isolated from humans in Mexico, in April 2009 it was found the United States of America. In June 2009, WHO declared it the first influenza pandemic of the 21st Century. Within a few weeks, the virus had spread rapidly, and there was sustained human-to-human transmission worldwide.

Table 1: List of some Influenza flu pandemics (Source: WHO, 2017)

Pandemic year of emergence and common name	Area of emergence	Influenza A virus subtype	Estimated reproductive no.	Estimated case fatality rate	Estimated attributable excess mortality worldwide	Age groups most affected
1918-1919 "Spanish Flu"	Unclear	H1N1(unknown)	1.5-1.8	2-3%	20-50 million	Young Adults
1957-1958 "Asian Flu"	Southern China	H2N2 (avian)	1.5	<0.2%	1-4 million	All age Groups
1968-1969 "Hong Kong Flu"	Southern China	H3N2 (avian)	1.3-1.6	<0.2%	1-4 million	All age groups
2009 -2010 "influenza A	North America	H1N1 (swine)	1.1-1.8	0.02%	100 000-400 000	Children and young adults

- Acute hemorrhagic conjunctivitis (AHC)- About more than five decades ago, a new clinical entity- Entero-viral Conjunctivitis was first recognised, which has two major genetically distinguished etiological agents i.e. entero virus 70 (EV70) and coxsackievirus A24v variant (CA24v) although the diseases they cause are clinically indistinguishable and constitute the AHC syndrome. EV70 infection first appeared in West Africa in 1969 and in next few years observed from the Eastern Hemisphere, which progress further in the second Pandemic to various parts of the Western Hemisphere in 1980 and (CA24v) were first recognised in 1970 in Singapore, and have been localised mainly in Southeast Asia and India. Today both causative agents spread almost all over the world. Several AHC outbreaks had primarily emerged in Africa which swiftly sailed all along with the coastal areas of East, West and North Africa. By 1971 it was in India, Southeast Asia, and Japan. Tens of millions of people were affected during the Pandemic. This contagious disease, generally affect the eye, EV70 spread swiftly in crowded and unhygienic conditions; particularly warm, humid, coastal climates are beneficial for its transmission. Spread within a family or home is most common. Some localised outbreaks, especially in developed countries, have centred around eye clinics (Melnick, 1989).
- COVID-19- Corona viruses are a large family of viruses circulate among animals, with no negative effects to us. They can also be found in humans, where they can cause illnesses ranging from the common cold to more serious diseases as MERS (Middle East respiratory syndrome) and SARS (severe acute respiratory syndrome)(Wang *et al*. 2020). Such an outbreak among humans of viruses previously circulating only in the animal world is a phenomenon known as spillover (Thompson, 2013). In December 2019, a novel corona-virus was detected in the Chinese city of Wuhan, which is thought to be originated because of spillover and referred as SARS-CoV-2 by International Committee on Taxonomy of Viruses and World Health Organization has given the disease the official name CoVID-19 (Corona VIrus Disease-2019). Viruses can be classified as DNA or RNA viruses, depending upon what type of genetic material they carried. These DNA or RNA viruses can have double- or single-strand nucleic acids. SARS-CoV-2 is an RNA virus, it is one of the 158 viruses known to infect humans; other dangerous RNA viruses are HIV, SARS, Hendra, Nipah and MERS. SARS-CoV-2 estimated incubation period is 2-14 days and could be longer, it primarily causes mild, non-specific symptoms like cough, fever, tiredness, muscle pain and difficulty in breathing whereas, in serious cases it can develop severe pneumonia, acute respiratory distress syndrome and kidney failure, sepsis and septic shock that can lead to death (Wang *et al*. 2020). This virus highly infectious it spreads through respiratory droplets and within short span of time it spread immensely within China from Wuhan and then outside the country. At the end of January, sensing the severity of spread WHO declared a public health emergency of international concern but by the time it had already traveled all major countries of Europe, North and South America, Asia and Africa around the world. Presently, there is no vaccine to prevent this pandemic disease, and no cure has yet been found. So, the WHO outlines the measures required to deal with the current crisis, in its strategic preparedness and response plan. At the moment, the novel corona virus pandemic is ongoing and it will be so early to analyse its impact but it to be sure that human race had not seen a pandemic of such scale and with of such a devastating magnitude in term of socio-economic impact. Moreover in post-pandemic period

economies will suffer from unemployment, poverty, lower consumption, fewer tourists and recession in retail, hospitality and entertainment sectors.

India's profile of Pandemic

Overpopulation and poverty are the primary contributing factors that brought epidemic or pandemic and are strongly linked with weak, malnourished populations which serve as the breeding grounds for different pandemics. Over the centuries Indian subcontinent is home for a large chunk of the world population and over the time suffered from various epidemic or pandemics. Few of them are discussed below.

- Smallpox-It was a highly contagious, defacing and often deadly disease of the 18th and19th centuries. During this period, it accounts for nearly a third of all deaths of which nearly 85-90% of the deaths occurred in infants and children. It was endemic in India with characteristic epidemic spells ranging from 4-7 years. Although vaccination was introduced in India by the British in 1802, its propulsion was very slow and so were the results. Due to its infectious Nature, it blazes up in between many time and in the late 1950s and claimed over 150,000 lives (Gupte, 2001) [8]. The final eradication of smallpox came about, with the last case recorded in Assam in 1975, through the adoption of a revised strategy of re-vaccination, isolation of infected individuals and improved level of primary infant vaccination.
- Plague- India has a history of several epidemics of plague, which were reported since Biblical and Puranic times. Several outbreaks of plague were seen across India from 1031-32 to 1812-21(the Pali plague). In 1895-96, the major cities of India i.e. Calcutta and Bombay was caught in the major Pandemic and being sea ports cities they were believed to have provided the portals of entry for the infection from where it spread to other parts of the country. The Pandemic reached its peak in 1907 and thereafter continued till 1918 with the annual mortality totalling over 500,000 deaths between 1898 and 1908. Until the mid-1940s, it was considered a major public health problem but in subsequent years it become quieter due to massive scale spraying of DDT meant for malaria control. The last laboratory-confirmed human cases in India were reported in 1966 from Karnataka (Gupte, 2001) [8]. India which was expected to be plague free but in 1994, 876 cases and 54 deaths of presumed plague was reported between August and October. The reported cases were from Maharashtra (596), Gujarat (151), Delhi (68), Karnataka (50), Uttar Pradesh (10) and Madhya Pradesh (12). Out of the 54 fatal cases, 52 were reported from Gujarat, one from Delhi and Karnataka each (WHO 1999) [34]. None of the clinical, epidemiological as well as microbiological/serological results were found to have definite evidence to substantiate the diagnosis of plague (Sathe and Sathe, 1997) [24]. Such contentious pieces of evidence strengthen the importance of installing an effective and efficient disease surveillance system in the country which enable and ensures quick identification of outbreaks and their containment.

Table 2: Plague in India. Source: Nath (1998).

Period	Total deaths due to plague	Percentage of total deaths
1898-1908	6,032,693	4.32
1909-1918	4,221,529	2.32
1919-1928	1,762,718	1.34
1929-1938	422,880	0.33
1939-1948	368,596	0.21
1949-1958	59,059	0.55
1959-1966	211	-
1994	54	-

- **HIV- AIDS** as a dreadful disease is among the new infectious diseases which spread over the past few decades and caused much havoc in the world which draw the attention, ever since it was reported. In India the first case of HIV/AIDS was reported in commercial sex workers from Chennai in April, 1986. There are about 36 million people affected with HIV/AIDS up to 2000 in India (UNAIDS/UNICEF, 2000). Gujarat, Goa and Haryana have concentrated cases of HIV, where less than 1% of those women engaged in antenatal clinics and more than 5% in STD clinics. Whereas in states like Andhra Pradesh, Tamil Nadu, Maharashtra, Karnataka, Manipur, and Nagaland have the generalise population of HIV infection. Most of the confirmed cases of the HIV occurs in sexually active along with economically productive age groups between 18-40, with 50% below 25 age and 21% are women (Gupte, 2001) [8] In addition to the high levels of morbidity and mortality, in more than 30 years, HIV/AIDS threaten to reverse much of the progress achieved in the health, social, demographic and economic sectors. In a country like India, within individual states, there is no single HIV epidemic but there are different localised focal epidemics. In the intravenous drug users (IDUs) spread of the epidemic could be explosive. HIV in men having sex with men may have varying intensity. Heterosexual transmission is the main mode of transmission in men and women with multiple partners involved in unprotected sex (Gupte, 2001) [8]. Presently, there are no clear indications regarding the size of the HIV epidemic in India. Experts believe that the epidemic is stabilises.

- **Tuberculosis:** Tuberculosis has been endemic to India from centuries and continues to pose a major public health problem. It is one of the infectious diseases among tuberculosis, malaria and diarrhoeal diseases, which once regarded as controlled but resurfaced with enormity. Even India bears nearly 25% of the global burden of tuberculosis (Ghai and Gupta 1999). The ICMR National Sample Survey in 1955-1958 as well as other subsequent studies, revealed that nearly 1.5% of the population suffers from radiologically active pulmonary tuberculosis, of which 25% are sputum positive. It is estimated that there are 14 million cases of active tuberculosis in the country. Of these 3.5 million are sputum positive and therefore infectious. It is further estimated that annually nearly 1.5 million to 2.2 million cases are added, of whom 20-25% are sputum positive (Gupte, 2001) [8]. The incidence of tuberculosis may increase significantly with the HIV-TB co-infection. It is observed that in India nearly 60%

of AIDS patients have evidence of active tuberculosis. Further, those infected with HIV have a 25 times greater risk of developing tuberculosis. This may be due to either new infection or revivify of prior tuberculosis infection in the HIV infected person (Chakraborty 1998) [5].

- **Malaria:** Malaria has been a major public health problem in our country for centuries. But, in the late 1940s spraying of DDT on an exploratory purpose, turns the coin in the history of malaria control and its elimination. At the time of introducing the National Malaria Control Programme in 1953, India had 75 million new cases and 0.8 million deaths annually. Under the national programme, remarkable success was achieved which raises the expectation of malaria elimination. So in 1958, National Malaria Control Programme transformed into an elimination Programme and within 5 to 7 years malaria was successfully controlled from nearly 3/4th of the country and occurrence rates fall from 75 million new cases in 1953 to 0.05 million cases in 1961 (Ghai and Gupta 1999). The reduction in malarial cases indicated that malaria could be controlled and was no longer considered a threat to public health.

Origin of Pandemic Virus

Viral pathogens are of great anxiety due to their high rates of nucleotide substitution, poor mutation error-correction rate ability and capacity to quickly adapt to human hosts. The current outbreak of MERS-CoV, Ebola, H1N1, Makona variant (EBOV), SARS-CoV1 &2 have shown their fatality and potential as prominent future Pandemic (Allen, 2015) [2] [2]. These pandemic viruses have been reported to arise through by any one of the process, but due to gaps in the virological record, it has not been possible to determine precisely which of these processes have occurred.

- **Genetic reassortment:** a process in which a virus infects a host, it can mix its genetic heritage with that of other viruses present in the host (such as influenza viruses)
- **Genetic mutation:** a process in which genes in an animal virus change allowing the virus to infect and transmit easily in humans.
- **Combination of both**.

Example- Influenza B viruses responsible for human disease whereas, influenza A viruses are found in human, avian and some mammalian species. A pandemic occurs when influenza A virus to which most humans have little or no existing immunity acquires the ability to cause sustained human-to-human transmission leading to community-wide outbreaks. Such a virus has the potential to spread rapidly worldwide, causing a pandemic.

Biodiversity

Biodiversity is the richness of variety among living things i.e. in plants, animal, microorganism and in the ecosystem where they survive and give their contribution to the beauty of the Nature and its stability. It is also the measurement or documentation of various life forms present in an ecosystem or on earth.

Biodiversity can be divided into three main types:

- Genetic diversity (i.e. diversity within species)
- Species diversity (between the species)
- Ecosystem diversity

There are about 2 million to 10 [12] million species present on the earth recently out of which only 1.74 million have been described so far (Locey and Lennon, 2016) [15]. In another similar study approximately 1.9 million extant species are believed to described, of which about 20% considered as synonym by the scientists, therefore, reducing this value to about 1.5 million (Chapman, 2009) [6]. There are 17 mega-biodiversity centres identified in 1998 by Conservation International (CI to promote awareness for biodiversity conservation in the world nation), the world that contained more than 70% of earth's biodiversity. India is one of the world's mega-diversity countries with tremendous biodiversity, which includes at genetic, species as well as the level of the ecosystem and is about 7% of world biodiversity. The number of plant species in India is estimated to be over 45523 which are 11.8% of the world's flora. The total number of animal species estimated is about 91307 which constitutes about 7.46% of world's fauna (Basavarajaih, 2018). This huge biodiversity of India is due to different landform, the climatic condition resulted in ranging habitat.

Importance of biodiversity

Biodiversity is the heart of all life present on this earth. It fulfils all necessities of life required to sustain life on this planet. It plays an important role in the formation of the soil and also maintain its quality and therefore prevent soil erosion; Purify the air and thus maintain the air quality; maintain water quality; detoxification and decomposition of waste by decomposers i.e. about 130 billion metric tonnes are processed every year; It helps in crop production and pollination ; helps to reduce CO_2 in the atmosphere as the ocean, soil and vegetation act as a carbon sink: and provides food security(Rathore and Jasrai, 2013) [22]. All of these importances can be divided into ecological and economic importance of biodiversity.

All the species in an ecosystem provide or have its role for mankind by taking part in physiological processes. If the ecosystem is diverse it is better able to withstand the environmental stresses and is more productive.

Factors affecting the biodiversity

Human beings have the environment through various development activities in the name of modern living. These developmental activities lead to Changed the bio-geochemical cycles and causes the destruction of biological diversity. There is the number of factors which influence the biodiversity directly or indirectly like overexploitation, habitat destruction invasion of exotic species, climatic changes, soil degradation, pollution, infrastructural development, mining activities and stone crushing activities etc.

Biodiversity and Ecosystem

In ecosystems, biodiversity behaves like a controller of ecosystem processes, as a concluding ecosystem service, and as something of utility for humans. Therefore, ecosystem properties rely on biodiversity to a great extent for balancing the ecological functions of different organisms living inside the system and the spreading of those organisms all over the area. The more diverse ecosystem

can provides more economical important commodities to human kinds i.e. it acts as source material for breeding improved varieties; food supply to the human in the form of crops, livestock, forestry, fishes etc; source of medical drugs (i.e. quinine comes from Cincona tree, digitalis from foxglove plant, morphine from poppy plants etc). It also has an essential role in industries since the fibres obtained from plants are used in making cloths, woods for furniture. Other industrial articles include soil, dye, paper, rubbers waxes etc.

Ecosystem diversity can be characterised in three different ways

1. By the number of different entities (eg. species richness);
2. By the relative abundance of various entities (eg. species evenness);
3. By the specific identities of other entities (community composition).

Although species can become extinct naturally due to human involvement, the rate of extinction has been increased by a factor of approximately 1,000-10,000 in ecosystems. The prominent factors behind the increased extinction rate are considered to be growth in human population and socio-economic development resulting in changes in land use, and therefore habitat fragmentation, overexploitation or destruction, pollution, biotic changes, the introduction of new species, and climate change occur. The worldwide extinction crisis has been reported by the scientific and intellectual community, and various plan of action has been formulated at various forums to revert these trends, with respect to human health also.

Besides this, invasive hosts and pathogens can leads to loss of biodiversity in natural ecosystems. Moreover, there are several studies which show that there is a direct relationship between biodiversity loss and reduction of ecosystem services (Balvanera *et al*., 2006; Thompson *et al*., 2009) [3, 28].

Biodiversity and Human Health

Biodiversity can be considered as a foundation for human health and happiness, as it underlines the functioning of the ecosystems on which we depend for our food, water, regulating climate, floods and diseases. Biodiversity has four major drivers of human health.

- Quality of life (by securing life-sustaining goods and services)
- Medical and genetic resources (researching plants, animals or microorganisms for their beneficial properties and use them commercially and non-commercially)
- Ecosystem services (benefits that humans receive from ecosystems)
- Constraints on infectious diseases (high biodiversity decreases the spread of diseases, while decreasing biodiversity may accelerate the spread of disease to human populations). Therefore, biodiversity is considered to be critical.

The loss of habitats, invasion of exotic species, climatic changes, pollution, infrastructural development, mining activities modification of a natural parameter of environments, and decline in biodiversity are all factors in the spread of different infectious diseases (WWF, 2020) [35]. This can happen through various mechanisms:

- Increased breeding sites for disease vectors, such as irrigation channels and dams where mosquitoes proliferate.
- Widespread wet market around the world.
- Increased spread of host species due to habitat loss.
- Keeping wild species captive with domestic animals.
- The Shift of pathogens from one species to another different species.
- Dropping in number of predatory species.
- Overuse, poor infection control and absence of new medicines-induced genetic changes in disease vectors or pathogens which leads to development of resistance to available treatments.

Over the decades, scientific studies helps us to understand various phenomena but still our understanding of different interactions between ecosystem change, disease spread, regulation among human being is limited.

Biodiversity and Pandemics

Tropical forests are closed-canopy forests, housed in the area between tropic of cancer and tropic of Capricorn, this area, in particular accommodates millions of species, many of which are largely still unknown to researchers. Beside numerous bird and mammal species (often used as proxies for overall biodiversity) they are home to countless viruses, bacteria, fungi and parasites. Most of them are harmless and cannot live outside their host, still some RNA viruses(e.g. HIV, SARS cov1&2, Ebola, West Nile Virus, Ebola, Makona variant (EBOV), MERS-CoV, H1N1, Hantavirus, type A influenza) in particular can quickly mutate and adapt to new conditions and new hosts which leads to numerous disease in human (Allen et. al., 2015) [2]. Therefore, biological diversity is also essential to explain the overall richness of many infectious endemic, epidemic and Pandemic diseases around the globe. The majority of these diseases are zoonotic, that is of wildlife origin, thus, signifies the importance of biodiversity (WWF, 2020) [35].

Table 3: Emerging diseases and potential impact mechanisms of human activities related to ecological changes (source: WWF, 2020) [35]

Disease	Geogrophical Distribution	Case/year	Emergence mechanism	Anthropogenic drivers
Malaria	Tropical America, Asia, and Africa)	350 million	Niche invasion; vector expansion	Deforestation; water projects
Schistosomiasis	America; Africa; Asia	120 million	Intermediate host expansion	Dam building; irrigation
Dengue fever	Tropical	80 million	Vector expansion	Urbanisation; poor housing conditions
Rabies	Tropical	35,000 (deaths)	Biodiversity loss, altered host Selection	Deforestation and mining
Lyme disease	North America and	23,763	Depletion of predators;	Habitat

	Europe	(U.S. 2002)	biodiversity loss; reservoir expansion	Fragmentation
West Nile virus and other encephalitides	Americas; Eurasia	5,483 (US average 2002-2004	Niche invasion	International travel; climate variability
Ebola	Africa	-	Forest encroachment; bushmeat hunting	Forest encroachment

Biodiversity can be related to lower pathogen transmission through a dilution effect, which may take place when one or more host species is added to a host community, it is associated as wasted transmissions, and thus leads to, reduction of pathogen persistence (Allen et. al., 2015) [2].

- The initially proposed mechanism was a "direct dilution effect'' which leads to successful off track of infective stages in wrong arthropod vectors (i.e. Lyme disease, West Nile fever). However, a recent analysis of data related to it, shows the varied connection between host biodiversity and disease, which suggests that, the disease risk is more likely a local phenomenon that relies on the specific composition of reservoir hosts and vectors, and their ecology, rather than patterns of species biodiversity. So, the anticipated connection between host diversity and parasite transmission may be quite complicated.
- Another proposed mechanisms for directly transmitted diseases, were "indirect dilution effects", where higher host diversity may result in depletion of the susceptible host population size via inter-specific competition, which in turn will decrease the transmission. Hence the local conditions of host species abundance and distribution of reservoir hosts may be the regulating component, to whether an enhanced number of potential hosts will divert transmission from highly competent reservoir host species and leads to very few new infections or not.

Hence, loss in biodiversity at the local level may lead to an increase in the frequency and transmission rates of certain vector-borne diseases through a "dilution effect" mechanism, suggesting that decreased biodiversity, linked to the loss an ecosystem's capacity to buffer the spread of pathogens, is a source of both increased frequency of existing diseases and the emergence of new infectious endemic/ epidemic or pandemic diseases.

Steps to Save Biodiversity

According to the UN Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), 3/4 of land and 2/3 of the marine environment have been altered to a notable degree, and around 1 million plant and animal species are at the verge of extinction. Similarly, Living Planet Report 2018 of WWF's shows that in just over 40 years, 60% average decline in abundance of vertebrate populations across the globe (WWF, 2020) [35] These changes all around indicates an uncertain future, not only for the biodiversity but also for sustainability of human being, so concrete, comprehensive step should be taken to protect and conserve it.

- Ecosystem approach-Millennium Ecosystem Assessment emphasised on the ecosystem approach, which defines ecosystem services as the benefits that people obtain from healthy ecosystems. One such ecosystem service is the regulation of human and animal diseases, a benefit largely due to the positive effects of biodiversity on disease regulation. Thus this approach act as a conceptual framework and stresses on the fact that well-preserved biodiversity could act insurance against outbreaks, although it is a source of pathogens.
- Surveillance-The importance of biodiversity, in the transmission of infectious diseases suggests that, determined surveillance, both geographic and temporal, is needed. With better surveillance one could, for example, study the statistical relationships between the changing uses of land (fragmentation of the landscape, increasing or reducing forest areas) and the occurrence of epidemics/ pandemics (Allen, 2015) [2].
- One Health approach- Over the last decade, a new future-oriented concept has been promoted all around the globe, which emphasis on the close relation between human health, other animal health and environmental health. It has been formally recognised by many UN bodies, the World Organization for Animal Health (OIE), the European Commission, research institutes and by many others agencies. Thus, by acknowledging that our health and well-being are closely associated with that of the natural world and by protecting our species we can avoid the most harmful effects of pandemics (Allen, 2015) [2].
- With the aim of preventing zoonosis, people have started using extreme measures to reduce the population of host or vector species. Thus, they are engaged in the uncontrolled use of pesticides, insecticides and killing of infected livestock. All these types of interference have short -termed limited benefits.
- The proper action plan is required to restore those losses that have been destroyed or degraded, along with maintaining our present natural systems. So, action plans are needed in such a way that biome present in the Nature could revive themselves, along with its benefits to human. Keeping this in view, the UN has dedicated the 2020s as the Decade on Ecosystem Restoration (WWF, 2020) [35].

Perspectves

This study provides a guideline on the basis of different epidemics and pandemics from the historical evidence that how they evolved; spread and what are the core measures that should be taken into account to restrain their effect. As the present, the world is a global village and nowadays the cities, states, countries boundaries don't matter so, the need of the hour is for a more coherent, efficient, unbiased mechanism should be established to set up the preparedness, response and recovery approach during emergency conditions.

The emergence of various infectious diseases shows that, till now we only able to explore the tip of the unexplored world and tremendous and rigorous efforts are required to just know, identify and understand that part. This also shows

that at present we are not in position and that much equipped, to make any prediction about pandemics. So we have to restrain our self from indulging with Nature. Continuous assessment of condition of Nature should be done to minimise the risk of emergence and spread of any bacteria, fungi, virus or protozoa infectious disease, which could eventually, can lead to spreading of any potential future pandemic.

There is need to address the practices of Hindu way of living in Nature with the harmony which emphasis the human development with the management of our natural resources for our sustain development as we are doing this from generation. Stringent actions should be taken to curb the illegal wildlife trade and to close unregulated wet markets. The proverb "Prevention is better than cure" should now be taken as "Prevention is better until we explore". To consolidate the health mechanism with one health theme and try to eradicate the hurdles to preserve the ecosystems and help to restore their deteriorated and degenerated health.

In the near future, human action will be enormously affected by the unwanted and adverse effects from the COVID-19 Pandemic, which will dominate the global agenda for the foreseeable future. Thus as a global community, it is our responsibility to take steps to reduce the risk of future pandemics.

Conclusion

This review is an effort to relate the emergence of various Pandemic over the time with their known as well as unknown causes, which all again lies in the core of Nature that is in its biodiversity. The diverse areas rich in flora and fauna are a source of origin of various zoonotic disease pathogens, which through the direct diluted effect or indirect dilution effect mechanism get spillover to the humans by genetic mutations or assortment. All these many times enables pathogens capable of spreading the infection to humans, which ultimately spread human to human. Poverty, overpopulation, higher density and malnutrition among people are the primary factors which contribute to the severity and extension of any epidemic and Pandemic especially in low and middle-income countries and in the present scenario if we link these factors with global warming, environmental degradation, habitat destruction, and increased human/host/reservoir interaction than the range and gravity of any future pandemic will be exponential.

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