Vizyoner Dergisi

Süleyman Demirel Üniversitesi Vizyoner Dergisi, Yıl: 2023, Cilt: 14, Sayı: 37, 24-36.
Süleyman Demirel University Visionary Journal, Year: 2023, Volume: 14, No: 37, 24-36.

ISSN: 1308-9552

ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

THE EFFECTS OF THE GOVERNMENT POLICIES ON THE SPREAD OF THE COVID-19 PANDEMIC

HÜKÜMET POLİTİKALARININ COVID-19 PANDEMİSİNİN YAYILMASI ÜZERİNDEKİ ETKİLERİ

Assoc. Prof. Dr. Çiğdem BASKICI[1]
Prof. Dr. Yunus GÖKMEN[2]
Prof. Dr. Yavuz ERCİL[3]

ABSTRACT

The study aims to determine whether government policies to control population mobility have been successful in the fight against the coronavirus disease 2019 (COVID-19) pandemic. Policies implemented by governments for controlling population mobility are identified with the Stringency Index prepared by Oxford University. Population mobility is observed through data provided by Google Community Mobility Report. The success of countries in the fight against the COVID-19 pandemic is measured by the Reproduction Rate. The intersection of valid data covering 104 countries is gathered from databases of relevant official websites for the period between the date of reaching the 100th cumulative case and the date 360 days later. The data is analyzed by conducting panel data analysis method to test the hypothesis. Results show that the Stringency Index demonstrating the stringency of government policies implemented by countries to prevent the spreading of pandemic affected human mobility dimensions significantly and reversely. Human mobility dimensions have a reverse and significant impact on staying at home at different levels at the 95% confidence interval. Furthermore, a significant relationship with a very small b_i value (-0.00008) emerges between staying at home and the Reproduction Rate in the reverse direction.

Keywords: COVID-19, Pandemic, Human Mobility, Stringency Index, Panel Data Analysis.

JEL Classification Codes: I10, I12, I18.

ÖZ

Çalışmanın amacı, devletlerin insan hareketliliğini kontrol etme politikalarının COVID-19 pandemisiyle mücadelede başarılı olup olmadığını belirlemektir. Hükümetler tarafından insan hareketliliğini kontrol etmek için uygulanan politikalar Oxford Üniversitesi tarafından oluşturulan Sıkılık Endeksi ile belirlenmiştir. İnsan hareketliliği, Google Topluluk Hareket Raporu tarafından sağlanan verilerle gözlemlenmiştir. Ülkelerin COVID-19 pandemisi ile mücadeledeki başarısı Çoğalma Oranı ile ölçülmüştür. 104 ülkeyi kapsayan veriler, ülkelerin 100. kümülatif vakaya ulaşma tarihleri ile 360 gün sonraki tarih arasındaki süre için ilgili resmi web sitelerinin veri tabanlarından toplanmıştır. Hipotezleri test etmek için veriler, panel veri analiz yöntemi ile analiz edilmiştir. Sonuçlar, ülkeler tarafından pandeminin yayılmasını önlemek için uygulanan hükümet politikalarının sıkılığını gösteren Sıkılık Endeksi'nin insan hareketliliği boyutlarını anlamlı ve ters yönde etkilediğini göstermiştir. İnsan hareketliliği boyutları evde kalma üzerinde %95 güven aralığında farklı düzeylerde ters ve anlamlı bir etkiye sahiptir. Ayrıca, evde kalma ile Çoğalma Oranı arasında ters yönde çok küçük bir b_i değeri (-0,00008) ile anlamlı bir ilişki ortaya çıkmıştır.

Anahtar Kelimeler: COVID-19, Pandemi, İnsan Hareketliliği, Sıkılık Endeksi, Panel Veri Analizi.

JEL Sınıflandırma Kodları: I10, I12, I18.

[1] Başkent University, Faculty of Health Sciences, Department of Healthcare Management, cbaskici@baskent.edu.tr

[2] Başkent University, Faculty of Communication, Department of Public Relations and Publicity, yunusgokmen@baskent.edu.tr

[3] Başkent University, Faculty of Communication, Department of Public Relations and Publicity, yercil@baskent.edu.tr

Makale Geliş Tarihi / Received : 08.02.2022
Makale Kabul Tarihi / Accepted : 21.09.2022

https://doi.org/10.21076/vizyoner.1069827

Süleyman Demirel Üniversitesi Vizyoner Dergisi, Yıl: 2023, Cilt: 14, Sayı: 37, 24-36.
Süleyman Demirel University Visionary Journal, Year: 2023, Volume: 14, No: 37, 24-36.
ISSN: 1308-9552

GENİŞLETİLMİŞ ÖZET

Amaç ve Kapsam:

COVID-19 pandemisinin başında virüs enfeksiyonuna karşı aşı ve antiviral ilaçların yokluğu pandemi ile mücadelede ilaç dışı önlemlere güvenmeyi zorunlu kılmıştır. Bu önlemler genel olarak kişisel koruyucu önlemleri, çevresel önlemleri, sosyal mesafe önlemleri ve seyahatle ilişkili önlemleri içermekle birlikte her ülkede farklı düzey, süre ve kombinasyonda uygulanmıştır. Bu çalışmanın amacı hükümetlerin insan hareketliliğini kontrol etmeye yönelik ilaç dışı önlemlerinin COVID-19 pandemisi ile mücadelede başarılı olup olmadığını tespit etmektir. Bu doğrultuda izleyen araştırma sorularına yanıt aranmıştır: (i) Hükümet önlemlerinin insan hareketliliğinin boyutları üzerindeki etkisi nedir? (ii) İnsan hareketliliğinin boyutlarının evde kalma davranışları üzerindeki etkisi nedir? (iii) Evde kalma davranışlarının pandemi ile mücadelenin başarısına etkisi nedir? Biyolojik ve epidemiyolojik akıl yürütme, virüsün yayılmasının önlenmesinde insan hareketliliğini kontrol etmeye yönelik önlemlerin potansiyel etkinliğini desteklese de bu süreçte önlemlere uyma veya uymama gibi sosyal tepkilerin önemi göz ardı edilmektedir. Bu çalışma, pandemi ile mücadelenin başarısında sosyal tepkilerin rolünün anlaşılmasına yardımcı olması açısından önemlidir.

Yöntem:

Hükümetler tarafından insan hareketliliğini kontrol etmek için uygulanan politikalar Oxford Üniversitesi tarafından oluşturulan Sıkılık Endeksi (SI) ile belirlenmiştir. Sıkılık endeksi ülkeler tarafından sınırlama ve kapatma politikalarına ilişkin önlemleri içeren bileşik bir endeks olup 0-100 arasında bir değer almaktadır ve İnsan hareketliliği, Google Topluluk Hareket Raporu tarafından sağlanan verilerle gözlemlenmiştir. Bu veriler perakende satış ve rekreasyon yerleri (RR), parklar (P), toplu taşıma istasyonları (TS), iş yerleri (WP) ve konut (R) gibi farklı kategorilerde zaman içindeki hareket trendlerini içermektedir. Ülkelerin COVID-19 pandemisi ile mücadeledeki başarısı Çoğalma Oranı (RepR) ile ölçülmüştür. 104 ülkeyi kapsayan veriler, ülkelerin 100. kümülatif vakaya ulaşma tarihleri ile 360 gün sonraki tarih arasındaki süre için ilgili resmi web sitelerinin veri tabanlarından toplanmıştır. Hipotezleri test etmek ve dışsal değişkenlerin içsel değişkenler üzerindeki açıklayıcı gücünü araştırmak ve etki düzeyini ve yönünü tespit etmek için altı farklı panel veri regresyon modeli önerilmiştir. Ayrıca, her ülkeye ait R değişkenin RepR değişkeni üzerindeki gerçek etkisini doğru bir şekilde hesaplamak için ilgili zaman serisi verilerine yedi günlük gecikme ilave edilmiştir. Öncelikle veri setinde yer alan değişkenlerin veri tanımlamaları ve betimsel istatistikleri verilmiş ve bu değişkenlerin durağan olup olmadıkları uygun panel birim kök testleri ile test edilmiştir. Durağan olduğu gözlemlenen bu değişkenler vasıtasıyla dışsal değişkenlerin içsel değişkenler üzerinde etkisini ölçmek maksadıyla panel veri regresyon analizi uygulanmıştır. Tahmin edilen panel regresyon modelleri ile ilgili temel varsayımlar kontrol edilmiş ve tüm regresyon modellerinde yatay kesit bağımlılığı, değişen varyans, oto-korelasyon varsayımlarına ilişkin ihlaller olduğu saptanmıştır. Panel veri regresyon modellerinde kesit bağımlılığı ve değişen varyans ve oto-korelasyon problemleri olması durumunda, Sıradan En Küçük Kareler (Ordinary Least Squares-OLS) yönteminden elde edilen tahmin edicilerine göre daha etkili sonuçlar vermesi nedeniyle Uygun Genelleştirilmiş En Küçük Kareler (Feasible Generalized Least Squares-FGLS) tahmin edicileri hesaplanmıştır.

Bulgular:

İlk bulgu, SI'nın tüm ülkeler için aynı nedensellik etkisini gösterdiği ve insan hareketliliği boyutları olarak tanımlanmış RR, P, TS ve WP'yi önemli ölçüde ve ters yönde etkilediğidir. Bulgular, ülkeler tarafından uygulanan önlemlerin genel olarak insan hareketliliğini sınırladığını veya azalttığını göstermektedir. Önlemlerin en büyük etkiyi sırasıyla RR, TS, WP ve P üzerinde gösterdiği gözlemlenmiştir. İkinci önemli bulgu ise, insan hareketliliği boyutlarının evde kalma üzerinde %95 güven aralığında farklı düzeylerde ters ve anlamlı bir etkiye sahip olmasıdır. En etkili boyut WP iken, diğer boyutlar sırasıyla TS, P ve RR'dir. Üçüncü önemli bulgu, evde kalma sürelerini artırmaya yönelik tüm önlemlerin, RepR üzerinde beklentilerin altında küçük bir etki (bi= -0,00008) yaratabilmesidir.

Sonuç ve Tartışma:

Bu tarihe kadar yapılan müdahalelerin çoğu, patojenin yayılmasını kontrol etmek için insan hareketliliğini önlemeye odaklanmıştır. Ancak bu çalışma, insanları evde kalmaya zorlayarak birbirlerinden ayırmanın pandemi ile mücadelede etkili bir araç olmadığını göstermiştir. Hükümetler, insan hareketliliğini kontrol altına almaya yönelik politikalarını, yaptırımlar yoluyla büyük ölçüde uygulayabilmektedir. Hükümetler insanları olabildiğince birbirinden ayırarak pandemiyi durdurmaya çalışsa da insanlar tekrar bir araya geldiğinde tüm bu çabalar boşa çıkabilmektedir. Burada dikkat edilmesi gereken önemli nokta, uygulanan politikaların bireylerde davranış değişikliğine yol açıp açmadığıdır. Uzak Doğu'nun SARS-CoV ve MERS-CoV ile ilgili deneyimlerinin toplumda bir davranış değişikliği yarattığı kesindir. Dolayısıyla COVID-19 pandemisi ile mücadelede başarılı olan ülkelerin çoğunun bu bölgeden olması şaşırtıcı değildir. Bugün pandemi ile mücadelede davranışlarını değiştirebilen ülkelerin gelecekteki olası pandemilerle mücadelede daha başarılı olmaları daha mümkündür. Hükümetlerin insan hareketliliğini kontrol altına almaya yönelik politikalarının istenilen başarı düzeyine ulaşamaması, pandemi yönetimine dar bir yaklaşım benimsendiğinin kanıtı olarak görülebilir. COVID-19 pandemisi ile mücadele edebilmek için çok boyutlu ve detaylı yaklaşımlara ihtiyaç olduğu açıktır. Virüs enfeksiyonlarına karşı aşılar veya antiviral ilaçlar bulunsa bile olası pandemiler karşında başarılı olmak toplumsal düzeyde davranış değişikliğini her zaman gerektirecektir.

1. INTRODUCTION

At the beginning of the pandemic, a lack of vaccines and antivirals has made it compulsory to count on non-pharmaceutical measures in the fight against the COVID-19 pandemic (Wilder-Smith & Freedman, 2020). These measures broadly include individual preventive measures, environmental measures, social distancing measures, and travel measures (WHO, 2019) but are implemented in every country at different levels, durations, and combinations. The SARS-CoV-2 virus, which is the reason for the COVID-19 pandemic, is known to be transmitted via respiratory droplets spread by speaking, sneezing, and coughing (Chaudhur et al., 2020). Therefore, controlling population mobility to keep people away from each other has been the main objective to prevent human-to-human contagion of the virus (Wilder-Smith & Freedman, 2020). Thus, social distancing precautions such as contact tracing, isolation, lockdown, school measures and closures, workplace measures and closures, and avoiding crowds (WHO, 2019) have gained in importance. However, social distancing measures widely implemented by countries as part of check and palliation endeavors against the COVID-19 pandemic have led to serious psychosocial and economic outcomes worldwide. Until the end of April 2020, country-wide school closures were implemented across 162 countries, which affected nearly 1.5 billion students. Although today schools are open in many countries, the costs stand to be tremendous in terms of learning losses, health and well-being, and drop-out (UNESCO, 2022). As a result, it seems this situation will have a serious impact on future human capital. Additionally, hundreds of millions of adults have had to stop or slow down their economic activities due to workplace closures (Jamison et al., 2020). It is estimated that global labor income has seen an 8.3% decrease in 2020 (ILO, 2021). Global unemployment is projected to stand at 207 million in 2022, surpassing its 2019 level by some 21 million (ILO, 2022). In the "World Economic Outlook" report released on April 14, 2020, the International Monetary Fund remarked that it is expecting the deepest economic recession since the Great Depression in 1929 as lockdown and social distancing precautions taken owing to the COVID-19 pandemic brought most of the economies to a halt (IMF, 2020). Finally, the global economy grew by 5.5 percent in 2021 after contracting by 3.4 percent in 2020 (UN, 2022). In addition, psychological aspects such as sadness, fear, helplessness, and loneliness (Mamun & Griffiths, 2020; Ornell et al., 2020) have reached alarming levels. The overall picture is much more than a global health crisis, and these costs that the world has paid raise the question of how successful/effective the measures are taken. In other words, the question of whether restricting population mobility for reducing contact rates has provided a sufficient solution in the struggle against the COVID-19 pandemic still awaits an answer.

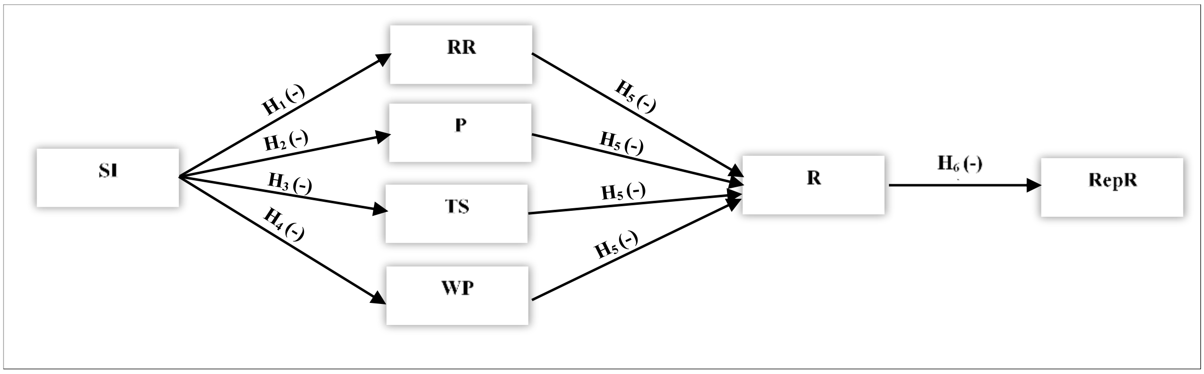
Studies on non-pharmaceutical measures for isolating people from each other can be divided into two groups. The first group comprises studies on the effectiveness of such measures. The results of Banzolher et al.'s (2020) study, in which they compare the effectiveness of non-pharmaceutical measures for 20 countries, specify that prohibiting gatherings induces a significant decrease in the number of cases. However, school closures and cancellations of public events ensure a less significant reduction in the number of cases. Chen and Qiu's (2020) research on nine countries indicates that centered isolation is the most influential non-pharmaceutical measure, which is followed by lockdown and school closures. In their study on different scenarios of transmission and control of the COVID-19 pandemic in the United Kingdom, Davies et al. (2020) discovered that moderate measures, such as 12-week school closure, self-isolation, or shielding of older people, are not sufficient for controlling the epidemic or avoiding exceeding the present capability of Intensive Care Unit, even when used in combination. On the other hand, studies in the second group focus on the impacts of measures on people's mobility. Brzezinski et al. (2020) use mobile phone data in their studies and devise that lockdown increased the rate of people staying at home by 8%. Engle et al.'s (2020) study on U.S. states reveals that a formal stay-at-home limitation order reduces mobility by 7.87%. It is possible to say that these two groups of studies have two basic deficiencies. The first group of studies does not investigate whether the population follows the measures, while the second group of studies does not investigate the effectiveness of the measures. In our study, we combine these two approaches and investigate in a holistic approach whether a population follows the measures as well as whether success has been achieved in the struggle against the COVID-19 pandemic.

2. HYPOTHESES

Within this framework, our research aims to specify whether government policies to control population mobility have been successful in the fight against the COVID-19 pandemic. Accordingly, we sought answers to the following research questions in a sequential manner: (i) What is the impact of government measures on dimensions of population mobility? (ii) What is the impact of dimensions of population mobility on stay-at-home behaviors? (iii) What is the impact of stay-at-home behaviors on the success of the fight against the pandemic?

Since the study used three different datasets, and there were certain deficiencies in the country data from these datasets, the research is limited to 104 countries. Within this scope, policies implemented by governments for controlling population mobility were identified with the Stringency Index (SI) prepared by Oxford University Blavatnik School of Government (OUBSG) (Oxford University, 2020). Population mobility was observed through data provided by Google Mobility Report (Google, 2020). The success of countries in the struggle against the COVID-19 pandemic was measured by the Reproduction Rate (RepR) (Our World in Data, 2020). Data gathered on the day when the 100th case in countries occurred, as well as the following 360 days, were assessed by the panel data analysis method. The research hypotheses were modelled as illustrated in Figure 1.

Figure 1. Research Model



P: Mobility tendencies for locations like public beaches, parks, gardens, marinas, plazas, etc.

RepR: Reproduction Rate.

R: Mobility tendencies for locations of residence.

RR: Mobility tendencies for locations like shopping centers, restaurants, museums, libraries, cafes, etc.

SI: Stringency Index.

TS: Mobility tendencies for locations like public transport points (bus, subway, train stations, etc).

WP: Mobility tendencies for locations of work.

Although biological and epidemiological reasoning supports the potential effectiveness of measures for controlling human mobility in the prevention of the spread of the virus, the importance of social reactions in this process is overlooked. This study is important in that it helps understand the role of social reactions in the success of the fight against the pandemic.

3. MATERIALS AND METHODS

In this study, to check the hypotheses, we gathered data from three different databases currently published on official websites. Owing to the deficiency of data related to some countries, the intersection of valid data from three different databases was gathered for the period between the date of reaching the 100th cumulative case and the date 360 days (12 months) later, for 104 countries.

To explore the effect of containment and closure policies on human mobility, we collected SI data, which sorts the measures concerning containment and closure policies taken by countries as a composite index, have scores from zero to 100, and published in cross-national and time-series structure by OUBSG on their formal website (Oxford University, 2020). The components of SI, which is the most concerning index with human mobility dimensions, are illustrated in Table 1.

Süleyman Demirel Üniversitesi Vizyoner Dergisi, Yıl: 2023, Cilt: 14, Sayı: 37, 24-36.
Süleyman Demirel University Visionary Journal, Year: 2023, Volume: 14, No: 37, 24-36.
ISSN: 1308-9552

Table 1. The Component of SI

Index name	*k*	Components*														
		C1	C2	C3	C4	C5	C6	C7	C8	E1	E2	E3	E4	H1	H2	H3
Government Response Index	13	X	X	X	X	X	X	X	X	X	X			X	X	X
Containment and Health Index	11	X	X	X	X	X	X	X	X					X	X	X
SI	***9***	***X***	***X***	***X***	***X***	***X***	***X***	***X***	***X***					***X***		
Economic Support Index	2									X	X					

(k): The number of components.

(*): C1: School closing, C2: Workplace closing, C3: Cancel public events, C4: Restrictions on gatherings, C5: Close public transport, C6: Stay at home requirements,

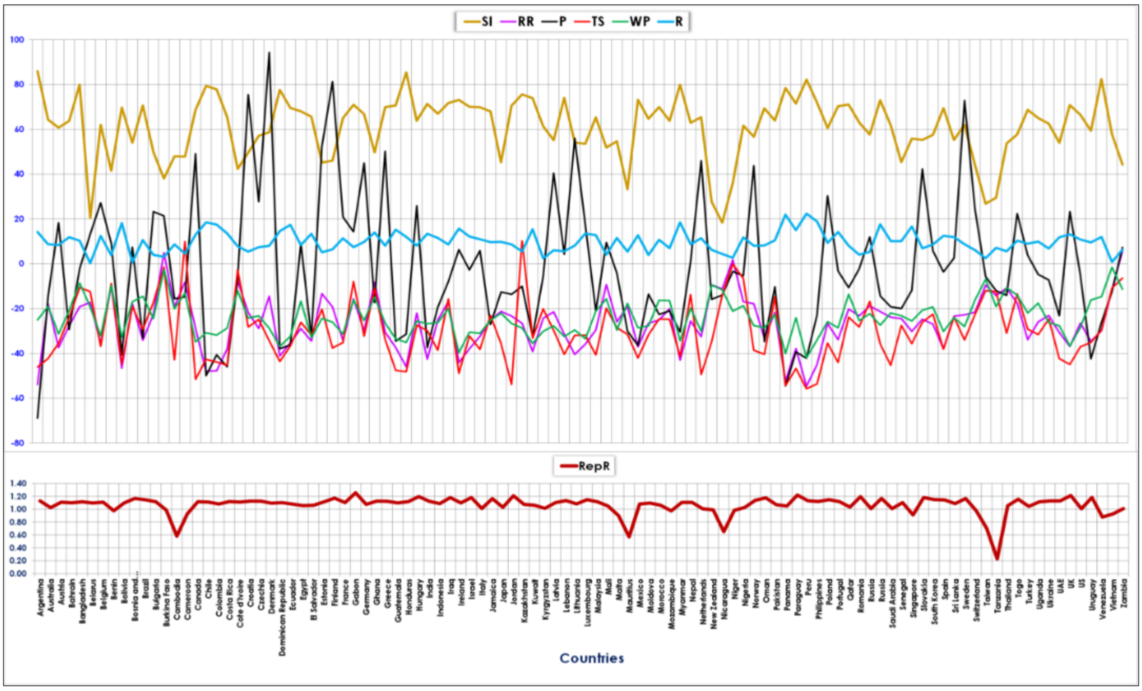
C7: Restrictions on internal movement, C8: International travel controls, E1: Income support (for households), E2: Debt/contract relief (for households), E3: Fiscal measures,

E4: International support, H1: Public information campaigns, H2: Testing policy, H3: Contact tracing.

To examine the impacts of human mobility dimensions RR, P, TS, and WP on the mobility dimension of R, which presents the changes of popular times for locations in Google Maps for each day compared to a basic value (the median value, for the related day of the week, covering the five-week term of Jan 3–Feb 6, 2020) for that day of the week and is published as a daily data (Google, 2020) and to scrutinize the effect of human mobility dimension of R on the RepR, which is determined as an index of how many people are contaminated by one individual and commonly used for specifying the spread in a population in epidemiology (Dietz, 1993; Linka et al., 2020; Noland, 2021) we collect the relevant data from their formal websites (Google, 2020; Our World in Data, 2020).

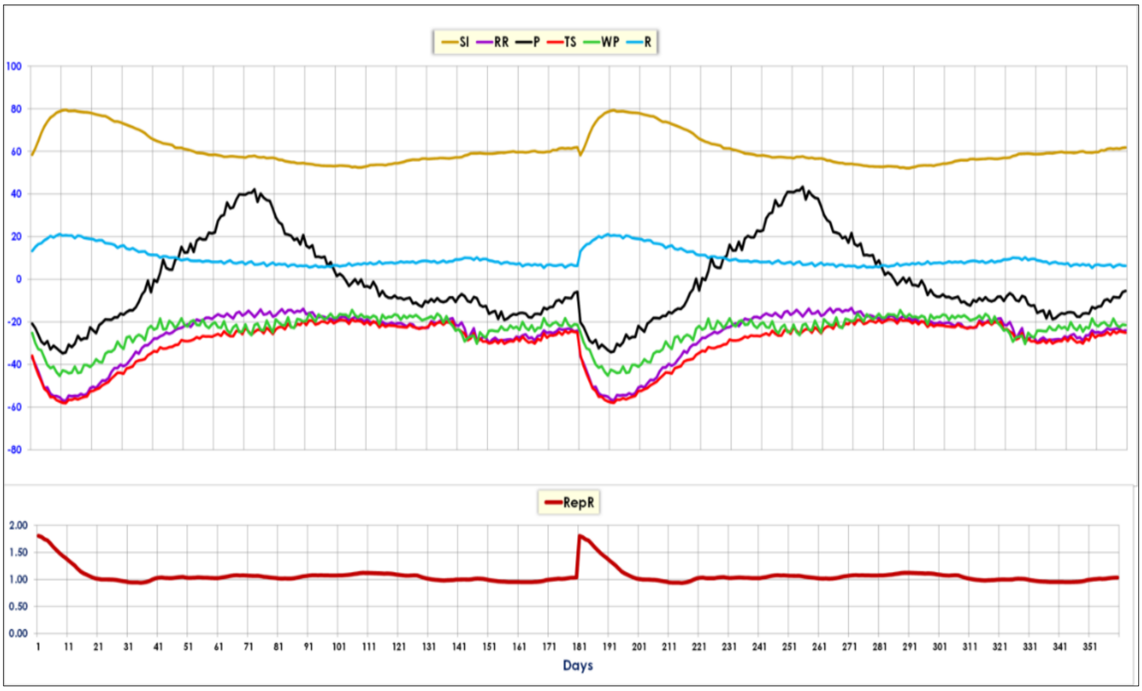
The mean of human mobility dimensions (R, RR, P, TS, and WP) percent change from baseline, the mean of SI and RepR related to countries consisting of 360 days-period are expressed in Figure 2. For scrutinizing the structure of time-series of R, RR, P, TS, WP, SI, and RepR, the mean of their time series covering 360 days-period is illustrated in Figure 3. It is seen that the more increase in SI, the more decrease in RR, P, TS, and WP and the more increase in R. Similarly, the more increment in R releases the more abatement in RepR.

Figure 2. The Mean of R, RR, P, TS, WP, and SI Related to Countries



ISSN: 1308-9552

Figure 3. The Mean of Time Series of R, RR, P, TS, WP, and SI



For perusing the structure of our data set, the definition, summary statistics, and correlations among variables are demonstrated in Table 2.

Table 2. Data Definition, Summary Statistics, and Correlations

Variable	Abbr.	Source	Unit of Measurement	Mean	SD	Min	Max
Stringency Index	SI	Blavatnik School of Government. University of Oxford	Index Value (0-100)	61.24	19.86	0.00	100.00
Reproduction Rate	RepR	Our Data in World	>0	1.07	0.36	0.00	5.77
Residential	R			9.89	8.81	-35.00	55.00
	RR			-26.76	23.18	-97.00	59.00
Parks	P	Google Mobility	Percent Change from Baseline	-2.45	51.34	-100.00	517.00
Transit Stations	TS			-30.00	23.25	-98.00	62.00
Workplaces	WP			-24.07	18.71	-94.00	80.00
Period		The period between the date of reaching the 100th cumulative case and the date 360 days (12 months) days later.					
Countries (N=104)		Argentina, Australia, Austria, Bahrain, Bangladesh, Belarus, Belgium, Benin, Bolivia, Bosnia and Herzegovina, Brazil, Bulgaria, Burkina Faso, Cambodia, Cameroon, Canada, Chile, Colombia, Costa Rica, Cote d'Ivoire, Croatia, Czechia, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Finland, France, Gabon, Germany, Ghana, Greece, Guatemala, Honduras, Hungary, India, Indonesia, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kuwait, Kyrgyzstan, Latvia, Lebanon, Lithuania, Luxembourg, Malaysia, Mali, Malta, Mauritius, Mexico, Moldova, Morocco, Mozambique, Myanmar, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russia, Russia, Saudi Arabia, Senegal, Singapore, Slovakia, South Korea, Spain, Sri Lanka, Sweden, Switzerland, Taiwan, Tanzania, Thailand, Togo, Turkey, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Venezuela, Vietnam, Zambia.					

ISSN: 1308-9552

Correlations Matrix							
	SI	RepR	R	RR	P	TS	WP
SI	1.000						
RepR	0.127*	1.000					
R	0.614*	0.097*	1.000				
RR	-0.659*	-0.090*	-0.764*	1.000			
P	-0.361*	0.022*	-0.484*	0.536*	1.000		
TS	-0.585*	-0.092*	-0.749*	0.822*	0.410*	1.000	
WP	-0.459*	-0.075*	-0.734*	0.657*	0.185*	0.677*	1.000

(*): The correlation is significant at the level of α=0.01 (2-tailed).

In our investigation, to test our hypotheses and explore the explanatory strength of exogenous variables on endogenous variables, and detect causality between these variables, the panel data regression analyses are conducted for 104 countries during the period spanning the date of reaching the 100th cumulative case and the date 360 days (12 months) later. For calculating the real effect of RR on RepR of each country accurately, seven-day lag is added to the time series data as proposed by Banholzer et al. (2020) and Chen and Qiu (2020).

To achieve our aims, we propose six panel data regression models as indicated in Equations 1–6.

$$RR_{it} = \beta_0 + \beta_1 SI_{it} + u_{it} \quad (1)$$

$$P_{it} = \beta_0 + \beta_1 SI_{it} + u_{it} \quad (2)$$

$$TS_{it} = \beta_0 + \beta_1 SI_{it} + u_{it} \quad (3)$$

$$WP_{it} = \beta_0 + \beta_1 SI_{it} + u_{it} \quad (4)$$

$$R_{it} = \beta_0 + \beta_1 RR_{it} + \beta_2 P_{it} + \beta_3 TS_{it} + \beta_4 WP_{it} + u_{it} \quad (5)$$

$$RepR_{it} = \beta_0 + \beta_1 R_{it-7} + u_{it} \quad (6)$$

SI_{it} : *SI value of i^{th} country relevant to t^{th} day.*

$RepR_{it}$: *RepR value of i^{th} country relevant to t^{th} day.*

R_{it} : *R point of i^{th} country relevant to t^{th} day.*

RR_{it} : *RR point of i^{th} country relevant to t^{th} day.*

P_{it} : *P point of i^{th} country relevant to t^{th} day.*

TS_{it} : *TS point of i^{th} country relevant to t^{th} day.*

WP_{it} : *WP point of i^{th} country relevant to t^{th} day.*

u_{it} : *is the error term of the models.*

3.1. Econometric Analysis

Researchers have commonly utilized panel data analysis for the last two decades. The basic form of panel data regression diverges from a normal time-series/cross-section regression with a dual subscript as illustrated in Equation 7 (Baltagi, 2005).

$$y_{it} = \alpha + X'_{it}\beta + u_{it} \quad i = 1,...,N; \quad t = 1,...,T \quad (7)$$

In this equation, i denotes countries, firms, families, etc., and t expresses time. The i subscript indicates the dimension of the cross-section, whereas t demonstrates the dimension of the time-series. α is a scalar, β is K×1, X_{it} is the it^{th} observation of K exogenous variables, and u_{it} is an error term. Before applying panel data regression, all series in the panel regression model should be checked by performing a unit root test for the panel regression model. Thus, we employ panel unit root tests for all series in the next section.

ISSN: 1308-9552

3.1.1. Panel Unit Root Test

As a rule of thumb in panel data models, firstly, the unit root test of the panel data models should be employed for detecting if the concerning variables are stationary or not. If variables in the models are non-stationary, it may induce spurious regressions relevant to the analysis (Baltagi, 2005). Two kinds of panel unit root tests have widely been used in literature. If the persistent parameters of the model are common over the cross-section, then this kind of process is designated as a common unit root test. A common unit root process (LLC) improved by Levin et al. (2002) utilized this assumption. Conversely, if the persistent parameters freely act over the cross-section, the kind of the process is denominated as a process of the individual unit root. The Fisher-PP, Fisher-ADF, and IPS (Im et al., 2003) tests are designed based on this form. The results of these unit root tests are expressed in Table 3.

Table 3. The Results of Panel Unit Root Test**

Variables	Common Unit Root Tests		Individual Unit Root Tests					
	Levin, Lin, and Chu		Im, Pesaran, and Shin		ADF Fisher Chi-square		PP Fisher Chi-square	
	Statistic	p	Statistic	p	Statistic	p	Statistic	p
Level								
SI	-4.926	0.000*	-7.558	0.000*	519.598	0.000*	651.506	0.000*
RepR	-20.217	0.000*	-27.053	0.000*	1,442.170	0.000*	1,176.780	0.000*
R	-2.639	0.004*	-7.901	0.000*	404.066	0.000*	4,113.750	0.000*
RR	-5.183	0.000*	-8.059	0.000*	399.915	0.000*	2,672.610	0.000*
P	-2.435	0.007*	-7.656	0.000*	468.344	0.000*	2,607.670	0.000*
TS	-4.404	0.000*	-6.924	0.000*	354.318	0.000*	2,326.920	0.000*
WP	-6.732	0.000*	-20.987	0.000*	1154.350	0.000*	7,422.220	0.000*

Null Hypothesis of the Analyses: Unit Root

(*) : The test points are significant at the level of α=0.01.

(**): Probabilities for Fisher tests are calculated by utilizing an asymptotic Chi-square distribution. All other tests presume asymptotic normality. Lag length selection is dependent on SIC and Bartlett kernel spectral estimation, and Newey-West automatic bandwidth selection is specified.

Scrutiny of Table 3 reveals that all variables in the models are stationary in level form. We conclude that the null hypothesis is rejected for all variables at a α=0.05 level. Thus, we can perform panel data regression for the models stated in Equations 1–6.

3.1.2. Model Estimation and Results

To find the proper model, the assumption of residuals (autocorrelation, normality, homoscedasticity, etc.) are checked by suitable statistic tests for all panel regression models expressed in Equations 1–6. EViews 10.0 and Stata 11.0 statistical package is used for computing these analyses. When controlling the assumption of residuals in panel regression models, it is found that there are violations related to the assumption of autocorrelation cross-sectional dependence, and heteroskedasticity in all regression models. Thus, we compute the Feasible Generalized Least Squares (FGLS) estimators recommended by Hansen (2007) and Bai et al. (2021) as more effective than the Ordinary Least Squares (OLS) in case of the problems of serial and cross-sectional correlations (cross-sectional dependence), and heteroskedasticity problems. The results of the panel regression models are indicated extensively in Table 4.

Table 4. The Results of Panel Regression Models

Model ID		**1**		**2**		**3**	
DV		**RR**		**P**		**TS**	
Model Type		**OLS**	**FGLS**	**OLS**	**FGLS**	**OLS**	**FGLS**
IDV	Constant (β_0)	20.4641 (69.855)*	12.391 (19.090)*	54.729 (67.906)*	4.495 (4.140)*	11.979 (37.822)*	-0.044 (-0.060)
	SI	-0.770 (-169.130)*	-0.622 (-61.710)*	-0.934 (-74.582)*	-0.366 (23.220)*	-0.685 -139.188)*	-0.507 (-47.650)*
	R						
	RR						
	P						
	TS						
	WP						
Number of Time Period (Days)		360		360		360	
Number of Countries		104		104		104	
Observations:		37,246		37,098		37,198	
Breusch-Pagan LM Test		200,815.3[♣]		251961.5[♣]		180,834.1[♣]	
Wald (χ^2) Test		11,410.440[♠]		6.4e+05[♠]		19,336.610[♠]	
Baltagi-Wu LBI Test		0.411[♥]		0.259[♥]		0.356[♥]	
Model ID		**4**		**5**		**6**	
DV		**WP**		**R**		**RepR**	
Model Type		**OLS**	**FGLS**	**OLS**	**FGLS**	**OLS**	**FGLS**
IDV	Constant (β_0)	2.445 (8.785)*	1.591 (-3.040)*	0.578 (13.347)*	1.640 (28.870)*	1.041 (406.312)*	1.102 (254.170)*
	SI	-0.433 (-99.973)*	-0.408 (-50.690)*				
	R					0.001 (5.485)*	-0.00008 (-3.090)*
	RR			-0.076 (-36.611)*	-0.025 (16.010)*		
	P			-0.036 (-63.294)*	-0.031 (-57.290)*		
	TS			-0.0806 (-42.068)*	-0.069 (-34.180)*		
	WP			-0.198 (-106.330)*	-0.223 (-230.02)*		
Number of Time Period (Days)		360		360		360	
Number of Countries		104		104		104	
Observations:		37,359		37,080		36,632	
Breusch-Pagan LM Test		98,233.71[♣]		163,167.6[♣]		254,417.1[♣]	
Wald (χ^2) Test		1,889.510[♠]		1,4950.980[♠]		5.6e+05[♠]	
Baltagi-Wu LBI Test		0.829[♥]		0.456[♥]		0.050[♥]	

DV: Dependent Variable, IDV: Independent Variable, OLS: Ordinary Least Squares, FGLS: Feasible Generalized Least Squares, t-statistics for OLS and z- statistics for FGLS are shown in parenthesis.

(*) : The test value is significant at α=0.05 level.

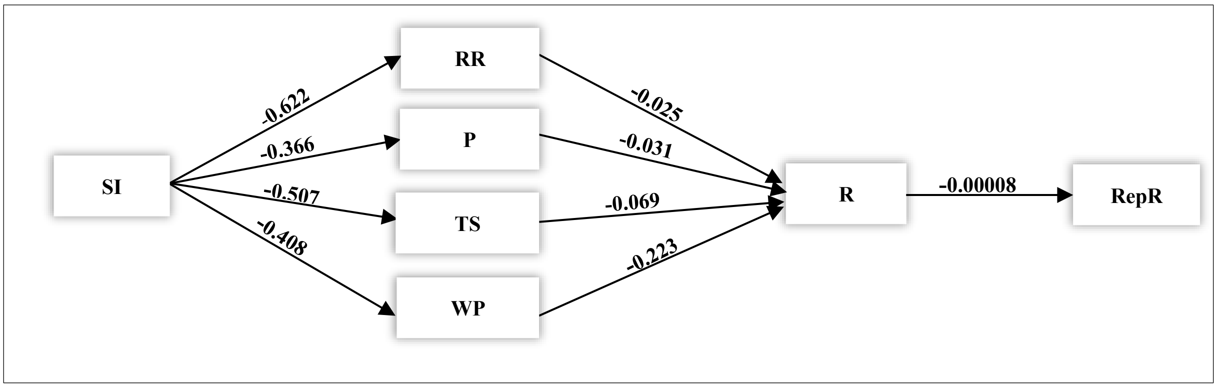
(♣) : Since T>N, Breusch-Pagan LM Test is performed. H_0: No cross-section dependence (correlation) in residuals. The null hypothesis is rejected at α=0.05 level.

(♠) : A Modified Wald Test for group-wise heteroscedasticity is conducted for heteroscedasticity. H_0: There is homoskedasticity in the model. Consequently, the null hypothesis of the models is rejected at the level of α=0.05.

(♥) : Baltagi-Wu LBI Test for autocorrelation in panel data is used (Baltagi, 2005). H_0: No first-order autocorrelation. As a result, the null hypothesis is rejected at α=0.05 level.

In Table 4, we examine the results of FGLS which provide a more efficient estimation than OLS as stated before. All coefficients (except the constant coefficient of model 3 [FGLS]) in the regression models are significant with a significance level of 5%. The coefficients of independent variables in models 1, 2, 3, 4, 5, and 6 are significant in the reverse direction according to the estimation results of FGLS. It can be inferred that all the specifications for the models are appropriate, and the signs of most coefficients complied with our theory. In the theory we developed, our prospect for endogenous/exogenous variables is that the greater the increase in exogenous variables, the greater the decrease in endogenous variables in all proposed models. However, according to the result of model 6, there is a significant casualty from R to RepR with the reverse direction at a 95% confidence level, but the coefficient of the independent variable in this model is very small. The results of the association between dependent and independent variables related to our hypothesis are illustrated in Figure 4.

Figure 4. The Results of the Panel Regression Between Dependent and Independent Variables



4. DISCUSSION

This study, which aims to determine whether government policies for controlling population mobility have been successful in the struggle against the COVID-19 pandemic, provided several important findings. The first finding is that the SI showed the same causality impact for all countries and affected RR, P, TS, and WP significantly and reversely. Findings indicate that the measures implemented by countries limited or reduced human mobility in general. The measures were observed to have the biggest impact on human mobility dimensions RR, TS, WP, and P respectively. This may lead to the consideration that the measures had one of the least impacts on workplaces because of economic concerns. And it can be thought that the biggest impact was on retail and recreation because the most drastic measures are taken in this area and can be more easily controlled.

The second important finding is that human mobility dimensions (RR, P, TS, and WP) had a reverse impact on staying at home at different levels. While the most effective dimension is WP, the other dimensions are TS, P, and RR respectively. Considering that the ultimate purpose of measures is to increase the stay-at-home duration, it may be said that this can be most easily achieved through reducing human mobility in workplaces. In a nutshell, the leverage point for increasing the stay-at-home durations -which is the main purpose- is to reduce gathering in workplaces. One way to achieve this might be to include more measures related to reducing gathering in workplaces and to give more weight to these measures in the SI to a larger extent while the index is created.

The third important finding is that all measures for increasing stay-at-home durations can create a little impact on RepR below expectations. This can be considered one of the main reasons for having a minor effect to abate the number of cases in all the countries.

Most of the interventions performed up to this date have focused on preventing human mobility to control the spread of the pathogen. However, this study has shown that separating people from each other by making them stay at home is not an effective instrument in the fight against the pandemic. Governments can implement their policies for controlling population mobility to a great extent through enforcement. Although governments strive to stop this pandemic by separating people from each other as much as possible, all this effort can be destroyed once people come together again. The important point to consider here is whether the policies utilized lead to behavioral changes in individuals. As emphasized by Anderson et al. (2020) the only thing people can do to stop the COVID-19 pandemic is to change their behaviors. Certainly, the Far East's experiences with Middle East respiratory and syndrome severe acute respiratory syndrome created a behavioral change in society in response to the fight against pandemics. Therefore, it is not surprising that most of the countries that are successful today in the fight against this pandemic are from this region. It seems possible that those countries that can change their behaviors in the fight against the pandemic, today, will be more successful in handling pandemics in the future.

Moritz et al.'s (2020) experimental research supports these discussions from other aspects. The authors dissected the transmission risk of SARS-CoV-2 pending an experimental enclosed mass gathering incident in which N95 masks and contact tracing tools were used. They found that seated enclosed incidents, when performed with hygiene measures and sufficient aeration, have little effect on the diffusion of the COVID-19 pandemic. This finding leads to the requestioning for the strict controls for isolating people from each other. Reevaluation of the importance of individual preventive measures and environmental measures in the spread of the pandemic may be more effective in terms of both the social and economic costs that must be endured.

Horton (2020) regards the COVID-19 pandemic as a syndemic, which can potentially contribute to these discussions. Such a redefinition is made to underline the social origins of the pandemic. The author argues that if policies and programs to reverse social inequalities in societies are not developed, then societies will never really be secure against the COVID-19 pandemic. Therefore, any policy that is implemented without considering society's social welfare level cannot be completely successful.

5. CONCLUSION

The fact that government policies for controlling population mobility have not been able to achieve the desired level of success is proof that we have adopted a narrow approach to the management of the pandemic. We need multidimensional and detailed approaches to be able to fight against the COVID-19 pandemic. Even though vaccines or antivirals are found, our need for the approach in question will always exist if we are to fight against potential pandemics in the future.

The SI, which specifies the measures concerning containment and closure policies taken by countries is calculated and published by OUBSG as a single value covering the whole country, although a small number of countries apply these measures at various levels based on different regions. Therefore, the limitation of the study could be that some analysis results are obtained using a single SI representing the whole country.

In future research, conducting similar analyses on countries for different economic, social, and cultural structures may provide different aspects of the struggle against the COVID-19 pandemic. Additionally, analyses to be made for different regions of a specific country may also contribute to the determination of various policies in the fight against COVID 19 pandemic.

DECLARATION OF THE AUTHORS

Declaration of Contribution Rate: The authors have equal contributions.

Declaration of Support and Thanksgiving: No support is taken from any institution or organization.

Declaration of Conflict: There is no potential conflict of interest in the study.

REFERENCES

Anderson, R. M., Heesterbeek, H., Klinkenberg, D., & Hollingsworth, T. D. (2020). How will country-based mitigation measures influence the course of the COVID-19 epidemic? *The Lancet, 395*(10228), 931-934. https://doi:10.1016/S0140-6736(20)30567-5

Bai, J., Choi, S. H., & Liao, Y. (2021). Feasible generalized least squares for panel data with cross-sectional and serial correlations. *Empirical Economics, 60*(1), 309-326.

Baltagi, B. H. (2005). *Econometric analysis of panel data* (Third Edition). John Wiley & Sons Ltd.

Banholzer, N., van Weenen, E., Lison, A., Cenedese, A., Seeliger, A., Kratzwald, B., .Vach, W. (2020). Estimating the effects of non-pharmaceutical interventions on the number of new infections with COVID-19 during the first epidemic wave. *PLoS ONE, 16*(6), e0252827.

Brzezinski, A., Deiana, G., Kecht, V., & Van, D. (2020). The COVID-19 pandemic: government vs. community action across the United States. *Covid Economics: Vetted and Real-Time Papers, 7*, 115-156.

Chaudhur, S., Basu, S., Kabi, P., Unni, V. R., & Saha, A. (2020). Modeling the role of respiratory droplets in Covid-19 type pandemics. *Physics of Fluids, 32*(6), 063309. https://doi:10.1063/5.0015984

Chen, X., & Qiu, Z. (2020). Scenario analysis of non-pharmaceutical interventions on global COVID-19 transmissions. *arXiv:2004.04529*.

Davies, N. G., Kucharski, A. J., Eggo, R. M., Gimma, A., & Edmunds, W. J. (2020). Effects of non-pharmaceutical interventions on COVID-19 cases, deaths, and demand for hospital services in the UK: a modelling study. *Lancet Public Health, 5*(7), e375-e385. https://doi:10.1016/S2468-2667(20)30133-X

Dietz, K. (1993). The estimation of the basic reproduction number for infectious diseases. *Statistical Methods in Medical Research, 2*(1), 23-41.

Engle, S., Stromme, J., & Zhou, A. (2020). Staying at home: mobility effects of COVID-19. *SSRN*. http://dx.doi.org/10.2139/ssrn.3565703

Google. (2020). *COVID-19 community mobility reports*. Retrieved October 1, 2020 from https://www.google.com/covid19/mobility/?hl=en

Hansen, C. B. (2007). Generalized least squares inference in panel and multilevel models with serial correlation and fixed effects. *Journal of Econometrics, 140*(2), 670-694.

Horton, R. (2020). Offline: COVID-19 is not a pandemic. *The Lancet,* 396(10255), 874.

ILO. (2021). *ILO Monitor: COVID-19 and the world of work.* Retrieved May 20, 2022 from https://www.ilo.org/global/topics/coronavirus/impacts-and-responses/WCMS_767028/lang--en/index.htm%20a

ILO. (2022). *World employment and social outlook – Trends 2022.* Retrieved May 20, 2022 from https://www.ilo.org/global/research/global-reports/weso/trends2022/lang--en/index.htm

Im, K. S., Pesaran, H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics, 115*(1), 53-74. https://doi:10.1016/S0304-4076(03)00092-7

IMF. (2020). *World economic outlook, April 2020: The great lockdown.* Retrieved October 6, 2020 from https://www.imf.org/en/Publications/WEO/Issues/2020/04/14/weo-april-2020

Jamison, J., Bundy, D., Jamison, D., Spitz, J., & Verguet, S. (2020). Comparing the impact on COVID-19 mortality of self-imposed behavior change and of government regulations across 13 countries. *medRxiv*. https://doi:10.1101/2020.08.02.20166793

Levin, A., Lin, C. F., & Chu, C. S. (2002). Unit root test in panel data: asymptotic and finite sample properties. *Journal of Econometrics, 108*, 1-24. https://doi:10.1016/S0304-4076(01)00098-7

Linka, K., Peirlinck, M., & Kuhl, E. (2020). The reproduction number of COVID-19 and its correlation with public health interventions. *Computational Mechanics, 66*(4), 1035-1050. https://doi:10.1101/2020.05.01.20088047

Mamun, M. A., & Griffiths, M. D. (2020). First COVID-19 suicide case in Bangladesh due to fear of COVID-19 and xenophobia: possible suicide prevention strategies. *Asian Journal of Psychiatry, 51*, 102073. https://doi:10.1016/j.ajp.2020.102073

Moritz, S., Gottschick, C., Horn, J., Popp, M., Langer, S., Klee, B., Mikolajczyk, R. (2020). The risk of indoor sports and culture events for the transmission of COVID-19 (Restart-19). *medRxiv*. https://doi:10.1101/2020.10.28.20221580

Noland, R. B. (2021). Mobility and the effective reproduction rate of COVID-19. *Journal of Transport & Health, 20*, 101016. https://doi:10.1016/j.jth.2021.101016

Ornell, F., Schuch, J. B., Sordi, A. O., & Kessler, F. H. (2020). ''Pandemic fear'' and COVID-19: mental health burden and strategies. *Braz J Psychiatry, 42*(3), 232-235. https://doi:10.1590/1516-4446-2020-0008

Our World in Data. (2020). *Coronavirus source data.* Retrieved October 1, 2020 from https://ourworldindata.org/coronavirus-source-data

Oxford University. (2020). *Coronavirus government response tracker.* Retrieved October 1, 2020 from https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker

UNESCO. (2022). *Education: from disruption to recovery*. Retrieved May 19, 2022 from https://en.unesco.org/covid19/educationresponse

UN. (2022). *World economic situation prospects.* Retrieved May 20, 2022 from https://www.un.org/development/desa/dpad/publication/world-economic-situation-and-prospects-2022/

WHO. (2019). *Non-pharmaceutical public health measures for mitigating the risk and impact of epidemic and pandemic influenza.* Retrieved October 20, 2020 from https://www.who.int/influenza/publications/public_health_measures/publication/en/

Wilder-Smith, A., & Freedman, D. O. (2020). Isolation, quarantine, social distancing and community containment: pivotal role for old-style public health measures in the novel coronavirus (2019-nCoV) outbreak. *Journal of Travel Medicine, 27*(2), 1-4.