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Review article

Impact of climatic factors on viability of SARS-CoV-2 and transmission prospective of COVID-19: An overview

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ABSTRACT

The emergence of the new coronavirus disease-19 (Covid-19) from exotic wild animal market in Hubei, China during the late December 2019 has spread in 250 countries and territories posing menace to health of people around the globe. Coronavirus disease-19 has a great impact on public health, mortality and economy. The causing agent of Covid-19 is severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Due to unavailability of the potential drug or treatment for Covid-19, multi factorial research is conducted to reduce its transmission. Climatic factors play a key role in regulating the transmission of the infectious diseases like Severe Acute Respiratory Syndrome (SARS), Middle East Respiratory syndrome, and influenza. So, the rate of prevalence of the infectious disease is likely to be inclined by the variation in climatic indicators. We conclude from the past and present experiences that coronavirus transmission is elevated under low temperature and high humidity and vice versa. It further infers that after three hours of incubation of SARS-CoV-2, no infectious virus could be recovered from tissue paper and printing. Smooth surfaces are found to be more favorable for SARS-CoV-2. We may infer that climatic variations greatly affects infectious disease transmission pattern. We need more to study about under laying multifaceted casual affiliation between climate and communicable diseases and employ this information to the forecast of their upcoming impact.

Climate and infectious diseases; Historical background

Humans are well familiar with the role of the climatic factors in transmission of the epidemic diseases long before the discovery of the infectious agents in the late 19th century. For example, Romanian aristocrats retreated back to hills to avoid malaria and south Asians people utilize strongly curried food as preventive measure of diarrhea. The climate is reported to affect infectious disease in three ways i.e., regulation of the infectious agent viability and transmission, indication of the already emerged infectious disease and prediction of the early infectious disease to estimate future infectious disease burden under climatic variation circumstances [1].

Globally, the increasing trends of the infectious diseases are due to imitate combined aspects like climatic, demographic, technological, and change in the living standard of human. Variations in the climatic factors like temperature, relative humidity, rain fall, and precipitation also

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participate in governing the emergence and transmission of infectious diseases. Natural or anthropogenic environmental modifications disturb the ecological balance and background providing favorable conditions for breeding and transmission of infectious disease [2].

Outbreak of Covid-19

From the past two decades, coronavirus (CoV) has caused severe outbreaks and deaths in Middle East and East Asia. Severe Respiratory syndrome (SARS) with severe pneumonia emerged in 5 continents and 30 countries in 2003 [3,4]. Severe Respiratory syndrome left dramatic impacts on health care services of affected countries with 9% overall mortality and 50% in people with age of 60 years or above [5].

In December 2019, the novel coronavirus (2019-nCoV) which was later renamed as" Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) by the International Committee on Taxonomy of Virus (ICTV) and disease is termed as Coronavirus disease (Covid-19) was emerged in wild animal market of Wuhan City of Hubei Province of China [6,7]. Severe Acute Respiratory Syndrome Coronavirus-2 is rapidly spreading globally imposing serious health threat in 205 countries and territories [8]. Till 05-07-2020, around 11,480,014 cases and 535,159 deaths of Covid-19 has been reported globally [9].

In the absence of the effective vaccine and drug treatment of Covid-19, awareness of its transmission to general public is the only preventive strategy for its effective control. Transmission risk assessment of Covid-19 is still incomplete. Earlier epidemiological analysis in Wuhan city during earlier outbreak in China identified an initial association with sea food market [10].

Covid-19 Transmission

Climatic factors like air temperature, air humidity, wind speed and precipitation play key role in outbreak and regulation of the infections disease like Middle East Respiratory Syndrome (MERS), SARS, and influenza [11] The air born transmission of the infectious viruses like influenza virus, H5N1, MERS-CoV and SARS-CoV-1 are well documented in literature [12-18]. Common coronaviruses are transmitted by the gastrointestinal or respiratory routes [19]. As the SARS-CoV-2 genome is different from other human coronaviruses (HCV) like MERS-CoV and SARS-CoV, its mode of transmission is expected to be different [20].

The current literature has advocated air born transmission of SARS-CoV-2 [21-29]. Air borne transmission of the SARS-CoV-2 mostly occur through aerosol generating procedure or under some cases with our aerosol generating especially indoor setting with poor ventilation **(figure 2)** [30]. The current research has hypothesized that respiratory droplets produce small aerosol of less than 5 µm by evaporation, and even normal breathing and talking releases aerosol [31-34]. However, infectious dose to cause infection in recipient by aerosol counting SARS-CoV-2 is not known [35]. Touching infected surfaces and the mouth and nose may also infect a person.

Stability of SARS-CoV-2 on different surfaces

Transmission of the nosocomial viral infections is mainly contributed by different environmental surfaces [36]. Surface sampling in health care facilities during SARS-CoV-2 outbreak revealed presence of SARS-CoV-2 nucleic acid on inanimate objects and surfaces [37,38]. So, survival of the SARS-CoV-2 on different surfaces and environmental variables like relative humidity of and air temperature could help us in evaluation of risk assessment posed by SARS-CoV-2.

In previous studies conducted by **Casanova et al.** in 2010, working on transmissible gastroenteritis virus (TGEV) and mouse hepatitis virus (MHV) the relationship of the relative humidity and inactivation was declared non-monotonic i.e. there was great survival effect at low relative humidity (20%) and high relative humidity (80%) than at moderate relative humidity (50%). More rapid inactivation of SARS-CoV-2 was reported to occur at 20 ^{o}C than 4 ^{o}C [39].

In 2011, a study conducted by **Chan et al.** showed the viability of the dried virus can survive over 5 days at temperature of 22-25 $^{\circ}$C and 40-50% relative humidity [40]. The viability of SARS coronavirus reduced rapidly at 38°C and humidity > 95%. The low community outbreak of SARS coronavirus in Asian countries was predicted owing to high temperature and high relative humidity than subtropical area. Severe Acute Respiratory Syndrome Coronavirus associated with common cold was reported to remain viable only for three hours on environmental surfaces after drying and viability increase for many days in liquid [41]. In retrospect studies, the outbreak of the SARS in Guangdong in 2003, gradually faded with rise in temperature and ended in July [42].

Previous studies have proved that climatic factors especially temperature variations affect outbreak of SARS [43]. During the year 2003, risk influence of the influenza in Korea decrease with rise in temperature and low humidity of air [44]. In the previous studies, significant correlation has been found between influenza virus viability and transmission [45]. Stability of SARS-CoV-2 on different surfaces is shown in **figure (3)**.

A study conducted by **van Doremalen et al.** reported that SARS-CoV-2 remained viable in aerosols up to three hours. About 72 hours stability of SARS-CoV-2 was noted on plastic and stainless steel [22]. Although still uncertainties exist about transmissions mechanism of COVID-19, airborne precautions are strongly recommended in most situations.

Oral and fecal transmission is not reported to be significant in transmission of novel coronavirus [46]. A study conducted by **Zhang et al.** reported that Covid-19 may lead to intestinal infection and be present in the faces [47]. According to a report recently published in "Nature", some patients show negative SARS-CoV-2 test from nasopharyngeal sampling, and positive from rectal swab. This clearly propose alternate oral fecal transmission route [48]. However, the role of the environmental contamination and fomites in transmission of infection are presently still imprecise. As Amoy Garden reported an outbreak affecting more than 300 people in high rise residence of Hong Kong could not be justified by respiratory globule transmission [49]. So, SARS might be detectable in faces from infected persons and infection can be transmitted by aerosolization of faces of infected patients [50,51].

Now the question is whether the survival pattern of SARS-CoV-2 will be different from previous coronavirus or not. A recently published article has shown that SARS-CoV-2 is highly stable at 4°C. With an increase of temperature up to 70°C, the time of the inactivation is reduced up to 5 minutes. It further infers that after 3 hours of incubation of SARS-CoV-2, no infectious virus could be recovered from tissue paper and printing. By contrast, SARS-CoV-2 was more stable on smooth surfaces. No infectious virus could be detected from treated smooth surfaces on day 4 (glass and banknote) or day 7 (stainless steel and plastic) [40].

Overall, SARS-CoV-2 can be highly stable in a favorable environment under low temperature and high humidity level, but it is also susceptible to standard disinfection methods. Temperature variations are also reported to regulate respiratory disease mortality and strongly associated with low temperature. In 2020, couple of studies has shown that Covid-19 decreases with rise in temperature [20,52]. Recent work of **Yueling et al.** on Covid-19 mortality in relation to diurnal temperature range has also shown that rise in temperature has negative assertion with Covid-19 mortality; and humidity has positive association [53]. The current investigations of SARS-CoV-2 are also supported by the previous work [54-59]. Hence, we may presuppose that the climatic pattern might contribute in mortality of Covid-19.

Although the above discussion has fully supported the regulation of Covid-19 mortality and transmission with variations of temperature and air humidity, we cannot close the eyes to other factors like intercity or country migrations, investigational mechanism and precautionary measurements. There is also a strong need to mitigate the zoonotic transmission of SARS-CoV-2 through policy developments keeping climate as major factor [60].

Table 1. Studies on climatic changes and COVID-19

Aim of study	Results	Country	References
The effect of temperature & air humidity on Covid-19	Low temperature and high air humidity level may assist Covid-19 transmission	China	(52)
Association of coronavirus disease and climatic parameters	Temperature and humidity factors are playing important role in regulating Covd-19 spread	China	(53)
Summer impact on Covid-19	The local weather pattern will affect Covid-19	USA	(58)
Predict potential of spread and seasonality of Covid-19	Areas with significant Covid-19 distribution are roughly along 35-50ºN with average temperature of 5-11ºC	Iran	(59)

Conclusions

Severe Acute Respiratory Syndrome Coronavirus-2 is highly stable at low temperature and high air humidity. Different non-living surfaces show different patterns of survival of SARS-CoV-2. Special need of investigation is required for predicting international patterns of Covid-19 pandemic transmission. World is looking for weather the rise in temperature will wipe out Covid-19 or not.

Recommendations

Changes in infectious disease transmission patterns are a likely major consequence of climate change. We need to learn more about the underlying complex causal relationships between climatic factors and infectious diseases transmission and apply this information to the prediction of future impacts, using more complete, better validated, integrated, models.

Figure1. Graphical explanation of climatic impact on transmission of Covid-19.

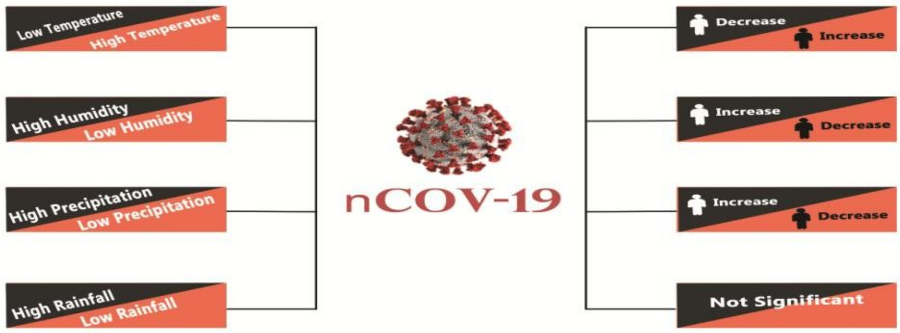


Figure 2. Airborne SARS-COV-2 transmission

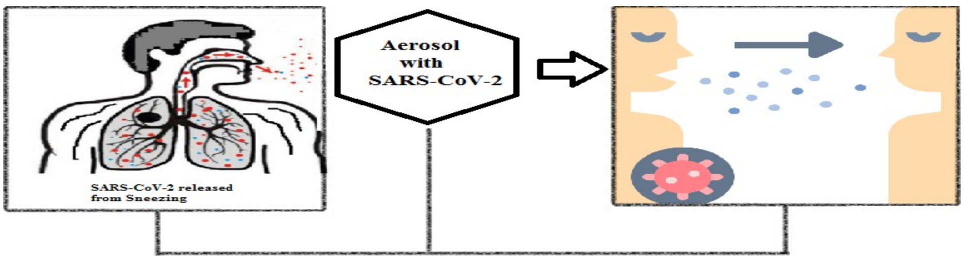
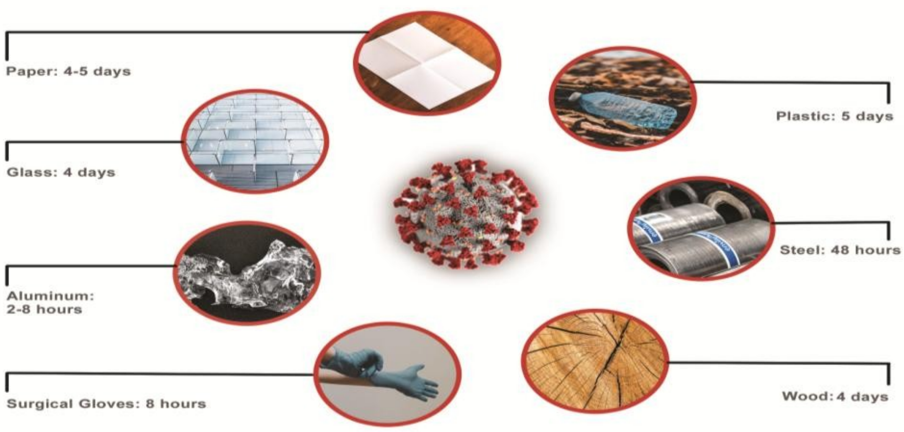


Figure 3. Viability of SARS-CoV-2 on different surfaces



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