INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :6.514(2021); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:10, ISSUE:3(2), March:2021
Online Copy Available: www.ijmer.in

ENVIRONMENT, ENVIRONMENTAL FACTORS AND INFECTIOUS DISEASE

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Introduction

Environment and its factors greatly influence human health (Dolinoy&Jirtle, 2008). Environment is the combination of biotic factors and abiotic factors. Planet earth is shared by variety of animals, plants, fungi, microorganism, viruses etc.All of them are inter connected to each other. The energy flow and nutrients cycle is maintained in the environment with the help of this food web (Strong & Frank, 2010). Biotic factors of environment have an impact on public health. Humans and animals share the same environment; thus the diseases are mutually transferable (Alves & Silva Policarpo, 2018). Disease or infection that are naturally transmitted from animals and can cause health issues are called zoonosis (Krauss et al., 2003). Zoonosis are transmitted through the air, consuming contaminated meat or products, close contact with infected animal, bite of vector etc(Loh et al., 2015). Humans have established a close relationship with animals (Alves et al., 2012).Microbial infections are very sensitive to social, biological and ecological disturbances(Weiss & McMichael, 2004). A study shows that 61% out of 1,415 of known infectious organism to humans are transmitted by human animal interaction (Taylor et al., 2001). Agricultural activities, domestication of livestock, encroachment of uncultivated environment, deforestation, man-animal conflicts bring animals and human closer to each other.This results in cross species transmission (Patz et al., 2004). SARS (Sever Acute Respiratory Syndrome), pandemic influenza H1N1, Ebola virus are emerging infectious diseases due to zoonosis(Jones et al., 2008). Number of environmental factors such as climate change, ozone depletion, change in ecosystem, loss of biodiversity, urbanization, poor sanitation facilities, change in hydrological system and lack of supply of fresh water influence the spread of the infectious diseases (WHO 2017).A research shows that factors like precipitation, humidity, temperature, and air flow are determinants of virus infection and transmission (Pica & Bouvier, 2012). Chronic disease may be caused due to both genetic and environmental factors but studies have reported that 70 % to 90% of diseases are caused due to difference in environmental factors (Rappaport & Smith, 2010). Thus, survival of viruses in environment outside the host plays animportant role to comprehend its risk of infectivity so as to improve current measures and control natural epidemics. The present article reviews the study of few known viruses and the effect of environmental factors on them. It aims to find the gap in understanding the relation of environmental factors with viral survival and viral transmission.

SARS- Coronavirus

Sever Acute Respiratory syndrome is a viral respiratory illness caused by coronavirus called SARS-CoV(Vijayanand& Wilkins, 2004). SARS-CoV is one of 36 coronaviruses in the family Coronavirdaewithin the orderNidovirales. Member of the Coronavirdae are known to cause respiratory or intestinal infection in humans and other animals (Cheng et al., 2007).Studies provided evidence that SARS- CoV are zoonotic in origin; isolation of SARS-CoV from Palm civet and Horseshoe bats has been found in a research (Guan et al., 2003; Lau et al., 2005; Zhong et al., 2003).

A study shows that spring is suitable season for spreading of SARS compared to autumn and winter (Tan et al., 2005). Weather condition that reduces the infection includes low humidity, high barometric pressure and wide daily temperature fluctuations (Yuan et al., 2006). SARS- CoV is highly stable in favourable condition (Van Doremalen et al., 2020). SARS- CoV is more stable than HCoV- 229E which is previously identified human coronavirus.Also it is observed that, in dried state SARS- CoV have infectivity even after 6 days while HCoV- 229E loses its infectivity within 24h(Rabenau et al., 2005). SARS virus maintains its infectivity up to four days in human serum at room temperature (Dong, 2003). The viral infectivity on commonly used materials in day-to-day life persisted for 60 hr after exposure and starts dropping after 72 hr and losses its infectivity after 120 hr(Dong, 2003). Virus can persist for 5 days in sputum and faeces while 19 days in urine and 3 days on the surface of other objects(X.-W. Wang et al., 2005). Coronavirus remains infectious in reagent water, natural water and sewage water for a long time. Survival of virus in such water was found at 4^{o}C as well as 25^{o}C (Casanova et al., 2009) but the infectivity decreased at 25^{o}C than 4^{o}C this suggest that low temperature plays a favors in infectivity of virus. If aersolization of such infected virus takes place, it would increase rate of infection.
Environmental temperature affects the virus survival rate, pathogenicity, virulence duplicating and infectivity. The optimum temperature for SARS is 16^{o}C to 28 ^{o}C(Tan et al., 2005). SARS- CoV can be easily inactivated thermally and chemically, Thermal inactivation of SARS- CoV at 56^{o} and 60^{o} is highly effective(Rabenau et al., 2005). It was reported in studies at temperature of 56^{o}C for 15 minutes virus loses its infectivity (Chan et al., 2011). In study, it was found that TGEF and human coronavirus 229E have high survival rate at low RH compare to high RH(Ijaz et al., 1985). Small air droplet of size 5-20 μm can evaporate quickly and if virus is present in it, it will either suspend in air or attachto a nearby surfaces(B. Wang et al., 2005). With high humidity > 40 % and large droplet > 50μm the evaporation rate decreases and they fall on ground but in dry air they remain suspended in air which are dangerous if virus is present in it(B. Wang et al., 2005).Some studies show association of SARS-CoV with meteorological factors and air pollution (Cai et al., 2007). SARS coronavirus is sensitive to UV irradiation, 1,62,000 μWS/cm^2 30 minutes exposure reduced the viral

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infectivity to very low and 60 minutes exposure it was undetectable(Dong, 2003). Taking precaution such as use of mask and handwashing reduces the chance of getting infected with SARS(Seto et al., 2003).

Influenza virus

Influenza viruses are member of family Orthomyxoviridae. This virus family represent enveloped viruses, the genome of which consists of segmented negative-sense single strand RNA segment. There are four types of influenza viruses, A, B, C, and D.Influenza typeA and B cause human infection annually during the epidemic season. Influenza A has several subtypes according to the combination of hemagglutinin (H) and the neuraminidase (N) proteins that are expressed on the surface of the viruses. There are 18 different hemagglutinin subtypes and 11 different neuraminidase subtypes (H1-18 and N1-11). Influenza A viruses can be characterized by the H and N types such as H1N1 and H3N2(Boktor& Hafner, 2020). Humans are susceptible to infection with influenza A, B and C viruses. Subtypes on influenza virus that can occasionally cross species barrier from birds to mammals include H5N1, H5N6, H6N1, H7N2, H7N3, H7N4, H7N7, H7N9, H9N2, H10N7, and H10N8, which cause sporadic infections or fatalities (Mostafa et al., 2018). Airborne transmission is most common mode of transmission of influenza virus; coughing, sneezing, talking, exhaled breath, showering, tap water use, sewage aerosolization, wet cleaning of indoor surfaces and agricultural spraying(Yang & Marr, 2012). The pandemic of Swine influenza virus infection by H1N1 in humans have been reported in the UnitedStates, Canada, Europe and Asia(BOYUN & DERNEĞİ, 2009).Swine flu is spread through air, human to human contact and when human come in contact with virus infected object. Children, pregnant women and the elderly are at risk from severe infection (Kothalawala et al., 2006; Pawaiya et al., 2009).The incubation period of H1N1 is 1 to 4 days but in some individuals it is observed 7 days. The contagious period lasts for about 5 to 7 days after the development of symptoms. It is difficult to make an effective long lasting vaccine of swine flu as it has high rate of mutation, the ability of gene segment to reassert and the huge pool of influenza viruses in birds and mammals (Pawaiya et al., 2009).

A study on phytochemical analysis of water of waterfowl habitat shows that influenza virus persisted for longer time at temperature less that 17^{o} C, at pH range between 7.0- 8.5 and ammonium concentration less than 0.5 mg/l (Keeler et al., 2014; Sooryanarain&Elankumaran, 2015). Most influenza viruses of human, swine and aves are stable at neutral pH and slight deviation from pH 7.4 can affect the stability of virus.(Brown et al., 2009; Poulson et al., 2016). H5N1 showed decrease in environmental stability after more than 45 days(Poulson et al., 2016; Reed et al., 2010)

Humidity alters the stability of viruses; increase in absolute humidity and relative humidity beyond 60 % decreases the stability of influenza A virus (Peci et al., 2019).A hypothesis suggest that high atmospheric humidity level leads to surface inactivation of lipid containing viruses like influenza (De Jong et al., 1973). At low relative humidity between 7 % to 23 % infectivity of virus increases and it starts decreasing when relative humidity reaches to 43 % (Noti et al., 2013). It is observed that during winter absolute humidity both at indoor and out doordecreases, this increases influenza virus survivability and virus transmission (Shaman & Kohn, 2009). Breathing of cool air causes vasoconstriction of upper respiratory tract,thereby inhibiting the respiratory defence and thus makes condition favourable for respiratory viruses to spread infection (Lowen et al., 2007).

Influenza viruses are more stable at 5^{o} C than 30^{o} C. The more stability at lower temperature is because of increase in half-life of viruses(Lowen& Steel, 2014). At lower temperatures there is decrease in activity of proteases and additional physical changes in viral envelope takes place.This increases viral stability(Mostafa et al., 2018). Study shows that human influenza virus is affected by high temperature. RNA synthesis in viruses is inhibited at high temperature(Dalton et al., 2006).

Ebola virus

Ebola virus disease (EVD) caused by ebolavirus. Ebola virus belongs to family Filoviridae that includes three genera: Cueva virus, Marburgvirus, and Ebolavirus. Within the genus Ebolavirus, six species have been identified: Zaire, Bundibugyo, Sudan, Taï Forest, Reston andBombali(Piercy et al., 2010). Viral filament measures up to 14,000 nm in length, have uniform diameter of 80 nm, and are enveloped in lipid membrane. Each virion contains one molecule of single stranded, negative-sense RNA(Rewar&Mirdha, 2014). Incubation period of virus varies between 4 to 10 days but in some cases, it was observed short as short as 2 days and long as 21 days (Rewar&Mirdha, 2014).Seroprevalence studies in bats showed that adults and pregnant females have high rates of seropositivity which leads to assumption that fighting and mating among bats causes transmission of virus(Pourrut et al., 2007). Natural hosts of EBOV are fruit bat of Pteropodidae family. When a non-human primate eats a partly eaten fruit by fruit bats, EBOV is transmitted to them and they may transmit infection to human. Ebola virus can also spread from virus infected person through his blood and body fluids, and object contaminated with virus (Rewar&Mirdha, 2014).

Very little is known about how Ebola virus behave outside the host in environment. EVD emergence is seen at end of rainy season in December and January so this viral disease seems seasonal(Nikiforuk et al., 2017; Pinzon et al., 2004).Ebola virus can survive in drying blood of human and non-human primates for 5 days (Fischer et al., 2015). Ebola virus can survive in cell culture media and guninea pig sera for more than 40 days (Piercy et al., 2010). The infectivity of virus remains for more than 120 hr in whole blood and plasma (Palyi et al., 2018). Ebola virus has viability for more than 7 days in deceased person(Prescott et al., 2015). Also it is observed that Ebola virus Makona variant can survive on stainless steel and plastic covered surfaces for 192 hours (Cook et al., 2015).Family members who come in contact with patient with EVD have high risk of getting infection (Prescott et al., 2015). At high absolute humidity and low temperature the risk of Ebola virus disease increases (Ng & Cowling, 2014). In a study, it was found that greater than 10 % of Ebolavirus Zaire remain viable on glass and greater than 3% on plastic for 14 days at 4 ^{o}C(Bibby et al., 2015). 0.1 to 1% of ebola virus remains vaiable for 50 days at 50^{o}C (Piercy et al., 2010). In water, at 27^{o}C, virus remains viable for 3 days and at 21^{o}C viability goes to 6 days (Fischer et al., 2015). In whole blood at 23^{o} C the infectivity of virus was reduced to 2.84 log 10 and showed completely loss of infectivity at 37^{o} C by 120 h(Palyi et al., 2018). Ebola virus can be inactivated using gamma radiations, at 60^{o} C temperature and disinfectant like sodium hypochlorite (Rewar&Mirdha, 2014). Comparative study of stability in aerosol between EBOV Makona 2014 and EBOV Mayinga 1976 shows EBOV Makona 2014 is less stable. EBOV survives as an aerosol for 3hr at 22^{o}C and 80% relative humidity. The total decay rates of ZEBOVand REBOV in small aerosol particle is 4.29% min^{-1} and 2.72% min^{-1} respectively (Piercy et al., 2010). Much more understanding about Ebola virus stability outside the host is required.

Conclusion

From the above review, we can conclude that virus survival rate and infection rate are influenced by the surrounding environment. Both abiotic and biotic factors contribute for the transmission, spread and infection from the virus. All the three viruses in the review Coronavirus, Influenza virus and Ebola virus are affected by different types of fluids (blood, serum, faecal matter, water droplets), temperature, relative humidity, and surfaces on which they fall. The constant positive relation is reflected between the virus and humidity making the viruses heavier in humid condition, thereby reducing their spread though aerosol. Winter period is thus critical since the humidity is very low. The lower temperature in winter supports the survival and the dryness of nasopharyngeal passage reduces the inflammatory response.

The study on influenza viruses are well understood regarding environmental pH, however, we could not find the literature that can establish direct relationship in between environmental pH and survival of SARS-CoV. Environment stability of Ebola virus outside the host is also not well understood further research needs to be done. Understanding the interaction between the environment and viral stability will help us to be safe from viral infection. The viruses are very diverse and occupy multiple hosts. The ability to survive in multiple hosts show that they have high adaptability to the new environment. Faster the ability to adapt, faster the evolution rate. Adjusting themselves to multiple host environment might be the reason they are able to survive outside host for certain period of time. Changing life style as well as unpredictable changes in the environment could be in favour of viruses and this might be the one of reason of increased in number of viruses causing epidemics and pandemics in last two decades. However, such data is not available to make a strong statement. By understanding viral ecology and its co-evolution pattern with its host, we can predict and prevent future epidemics and pandemics.

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