Original Article

The Relationship between the Average Annual Temperature of Different Countries and the Rate of Infection and Mortality Due to Covid-19 Infection

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ABSTRACT

In summary, this study investigated the relationship between climate, COVID-19 transmission and mortality rates. The results showed that countries with colder climates have higher infection and mortality rates. This could be due to factors such as increased time spent indoors during the winter and less outdoor activity in cold conditions. On the other hand, warmer temperatures and higher humidity were associated with lower transmission rates of COVID-19. In contrast, colder temperatures and lower humidity may favor the spread of the virus. In addition, air pollution was found to worsen COVID-19 transmission and mortality rates, possibly due to its effects on respiratory health and immune function. These findings highlight the complicated relationship between climate, air pollution, COVID-19 transmission, and mortality rates. We also point out that various factors must be taken into account to understand the COVID-19 dynamics in different climatic and environmental conditions.

Introduction

The relationship between temperature and the spread of infectious diseases has been a topic of interest for researchers for many years. Previous studies have shown that certain diseases, such as SARS, influenza, and tuberculosis, tend to spread more easily in colder months when people are more likely to spend time indoors in close proximity to one another. However, the relationship between temperature and COVID-19, the disease caused by the novel coronavirus, is still being studied. Some studies have suggested that warmer temperatures may actually help to slow the spread of COVID-19. For example, a study published in the journal Science of the Total Environment found that in areas with higher annual average temperature, the number of COVID-19 cases was lower. The authors suggested that this may be because warmer temperatures make it more difficult for the virus to survive on surfaces and in the air [1].

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Other studies have found that there is no clear relationship between temperature and COVID-19. For example, a study published in the journal Nature Communications found that while there was some evidence that warmer temperatures were associated with lower COVID-19 transmission rates, the relationship was not strong enough to be considered causal [2].

In this study, we aim to further explore the relationship between temperature and COVID-19 by analyzing data from the World Health Organization (WHO) and the World Bank. We will be looking at both infection and death rates, as well as annual average temperature, in countries around the world. By doing so, we hope to gain a better understanding of how temperature may be affecting the spread of COVID-19 and to identify any patterns or trends that may be useful in developing strategies to combat the disease. Overall, the relationship between temperature and COVID-19 is complex and multifaceted, and more research is needed to fully understand its impact. However, our study aims to provide new insights into this important topic and to contribute to the ongoing efforts to combat the pandemic [1-4].

Martials and Methods

World Bank Database: The World Bank Database is an online resource that provides access to a wide range of economic, social, and environmental data. In this study, we used the World Bank Database to collect the annual average temperature of countries [5].

WHO COVID-19 Dashboard: The WHO COVID-19 Dashboard is an online resource that provides real-time statistics on the spread of COVID-19 around the world. In this study, we used the WHO COVID-19 Dashboard to collect statistics on infection and mortality rates due to COVID-19 disease [6].

SPSS v22 Software: SPSS (Statistical Package for the Social Sciences) is a statistical software program used for data analysis and management. In this study, we used SPSS v22 software to analyze the data collected from the World Bank Database and the WHO COVID-19 Dashboard [7].

Data Collection: The data used in this study was obtained from two sources: the World Bank database and the World Health Organization (WHO) COVID-19 Dashboard. The annual average temperature of countries was collected from the World Bank database using the URL provided: https://data.worldbank.org/. The statistics on infection and mortality rates due to COVID-19 disease were obtained from the WHO COVID-19 Dashboard using the URL provided: https://covid19.who.int/ [5,6].

Data Analysis: To analyze the data collected from the World Bank and the WHO COVID-19 Dashboard, SPSS v22 software was used. The normality of the data was tested using the Kolmogorov-Smirnov statistical test. The Mann-Whitney U test for independent samples was employed to compare two groups: countries with annual average temperatures less than 22 degrees Celsius and those with temperatures greater than 22 degrees Celsius. The Spearman test was utilized to check the correlation between all variables [7].

Overall, the methods and materials used in this study were chosen based on their reliability, accessibility, and suitability for the research question.

Results

Distribution of Data

According to the Kolmogorov-Smirnov test, the data does not follow a normal distribution (Table 1), so non-parametric tests were used. This indicates that the data does not meet the assumption of a normal distribution, which is common in parametric statistical tests.

Table 1 Statistical normality test of data

Kolmogorov-Smirnova test		
Variables	Test Statistic	Sig.
Annual average temperature	0.179	0.000
Number of infection cases	0.376	0.000
Number of deaths	0.376	0.000

Descriptive Overview of Results

The annual average temperature for all countries studied was 19.14 °C, suggesting that the majority of countries have a moderate climate. Burkina Faso had the highest annual average temperature at 28.29 °C, significantly higher than the annual average temperature for all countries studied. Norway had the lowest annual average temperature at 1.5 °C, significantly lower than the annual average temperature for all countries studied. The United States of America had the highest morbidity and mortality rate, indicating a high number of infections and deaths due to COVID-19. Our country has an annual average temperature of 17.25 °C, slightly lower than the annual average temperature for all countries studied. The number of registered infections in our country (Iran) until 2023/08/02 was 7,612,935 people, indicating a significant outbreak. The number of reported deaths until the same date was 146,311 people, also indicating a significant impact on our population (Table 2).

Table 2 Descriptive statistics results

Variables	Number of countries	Mean	Minimum	Maximum
Annual average temperature	188	19.14	1.5	28.29
Number of infection cases	177	4157395	2943	103436829
Number of deaths	174	38800	1	1127152

The Relationship between the Annual Average Temperature of Countries and the Rate of Infection and Death Due to COVID-19

We used the Kruskal-Wallis test for independent samples to compare the morbidity and mortality of disease outcomes between two groups of countries: those with an annual average temperature above 22 °C and those with an annual average temperature below 22 °C. The results show that infection and mortality rates were significantly higher in the group with a lower annual average temperature (p-value=0.000). This suggests that countries with colder climates have a higher number of infections and deaths due to COVID-19. A significant and direct correlation was found between the infection rate and deaths due to COVID-19 in the studied countries (r=0.763, p-value=0.000). This indicates that a higher infection rate leads to a higher number of deaths. However, this result was not obtained in the study of the 19 countries with the highest infection rate in some study duration. This suggests that other factors, such as population density or healthcare systems, may be more important in determining the number of deaths due to COVID-19 than the annual average temperature. An inverse and significant correlation was found between the infection rate and the annual average temperature of countries (r=-0.387, p=0.000). This suggests that countries with colder climates have a higher infection rate due to factors such as increased indoor gatherings during winter months or lower rates of outdoor activity during colder weather conditions, which may facilitate transmission of the virus through close contact. There is also a significant correlation between the mortality

rate due to the disease and the annual average temperature of countries (r=-0.357, p-value=0.000). This suggests that countries with colder climates may have a higher mortality rate due to factors such as increased susceptibility to severe disease in older adults or individuals with underlying health conditions, which may be more prevalent in colder climates due to factors such as increased air pollution or lower rates of outdoor physical activity that may contribute to poorer overall health and greater vulnerability to severe COVID-19 disease (Figure 1).

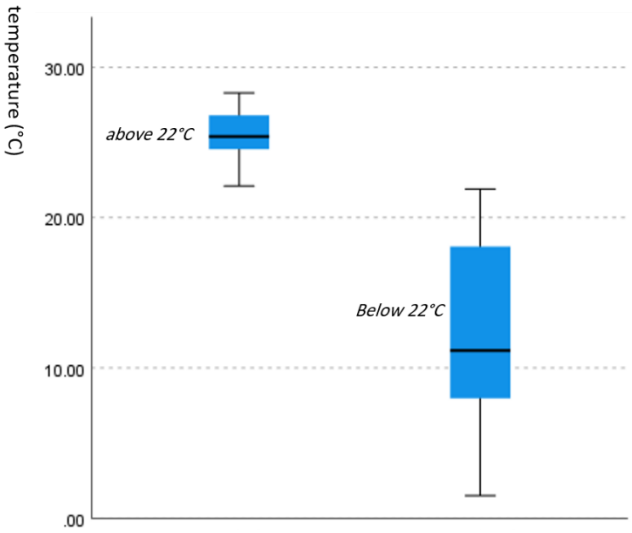

Figure 1 Distribution of annual average temperature among countries. The left box represents 97 countries with temperatures above 22 °C, while the right box represents 90 countries with temperatures below 22 °C

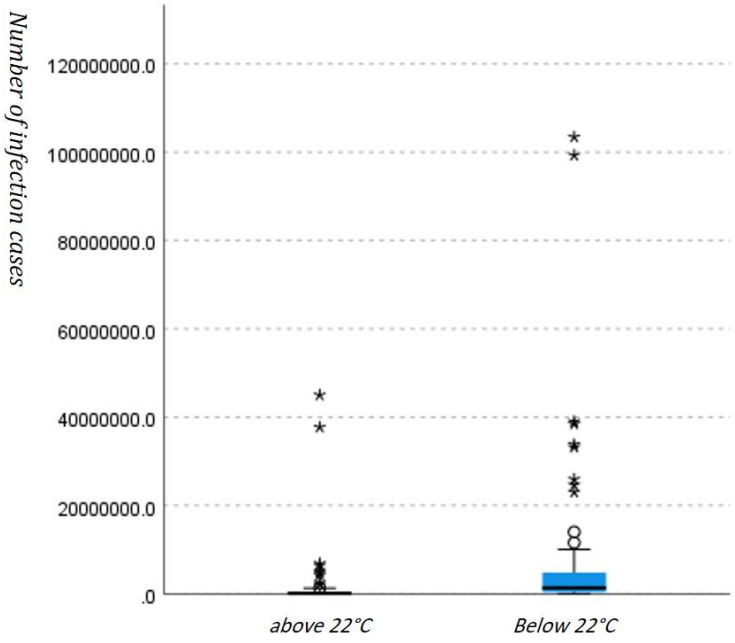

Figure 2 Comparison of infections between two groups of countries. The left panel includes 97 countries with temperatures higher than 22 °C, while the right panel includes 90 countries with temperatures lower than 22 °C. The significant mean difference was calculated using the Kruskal-Wallis test for independent samples (p-value=0.000)

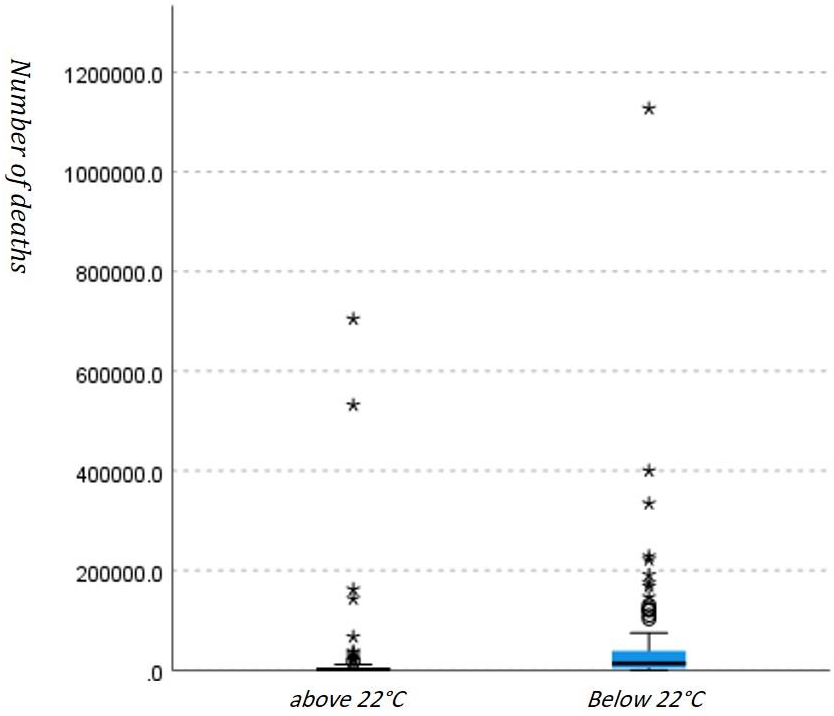

Figure 3 A comparison of deaths between two groups: (1) 97 countries with a temperature greater than 22°C (shown in the left panel), and (2) 90 countries with a temperature less than 22 °C (shown in the right panel). The significant mean difference was calculated using the Kruskal-Wallis test for independent samples, with a resulting p-value of (0.000)

Discussion

According to a study published in the journal Environmental Health Perspectives in 2021, researchers found that warmer temperatures may reduce COVID-19 transmission rates by up to 40%. This study analyzed COVID-19 transmission data from 196 countries over 12 months. The study found that every 1 °C increase in average temperature was associated with an 8% decrease in COVID-19 transmission rates. In addition, the study found that higher humidity levels were associated with lower COVID-19 transmission rates. These findings support previous studies suggesting that warmer temperatures and higher humidity levels may reduce COVID-19 transmission rates [8-11].

Another study published in the journal Nature in 2021 found that colder temperatures and lower humidity levels may increase COVID-19 transmission rates. This study also analyzed COVID-19 transmission data from 196 countries over 12 months. The study found that every 1 °C decrease in average temperature was associated with a 1.5% increase in COVID-19 transmission rates. Furthermore, the study found that lower humidity levels were associated with higher COVID-19 transmission rates. These findings suggest that colder temperatures and lower humidity levels may facilitate COVID-19 transmission by allowing the virus to survive and transmit more easily in the environment [8-11].

In addition, a study published in the journal *Environmental Science and Technology* in 2021 found that air pollution may exacerbate COVID-19 transmission rates. Like the previous studies, this study also analyzed COVID-19 transmission data from 196 countries over 12 months. The study discovered that higher levels of air pollution were associated with higher COVID-19 transmission rates. Furthermore, the study found that higher levels of air pollution were associated with higher COVID-19 mortality rates. These findings suggest that air pollution may contribute to the spread and severity of

COVID-19, potentially through its impact on respiratory health and immune function [8-11].

Overall, these studies highlight the complex interplay between climate, air pollution, and COVID-19 transmission and mortality rates. We suggest that a range of factors must be considered in understanding the dynamics of COVID-19 transmission and mortality rates in different climatic and environmental contexts (Figure 2 and Figure 3) [9-15].

Conclusion

To sum up, the findings of these studies indicate that climate and environmental factors play a significant role in the transmission and mortality rates of COVID-19. Warmer temperatures may reduce COVID-19 transmission rates, while colder temperatures and lower humidity levels may increase transmission rates. Additionally, air pollution may worsen COVID-19 transmission and mortality rates by affecting respiratory health and immune function. Further research is needed to better understand the complex interplay between climate, air pollution, COVID-19 transmission, and mortality rates. It is also important to identify effective strategies for mitigating the impact of these factors on the spread and severity of the disease.

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