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# Social and Environmental Factors Influencing COVID-19 Transmission and Mortalities in Developing and Developed Nations

*Soheli Chowdhury*[(1)], *Majeedul H. Chowdhury*[(2)]

*(1) Department of Natural Sciences, Hostos Community College, The City University of New York (CUNY), NY 10451, USA –tel +1 347 3371253*
*(2) Department of Biology, Touro University, Flatbush Campus, NY 11230, USA –tel +1 347 3371279*

CORRESPONDING AUTHOR: Dr Soheli Chowdhury, Department of Natural Sciences, Hostos Community College, CUNY, 500 Grand Concourse, Bronx, NY 10451, USA – tel +1 347 3371253. schowdhury@hostos.cuny.edu

## SUMMARY

Background: The study sought to establish environmental and social factors that influenced the transmission and mortalities of COVID-19 in developing and developed nations. The factors that were assessed included temperature, average age of the population, urbanization, population density, and percentage of old-aged people in the population. The dependent variables were COVID-19 transmission and COVID-19-related deaths.
Methods: The study employed a pragmatism research philosophy. It also relied on a deductive research approach and a descriptive research design. It adopted a mixed-method approach as it used both qualitative and quantitative data. It was a cross-sectional study, given its data measurement at a particular point in time. Data was analyzed and presented using descriptive techniques.
Results: Statistical analyses were conducted to quantify the relationships between various factors and COVID-19 outcomes. A Kendall's Tau test revealed a robust negative correlation between COVID-19 cases and temperature (Tb = -0.560, p<0.005). This result was further confirmed by Spearman's rank correlation, showing a strong negative correlation with r(13) = -0.684, p<0.007. Similarly, a strong negative correlation was observed between COVID-19 deaths and average annual temperature using both Kendall's Tau (Tb = -0.495, p<0.014) and Spearman's rank correlation (r(13) = -0.648, p<0.012). Age emerged as a significant factor, with a strong positive correlation found between age and both COVID-19 infections (Tb = 0.516, p<0.010; r(13) = 0.670, p<0.009) and COVID-19-related mortalities (r(13) = 0.516, p<0.029). Urbanization was also positively correlated with COVID-19 infections (Tb = 0.530, p<0.008; r(13) = 0.640, p<0.014) and COVID-19 deaths (Tb = 0.398, p<0.048; r(13) = 0.561, p<0.037). Interestingly, no significant correlation was found between population density and COVID-19 infections or deaths in both developed and developing countries, as evidenced by Kendall's Tau (TB = 0.331, p<0.1; Tb = 0.133, p<0.511) and Spearman's rank correlation (r(13) = 0.425, p<0.130; r(13) = 0.161, p<0.583), respectively. Moreover, the percentage of elderly individuals in a country exhibited a strong positive correlation with both COVID-19 infections (Tb = 0.464, p<0.021; r(13) = 0.642, p<0.013) and COVID-19-related deaths (r(13) = 0.541, p<0.046).
Conclusion: The study focused on social, demographic, and environmental factors influencing COVID-19 incidence and mortality in developing and developed nations. The study highlights significant COVID-19 transmission and mortality disparities between developed and developing countries. Developed countries exhibited higher infection and mortality rates, coupled with elevated death rates per million and infection rates per million, as compared to their developing counterparts. The research identified a correlation between lower average annual temperatures and increased mortality in developed countries. Contrary to this, high average annual temperatures were associated with a decline in COVID-19 infections.
Moreover, developed countries, characterized by higher urbanization levels, population densities, and percentages of aged individuals, experienced elevated COVID-19 infection rates. The study also unveiled a positive correlation between age and COVID-19 infections, with developed countries hosting signifi-

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cantly older populations than their developing counterparts. However, population density did not clearly correlate with COVID-19 infections or deaths.

*Keywords: Medical Education; Competition; Young medical doctor; Medical specialities; Career choice.*

## INTRODUCTION

The outbreak of COVID-19 resulted in the infection of hundreds of millions of people globally and left millions of others dead. The COVID-19 pandemic had significant social and economic ramifications. However, the patterns of its effects in developed and developing countries significantly differed. At the earlier stages of the pandemic, predictions had been made that developing nations would be significantly more affected by the pandemic than developed countries. However, it became apparent that developed nations had higher disease prevalence and deaths than low-income countries [1]. Studies established that high-income countries had three times higher disease prevalence rates than low-income countries [1, 2]. The disparity has been linked to ecological and environmental factors such as average population age, average annual temperature in specific countries, population density, urbanization, and percentage of aged people in each country. Other studies have also mentioned the factors influencing COVID-19 transmission and mortality [3-5]. However, a critical limitation of our study is its reliance on country-reported data, which introduces a degree of uncertainty. Disparities in testing infrastructure among countries may contribute to an underestimation of the actual burden of COVID-19. Our findings illuminate a stark reality, with less than 20% of populations in developing countries having been tested for the virus. Our study brings to light the stark contrast in testing efforts between developed and developing nations, with the former conducting more extensive testing, thus providing a more comprehensive picture of the pandemic's impact.

Controlling for economic factors, it is evident that other factors influenced the disparities in infections and deaths from COVID-19 in high-income and low-income countries [6]. It is, therefore, significant to understand the factors that influenced the transmission of the disease and eventual deaths in both developed and developing countries. Several models suggested that environmental factors were responsible for the morbidities and mortalities of COVID-19, while other investigations point to social factors [6, 7]. Suggestions indicate that environmental and social factors influenced these disparities in the disease's transmission and fatalities [7]. However, there are contrasting findings in current investigations on the extent to which environmental and social factors influence the spread of the disease. Therefore, this study aims to investigate the following social and environmental factors, like temperature, population density, urbanization, average age, and the percentage of aged people in the population, influencing COVID-19 transmission and mortality in developing and developed nations.

## MATERIALS AND METHODS

### Theoretical perspectives

The study utilizes the transmission mechanism theory of disease dynamics [8]. Therefore, the theory seeks to help individuals understand a single-level interaction between a pathogen, an organism, and its environment. In the case of this study, the organisms are human beings. The theory has four significant assumptions. The first assumption asserts that infectious disease patterns result from two transmission models: direct transmission and environmental transmission processes. The direct transmission of disease is mediated through the direct contact of an infected individual with a vulnerable individual [8]. However, in environmental transmission, a disease is transmitted when a vulnerable individual comes into contact with an environment contaminated by an infectious pathogen. The direct transmission process of disease transmission focuses on the infectiousness of the disease host, such as the individual being mildly infectious, symptomatic, asymptomatic, or vaccinated [9].

The second assumption of the theory is that a communicable disease has seven primary levels of organization it can emanate at, in a hierarchical order from the simplest to the most complex: at the cell level, the tissue level, the organ, level, the microecosystem level, the organism level, the community level, and at the microecosystem level [8]. The third assumption is that the spread of an illness can be local through a pathogen or both local and global spread of the infectious agent [8]. The local spread of the infection is through direct contact between the vulnerable victim and the infectious agent. However, global transmission of the ailment happens when the infectious agents are transported by other agents like wind, which blows it over distances locally, nationally, regionally, or globally. The fourth assumption is that a virulent infection results from interactions between the host, the disease agent, and the environment [8]. This may help explain the relationship between high population density and COVID-19 infections and the influence of temperature on COVID-19 infections.

## Conceptual framework

The conceptual framework is based on the interactions between factors influencing COVID-19 infections and deaths. The factors that form the independent variables are average annual temperature, average population age in respective countries, percentage urbanization in respective countries, population densities in respective countries, and percentage of aged people in respective countries. The dependent variables are COVID-19 infections and COVID-19 deaths because the aforementioned independent variables influence them.

## Research philosophy

The study relied on a pragmatism research design. The philosophy was selected for this study because it would help explain the interconnectedness of the issues under study [10]. Besides, it provided grounds for explaining the complex issue quickly because it accommodated both expected and unexpected results. Moreover, the pragmatism philosophy approach was ideal for the study as it provided avenues for generalizing the findings to a larger population.

## Research approach

The study relied on a deductive research approach. The deductive approach was ideal for this study because it would enable using both observable phenomena and subjective meanings to help explain the study issue under study [11]. It allowed for the generalization of the research findings. Also, the approach was ideal as it would allow for mixed research approaches to help explain the phenomenon. Moreover, the deductive approach provided the ideal ground for testing the research theory.

## Research design

The study employed a descriptive research design. The design was appropriate for this study as it provided grounds for an in-depth understanding of the issue. The design was also selected for this study as it enabled a comprehensive and accurate description of the issue under study by describing the trends and patterns that arose from the data [12]. Besides, the design was the best in describing the natural behavior of the target population in their various natural settings.

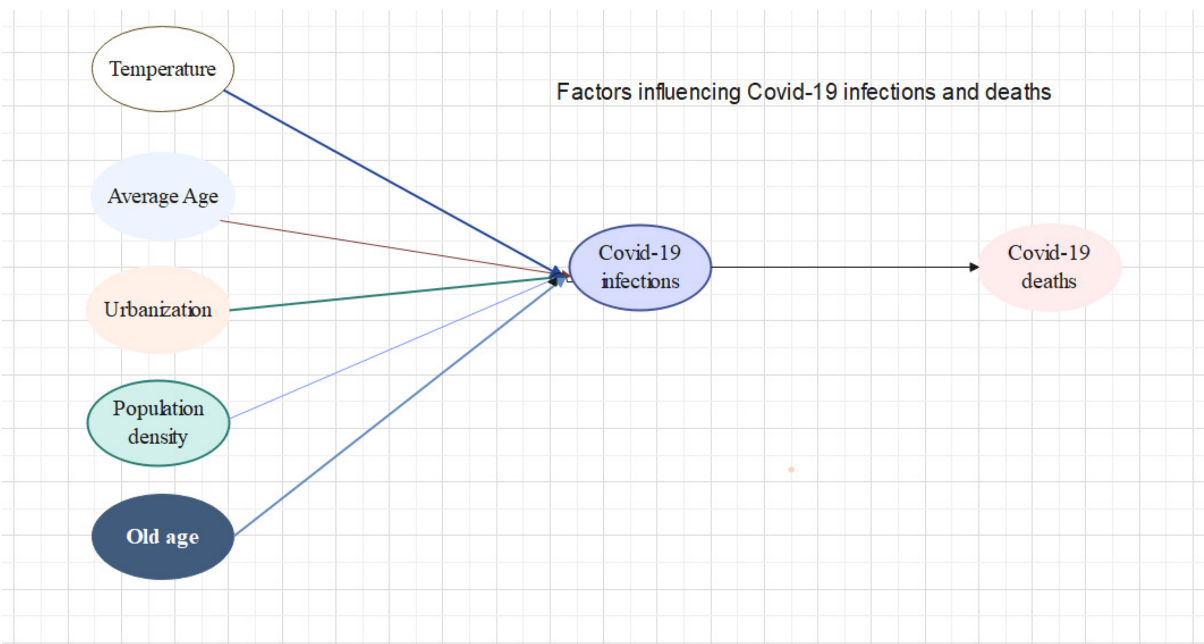
## Research choice

The study was based on a mixed research choice. This is because it utilized both qualitative and quantitative approaches. The choice was appropriate for this study because quantitative or qualitative data alone was insufficient to explain the phenomenon, therefore calling for the use of both qualitative and qualitative data to understand the issue under study comprehensively [13]. This provided a broader perspective of understanding the complex issue being examined.

## Time horizon

The study relied on a cross-sectional research approach. The approach was appropriate because the study needed more time and resources. As such, the approach would enable the completion of the study in a short time. Besides, the cross-sectional approach enabled the observation of the study phenomenon at

*Figure 1: Factors influencing COVID-19 infections and deaths in developing and developed countries*



a specific time [14]. It was also the best approach in analyzing data based on group differences, as the aim was to establish whether there were differences in developing and developed countries.

## Study sample

The study population was all the countries affected by COVID-19, from developing and developed nations. The researcher used stratified sampling to get a sample for this study. Stratified sampling enabled the grouping of countries by region and economic strata of developing and developing countries. Based on this approach, the researchers selected developed countries from North America, Europe, and Asia as they are the only regions with developed nations. The researcher also used the stratified sampling approach to select six countries from South America, Africa, and Asia. The final sample comprised 14 countries, including the USA, the UK, Italy, Spain, Germany, South Korea, and Japan, for developed nations. Peru, Bolivia, Mozambique, Uganda, Kenya, India, and Cambodia represented developing nations.

The selection of our study sample was guided by a deliberate and thoughtful approach aimed at ensuring a meaningful and representative analysis of the diverse global landscape in the context of COVID-19. One aim was to strike a balance between the depth and manageability of our analysis. A smaller, more focused sample allowed for a thorough examination of each country's social and environmental factors, ensuring a comprehensive understanding of the nuanced relationships between these variables and COVID-19 outcomes. Including both developed and developing nations was intentional, enabling a comparative analysis that sheds light on the potential disparities in COVID-19 transmission and mortality between the two categories. Resource constraints, including time and data availability, played a role in determining the sample size. Analyzing a smaller set of countries allowed us to thoroughly examine and validate the data while adhering to practical limitations. This approach ensures a rigorous and focused analysis, enhancing the reliability and robustness of our findings.

## Data collection approach

The researchers employed the secondary data collection approach. This is because data was accessed from already collected sources. To ensure data reliability, data was accessed only from revered sources, including the World Bank, the World Health Organization, and government websites. The researcher also collected quantitative and qualitative data from peer-reviewed journals, books, government websites, and other organization websites.

## Data analysis

The collected data was checked for completeness and clarity before it was analyzed. It was then analyzed quantitatively using descriptive techniques that included means and cross-tabulations. The data was summarized and presented in table format. Using the data analysis tool IBM's SPSS, the researcher performed Spearman's rank correlation, Kendall's Tau test, and Pearson's moment correlations. The correlation approaches were selected because they enabled the establishment of the relationship between the variables besides indicating the direction of the relationship [15]. This enabled the establishment of relationships, or lack of it, between the environmental and social factors and the transmission of COVID-19 and death rates in developing and developed nations.

The utilization of the three distinct correlation coefficients, Kendall's Tau, Spearman's rank correlation, and Pearson correlation, reflects a deliberate choice to assess the relationships between various quantitative variables comprehensively. This decision was influenced by the nature of our data, which primarily consisted of numerical measurements of social and environmental factors across the selected countries. Kendall's Tau was employed to gauge the strength and direction of correlation between non-parametric variables. This coefficient is robust in handling data with ties and is particularly suitable for assessing associations between variables when the normality assumptions are unmet [16]. Given the diverse range of social and environmental factors considered in our study, Kendall's Tau offered a valuable tool for capturing relationships robustly and distribution-free.

Spearman's rank correlation complemented our analysis, offering an alternative non-parametric measure that assesses monotonic relationships between variables. This coefficient is particularly useful when dealing with ordinal data or situations where the assumption of linearity may not hold [16]. While our variables were primarily non-parametric, including Pearson correlation provided a helpful comparison. Pearson correlation is well-suited for detecting linear relationships between variables [17]. Its use allowed us to explore potential linear associations among the quantitative factors considered in our study, providing a comprehensive perspective on the nature of these relationships.

## Research ethics

The study sought to observe the principles of ethical research. Firstly, the researcher sought the original researcher's consent to use data. Care was also taken to ensure that data used in the study was publicly available. Besides, the study ensured that there was no social profiling in the study by not referring to any region or its population in derogatory terms. However, it ensured objective reporting of the findings as they

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were established. Besides, the principle of provenance was observed by first establishing the origin of the data accessed for this study before it was analyzed. Only data from authentic sources was employed to generate the findings [18]. To ensure anonymity and confidentiality, the researcher took all measures to ensure no subjects would be reidentified from the analysis outcomes. Finally, the researcher made the research findings available to the scientific community for critique by publishing the findings.

## RESULTS

The study carried out a descriptive analysis of selected developed and developing countries. The data are summarized in Table 1. The study revealed that developed countries had the highest number of cases. In descending order, the most affected countries were the USA, Germany, Japan, Italy, the UK, Spain, Peru, Bolivia, Kenya, Mozambique, and Uganda. The tests established a significantly higher number of cases per million populations in the developed countries.

### COVID-19 cases per million

The descriptive analysis revealed the COVID-19 cases in each country per million population. The cases in Germany were 461,467 per million population; in Italy, were 440,360; in the UK, 364,011; in the USA, 304,229; in South Korea, 665,885; and 294,201 in Spain. Therefore, although the USA had significantly higher infections overall, South Korea, Germany, the UK, and Italy had higher infections per million people. This could indicate that other variables influenced the higher infection rates in these countries compared to the USA. Besides, the findings reveal that about a third of the population in developed countries contracted COVID-19 infections.

This can be deciphered from Table 2, where three particular variables stand out: population density, average age, and percentage of older adults. While the USA has a population density of 35 people per square kilometer, the UK has 277, Spain 94, Italy 196, Japan 338, South Korea 516, and Germany 233. This would indicate that the higher population densities in these countries influenced higher infection rates among their populations. Secondly, while the USA has an average age of 39 years, the other countries have significantly higher average ages in their populations where the UK's average age is 41 years, Spain is 44 years, Italy is 46 years, Japan is 49 years, South Korea is 43 years, and Germany stands at 48 years. Thirdly, the USA has a lower percentage of old-aged people than the other developed nations. While the USA's percentage of old-aged people in its population stands at 17%, it is 19% in the UK, 20% in Spain, 23.5% in Italy, 29.8% in Japan, 17.5% in South Korea, and 22.3% in Germany.

In developing nations, COVID-19 cases are relatively low. In Kenya, there were 6,242 cases per million; in Mozambique, 6,886 cases per million; in Uganda, 3,535 cases per million; in Bolivia, 97,383 cases per million; Peru had 131,490 cases per million; India had 31,989; Cambodia recorded 8,200 cases per million. This indicates that less than 10% of the population in developing countries contracted COVID-19 infections. This is three times less than the infection rate in developed nations.

### COVID-19 tests and their relation with COVID-19 Infections

The results for developing nations indicate that Kenya had a test rate of 71,997 tests per million, Mozambique carried out 40,449 tests per million, Uganda did 62,006 tests per million, Bolivia carried out 218,771 tests per million, Peru had 1,128,095 tests per million, India had 661,721 tests per million, and Cambodia had 182,440 tests per million. The results reveal that less than 20% of populations in developing countries were ever tested for COVID-19. While this does not influence infection rates, it helps to explain the lower infection rates officially reported, as some cases might have been underreported. Alvarez et al. (2023) state that developing nations recorded significantly low COVID-19 tests due to a lack of test kits and trained staff. The low testing rates would have led to missed cases and lower official cases being reported [19].

The study revealed that more tests were carried out in developed nations than in developing ones. The USA carried out 3.474,844 tests per million, Spain did 9,912,458 tests per million, the UK carried out 7,714,071 tests per million, Italy had 4,664,194 tests per million, and Germany had 1,468,671 tests per million. In comparison, Japan had 814,431 tests per million. The data reveals that other than Japan, people in developed nations underwent more than one test, with countries like Spain and the UK carrying out 9 and 7 tests per person, on average. The high test rates would correlate to the high COVID-19 cases established in these countries. Correspondingly, Van Gordon et al. [20] argue that the high testing rates of COVID-19 in developed countries partly indicated their higher COVID-19 cases compared to developing nations.

### Death rates

The study compared mortality rates between developed countries and developing countries. As illustrated in Table 1, the USA had 3,315 COVID-19-related deaths per million population; the UK had 3,375 deaths per million population; Spain had 2,564 deaths per million population; Italy had 3,246 deaths per million population; Japan had 606 deaths per million population, South Korea had 1,451 deaths per million, while Germany had 2,101 deaths per million

*Table 1: COVID-19 country specific data*

| | Population | COVID-19 cases | COVID-19 deaths | COVID-19 Tests | Infection Rate | Testing Rate | Mortality Rate |
|---|---|---|---|---|---|---|---|
| **Kenya** | 55100586 | 343,918 | 5,689 | 3,967,062 | 6,242 | 71,997 | 103 |
| **Mozambique** | 33897354 | 233,417 | 2,243 | 1,371,127 | 6,886 | 40,449 | 66 |
| **India** | 1430687966 | 44,996,919 | 531,928 | 930,797,975 | 31,989 | 661,721 | 378 |
| **Uganda** | 48582334 | 171,729 | 3,632 | 3,012,408 | 3,535 | 62,006 | 75 |
| **Bolivia** | 12388571 | 1,206,420 | 22,399 | 2,710,261 | 97,382 | 218,771 | 1,808 |
| **Peru** | 34352719 | 4,517,034 | 221,364 | 38,753,114 | 131,490 | 1,128,095 | 6,444 |
| **Cambodia** | 16944826 | 138,940 | 3,056 | 3,091,420 | 8,200 | 182,440 | 180 |
| **USA** | 339996563 | 103,436,829 | 1,127,152 | 1,181,435,124 | 304,229 | 3,474,844 | 3,315 |
| **UK** | 67736802 | 24,656,914 | 228,622 | 522,526,476 | 364,011 | 7,714,071 | 3,375 |
| **Spain** | 47519628 | 13,980,340 | 121,852 | 471,036,328 | 294,201 | 9,912,458 | 2,564 |
| **Italy** | 58870762 | 25,924,308 | 191,118 | 274,584,632 | 440,360 | 4,664,194 | 3,246 |
| **Japan** | 123294513 | 33,803,572 | 74,694 | 100,414,883 | 274,169 | 814,431 | 606 |
| **Germany** | 83294633 | 38,437,756 | 174,979 | 122,332,384 | 461,467 | 1,468,671 | 2,101 |
| **South Korea** | 51777405 | 34,179,800 | 35,687 | 15,804,065 | 665,885 | 307,892 | 1451 |

population. Among the developing nations, Kenya had 103 deaths per million population, Mozambique had 66 deaths per million population, Uganda had 75 deaths per million population, Bolivia had 1,808 deaths per million population, Peru had 6,444 deaths per million population, India had 378 deaths per million, and Cambodia had 180 deaths per million population. Other than Peru, which had a significantly high death rate, the COVID-19-related death rates among developing countries were relatively lower than those in developed countries.

## Demographic data of each country

The demographic data from each country was significant for this study as it provided independent variables that would have influenced the rate of COVID-19 infections and deaths. The data represents averages of the country's annual temperature, age, urbanization, population density, and percentage of older adults in the country as of the end of 2022. The data was obtained from the Worlddata.info website. The results are summarized in Table 2.

The study sought to establish whether temperature was linked to high COVID-19 infections and deaths. The study compared the average annual temperatures in both developed and developing countries. The study revealed that the USA had an average annual temperature of 10 °C, the UK had 9 °C, Spain had 14 °C, Italy had 12.44 °C, Japan had 12.4 °C, South Korea had 13.04 °C, and Germany had 9.5 °C. Comparatively, in the developing countries, Kenya had an average annual temperature of 26 °C, Mozambique had 25 °C, Uganda had 23 °C, Bolivia had an average annual temperature of 21 °C, Peru had 20 °C, India had 24.99 °C, and Cambodia had 27 °C. The outcome revealed that developing countries had higher average annual temperatures than developed countries. A correlation analysis in subsequent sections will seek further to explain the relationship between temperature and country-specific COVID-19 cases.

The study established that developing countries had relatively younger populations than developed countries. In developing countries, the average age was 20 years in Kenya, 17 years in Mozambique, 16 years in Uganda, 25 years in Bolivia, 29 years in Peru, 29 years in India, and 26 years in Cambodia. In the developed world, the average age was 39 years in the USA, 41 years in the UK, 44 years in Spain, 46 years in Italy, 49 years in Japan, 43 years in South Korea, and 48 years in Germany.

The study analyzed the urbanization levels in the targeted countries. It was revealed that developing countries had relatively low levels of urbanization. The urbanization rate in Kenya was 28%; in Mozambique, it was 37%; it was 25% in Uganda; 70% in Bolivia; 78% in Peru; India was 34.9% urbanized, while it was 24% in Cambodia. The developed countries were highly urbanized. The USA was 83% urbanized; the UK was 84% urbanized; Spain 81%; Italy 71.4%; Japan 91.7% urbanized; South Korea 81.4% urbanized; while Germany was 78%.

The study carried out an analysis of population density in the targeted countries. The population densities in developing countries were relatively low, except in Uganda, which had a population density of

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*Table 2: Country specific demographic data*

| Country | Temperature (°C) | Average Age (Years) | Urbanization (%) | Population Density (people/km²) | Percentage of Old People (%) |
|---|---|---|---|---|---|
| **Kenya** | 26 | 20 | 28 | 93 | 3 |
| **Mozambique** | 25 | 17 | 37 | 42 | 3 |
| **Uganda** | 23 | 16 | 25 | 201 | 2 |
| **Bolivia** | 21 | 25 | 70 | 11 | 5 |
| **Peru** | 20 | 29 | 78 | 27 | 8 |
| **Cambodia** | 27 | 26 | 24 | 94 | 6 |
| **India** | 24.99 | 29 | 34 | 435 | 6.9 |
| **USA** | 10 | 39 | 83 | 35 | 17 |
| **UK** | 9 | 41 | 84 | 277 | 19 |
| **Spain** | 14 | 44 | 81 | 94 | 20 |
| **Italy** | 12.44 | 46 | 71.4 | 196 | 23.5 |
| **Japan** | 12.4 | 49 | 91.7 | 338 | 29.8 |
| **Germany** | 9.5 | 48 | 78 | 233 | 22.4 |
| **South Korea** | 13.04 | 43 | 81.4 | 516 | 17.5 |

201 people/km$^2$; in Kenya, it was 93 people/km$^2$; in Mozambique, it was 42 people/km$^2$; in Bolivia, it was 11 people/km$^2$, in Peru it was 27 people/km$^2$, in India it was 435 people/km$^2$, and in Cambodia it was 94 people/km$^2$. Other than the USA, with 35 people/km$^2$, the developed nations had relatively high population densities. The UK had a population density of 277 people/km$^2$, Spain had 94 people/km$^2$, Italy had 196 people/km$^2$, Japan had 338 people/km$^2$, South Korea had 516 people/km$^2$, and Germany had 233 people/km$^2$.

The study sought to establish the percentage of older adults in the targeted countries. The aged people were those aged 60 years and above. It was established that developing nations had significantly low percentages of aged people in their populations. Kenya had a composition of 3% of its population being aged, Mozambique had 3%, Uganda 2%, Bolivia had 5%, Peru had 8%, India had 6.9%, and Cambodia had 6%. Developed countries had higher percentages of their population ageing. In the USA, 17% of their population were aged, in the UK, it was 19%, Spain had a 20% aged population, Italy had 23.5% of its population, Japan had 29.8% of its population, South Korea had 17.5% while Germany's 22.4% of its population aged.

## Discussion of the correlation analysis

Table 3 shows correlation analysis results for COVID-19 variables and Social/Environmental factors.

i) Infection Rate

As illustrated in Table 2, developing countries had significantly higher average temperatures than developed countries, yet lower COVID-19 cases. The study conducted a correlation analysis to establish the significance of the correlation between temperature and COVID-19 cases. Correlation analysis revealed a strong negative correlation between COVID-19 cases and average annual temperature, supported by both Kendall's Tau ($Tb = -0.560$, $p<0.005$) and Spearman's rank correlation ($r(13) = -0.684$, $p<0.007$). This suggests that higher temperatures are associated with a decline in COVID-19 infections, aligning with previous studies indicating a potential impact of climate on virus transmission. This affirmed that countries with higher temperatures had lower COVID-19 infections. Therefore, the high COVID-19 cases witnessed in developed nations would be correlated to the average lower temperatures the countries experienced. In contrast, the significantly lower COVID-19 cases in developing nations would partly be explained by their relatively high annual temperatures.

A positive correlation was established between age and COVID-19 infections, supported by both Kendall's Tau ($Tb = 0.516$, $p<0.010$) and Spearman's rank correlation ($r(13) = 0.670$, $p<0.009$). This indicates that for every unit increase in age, there is a corresponding rise in COVID-19 infections. Developed countries, characterized by higher elderly populations, exhibited higher infection rates. This underscores the vulnerability of older age groups to the virus. The results concluded that countries with lower average ages had lower COVID-19 infections while those with higher ages had higher COVID-19 infections. The demographic data in Table 2 indicates that developed countries had higher average ages than developing countries. A positive correlation was established between the percentage of older adults in a country and COVID-19 infections, supported by both Kendall's Tau ($Tb = 0.464$, $p<0.021$) and Spearman's rank

*Table 3: Correlation analysis results*

| Variables | Correlation coefficient (r) | p-value |
|---|---|---|
| COVID-19 Cases vs. Temperature | -0.684 | <0.007 |
| COVID-19 Deaths vs. Temperature | -0.648 | <0.012 |
| COVID-19 Infections vs. Age | 0.670 | <0.009 |
| COVID-19 Deaths vs. Age | 0.516 | <0.029 |
| COVID-19 Infections vs. Urbanization | 0.640 | <0.014 |
| COVID-19 Deaths vs. Urbanization | 0.561 | <0.037 |
| COVID-19 Infections vs. Population Density | No Correlation | >0.1 |
| COVID-19 Deaths vs. Population Density | No Correlation | >0.511 |
| COVID-19 Infections vs. Percentage of Old People | 0.642 | <0.013 |
| COVID-19 Deaths vs. Percentage of Old People | 0.541 | <0.046 |

correlation (r(13) = 0.642, p<0.013). The findings indicated that there was a related rise in COVID-19 infections for every unit rise in old age. As illustrated in Table 2, developed countries with higher proportions of elderly individuals recorded higher infection rates, emphasizing the vulnerability of this demographic. Developed nations were more vulnerable to COVID-19 infections than developing nations with relatively younger populations. This would help explain the high COVID-19 infections noted in developed countries compared to developing countries.

Urbanization demonstrated a positive correlation with COVID-19 infections, as indicated by both Kendall's Tau (Tb = 0.530, p<0.008) and Spearman's rank correlation (r(13) = 0.640, p<0.014). Developed nations with higher urbanization levels experienced elevated infection rates, emphasizing the role of population density and social interactions in virus transmission. Interestingly, no significant correlation was found between population density and COVID-19 infections. Both Kendall's Tau (TB = 0.331, p<0.1) and Spearman's rank correlation (r(13) = 0.425, p<0.130) indicated a lack of a clear association. This suggests that population density may not be a predominant factor influencing infection rates.

ii) Mortality Rate

Similar to infection rates, a negative correlation was observed between COVID-19 deaths and average annual temperature, supported by both Kendall's Tau (Tb = -0.495, p<0.014) and Spearman's rank correlation (r(13) = -0.648, p<0.012). This suggests that higher temperatures may contribute to lower mortality rates, aligning with the notion that milder climates may mitigate the severity of the disease. The results led to the conclusion that higher temperatures were partly responsible for lower COVID-19 cases witnessed in developing countries compared to the higher COVID-19 death rates in developed countries with relatively lower temperatures.

Positive correlations were established between age and both COVID-19 infections (r(13) = 0.516, p<0.029) and COVID-19 related mortalities (r(13) = 0.541, p<0.046). The increased mortality risk among older age groups is consistent with existing evidence, emphasizing the critical importance of age in understanding COVID-19 outcomes. This leads to the conclusion that older populations are more prone to COVID-19-related deaths. As illustrated in Table 2, developed nations have relatively older populations than developing nations.

Urbanization demonstrated a positive correlation with COVID-19 deaths, as indicated by both Kendall's Tau (Tb = 0.398, p<0.048) and Spearman's rank correlation (r(13) = 0.561, p<0.037). Higher urbanization levels in developed countries were associated with elevated mortality rates, reflecting the potential challenges in managing the pandemic within densely populated urban areas. The outcome indicates that an increment in urbanization would help explain the high number of COVID-19 deaths.

No significant correlation was found between population density and COVID-19 deaths, supported by both Kendall's Tau (Tb = 0.133, p<0.511) and Spearman's rank correlation (r(13) = 0.161, p<0.583). This suggests that, unlike infection rates, population density may not be a decisive factor influencing mortality rates. The findings would be explained by the stringent lockdowns that various nations imposed soon after the pandemic started to spread.

Positive correlations were established between the percentage of older adults in a country and both COVID-19 infections (r(13) = 0.642, p<0.013) and COVID-19-related deaths (r(13) = 0.541, p<0.046).

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This underscores the vulnerability of older populations not only to infection but also to more severe outcomes, emphasizing the need for targeted interventions for this demographic. This helps explain why countries like Germany, Italy, and Spain had higher death rates per million as compared to the USA, which had the highest infections.

## SUMMARY AND CONCLUSIONS

### Main findings of this study

The study was carried out to compare COVID-19 infections and deaths in developed countries and developing countries. The selected developed countries were the USA, UK, Spain, Italy, Germany, South Korea and Japan. The developing countries selected for this study included Kenya, Mozambique, Uganda, Bolivia, Peru, India, and Cambodia. Care was taken to select countries from every region globally. The results indicated that developed countries had higher COVID-19 infections and deaths than developing countries. They also had higher death rates per million and higher infection rates per million as compared to developing countries.

The study also reviewed demographic factors that would have influenced COVID-19 infections and deaths in developing and developed countries. The factors selected for this study were average age in the population; average annual temperature, percentage of urbanization in each country, population density, and percentage of old age in the country's population. The study revealed that developed countries had relatively lower temperature averages than developing countries. Developed countries also had higher urbanization levels, higher population densities, and high percentages of aged people.

The study established that high average annual temperature resulted in a decline in COVID-19 infections. This helped explain the low infection rates in developing countries with relatively high average annual temperatures. However, developed countries recorded high COVID-19 infections due to their relatively low average annual temperatures. The explanation for this was that high temperatures reduced the transmission of the COVID-19 virus and made it less severe in higher temperatures. The study also established that developed countries had higher mortality levels than developing countries due to their lower average annual temperatures.

The study established a positive correlation between age and COVID-19 infections, where a rise in average age also led to a rise in COVID-19 infections. Developed countries had significantly elderly populations compared to the relatively younger populations in developing countries. This helped explain the high COVID-19 infection rates in developed countries and low infection rates in developing countries. Older populations were also indicated to be more vulnerable to COVID-19 infections, which helped to explain the higher death rates in developed countries than in developing countries. Older people were found to have other comorbidities and weak immunities that compromised their resilience to COVID-19 infections.

The study established a correlation between urbanization and COVID-19 infections. It was revealed that the more urbanized a country is, the higher its COVID-19 infection rates. Developed countries had the highest urbanization levels and higher COVID-19 infection rates than the less urbanized developing countries. Urbanization was linked to high COVID-19 infections due to the attendant high population densities in such environments that led to the rapid spread of the disease. Urbanized areas were also linked to high infection rates due to their regional, global and local linkages as they served as transport hubs. Given similar reasons, urbanization and population density were linked to COVID-19 deaths where developed countries suffered more COVID-19 deaths than developing countries simply because urbanization had exposed them to higher infection rates that led to higher death rates.

The study did not establish any correlation between population densities and COVID-19 infections or deaths. This was linked to the stringent lockdowns that were imposed by various countries. The lockdowns helped to level out the influence of population densities in COVID-19 infections and deaths to a level that did not correlate by the end of the pandemic.

The study establishes a positive correlation between old age and COVID-19 infections. It was indicated that the higher the percentage of older adults in a given population, the higher the COVID-19 infection rates and deaths. Developed countries had higher percentages of aged people than developing countries; therefore, they had higher COVID-19 infections and deaths than developing countries. The explanation was that older people had other comorbidities, weak immunity, and were on other treatments that compromised their resilience against the COVID-19 virus.

### Strengths of this study

The study had two major strengths. Firstly, it selected countries from every global region, providing a more comprehensive comparison than if countries had been selected from a given geographical region. The other strength was that the study relied on the latest COVID-19 statistics on infections and deaths as of May 2023, which means that the findings were more reliable as they covered the entire period of the COVID-19 pandemic. Also, the demographic data was based on data from the end of 2022, which was within the pandemic period. This helped eliminate errors on spurious data spikes before and after the pandemic.

### Limitations of this study

However, the study had several limitations. Firstly, the sample size for the study was relatively small, as only 14 countries were selected, which would limit the generalization of the study findings. Secondly, the study relied on country-reported data. Therefore, the data may have disparities in its comprehensibility, especially among countries with limited testing capabilities that may have underreported actual cases. This was noted at the testing levels, where some developed countries had more than 800% testing levels above their populations.

In comparison, most developing countries had less than 10% testing levels of their populations. This may limit the accurate picture of actual morbidity and mortality rates, especially in the under-tested developing nations. Finally, the study focused on a cross-sectional difference in COVID-19 morbidities and mortalities at a given time. It did not investigate how and whether the independent variables influenced COVID-19 infections and deaths in specific countries. This would require a time series analysis model to explore the time lag influence of each factor in each country.

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