The Journal of Infectious Diseases
PERSPECTIVE

Will Coronavirus Disease 2019 Become Seasonal?

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This manuscript explores the question of the seasonality of severe acute respiratory syndrome coronavirus 2 by reviewing 4 lines of evidence related to viral viability, transmission, ecological patterns, and observed epidemiology of coronavirus disease 2019 in the Southern Hemispheres' summer and early fall.

Keywords. COVID-19; seasons; transmission.

Although the object of much speculation, few data exist that bear on the question of the seasonality of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [1] or, more succinctly, the question of whether the virus will "disappear magically by summer." There are 4 lines of evidence that bear on this question: (1) seasonality of other human coronaviruses and influenza A, (2) in vivo experiments with influenza transmission, (3) ecological data, and (4) the observed epidemiology of coronavirus disease 2019 (COVID-19) in the Southern Hemispheres' summer and early fall.

Human alpha and beta coronaviruses and influenza peak in winter months whereas many other respiratory viral pathogens do not [2–5]. Surges in incidence of these infections are thought to be due in part to environmental effects on viral stability and transmission as well as host behavior (eg, clustering indoors) and changes in immunity level over time [5, 6]. More specifically, winter months are generally associated with decreased temperatures, decreased absolute humidity, and decreased indoor relative humidity (where we spend most of our time interacting). Cool, dry environments have been associated with increased influenza and coronavirus stability and transmissivity [5–9]. This is thought to be due to changes in essential viral outer proteins and lipids [10] as well as droplet matrices during droplet, and fomite transmission [7]. For example, environments with lower relative humidity may lead to droplet evaporation and smaller droplet sizes. This affects how far virus-containing droplets travel through the air and where they deposit in the airways. Associations between environmental factors and viral propagation are typically made through controlled laboratory experiments and natural history observations.

Laboratory experiments have demonstrated that controlling temperature and humidity affects the viability of coronavirus and influenza. Severe acute respiratory syndrome coronavirus 1 was found to have longer viability at temperatures typical to air-conditioned environments (22–25°C) with relative humidity of 0–50% compared with higher temperatures (>38°C) and higher relative humidity (>95%) [9]. Severe acute respiratory syndrome coronavirus 2 has been found to have similar stability under experimental conditions [11]. One study found that the viability of SARS-CoV-2 decreased at higher temperatures. In this study, investigators incubated SARS-CoV-2 in virus transport medium with a final concentration of approximately 6.8 log units of 50% tissue culture infectious dose per milliliter and found only a reduction of 0.7 log units on day 14 at 4°C compared with complete inactivation of the virus at 14 days in 22°C and at 2 days in 37°C [12].

Beyond the impact temperature and humidity have on viral stability, researchers have also investigated the impact they have on transmission. Lowen and Steel [8] exposed individually housed guinea pigs to nebulized influenza virus at controlled temperatures and humidity levels. Transmission was found to be highly efficient at ambient temperatures of 5°C, variable at 20°C, and inefficient at 30°C [8]. Lower relative humidity (20%–35%) was also found to be more favorable for spread of the virus [8]. Data may be emerging regarding SARS-CoV-2 viability in different environments within engineered aerosols and simulated body fluids [13]. Laboratory experiments offer the possibility of strict control over environments with limited variables; however, these studies typically rely on animal models and/or engineered culture mediums, aerosols, or droplets and therefore may not generalize to clinical conditions.

Because SARS-CoV-2 is an emerging virus, we do not have the longitudinal data to determine whether COVID-19, the disease caused by SARS-CoV-2, cycles seasonally. However, recent research, still preprint and not yet peer-reviewed, has

Received 4 May 2020; editorial decision 9 June 2020; accepted 11 June 2020; published online June 21, 2020.

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The Journal of Infectious Diseases® 2020;222:719–21

DOI: 10.1093/infdis/jiaa345

examined ecological associations between transmission patterns and climate. In one study, researchers found that before March 22, 2020, 90% of SARS-CoV-2 global transmissions occurred within areas with temperatures ranging from 3°C to 17°C and absolute humidity ranges between 4 and 9 g/m^3 daily [13]. Similarly, Sajadi et al [14] found that areas across the globe with significant community spread (defined as ≥10 reported deaths by March 10, 2020) remained in a distribution approximately in the range of 30–50° north latitude with average temperatures of 5–11°C and low absolute humidity (4–7g/m^3). In addition, Notari [15] estimated that among countries with at least 30 COVID-19 cases and 12 days of data before April 1, 2020, the maximal transmission peak occurred at 7.7°C with decreased comparative doubling times at higher and lower temperatures. Supporting the ecological theory that temperature and humidity may impact the transmission of COVID-19, some investigators have found that as little as a 1°C increase in temperature and a 1% increase in relative humidity can lower the daily effective reproductive number (R_e) by 0.0383 and 0.0224, respectively [16]. Similarly, a study investigating 30 Chinese provinces found a 1°C increase in average temperature was associated with a decrease in daily confirmed cases by 36%–57% when average relative humidity ranged from 6% to 85.5% [17]. Furthermore, a 1% increase in average relative humidity led to a decrease in daily confirmed cases by 11%–22% when average temperature was between 5.04–8.2°C [17]. Athough these findings are not consistent throughout China, their conclusions that higher viral spread is observed in areas with moderate temperatures and lower humidity are similar. However, the evidence is still developing and is somewhat inconsistent [18]. In fact, recent research from a public bath center in Huai'an, Jiangsu Province, China found that a bathhouse with high temperature and humidity was the source of a cluster of COVID-19 cases [19].

It is important to note that causal inference is limited in these ecological studies exploring the relationship between environment and COVID-19 transmission rates. Moreover, these studies are limited by data quality, strong modeling assumptions, and reveal that temperature and humidity are only 2 of the many factors involved in viral transmission [13]. Two primary factors that potentially confound the relationship between environment and transmission include travel and behavioral patterns, which are also driven by public health policy, testing capacity, quality of healthcare, and per capita income. Furthermore, rapid viral spread is not solely limited to areas within ranges of 3–17°C temperature and 4–9 g/m^3 humidity. For example, COVID-19 has already spread very rapidly throughout Iran and Louisiana.

Finally, we should note that SARS-CoV-2 has occurred in 14 countries and 3 overseas French dependencies lying entirely in the Southern Hemisphere since January 25, 2020. On February 1, 12 cases had been reported from Australia with evidence of community transmission, but by the vernal equinox (March 19), 1055 cases had been reported from countries lying entirely south of the equator, including Argentina, Australia, Bolivia, Chile, Eswatini, French Polynesia, Mayotte, New Zealand, Namibia, Paraguay, Réunion, Rwanda, Seychelles, South Africa, Tanzania, Uruguay, and Zambia [20]. An additional 598 were from countries that crossed the equator, including major foci in Brazil, Ecuador, and Peru. All but 70 of these were from countries that the World Health Organization had classified as having local transmission.

CONCLUSIONS

So, although data suggest temperature and humidity may affect viral viability and transmission, given our limited data on the emerging pandemic, the seasonality of COVID-19 cannot yet be definitively determined. In addition, human factors, such as lack of sustainable social distancing and low immunity to a novel virus with high transmissibility, will likely outweigh the climate effects on transmission. Therefore, it seems unlikely that the coming Northern Hemisphere summer will have a significant effect on SARS-CoV-2 transmission reduction. As to whether COVID-19 will enter into regular circulation like other human coronaviruses and influenza, this will depend largely on the duration of immunity to the virus, which remains unknown. One study predicts that if duration of immunity to SARS-CoV-2 mimics other related coronaviruses, recurrent outbreaks are likely to occur [21].

Notes

Potential conflicts of interest. All authors: No reported conflicts of interest. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest.

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