

ORIGINAL ARTICLE

COVID-19 infection rate and time spent at home: analysis of the beginning of the pandemic

Taxa de infecção por COVID-19 e tempo gasto em casa: análise do começo da pandemia

Tasa de infección por COVID-19 y tiempo en casa: análisis del inicio de la pandemia

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ABSTRACT

Background and Objectives: Evidence suggests that the failure of epidemiological control impedes the resumption of socioeconomic activities. Therefore, this study aimed to describe epidemiological aspects and the pattern of mobility on each continent and to verify the association between the COVID-19 infection rate and time spent at home. **Methods:** We analyzed reports from Global Positioning System of 97 countries and their epidemiological indicators until May 27, 2020. **Results:** Cases of COVID-19 ranged from 22 to 1,745,803, and deaths ranged from 0 to 102,107. The highest rates per 100,000

population were observed in Europe and America. Approximately 54% of COVID-19 cases occurred in America and 51% of deaths in Europe. Countries reduced mobility in retail and recreation (-43.45%±20.42%), grocery and pharmacy (-17.95%±20.82%), parks (-18.77%±37.34%), transit stations (-43.09%±20.31%), workplaces (-21.74%±19.92%), and increased time spent at home (13.00%±8.80%). Linear regression showed that European inhabitants stayed at home less when compared those on the American continent ($\beta=-4.933$, SE=0.976, $p<.001$). In addition, every unit increase in the infection rate per 100,000 population increased 0.005 points in the mean time spent at home ($\beta=0.005$, SE=0.001, $p<.001$). **Conclusions:** We provide evidence that increased infection rate of COVID-19 is associated with increased length of stay at home. As a main lesson, COVID-19 showed that in the absence of pharmacological resources, government authorities need to act quickly to contain the spread of infectious diseases.

Keywords: Epidemics. Pandemics. Physical Distancing. Coronavirus Infections. Mortality.

RESUMO

Justificativa e objetivos: Evidências sugerem que as dificuldades no controle epidemiológico impedem a retomada das atividades socioeconômicas. Diante disso, tivemos os objetivos de descrever aspectos epidemiológicos e o padrão de mobilidade em cada continente e verificar a associação entre a taxa de infecção por COVID-19 e o tempo de permanência em casa. **Métodos:** Analisamos relatórios de *Global Positioning System* de 97 países e seus indicadores epidemiológicos até 27 de maio de 2020. **Resultados:** Casos de COVID-19 variaram de 22 a 1.745.803, e as mortes variaram de 0 a 102.107. Maiores taxas por 100.000 habitantes foram observadas na Europa e América. Aproximadamente 54% dos casos de COVID-19 ocorreram na América e 51% dos óbitos na Europa. Os países reduziram a mobilidade no varejo e recreação (-43,45% ± 20,42%), mercearia e farmácia (-17,95%±20,82%), parques (-18,77%±37,34%), estações de trânsito (-43,09%±20,31%), locais de trabalho (-21,74%±19,92%), e aumentaram o tempo em casa (13,00% ± 8,80%). A regressão linear mostrou que os habitantes europeus ficaram menos tempo em casa do que os habitantes do continente americano ($\beta=-4,933$, EP=0,976, $p<0,001$). Além disso, cada unidade de aumento na taxa de infecção por 100.000 habitantes aumentou 0,005 pontos no tempo médio de permanência em casa ($\beta=0,005$, EP=0,001, $p<0,001$). **Conclusões:** Fornecemos evidências de que o aumento da taxa de infecção por COVID-19 está associado ao aumento do tempo de permanência em casa. Como lição principal, a COVID-19 mostrou que, na ausência de recursos farmacológicos, as autoridades governamentais precisam agir rapidamente para conter a propagação de doenças infecciosas.

Descritores: Epidemia. Pandemia. Distanciamento Físico. Infecções por coronavírus. Mortalidade.

RESUMEN

Justificación y Objetivos: Dificultades en el control epidemiológico dificultan la reactivación de actividades socioeconómicas. Nuestros objetivos fueron describir aspectos epidemiológicos y el patrón de movilidad en cada continente y verificar la asociación entre tasa de infección por COVID-19 y duración de estancia en casa. **Métodos:** Examinamos informes del *Global Positioning System* de 97 países y sus indicadores epidemiológicos hasta 27 de mayo de 2020. **Resultados:** Casos de COVID-19 oscilaron entre 22 y 1.745.803, y muertes entre 0 y 102.107. Tasas más altas por 100.000 habitantes ocurrieron en Europa y América. Aproximadamente 54% de los casos de COVID-19 ocurrieron en América y 51% de las muertes en Europa. Los países

redujeron la movilidad en comercio y recreación (-43,45%±20,42%), tienda de comestibles y farmacia (-17,95%±20,82%), parques (-18,77%±37,34%), estaciones de tránsito (-43,09%±20,31%), lugares de trabajo (-21,74%±19,92%), y aumentaron la duración de la estancia en casa (13,00%±8,80%). La regresión lineal ($R^2=0,906$) mostró que los europeos permanecían menos tiempo en casa en comparación con los del continente americano ($\beta=-4,933$, $EE=0,976$, $p<0,001$). Además, cada unidad de aumento de la tasa de infección por 100.000 habitantes aumentó la duración media de la estancia en casa en 0,005 puntos ($\beta=0,005$, $EE=0,001$, $p<0,001$). **Conclusiones:** Mostramos que el aumento de la tasa de infección de COVID-19 se asocia con una mayor duración de la estancia en casa. Como lección clave, COVID-19 demostró que, en ausencia de recursos farmacológicos, las autoridades gubernamentales deben actuar rápidamente para contener la propagación de enfermedades infecciosas.

Palabras Clave: *Epidemia. Pandemia. Distanciamiento Físico. Infecciones por coronavirus. Mortalidad.*

INTRODUCTION

The rapid spread of SARS-CoV-2 promoted the World Health Organization (WHO) to declare a public health emergency at the end January 2020. Due to the substantial number of cases and deaths in a short period, collective efforts were needed to interrupt the SARS-CoV-2 transmission chains.¹ Despite the lower mortality rate compared to diseases caused by other coronaviruses such as SARS-CoV and MERS-CoV, the high transmissibility of SARS-CoV-2 resulted in more deaths than the sum of SARS-CoV and MERS-CoV.² In the initial months of the pandemic, when no vaccines were available, physical distancing has become the main strategy to contain the transmission of SARS-CoV-2.³

Despite recommendations from scientific community, social distancing has never been consensual in countries like Brazil and the United States. Specifically in Brazil, the reason for this resistance is that confinement would cause negative economic consequences such as bankruptcy and unemployment.⁴ However, in the State of São Paulo, the Brazilian region most affected by COVID-19, municipalities with the highest rates of social distancing did not have the worst unemployment rates or tax revenues.⁵ Historical records from 1918 reveal that cities in the United States that adopted faster and more rigid non-pharmacological measures were able to control infection and mortality curves more rapidly, with milder consequences in relation to economic crisis⁶. In contrast, regions that acted late had more difficulty in containing the health crisis, which impeded, for a long period, the resumption of economic activities.⁶ In this context, we hypothesize that countries most successful in controlling the SARS-CoV-2 transmission chains came

out of confinement quickly, while residents of countries with worse epidemiological indicators had to stay at home longer.

Investigating this hypothesis is important for understanding pandemic dynamics, especially in the absence of pharmacological resources. Currently, large-scale immunization faces difficulties due to factors such as mistrust of some social groups, centralized production of immunizers, slow governmental negotiations, and logistical problems. Furthermore, observations of reinfection⁷ and the uncertainty about the efficacy of vaccines against new coronavirus lineages⁸ indicates that there is still a long way to go.

Time spent at home is provided by smartphones, more specifically through Global Positioning System (GPS) technology. Because of the pandemic, Google started to periodically publish mobility reports about the occupation of different categories of places.⁹ These reports offer information regarding the mobility of residents of 132 countries in categories such as retail and recreation, grocery and pharmacy, parks, transit stations, workplaces, and residential. From these reports and considering the context presented, this study aimed to describe epidemiological aspects and the pattern of mobility on each continent and to verify the association between the COVID-19 infection rate and time spent at home.

METHODS

We analyzed the COVID-19 mobility, infection, and mortality reports recorded through May 27, 2020. The inclusion criterion was the availability of information, excluding those countries that did not make public the variables of interest in the databases accessed. We also excluded countries whose first case of COVID-19 occurred after March 14, 2020, and which had a population of less than 1 million or more than 1 billion inhabitants. Reports from 132 countries were identified, of which 97 met our study criteria. The distribution of countries by continent was as follows: 34 countries from Europe, 28 from Asia, 13 from Africa, 20 from America (Central=6, North=4 and South=10) and 2 from Oceania.

Procedures

Two independent researchers accessed the Worldometer,¹⁰ Our World in Data,¹¹ International Monetary Fund (IMF),¹² and Knoema¹³ databases to obtain information about epidemiological and sociodemographic aspects. Independent researchers also

accessed Google databases⁹ to gather information about mobility and time spent at home. All information was cross-checked and revised to remove divergences.

Infection and mortality

Worldometer¹⁰ statistics are based on official reports obtained from health departments or other government institutions. In this database, we recorded information about infections and deaths in each country considering the first case until May 27, 2020. Our World in Data¹¹ is an open-access database that allowed access to daily epidemiological indicators by COVID-19.

Potential confounders

Duration of epidemic: this was determined by subtracting the dates of the last and first case of COVID-19.¹⁰ The duration of epidemic was used as a counting variable.

Human Development Index (HDI): countries of different continents have discrepant social, demographic, and health conditions, which can be sized by the HDI. The HDI is a coefficient calculated based on literacy rates, schooling, life expectancy at birth, and per capita income. The HDI and total population were obtained from the IMF.¹² The HDI was used as a continuous variable.

GINI index: The GINI index evaluates the income concentration, discriminating the magnitude of difference between the richest and the poorest. This index varies from 0 to 1, where the highest numbers indicate income disparity in the country. The GINI index was obtained from the Knoema database¹³. The Gini index was used as a continuous variable.

Mobility in different categories of places

Google provides mobility reports⁹ based on user records of its applications, such as Google Maps. Users have to accept the application's privacy statement and enable the location history of the mobile device. Reports do not allow personal information to be identified, providing only a global estimate of the displacement pattern of the inhabitants of each country. Variation of mobility was based on the comparison of the baseline (i.e., the median between January 3 and February 6, 2020) with the records up to May 16, 2020. Reports issued by Google provided variation in frequency of occupancy of five categories of places: *Retail and recreation*, establishments such as restaurants, bars, shopping centers, museums, and libraries. *Grocery and pharmacy*, markets of food,

agricultural products, drugstores, and pharmacies. *Parks*, squares, gardens, public parks, and beaches. *Transit stations*, mobility in public transportation such as buses, trains, and subways.

Outcome

Google's mobility reports also provided the variation in time spent at home, which was based on the comparison of the baseline (i.e., the median between January 3 and February 6, 2020) with the records up to May 16, 2020. The variation in time spent at home was used as a continuous variable.

Statistical analysis

Descriptive statistics were used to characterize the variables. The Shapiro-Wilk test was used to verify if continuous variables had a normal distribution. The Kruskal-Wallis test was used to compare mobility in different categories according to the continent, and the Steel Dwaas test for paired comparisons. We performed a correlation matrix between the different mobility categories and observed that "Retail and Recreation," "Grocery and Pharmacy," "Parks," "Transit Stations," and "Workplaces" categories were strongly correlated (supplementary file 1). Given this, we created a factor named "out-of-home mobility" through the Principal Components method, followed by the sphericity and KMO tests (supplementary file 1). We also observed that the variables "HDI," "Gini Index," and "Continents" were associated (supplementary file 2). Considering these aspects, we performed a Linear Regression to test the following model:

$$Y_{\text{Time spent at home}} = \beta_0 + \beta_1 \text{ Out-of-home mobility} + \beta_2 \text{ Continent} + \beta_3 \text{ Duration of the pandemic in each country} + \beta_4 \text{ Cases per 100,000 population} + \varepsilon$$

As pre-requisites, we analyzed the R^2 , multicollinearity between independent variables, autocorrelation and the distribution of residuals through Durbin-Watson and Q-Q Plot tests, respectively (supplementary file 2). A statistical significance level of 5% was adopted in all analyses.

RESULTS

COVID-19 cases ranged from 22 to 1,745,803, and deaths ranged from 0 to 102,107. **Table 1** describes the epidemiological situation in each continent until May 27, 2020. The highest rates per 100,000 population were observed in Europe and the American continent. Approximately 54% of COVID-19 cases occurred in America and 51% of deaths occurred in Europe.

Table 1. COVID-19 Epidemiological reports until May 27, 2020.

| Region | N | Infections (per 100,000 population) | | | Deaths (per 100,000 population) | | |
|---------|----|-------------------------------------|--------|-----------|---------------------------------|-------|---------|
| | | Median | IQR | Total | Median | IQR | Total |
| Africa | 13 | 10.20 | 19.48 | 78,282 | 0.16 | 0.57 | 2,035 |
| America | 20 | 54.07 | 212.97 | 2,664,415 | 2.18 | 10.67 | 153,49 |
| Central | 6 | 21.25 | 56.22 | 25,742 | 0.47 | 2.34 | 752 |
| North | 4 | 259.28 | 366.51 | 1,919,610 | 12.93 | 21.18 | 117,321 |
| South | 10 | 55.61 | 253.49 | 719,063 | 2.01 | 11.79 | 35,417 |
| Asia | 28 | 19.38 | 190.65 | 458,628 | 0.43 | 0.85 | 7,187 |
| Europe | 34 | 159.79 | 255.00 | 1,707,376 | 5.53 | 22.49 | 170,112 |
| Oceania | 2 | 29.43 | N/A | 8,643 | 0.42 | N/A | 124 |
| World | 97 | 50.58 | 197.80 | 4,917,344 | 1.12 | 5.21 | 332,948 |

Abbreviations: N, number of countries; IQR, Interquartile range; N/A, not applicable.

Figure 1 superimposes the number of daily infections and deaths in each country. Africa presented low infection and mortality rates, but it is possible to observe ascending curves, indicating a tendency to worsen the epidemiological situation. In the American continent, there were three well-defined shades. The clearest indicates a pronounced rate of infection and mortality in the United States. In early April, the United States reduced transmission and mortality, but the Brazilian epidemiological situation worsened, giving rise to the ascending curve of intermediate tonality. Other countries presented with

relative low numbers, giving rise to darker tonality. Asia and Europe were the first continents affected by COVID-19. In Asia, there was an initial outbreak in South Korea, but it was quickly controlled. In mid-March, there was an upward curve indicating an increase of cases or large-scale testing, while daily mortality remained stable. Europe showed a peak of infection and mortality at the end of March with an abrupt reduction in the following weeks. On May 27, infection and mortality rates were low on this continent.

Layout Version

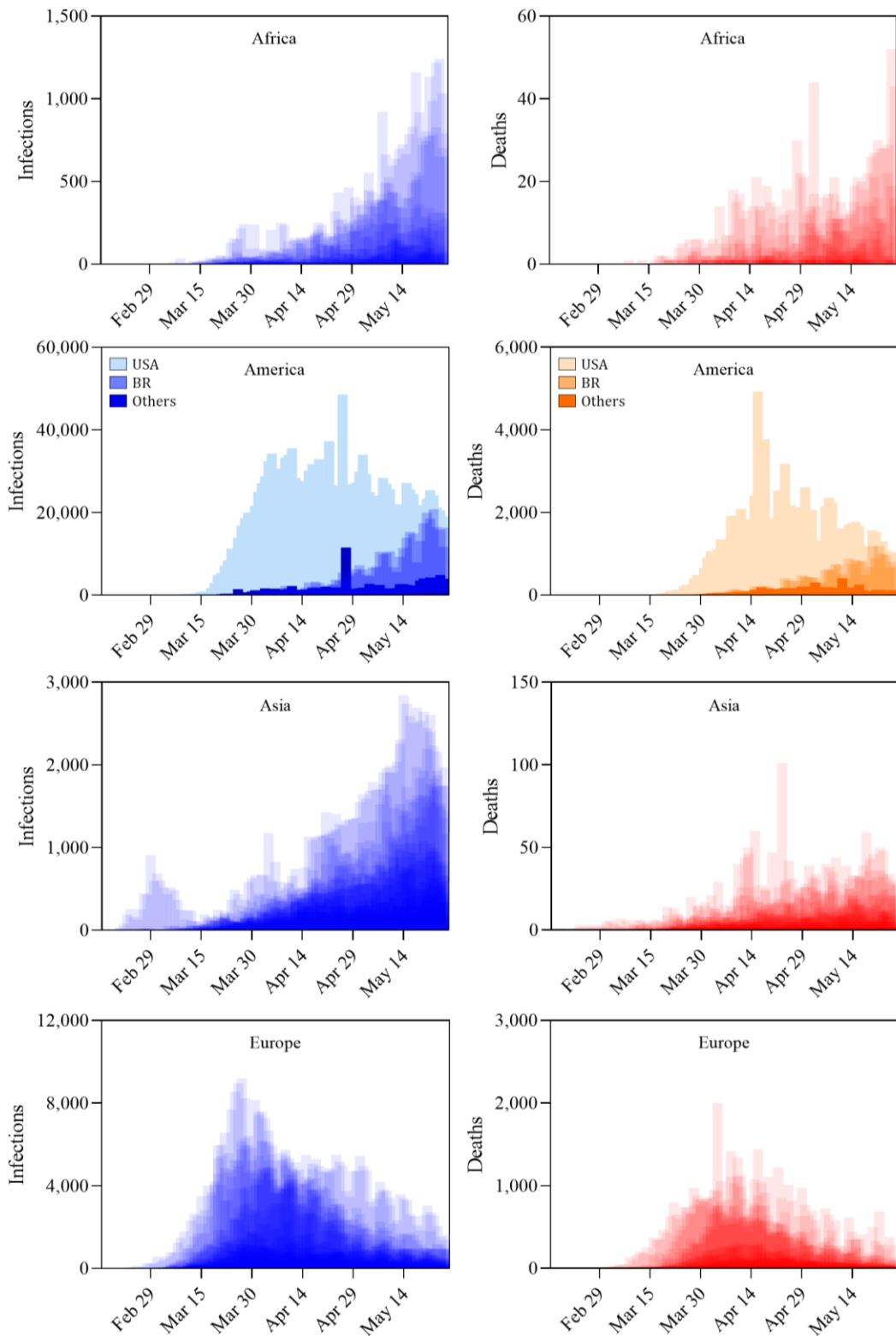


Figure 1. Infection and mortality by COVID-19 until 27 May, 2020. The superimposed bar charts contain the daily number of infections and deaths by COVID-19.

Regarding mobility in the different categories of places, world mean (\pm standard deviation) showed a reduction in retail and recreation ($-43.45\% \pm 20.42\%$), grocery and

pharmacy (-17.95% ± 20.82%), parks (-18.77% ± 37.34%), transit stations (-43.09% ± 20.31%), workplaces (-21.74% ± 19.92%), and increased the time spent at home (13.00% ± 8.80%). **Table 2** shows the variation of mobility according to continent. The largest reductions were observed in America, while Europe increased mobility in parks and spent less time at home.

Table 2. Variations of mobility during COVID-19 pandemic in the continents.

| Categories | Median | IQR | p | Paired comparisons |
|------------------------------|--------|-------|-------|----------------------------|
| Retail and recreation | | | | |
| Africa | -27.00 | 20.00 | | |
| America | -59.00 | 29.25 | | |
| Asia | -46.00 | 28.50 | <.001 | America < Africa (p<.001) |
| Europe | -35.00 | 25.25 | | America < Europe (p=0.002) |
| Oceania | -28.50 | N/A | | |
| Grocery and pharmacy | | | | |
| Africa | -14.00 | 15.50 | | |
| America | -28.50 | 31.50 | | |
| Asia | -16.00 | 29.00 | <.001 | America < Europe (p=0.002) |
| Europe | -6.50 | 11.00 | | |
| Oceania | -2.50 | N/A | | |
| Parks | | | | |
| Africa | -19.00 | 22.00 | | |
| America | -55.50 | 25.00 | | |
| Asia | -35.00 | 39.00 | <.001 | Europe > America (p<.001) |
| Europe | 19.00 | 43.50 | | Europe > Asia (p<.001) |
| Oceania | -24.50 | N/A | | |
| Transit stations | | | | |
| Africa | -33.00 | 19.00 | | |
| America | -61.00 | 26.50 | | |
| Asia | -49.00 | 39.00 | <.001 | América < Africa (p=0.004) |
| Europe | -31.50 | 19.00 | | América < Europe (p<.001) |
| Oceania | -36.00 | N/A | | |
| Workplaces | | | | |
| Africa | -7.00 | 14.50 | | |
| America | -30.00 | 30.50 | | |
| Asia | -23.00 | 18.50 | <.001 | América < Europe (p<.001) |
| Europe | -12.00 | 12.00 | | Asia < Africa (p=0.007) |
| Oceania | -17.00 | N/A | | |
| Residential | | | | |
| Africa | 12.00 | 6.00 | | |
| America | 20.50 | 13.00 | | |
| Asia | 14.50 | 12.25 | <.001 | Europe < America (p<.001) |
| Europe | 4.50 | 6.00 | | Europe < Asia (p<.001) |
| Oceania | 8.50 | N/A | | |

Abbreviations: IQR, Interquartile range; N/A, not applicable. Variation of mobility (%) was based on the comparison of the baseline (i.e., the median between January 3 and February 6, 2020) with the records up to May 16, 2020. Data from Google's mobility report.

Figure 2 describes the pattern of mobility in different categories of places according to continents. In all out-of-home categories, European countries were predominant in the upper region of the scatter plots, which was most pronounced in the category "parks." This result shows that inhabitants of 24 European countries frequented natural parks more than before the pandemic. Another observable pattern is the reduction of mobility in the countries of the American continent, concentrating at the base of the mobility categories and at the top of the residential category.

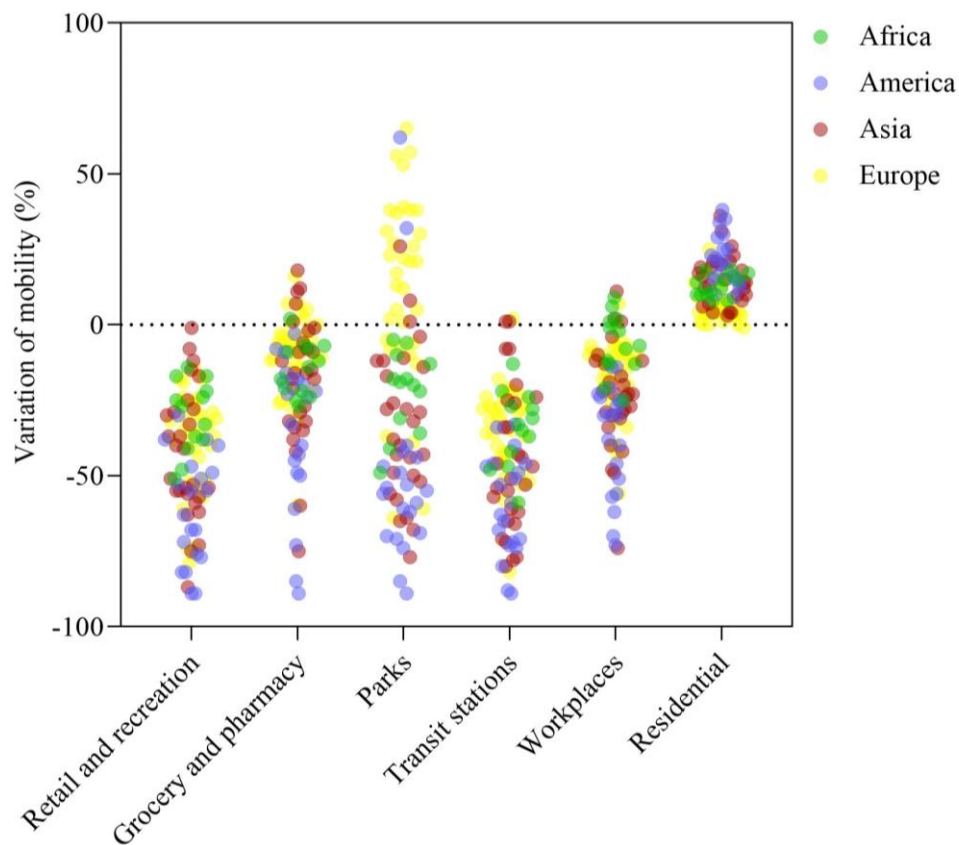


Figure 2. Scatter plots referring to variation of mobility in 97 countries according to the continent. Variation of mobility (%) was based on the comparison of the baseline (i.e., the median between January 3 and February 6, 2020) with the records up to May 16, 2020.

The statistical model (**Table 3**) was able to explain approximately 91% ($R^2=0.906$) of the variance of time spent at home in the initial months of the pandemic. There was good adherence to the pre-requisites, as described in the supplementary file 2. As expected, out-of-home mobility was the most explanatory factor in the model. We found a statistically significant difference for continent, in which the mean time spent at home in Europe was lower compared to America. We also observed that for every unit

increase in the infection rate per 100,000 population, there is an increase of 0.005 points in the mean time spent at home.

Table 3. Factors associated with time spent at home during the COVID-19 pandemic. Records up to May 16, 2020.

| Predictor | β | SE | 95% Confidence | | t | p |
|------------------------------|---------|-------|----------------|--------|---------|--------|
| | | | Interval | | | |
| | | | Lower | Upper | | |
| Intercept | 13.291 | 3.195 | 6.942 | 19.639 | 4.160 | < .001 |
| Out-of-home mobility | -7.110 | 0.356 | -7.818 | -6.403 | -19.970 | < .001 |
| Continents | | | | | | |
| Asia – America | -0.486 | 0.964 | -2.402 | 1.430 | -0.504 | 0.615 |
| Africa – America | 2.073 | 1.114 | -0.141 | 4.286 | 1.860 | 0.066 |
| Europa – America | -4.933 | 0.976 | -6.873 | -2.993 | -5.053 | < .001 |
| Oceania – America | -2.501 | 2.179 | -6.829 | 1.828 | -1.148 | 0.254 |
| Duration of the pandemic | 0.007 | 0.037 | -0.067 | 0.082 | 0.197 | 0.844 |
| Cases per 100,000 population | 0.005 | 0.001 | 0.002 | 0.007 | 3.459 | < .001 |

Abbreviations: SE, Standard Error.

DISCUSSION

As main findings, the epidemiological course in Europe suggests that the rapid control of COVID-19 causes a population to leave confinement more quickly. Furthermore, lack of control of SARS-CoV-2 transmission chains was associated with increased time spent at home at the beginning of the pandemic, indicating that social engagement is crucial in situations where there are no proven effective pharmacological resources.

About the epidemiological moment of each continent, Europe had already gone through the most severe phase, while other regions were at the beginning of the epidemic. It was natural that Europe would show worse epidemiological indicators since it was affected by COVID-19 weeks before America and Africa. Epidemiological curves showed that Europe was quite effective in its public strategies. After control of COVID-19, people were able to gradually return to the community, unlike other continents (except Asia) that showed a clear tendency of worsening infection and mortality rates after May 2020.

Apparently, natural parks are the first place to be massively frequented after the acute phase of the local epidemic. If there is physical distance between people and the correct use of personal protective equipment, parks seem to be relatively safe, because

there are lower risks of outdoor transmission as compared to indoor environments.¹⁴ Although widely studied, infectivity by airborne particles still remains uncertain. Faridi et al.¹⁵ did not find the presence of SARS-CoV-2 in air samples collected from rooms of critically ill patients in an Intensive Care Unit.¹⁵ In contrast, different studies find viral RNA in air samples, indicating that aerosol infection is a plausible mechanism of transmission.^{16,17} Despite this, it seems well established that the main route of transmission is via respiratory droplets (i.e. particles between 5 and 10 μm in diameter) and between the contact routes,¹⁸ and that masks have a protective effect against the coronavirus, considerably reducing the risk of infection.¹⁹

Our results are important for understanding the dynamics of the pandemic in the absence of pharmacological resources and may support public health strategies in future pandemics. We show that lack of epidemiological control can be associated with longer confinement, indicating that reactivation of economic activities requires control of SARS-CoV-2. Our evidence suggests that countries that quickly reduced the SARS-CoV-2 transmission chains came out of lockdown faster,²⁰ corroborating reports of the 1918 influenza pandemic.⁶ We emphasize that some Latin American countries have unfavorable sociodemographic conditions that make it difficult to adopt more rigid policies of social distancing. Therefore, we believe that communication and public assistance policies are critical for widespread popular acceptance. In Brazil, the denial of scientific evidence and the inaccuracy of the health surveillance systems may have favored the spread of the virus.²¹

In a broader perspective, we emphasize that failure to control a highly transmissible virus puts the world's public health at risk, as efforts must not only be regional, but coordinated globally. One example is the collapse of the health care system in Manaus,²² the capital of the Brazilian State of Amazonas. In 2020, approximately 70% of the population had been exposed to SARS-CoV-2.²³ Between May and December 2020, COVID-19 infection and mortality rates remained low in Manaus,²² suggesting collective immunity. However, a new unexpected outbreak began in January 2021 causing the health care system to collapse.²² Genome samples identified that 42% of infections were caused by the P.1 lineage,²⁴ which can be resistant to immunity acquired by previous infection.²² The lack of epidemiological control, besides being an ethical problem, increases the chances of co-infection of two variants of coronavirus,²⁵ which can generate even more dangerous lineages, putting the world's population at risk.

As limitations, results should be interpreted with parsimony due to short period of analysis, and also some confounding factors not considered, such as underreporting and seasons. Underreporting can be estimated by the crude mortality rate, which was predicted at 1% when the data was collected. This percentage can change according to age group, with higher values being associated with insufficient testing of the population. Crude mortality rate is available in the supplementary file 3 and reveals that underreporting occurred in most countries. Regarding seasons, rainy and cold periods are associated with longer stays at home, which was not considered in the statistical model. In addition, Asia and Africa had lower infection and mortality rates in the analyzed period, which may have underestimated our results.

Finally, examples from European countries suggest that rapid control of a highly transmissible virus is associated with low length of stay in the home. Current experience has shown that effectiveness of social distancing depends on multiple factors and its adherence appears to decrease over time. As a main lesson, COVID-19 showed that in the absence of pharmacological resources, government authorities need to act quickly to contain the spread of infectious diseases.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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Author contributions

Vinícius Nagy Soares conceptualized the study and performed the statistical analysis.

Hélio Mamoru Yoshida contributed to conceptualizing the study. **Daniel Eduardo da**

Cunha Leme contributed to interpretation of the results. **Ricardo Aurélio Carvalho**

Sampaio contributed to interpretation of the results. **Gabriel de Oliveira Rufino**

contributed to data collection. **Paula Teixeira Fernandes** guided the authors of the study.

All authors contributed to drafting and critical review the manuscript.

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