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Original Article

Causality Relationship Between Nonpharmaceutical Interventions and Coronavirus Disease 2019 in Turkey

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ABSTRACT

Objective: The aim of this study was to investigate the relationship between the level of nonpharmaceutical interventions and 2 major coronavirus disease 2019 (COVID-19) indicators: new confirmed cases of COVID-19 and new deaths from COVID-19 in Turkey.

Methods: Daily data from March 11, 2020, to March 8, 2022 were used. First, the number of new cases and new deaths per million and the average of the stringency index for each week were calculated. Then, the Toda and Yamamoto causality analysis was conducted to obtain robust results on the dual causality relationship between the stringency index and 2 major COVID-19 indicators: new COVID-19 cases and deaths.

Results: The study results show that an increase in the number of new cases and deaths in weekly data leads to an increase in the stringency level, but the stringency level does not have a significant effect on new cases and deaths in weekly data. However, it was concluded that increases in the stringency level led to a significant COVID-19 incidence reduction in the subsequent 28 days.

Conclusion: It can be said that there is a 1-way causal relationship between new COVID-19 cases and deaths in Turkey and the level of nonpharmaceutical interventions for a weekly period. In this context, it is crucial for governments to plan, considering the lagged effect of the stringency index on the number of cases and deaths. The findings may help decision-makers better understand the consequences of the COVID-19 pandemic interventions and determine the appropriate strategies in Turkey and elsewhere.

Keywords: COVID-19, containment measures, nonpharmaceutical interventions, stringency index, causality test

Introduction

Coronavirus disease 2019 (COVID-19), which first appeared in Wuhan City of Hubei province in China on December 31, 2019, has been reported as a respiratory illness of unknown origin, resembling viral pneumonia, with symptoms of fever, cough, and dyspnea. It has been determined that this new virus belongs to the Coronaviridae and the Nidovirales families.[1] On January 30, 2020, just 1 month after the date of the first case, the World Health Organization (WHO) declared the outbreak an international public health emergency. On March 11, 2020, the WHO declared COVID-19, which spread to 114 countries, as the first pandemic caused by a coronavirus.[2] Globally, as of March 9, 2022, there have been 451 503 987 confirmed cases of COVID-19, including 6 019 220 deaths attributed to COVID-19.[3]

During the COVID-19 pandemic, governments have tried to implement different approaches to minimize morbidity and mortality and limit the spread of the disease. These approaches can be classified under 2 main headings as nonpharmaceutical interventions (NPIs) and pharmaceutical interventions (PIs). Although studies are showing the importance of PIs such as vaccines and antiviral medications in struggling against COVID-19, most countries have difficulties accessing these resources.[4,5] In addition, once a new virus emerges, the development of a new vaccine takes about 4-6 months, and the production capacity to make it accessible is limited. For these reasons, in the absence of a vaccine or effective treatment, the various measures covered by NPIs are critical in struggling with the pandemic. Nonpharmaceutical interventions include social

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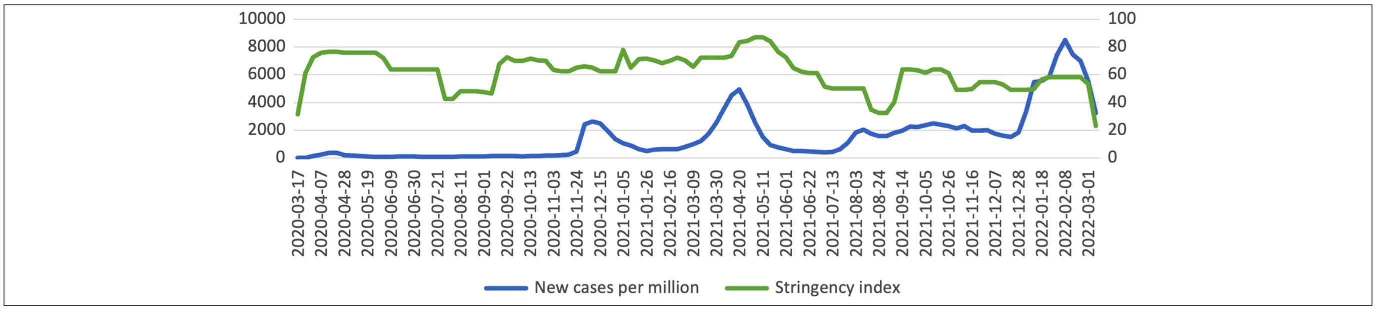

Figure 1. Weekly stringency index and new cases per million in Turkey. Source: Authors' calculations.

distance interventions such as school closures, travel restrictions, mass gathering cancellations, quarantine, and isolation and other measures such as personal protective measures, hygiene practices, contact tracing, education, and social awareness. While these interventions are not sufficient on their own, they are accessible, cost-effective, and effective tools. Nonpharmaceutical interventions reduce the impact of the COVID-19 pandemic by enabling them to achieve results such as providing more time for preparedness and response efforts, reducing the population affected by the pandemic, and reducing workforce loss. Nonpharmaceutical interventions and PIs provide partial protection when implemented alone. Therefore, combining NPIs with PIs such as vaccines and antiviral drugs is the most effective way to mitigate the pandemic.[6-8]

Several indices have been created to monitor the implementation of PIs and NPIs by governments in the fight against the pandemic. In this context, The Oxford COVID-19 Government Response Tracker monitors 20 indicators within the framework of individual policy measures to track the activities of governments. These indices have been created by using the simple averages of the selected ones from these indicators. Among these, the stringency index (SI) has been calculated with indicators related to containment and closure policies with just 1 additional indicator (public information campaigns), and the containment and health index has been calculated with indicators including health system policies such as COVID-19 testing and vaccination regime in addition to the SI indicators; these are the most frequently used indices.[9]

Coronavirus Disease 2019 Situation in Turkey

The first confirmed case detected in the COVID-19 pandemic in Turkey was announced by the Ministry of Health on March 11, 2020, the date when WHO declared the pandemic, and the first death attributed to COVID-19 was announced on March 15, 2020. On April 1, 2020, it was announced that the virus had spread throughout Turkey, and the cities with the highest number of cases were, respectively, Istanbul, Izmir, Ankara, Kocaeli, and Konya. Many measures have been taken in Turkey within the scope of NPIs in struggling against COVID-19, such as the suspension of face-to-face education and the cancellation and postponement of scientific, cultural, artistic, and other meetings or activities. Lockdowns were imposed on those aged 65 and over on March 21, 2020, and on those aged under 20 on April 3, 2020. As of April 11, 2020, the lockdowns, which are valid on weekends and public holidays, have been implemented for 30 big cities and Zonguldak.[10]

A total of 2 835 989 cases were reported in the year following the first case seen in Turkey, and this reached 14 513 774 as of March 9, 2022. While the total number of deaths attributed to COVID-19 was 29 290 at the end of the first year, this reached 95 954 as of March 9, 2022. Based on these, it is possible to say that Turkey was more affected in the second year of the pandemic compared to the first year.[3] When the SI is examined, the SI average was 65.12 in the first year of the pandemic in Turkey, while it was 58.79 in the second year. The weekly variation of SI, new cases per million, and new deaths per million according to the data between November 3, 2020, and August, 8, 2022, in Turkey are shown in Figure 1 and Figure 2.

As seen in Figure 1, the new cases per million in Turkey peaked in 3 different periods, namely December 2020, April 2021, and February 2022. Figure 2 shows that deaths peaked in April 2020, December 2020, May 2021, September 2021, and February 2022. According to the SI, May 2020, January 2021, May 2021, and October 2021 were the periods when the most stringent measures were taken in Turkey.

As of March 9, 2022, Turkey is one of the countries most affected by the pandemic worldwide. While Turkey ranks eighth worldwide in terms of the total number of cases, it ranks second after India in the Asian continent. Considering the total number of deaths, it is in the nineteenth rank in the world, and it is in the fourth rank in the Asian continent after India, Indonesia, and Iran. Vaccination studies in Turkey were initiated on January 14, 2021, by prioritizing health-care workers and the population over 65 years of age. Additionally, the

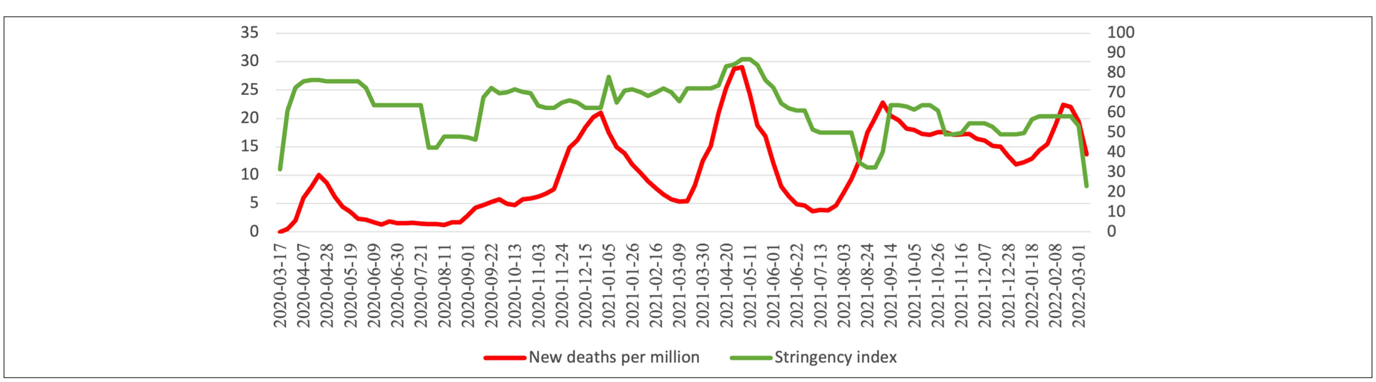

Figure 2. Weekly stringency index and new deaths per million in Turkey. Source: Authors' calculations.

fully vaccinated population in Turkey was 52 880 970 (62.18%), making it the seventh country in the world with the highest number of vaccinations.[3]

While the extent to which government interventions are implemented varies over time, the focus of all these efforts is to prevent the spread of the virus in the community and to reduce mortality and morbidity. In fact, although almost all countries have implemented these interventions, there are large variations in the evolution of the pandemic. This indicates that country-specific factors may have played an important role in explaining these variations.[11] Therefore, this study aimed to assess the relationship between the SI used as an NPI measure and the 2 major COVID-19 indicators during the 2-year period after the first case in Turkey.

Methods

Study Design

This study aimed to investigate the relationship between the SI and 2 major COVID-19 indicators: new confirmed cases of COVID-19 (NC) and new deaths attributed to COVID-19 (ND) using econometric causality models. The SI is a composite measure including 9 metrics such as suspension of public events, public information campaigns, closures of public transport, restrictions for public gatherings, restrictions on internal movements and international travel controls, stay-at-home requirements, and workplace and school closures. The index is the mean of these applications for a given day, and it is between 0 and 100. The closer the value is to 100, the greater the rigidity (100 = strictest response).[3] The reason for using the SI in this study is to determine the relationship between containment and closure policies and the number of new cases and deaths. This study focuses on reflecting the impact of NPIs in the absence of intervention with health resources such as vaccines and tests. For this reason, SI has been used instead of the containment and health index, which also includes health system policies.

Data Collection

The main research question is "In the two-year period after the first case in Turkey; what is the relationship between the stringency index, new confirmed cases of COVID-19, and new deaths attributed to COVID-19?" In this context, the data used in the estimation of causality data collection were obtained from the GitHub repository of the Center for Systems Science and Engineering at Johns Hopkins University on March 3, 2022. Permission is granted to use the data produced by Our World in Data in any medium, provided that the source is cited. All data are completely open access. Ethics committee approval and informed consent were not obtained as secondary data, which do not involve human intervention, were used in the GitHub repository. Daily data for the period of March 11, 2020-March 8, 2022, were used to determine causality between SI, NC, and CD. The explanations for the variables are summarized in Table 1.

Before analysis, the obtained daily data were converted into weekly data. Accordingly, the weekly sum of new cases and deaths was calculated from the data consisting of 728 observations. The number of new cases and new deaths per million and the average of the SI for each week were then calculated.

Statistical Analysis

Toda and Yamamoto (1995)[12] method was used for the causality approach. Toda–Yamamoto is a causality test. Causality tests are tests used to determine the direction of causality of the relationship statistically if there is a time-lagged relationship between 2 variables. For this purpose, the Toda–Yamamoto test was used in our study. This causality test is based on the vector autoregression model and allows the model with level values to be estimated regardless of whether the series to be examined contains unit roots. For this reason, it provides advantages to users and is frequently preferred. It is the preferred method to obtain robust causality for dual relationships such as SI, new COVID-19 cases, and new COVID-19 deaths. Clive W. Granger[13] was the first researcher to reveal causality theory in 1969. Accordingly, when examining the causality between the variables, it should be investigated that the variables have the same level of lag. The later causality approach gained new features, and the number of studies on it increased. Sims made a significant theoretical and empirical contribution to the Granger causality approach in 1980.[14] In addition to the work of Sims and Granger, different contributions have been made in the field of causality in the last 40 years, such as the Toda–Yamamoto Causality approach, used in this study, and the panel causality approach.[15] Although these methods serve the same purpose, they contain methodological differences. For instance, the variables must be stationary at the level of Granger (1969).[13] However, this situation is not mandatory in Toda–Yamamoto (1995).[12]

Toda and Yamamoto's method uses the maximum integration degree (dmax) and the lag length (k) of the variables for the causality analysis. Therefore, the value of $[k + (d\text{max})]$ needs to be calculated, and then the hypothesis test should be applied.[12,16] Thanks to Toda and Yamamoto's causality test; more successful predictions can be made, and more information can be obtained.[17]

In this context, the causality was tested with econometric Toda–Yamamoto analyses on weekly and monthly data. E-Views 9.0 program was used to estimate causality. In other words, it was examined whether there is a causal relationship between the 2 variables. Research hypotheses are:

H_{0a}: *The stringency index is not the cause of new positive COVID-19 cases.*

H_{1a}: *The stringency index is the cause of new positive COVID-19 cases.*

H_{0b}: *New COVID-19 cases are not the cause of the stringency index.*

H_{1b}: *New COVID-19 cases are the cause of the stringency index.*

H_{0c}: *The stringency index is not the cause of new COVID-19 deaths.*

H_{1c}: *The stringency index is the cause of new COVID-19 deaths.*

H_{0d}: *New COVID-19 deaths are not the cause of the stringency index.*

H_{1d}: *New COVID-19 deaths are the cause of the stringency index.*

Results

First, the maximum integration degree ($d$max) of the variables was determined using a standardized augmented Dickey–Fuller (ADF) unit root test. Table 2 shows the ADF test results.

According to Table 2, the SI series is I1 (stationary when first differenced), NC and ND series are I0 (stationary at levels). So, the $d$max was determined as 1 for causality analysis. Four different equations were created for causality analysis with the Toda Yamamoto causality approach. These are:

$$NC_t = \beta_{0a} + \sum_{i=1}^{k}(\alpha_{1i} NC_{t-i}) + \sum_{j=k+1}^{dmax}(\beta_{2j} NC_{t-j}) + \sum_{i=1}^{k}(\theta_{1i} SI_{t-1}) + \sum_{j=k+1}^{dmax}(\theta_{2i} SI_{t-i}) + \varepsilon_{1t} \quad \text{(1- Hypotheses a)}$$

Table 1. The Explanations of the Variables

Abbreviation	Variables Definition	Source	Period
SI	Stringency index composite measure based on 9 response indicators, rescaled to a value from 0 to 100.	https://github.com/owid/covid-19-data/tree/master/public/data	March 11, 2020-March 8, 2022
NC	New confirmed cases of COVID-19	https://github.com/owid/covid-19-data/tree/master/public/data	March 11, 2020-March 8, 2022
ND	New deaths attributed to COVID-19	https://github.com/owid/covid-19-data/tree/master/public/data	March 11, 2020-March 8, 2022

Table 2. Augmented Dickey–Fuller Unit Root Test Results (Intercept)

		Test Critical Values			
	t-stat	1%	5%	10%	*P*
SI	−2.678644 (0)	−3.496	−2.890	−2.582	.0812
SI (Δ)	−8.234267 (0)*				<.001
NC	−3.597051 (1)*	−3.496	−2.890	−2.582	.0074
ND	−4.166032 (1)*	−3.496	−2.890	−2.582	.0012

The values in square brackets indicate the lag lengths determined by the Schwarz Information Criterion (SIC) criteria.
SI, stringency Index; COVID-19, coronavirus disease 2019; NC, new confirmed cases of COVID-19; ND, new deaths attributed to COVID-19.
*Statistical significance at 1%.

$$SI_t = \beta_{0b} + \sum_{i=1}^{k}(\alpha_{1i} SI_{t-i}) + \sum_{j=k+1}^{dmax}(\beta_{2j} SI_{t-j}) + \sum_{i=1}^{k}(\theta_{1i} NC_{t-1}) + \sum_{j=k+1}^{dmax}(\theta_{2i} NC_{t-i}) + \varepsilon_{2t} \quad \text{(2- Hypotheses b)}$$

$$ND_t = \beta_{0c} + \sum_{i=1}^{k}(\alpha_{1i} ND_{t-i}) + \sum_{j=k+1}^{dmax}(\beta_{2j} ND_{t-j}) + \sum_{i=1}^{k}(\theta_{1i} SI_{t-1}) + \sum_{j=k+1}^{dmax}(\theta_{2i} SI_{t-i}) + \varepsilon_{3t} \quad \text{(3- Hypotheses c)}$$

$$SI_t = \beta_{0d} + \sum_{i=1}^{k}(\alpha_{1i} SI_{t-i}) + \sum_{j=k+1}^{dmax}(\beta_{2j} SI_{t-j}) + \sum_{i=1}^{k}(\theta_{1i} ND_{t-1}) + \sum_{j=k+1}^{dmax}(\theta_{2i} ND_{t-i}) + \varepsilon_{4t} \quad \text{(4- Hypotheses d)}$$

Prior to proceeding with causality analysis, the maximum degrees of integration for the model's time series were established. This was followed by the determination of optimal lag lengths (*k*) for each equation. Schwerts information criteria was used to estimate the maximum possible number of lags.[18] Subsequently, information criteria were utilized to pinpoint the optimal lag length for each equation. Based on the Akaike Information Criterion (AIC) and Hannan-Quinn Information Criterion (HQIC), a lag length of 2 was identified as optimal for Equations 1, 2, 3, and 4.

Table 3. Toda–Yamamoto Approach-Based Causality Test Results

Hypothesis	χ^2	*P*	Result
SI $\nRightarrow$ NC H0: No causality	2.822659	.244**	H_0: Accepted
NC $\nRightarrow$ SI H0: No causality	14.05045	<.001**	H_0: Rejected
SI $\nRightarrow$ ND H_0: No causality	1.816295	.403**	H_0: Accepted
ND $\nRightarrow$ SI H_0: No causality	16.99331	<.001**	H_0: Rejected

SI, stringency index; COVID-19, coronavirus disease 2019; NC, new confirmed cases of COVID-19; ND, new deaths attributed to COVID-19.
***P*-value was calculated according to 2(*k*) degree of freedom.

Under these conditions, for all the equations $k+d$max is 3. So, the causality relation test results between variables, based on models described by equations (1), (2), (3) and (4) with $k+d$max, are listed in Table 3, which shows the Modified Wald (MWALD) test results.

It was found that the first null hypothesis, that is *SI is not the cause of new positive COVID-19 cases*, has not been rejected. On the other hand, it was found that the second null hypothesis, that *new COVID-19 cases are not the cause of the SI,* was rejected. When focusing on the relationship between the SI and case-related deaths, the first null hypothesis, that is *the SI is not the cause of new COVID-19 deaths,* has not been rejected. On the other hand, the last null hypothesis, that is *new COVID-19 deaths are not the cause of the SI,* was rejected. So, according to the results of the established causality model, when the weekly averages of the 2-year daily data in Turkey are considered, it was found that there is a causality from the new cases and deaths related to COVID-19 to the degree of restrictions. There is a 1-way causal relationship between new COVID-19 cases and new COVID-19 deaths in Turkey and the SI for the analyzed period in weekly data. Moreover, sensitivity analysis was performed using different time periods (biweekly and 28-day) to examine the impact of the SI on COVID-19 infection or death rates. As a result, it can be concluded that increases in the stringency level led to a significant COVID-19 incidence reduction in the subsequent 28 days.

Discussion

Our major results show that the COVID-19 mortality variable (new deaths per million) and the infection rate (new cases per million) in weekly data lead to an increase in the stringency level of NPIs. These findings demonstrate that the level of implementation of NPIs in Turkey has increased in response to the weekly infection or mortality rates of COVID-19. However, the SI has no significant impact on the weekly infection or mortality rates of COVID-19. Based on the sensitivity analysis using a 28-day time period, it was concluded that the SI has a significant impact on reducing the number of new cases with 28-day averages. These results are in line with studies conducted in other countries and theoretical expectations. While the stringency level is changed in a relatively short time according to the situation of the cases, the effect of the measures taken on the cases is relatively longer. The reason for this result is the incubation period of COVID-19.

The SI provides information on what measures governments have taken, when, and to what extent. In this way, when the study findings are compared with the findings of studies conducted in different countries, it can help decision-makers understand the robustness and sustainability of government responses and expand measures to control and effectively manage the spread of the pandemic. First, the SI developed at the University of Oxford was used to represent NPIs in the study. Many studies have similarly used this tool to indicate NPIs or containment measures.[19-21]

Many studies have been conducted to explain the relationship between containment measures and COVID-19 through examples fromdifferent countries. The results of the studies show that the effect of containment measures differs according to the countries examined. Pninger et al (2022)[22] observed in their study that increases in the stringency level led to a significant reduction in weekly infections in Switzerland. Askitas et al (2021),[23] in their study at the onset of the COVID pandemic, observed that an increase in the implementation of the 4 policies (school and workplace closures, cancellation of public events, restrictions on private gatherings) significantly reduced the incidence of COVID-19 in the next 2 weeks. Similar results were obtained in our study. Consistent with our study findings, Hale et al (2021b)[20] found that NPIs significantly reduced COVID-19 incidence in the subsequent 28 days, according to 113 countries' data. Nanda et al (2021),[21] on the other hand, found that the average SI of the current month has a significant effect on the number of cases in the next month in their analysis of the data from 47 European countries.

Numerous studies have been conducted to explain the relationship between containment measures and COVID-19, based on the data of 2020, when COVID-19 affected the whole world. However, in the later stages of the pandemic, the differentiation of the government's responses to the pandemic makes it necessary to investigate over a broader time interval. In addition, even if different countries impose similar measures, the relationship between the measures and the COVID-19 cases may differ. The fact that there is no study in the literature that deals with the relationship between containment measures and COVID-19 over a broad period for only Turkey constitutes the eigenvalue of this study. This study contributes by revealing the relationship between NPIs (SI) and the COVID-19 mortality variable (new deaths per million) and the infection rate (new cases per million) from March 2020, when the pandemic started in Turkey, to March 2022.

Conclusion

Containment measures are one of the keys to halting the spread of the virus and limiting the number of fatalities, especially in the absence of a vaccine or effective treatments. According to the results, in the causality model established with weekly data in Turkey, a 1-way causality relationship was found between COVID-19 cases and case-related deaths and containment measures. Our data suggest that the deployment of NPIs in the country is promptly adjusted based on the progression of the pandemic. This is an indication that cases and related deaths are followed during the pandemic process, and an effective pandemic policy is made according to this quantitative evidence. In addition, it has been determined that there is a causality between the degree of the measures taken to the cases and deaths due to the cases, not over the weekly data but on the monthly data. This situation reveals that the measures taken in a short time (on a weekly basis) change according to the cases, and the effects of the measures taken on the cases show their effect after approximately 1 month. In other words, the focus of pandemic management measures is responsive to the case numbers. Furthermore, the data suggest that the effects of these responses are observable in the case numbers after approximately 1month. As a result, it can be said that implementing containment measures is an effective way that governments can use to minimize the negative effects of pandemics. The study findings may contribute to decision-makers to better understand the consequences of the COVID-19 pandemic interventions and to determine the appropriate strategies in Turkey and elsewhere.

Ethics Committee Approval: Ethics committee approval and informed consent were not obtained as secondary data, which do not involve human intervention, were used in the GitHub repository.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – F.Y., C.B.; Design – F.Y., C.B., İ.K.Ş., H.Ö.; Supervision – İ.K.Ş., H.Ö.; Materials – C.B., F.Y.; Data Collection and/or Processing – F.Y.; Analysis and/or Interpretation – F.Y., C.B., İ.K.Ş., H.Ö.; Literature Review – F.Y.; Writing Manuscript – F.Y., C.B., İ.K.Ş., H.Ö.; Critical Review – F.Y., C.B., İ.K.Ş., H.Ö.

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References

1. Chung M, Bernheim A, Mei X, et al. CT imaging features of 2019 novel coronavirus (2019-nCoV). *Radiology*. 2020;295(1):202-207. [CrossRef]
2. World Health Organization. *WHO Director-General's Opening Remarks at the Media Briefing on COVID-19-11 March 2020*. Available at: https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020, Accessed 4 April 2022.
3. Our world in data. Data on COVID-19 (coronavirus) by Our World in Data. 2022. Available at: https://github.com/owid/covid-19-data/tree/master/public/data Accessed 4 April 2022.
4. Moghadas SM, Vilches TN, Zhang K, et al. The impact of vaccination on coronavirus disease 2019 (COVID-19) outbreaks in the United States. *Clin Infect Dis*. 2021;73(12):2257-2264. [CrossRef]
5. Liang LL, Kuo HS, Ho HJ, Wu CY. COVID-19 vaccinations are associated with reduced fatality rates: evidence from cross-county quasi-experiments. *J Glob Health*. 2021;11:05019. [CrossRef]
6. Pan American Health Organization. Non-pharmaceutical interventions (NPIs): actions to limit the spread of the pandemic in your municipality. 2020. Available at: https://www.paho.org/disasters/dmdocuments/RespToolKit_11_Tool%2004_NonPharmaceuticalInterventions(NPIs).pdf, Accessed 16 April 202.
7. Moore S, Hill EM, Tildesley MJ, Dyson L, Keeling MJ. Vaccination and non-pharmaceutical interventions for COVID-19: a mathematical modelling study. *Lancet Infect Dis*. 2021;21(6):793-802. [CrossRef]
8. Rizvi RF, Craig KJT, Hekmat R, et al. Effectiveness of non-pharmaceutical interventions related to social distancing on respiratory viral infectious disease outcomes: a rapid evidence-based review and meta-analysis. *SAGE Open Med*. 2021;9:20503121211022973. [CrossRef]
9. Hale T, Angrist N, Goldszmidt R, et al. A global panel database of pandemic policies (Oxford COVID-19 Government Response Tracker). *Nat Hum Behav*. 2021;5(4):529-538. [CrossRef]
10. Ladikli N, Bahadir E, Yumusak FN, et al. The reliability and validity of Turkish version of coronavirus anxiety scale. *Int J Soc Sci Res*. 2020;3(2):71-80.
11. Deb P, Furceri D, Ostry J, Tawk N. The effects of containment measures on the COVID-19 pandemic. *IMF Working Papers*. 2020;20(159):53-86. [CrossRef]
12. Toda HY, Yamamoto T. Statistical inferences in vector autoregressions with possibly integrated processes. *J Econ*. 1995;66(1-2):225-250. [CrossRef]
13. Granger CWJ. Investigating causal relations by econometric models and cross-spectral methods. *Econometrica*. 1969;37(3):424-438. [CrossRef]
14. Sims CA. Macroeconomics and reality. *Econometrica*. 1980;48(1):1-48. [CrossRef]
15. Engeloglu O, Meral IG, Genc K. A literature review on the causality test applications about Türkiye. *Social Sciences Research Journal*. 2015;4(2):142-154.
16. Akkas ME, Sayılgan G. Housing prices and mortgage interest rate: toda-yamamoto causality test. *J Econ Fin Acc*. 2015;2(4):572-583.
17. Dogan B. Relationship between economic globalization and growth: toda-yamamoto causality analysis in the case of Türkiye. *Fin Pol Econ Interpretations*. 2017;54:19-27.
18. Schwert GW. Tests for unit roots: a Monte Carlo investigation. *NBER Technical Working Paper Series*. 1988;7(2):47-159.
19. Violato C, Violato EM, Violato EM. Impact of the stringency of lockdown measures on COVID-19: a theoretical model of a pandemic. *PLoS One*. 2021;16(10):e0258205. [CrossRef]
20. Hale T, Angrist N, Hale AJ, et al. Government responses and COVID-19 deaths: global evidence across multiple pandemic waves. *PLoS One*. 2021;16(7):e0253116. [CrossRef]
21. Nanda M, Aashima A, Sharma R. Review of COVID-19 epidemiology and public health response in Europe in 2020. *Clin Epidemiol Glob Health*. 2021;12:1103-1122. [CrossRef]
22. Pleninger R, Streicher S, Sturm JE. Do COVID-19 containment measures work? Evidence from Switzerland. *Swiss J Econ Stat*. 2020;158(1):1-24.
23. Askitas N, Tatsiramos K, Verheyden B. Estimating worldwide effects of non-pharmaceutical interventions on COVID-19 incidence and population mobility patterns using a multiple-event study. *Sci Rep*. 2021;11(1):1972. [CrossRef]