MEHMET AKİF ERSOY ÜNİVERSİTESİ
İKTİSADİ VE İDARİ BİLİMLER FAKÜLTESİ DERGİSİ
Mehmet Akif Ersoy University
Journal of Economics and Administrative Sciences Faculty

ISSN: 2149-1658
Cilt: 10 Sayı: 1 s.101-116
Volume: 10 Issue: 1 p.101-116
Mart 2023 March

THE EFFECT OF VACCINATION ON COVID-19 DEATHS: A RESEARCH ACCORDING TO COUNTRIES' INCOME GROUPS

AŞILAMANIN COVID-19 ÖLÜMLERİNE ETKİSİ: ÜLKELERİN GELİR GRUPLARINA GÖRE BİR ARAŞTIRMA

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Makale Türü / **Article Type**
Araştırma Makalesi / Research Article

Başvuru Tarihi / **Application Date**
07.12.2021 / 12.07.2021

Yayına Kabul Tarihi / **Admission Date**
18.01.2023 / 01.18.2023

DOI
https://doi.org/10.30798/makuiibf.1033552

Abstract

This study aims to reveal the impacts of Covid-19 vaccination on Covid-19 based deaths in countries with different income levels. In this context, the study investigated data between 01.03.2021 and 08.08.2021 by Panel data analysis. In the research, firstly, countries were divided into three different categories according to income groups: low-income level, middle-income level and high-income level. Therefore, each country group was examined separately and three different econometric models were produced. According to the results of the research, a 1% increase in the population vaccinated will result in a 2.1% decrease in the number of deaths from Covid-19 in low-income countries, a 0.5% decrease in middle-income countries and a 13% decrease in high-income countries. According to the results of the research, it was concluded that vaccination will significantly reduce deaths from Covid-19. For this reason, it is recommended that people complete their vaccine doses as fast as possible.

Keywords: ***Covid-19 Vaccination, Covid-19 Deaths, Vaccination, Panel Data Analysis, Vaccination.***

Öz

Bu çalışma, farklı gelir düzeylerine sahip ülkelerde Covid-19 aşısının Covid-19 kaynaklı ölümler üzerindeki etkilerini ortaya koymayı amaçlamaktadır. Bu kapsamda çalışma, 01.03.2021 ile 08.08.2021 tarihleri arasındaki verileri Panel veri analizi ile incelemiştir. Araştırmada ilk olarak ülkeler gelir gruplarına göre alt gelir düzeyi, orta gelir düzeyi ve yüksek gelir düzeyi olmak üzere üç farklı kategoriye ayrılmıştır. Bu nedenle her ülke grubu ayrı ayrı incelenmiş ve üç farklı ekonometrik model üretilmiştir. Araştırmanın sonuçlarına göre aşılanan nüfusta yüzde 1'lik bir artış, düşük gelirli ülkelerde Covid-19'dan ölüm sayısında yüzde 2,1'lik, orta gelirli ülkelerde yüzde 0,5'lik ve yüksek gelirli ülkelerde %13'lük bir düşüşe yol açacaktır. Yüksek Araştırmanın sonuçlarına göre aşının Covid-19 kaynaklı ölümleri önemli ölçüde azaltacağı sonucuna varılmıştır. Bu nedenle kişilerin aşı dozlarını olabildiğince hızlı tamamlamaları önerilmektedir.

Anahtar Kelimeler: ***Covid-19 Aşılama, Covid-19 Ölümleri, Panel Veri Analizi, Aşılama.***

GENİŞLETİLMİŞ ÖZET

Çalışmanın Amacı

Bu araştırmanın amacı, ülkelerin gelir gruplarını dikkate alarak Covid-19 kaynaklı ölümleri belirli değişkenler kapsamında incelemektir. Bu doğrultuda Covid-19 kaynaklı ölümlerde etkili olan faktörlerin ülkelerin gelir gruplarına göre nasıl farklılık gösterdiği tespit edilecektir.

Araştırma Soruları

Ülkelerin gelir gruplarına göre, aşılamanın covid-19 kaynaklı ölümler üzerinde bir etkisi var mıdır? Varsa aşılama covid-19 ölümlerinin nasıl etkilemektedir?

Literatür Araştırması

Covid-19'un yayılmasını kontrol edebilmek için DSÖ tarafından karantina uygulaması, hijyen kuralları, hızlı test ve bireylerle yakın temastan kaçınma gibi önlemler tavsiye edilmektedir (5. Dünya Sağlık Örgütü-Çin Ortak Misyonu). Koronavirüs Hastalığı, 2020). Öte yandan aşı, virüsün yok edilmesinde en önemli araç olarak görülmektedir. Aşılama sadece bireyleri korumakla kalmamakta, aynı zamanda yeterli sayıda kişiye uygulandığında virüsün yayılmasını, hastalık tablosunu ve dünya çapındaki ölümleri azaltmak için yeterli sürü bağışıklığı sağlamaktadır. Etkili ve ömür boyu sürecek bir bağışıklama aşısı bulunduğunda Covid-19 için gerekli olan sürü bağışıklığının yaklaşık %60-72 olduğu tahmin edilmektedir (Gürbüz ve ark., 2021). Bu nedenle, Ocak 2020'de Wuhan'daki ilk viral pnömoniden izole edilen virüsün genomunun ardından, bilim adamları için etkili ve güvenli bir aşı üretmek için dünya çapında bir yarış başlamıştır (Zhu ve ark., 2019). Aşı üretim çalışmaları sonucunda da birçok farklı aşı türü geliştirilmiştir.

Yöntem

Araştırmada, aşılamanın ülkelerin gelir gruplarına göre Covid-19 ölümlerine etkisi panel veri analizi yöntemi ile incelenmiştir. Araştırmada kullanılan değişkenlerin veri türü günlüktür. Araştırmanın zaman boyutu 01.03.2021 ile 08.08.2021 tarihlerini kapsamaktadır. Çalışmaya dâhil edilen örneklem, verilerine ulaşılabilen ülkelerle sınırlandırılmıştır. Düşük gelir grubunda 5 ülke, orta gelir grubunda 14 ülke ve yüksek gelir grubunda 24 ülke araştırmaya dâhil edilmiştir. Çalışmada öncelikle, uygulanacak panel veri analizi modeli belirlenmiş, daha sonra panel veri anlizi için temel varsayım testleri uygulanmıştır. Temel varsayım testler sonucunda, Driscoll-Kraay Standard Error dirençli tahmincisi ile katsayılar tahmin edilmiştir.

Sonuç ve Değerlendirme

Araştırmanın sonuçlarına göre aşılanan nüfusta yüzde 1'lik bir artışın, düşük gelirli ülkelerde Covid-19'dan ölüm sayısında yüzde 2,1, orta gelirli ülkelerde yüzde 0,5 ve yüksek gelirli ülkelerde 13'lük bir düşüşe neden olacağı tespit edilmiştir. Araştırmanın sonuçlarına göre aşının Covid-19 kaynaklı ölümleri önemli ölçüde azaltacağı sonucuna varılmıştır. Öte yandan ülkelerdeki gelir düzeyi azaldıkça toplam nüfus içinde yaşlı nüfusun daha fazla soruna neden olduğu tespit edilmiştir. Düşük gelirli ülkelerde toplam nüfusta yaşlı nüfusun artmasının yüksek gelirli ülkelere göre daha fazla ölüme neden olduğu belirlenmiştir.

1. INTRODUCTION

In December 2019, a new infectious disease that mutated from the coronavirus family was detected in Wuhan province of China and it was stated that many people applied to health institutions for this disease in a short time (Kumar et al., 2020; Wu et al., 2020). The names such as 2019-nCoV ', Novel CoV-19, SARSCoV-2 and Covid-19 have been given to the virus. Hovewer, a widely accepted name is finally Covid-19 (Kumar et al., 2020; Wu et al., 2020). Due to its rapidly contagious nature, the virus spread to many countries in a short time. This rapid spread of the virus caused the World Health Organization to declare the situation a pandemic in March 2011 (Cirakli et al., 2021). After this declaration, the necessity of joint struggle against Covid-19 has been underlined and joint studies have accelerated (Salathé et al., 2020).

To be able control the spread of Covid-19, certain measures such as quarantine, complying with hygiene rules, rapid testing and strictly close contact with individuals to combat Covid-19 are recommended by WHO (5. World Health Organization- China Joint Mission on Coronavirus Disease, 2020). On the other hand, the vaccination is seen as the most important tool in eliminating the virus. Vaccination not only protects individuals but, if administered to enough people, provides sufficient herd immunity to reduce the spread of the virus, the disease picture, and deaths worldwide. The required herd immunity for Covid-19 is estimated to be approximately 60-72% when an effective and life-long immunization vaccine is available (Gürbüz et al., 2021). Therefore, after the genome of the virus isolated from the first viral pneumonia in Wuhan in January 2020 has started a worldwide race to produce an effective and safe vaccine for the scientists (Zhu et al., 2019). As a result of vaccine production studies, many different types of vaccines have been developed. The table below shows the some of these vaccines.

Table 1. Types and Examples of Vaccines Developed for Covid-19

Types	**Examples**
Inactivated virus vaccine	Sinovac/CoronaVac, Sinopharm, Bharat Biotech, Selçuk University.
Live attenuated virus	Codegenix, Mehmet Ali Aydınlar University/ Acıbadem Labmed Health Services A.S.
Protein subunit	Novavax, Boğaziçi University
DNA-based	Osaka University, Inovio Pharmaceuticals, Ege University
RNA-based	Pfizer/Biontech, Moderna, Selçuk University
Replicating viral vector	Institut Pasteur
Non-replicating viral vector	AstraZenaca/Oxford, Sputnik V, Johnson & Johnson, CanSino Biologics, Erciyes University, Ankara University
Virus-like particle	Icosavax, Max-Planck Institute, Spybiotech, Medicago Inc., Bezmialem Vakif University, Middle East Techinal University
Others	Ose Immunotherapeutics

Source: Yavuz, 2020.

As seen in the table, although there are many vaccines for Covid-19, there are mandatory phases that must be applied to develop a vaccine. These phases are listed as follows (Yavuz, 2020):

- **Preclinic:** Data is collected for safety and suitability. Repeated animal studies are performed. Toxic and pharmacological effects are explored. It is carried out before human experiments begin.
- **Phase 1:** It is the first clinical phase. It is carried out in a small group of healthy people (20-100 volunteers). Safety and immune response at different doses are evaluated. It usually takes 1-2 years but is expected to take 3 months for Covid-19 vaccine studies.
- **Phase 2:** It is carried out with hundreds of people (100-300). Reliability and effectiveness are evaluated in more detail. It gives information about the optimal dose and vaccination schedule of the vaccine. It usually takes 2-3 years, but it is estimated that it will take 8 months for Covid-19 vaccine studies.
- Phase 3: It includes thousands of people (300-3000) in the scope of the study. Safety and efficacy are reassessed in a larger population. It usually takes 2-4 years but can be combined with Phase 2 in Covid-19 vaccine studies.
- **Regulatory Review:** The regulatory bodies of the states examine the results of the Phase 3 study and evaluate the licensing application. It may be concurrent with drug production. It usually takes 1-2 years but can be expedited to take several months for Covid-19.
- **Phase 4:** It is the next stage after the vaccine is started to be used massively. After approval, the real-life efficacy and safety of the vaccine is monitored.

While none of the vaccines related to Covid-19 have completed the required phases, some have been made available with early government approval. It is possible to list the vaccines that are in use and frequently mentioned as Pfizer/Biontech, Moderna, AstraZeneca/Oxford, Sinovac/CoronaVac and Sputnik V. According to the results of the efficacy studies of these vaccines, in general, protection rates against Covid-19 have been announced as 95% for Pfizer/Biontech (Polack et al., 2020), 70.4% for AstraZenaca/Oxford (Voysey et al., 2021), 50.6% Sinovac/CoronaVac (SINOVAC, 2021)] 91.6% for Sputnik V (Logunov et al., 2021), 66% for Johnson & Johnson (Ryser, 2021) and 94.1% for Moderna (Baden et al., 2021). According to the data of 8 May 2021 in Turkey, the rate of first dose vaccination in the community was 81.60%, while the second dose vaccination rate was 63.31% (Ministery of Health of Republic of Turkey, 2021). Novadays, it is argued that there is a vaccine hesitancy due to the low rate of the second dose vaccine. WHO defines the vaccine hesitancy as delay or refusal to accept vaccination despite availability of vaccine services (WHO, 2014). Factors such as adverse reaction concerns, distrust in the content of the vaccine, being influenced by the statements of anti-vaccine opponents, religious reasons, and negative news in the press can be listed as possible causes of vaccine hesitancy. Despite the various reasons of vaccine hesitancy, it causes delays, vaccine rejections, and negative public health consequences of vaccine preventable disease outbreaks (Erkekoğlu, et al., 2020).

The aim of this study is to determine the impacts of Covid-19 vaccination on the total number of death due to Covid-19. In this context, we investigeted the Covid-19 data of countries in different income groups between 01.03.2021 and 08.08.2021 by Panel data analysis. The results of the study may provide important contributions to both literature and people with vaccine hesitancy.

2. DATA AND METHODOLOGY

The data obtained within the scope of the research, Excel, Eviews 10.0 and STATA 15.0 analysis programs were used.

2.1. Purpose and Scope of the Research

The aim of this research is to examine the deaths caused by Covid-19 within the scope of certain variables, taking into account the income groups of the countries. In this direction, it will be determined how the factors that have an effect on deaths caused by Covid-19 differ according to the income groups of the countries.

2.2. Model and Data

In the research, firstly, countries were divided into three different categories according to income groups: low-income level, middle-income level, and high-income level. Countries are divided into income groups according to the World Bank classification. Although there are different studies on Covid-19 in the literature, it has been observed that Covid-19 deaths are not examined according to income groups. In this direction, deaths caused by Covid-19 will be analyzed by performing econometric tests within the scope of certain variables. In this way, the differences in deaths caused by Covid-19 according to income groups of countries and the effect levels of these variables on deaths caused by Covid-19 will be determined. The data type of the variables used in the research is daily. The time dimension of the research covers the dates between 01.03.2021 and 08.08.2021. The sample included in the study was limited to the countries whose data could be accessed. 5 countries in the low-income group, 14 countries in the middle-income group, and 24 countries in the high-income group were included in the research.

Table 2. Explanations on Variables

Variables	Symbol
Number of deaths from Covid-19	TDEATH
Number of Covid-19 cases	TCASE
Number of people vaccinated against Covid-19/Total Population	VACRATE
Number of Covid-19 diagnostic tests	TTEST
Number of patient beds per 1,000 people	BED
Proportion of 65+ people in the total population	AGE65
Proportion of 70+ people in the total population	AGE70

The variables to be used within the scope of the research are shown in Table 2. In the study, the number of deaths caused by Covid-19 will be the dependent variable and the other variables will be used as the independent variable. As a result of the separation of countries into three different groups, each country group will be examined separately and three different models will be produced. The equation for the models is shown below:

$$\Delta LNTDEATH_{it} = C + \sum_{j=1}^{pi} \lambda_{ij}\, \Delta LNTTEST_{i,t-j} + \sum_{j=0}^{qi} \varphi_{ij}\, \Delta LNTCASE_{i,t-j} + \sum_{j=0}^{qi} \varphi_{ij}\, \Delta LNVACRATE_{i,t-j} + \sum_{j=0}^{qi} \varphi_{ij}\, LNBED_{i,t-j} + \sum_{j=0}^{qi} \varphi_{ij}\, LNAGE65_{i,t-j} + \sum_{j=0}^{qi} \varphi_{ij}\, LNAGE70_{i,t-j}\varepsilon_{it} \quad (1)$$

Outputs of the three models:

Model 1: ΔLNTDEATH = 0.0004*ΔLNTTEST + 0.65*ΔLNTCASE - 0.0001*ΔLNVACRATE + 0.0003*BED - 0.0004*AGE65 + 0.0002*AGE70 + 0.001

Model 2: ΔLNTDEATH = 0.02*ΔLNTTEST + 80.79*ΔLNTCASE - 0.42*ΔLNVACRATE + 0.58*BED - 0.53*AGE65 + 0.63*AGE70 + 11.57

Model 2: ΔLNTDEATH = 0.18*ΔLNTTEST + 1.03*ΔLNTCASE - 0.04*ΔLNVACRATE + 0.02*BED - 0.04*AGE65 + 0.01*AGE70 + 7.85

In the equation; "Δ" is the first difference operator, "LN" is the logarithm of the series, and "ε_{it}" is error term with zero mean and variance constant within each unit, "i" is the cross-section and finally "t" is the information about the period.

The left-hand sides of the equations represent the dependent variable. On the right side of the equations, c represents the constant variable, α represents the estimator coefficients of the independent variables, ε represents the error term, i represents the horizontal section, and finally, t represents the information about the period. In panel data analysis models, the dependent variable cannot be estimated 100%. In this direction, there are different factors affecting deaths caused by Covid-19. But for the purpose of the study, the model is limited to the specified variables in question. In addition, the effect of the variables that we cannot predict within the scope of the model or that are not included in the model is collected in the "ε" error term.

2.3. Determination of Panel Data Model Methods

A panel data modeling is basically created with three different approaches. These approaches are pooled models, fixed-effect models, and random-effect models. Tests were developed to choose between models. First, the F test is applied when choosing between the classical (pooled) model and the fixed effects model, and the Hausman test is used when choosing between the fixed effects and the random-effects model.

According to the test results obtained, the most suitable approach to the model is determined and the model formation is completed. Although the variables to be used in the model are the same, since the number of observations covered by each model is different, the stationarity of the variables before each model setup was examined. The natural logarithmic transformation was first applied to the variables with high numerical values. The series that are not stationary at the level is made stationary by taking their primary differences.

3. FINDINGS

In this part of the study, the basic assumption test results for panel data models and the findings of the model created at the end of the process will be included.

3.1. Multiple Linear Connection Problem

Before modeling in panel data analysis, it is checked whether the model provides certain assumptions. The first of these assumptions is that there is no problem with multiple linear connections in the model. Different tests and methods have been developed for the detection of this problem. One of these developed methods is to calculate the Variance Inflation Factor (VIF) values of the variables. If there is a multicollinearity problem in a model, it will cause the calculation of wrong estimator coefficients, as stated by (Gujarati, 2004). In order to avoid this problem, care should be taken not to use variables with a high level of correlation with each other in the same model. In order to detect the problem in question, the VIF values of each variable are calculated using the formula (1/1-R2) (Brien, 2007). In the literature, it has been stated that acceptable VIF values can be accepted as 4 in some studies, up to 5, and even 10 in some studies (Açıkgöz et al., 2015).

Table 3. VIF Values of Variables

	Model 1 (Low Income Group)		**Model 2 (Middle Income Group)**		**Model 3 (High Income Group)**	
Variables	**R^2**	**VIF Values**	**R^2**	**VIF Values**	**R^2**	**VIF Values**
TDEATH	0.55	2.22	0.35	1.53	0.67	3.03
TCASE	0.56	2.27	0.24	1.31	0.61	2.56
VACRATE	0.12	1.13	0.33	1.47	0.69	3.22
TTEST	0.11	1.12	0.47	1.88	0.77	4.34
BED	0.17	1.20	0.63	2.70	0.40	1.66
AGE65	0.83	5.88	0.83	5.88	0.34	1.51
AGE70	0.62	2.63	0.87	7.69	0.49	1.96

In Table 3, the VIF values of the variables used within the scope of the research for each of the three models were calculated separately using the specified formula. Since VIF values can be accepted up to 10 in the literature and it is desired not to lose any variables in the model, the per capita income variable has not been removed from the model. Here, if the VIF values of the variables exceed the maximum acceptable limit of 10, the variable in question should be removed from the model. However, when the VIF values of the variables included in the model were examined in this study, all variables were included in the model and the analysis continued. The next step in panel data is to identify with which approach the model will be determined. To determine this, it is necessary to apply the necessary tests to the model and determine the most suitable tests for the model.

Table 4. Panel Data Model Determination Tests

	Model 1 (Low Income Group)		**Model 2 (Middle Income Group)**		**Model 3 (High Income Group)**	
	Statistics Value	Probability Value	Statistics Value	Probability Value	Statistics Value	Probability Value
F- Fixed Effects	13.71	0.000	218.39	0.000	5817.65	0.000
Hausman Test	22.96	0.000	17.42	0.000	16.79	0.000

One of the most important steps in panel data analysis is to determine which approach will be most suitable for each model. There are basically three different panel data approaches. These approaches are; pooled model, random-effects model, and fixed effects model approach. When choosing between approaches, it is first performed by F test, which of the fixed-effects model with the pooled models is valid. If the fixed effects approach is valid, the next step is to perform the Hausman test to test whether the random effects model or the fixed effects model is valid. When the said tests were performed for all three models, it was determined that the fixed effects approach was valid in the models. After determining the approach in question, it is to determine whether there is an autocorrelation problem to the models.

There should be no autocorrelation problem in the models obtained using the panel data method. The fact that there is an autocorrelation problem in the model means that the error terms of the variables are related to each other. The existence of such a situation leads to inaccurate results. For this reason, it is necessary to perform the autocorrelation test separately in each model and to apply the problem-solving tests in case of encountering the problem in question.

Table 5. Autocorrelation Test Results in Models

Test	**Model 1 (Low Income Group)**		**Model 2 (Middle Income Group)**		**Model 3 (High Income Group)**	
	Statistics Value	Probability Value	Statistics Value	Probability Value	Statistics Value	Probability Value
Bhargava et al. Durbin-Watson	0.8979	0.000	0.51	0.000	0.29	0.000
Baltagi-Wu LBI	0.9273	0.000	0.78	0.000	0.24	0.000

Table 5 shows the results of the autocorrelation test for the three models developed. When the test results are examined, it is seen that the H0 hypothesis that there is no autocorrelation was rejected. In other words, there is an autocorrelation problem in the models. After determining the autocorrelation status of each model, another issue to be examined is whether there is a changing variance.

Table 6. Heteroscedasticity Test

Test	Model 1 (Low Income Group)		Model 2 (Middle Income Group)		Model 3 (High Income Group)	
	Chi^2	Probability Value	Chi^2	Probability Value	Chi^2	Probability Value
Modified Walt Test	2247.13	0.0000	3473.18	0.000	8836.81	0.000

Models developed using the panel data method are built on homoscedasticity. The problem of heteroscedasticity is encountered as a result of the variance changing due to the changes in the unit. The heteroscedasticity problem is undesirable because it causes the efficient estimator coefficients to not be obtained. For this reason, whether there is a heteroscedasticity problem in each model was checked with the help of the relevant test. If the problem is encountered, necessary correction tests should be performed. The presence of heteroscedasticity in all three models was examined with the help of the modified Walt test. According to the test results obtained, it is seen that there are heteroscedasticity problems in all three models. Another issue that needs to be examined after the determination of the heteroscedasticity situation in the models is the control of the cross-section dependency problem.

Table 7. Horizontal Cross-Section Dependency Test

Test	Model 1 (Low Income Group)		Model 2 (Middle Income Group)		Model 3 (High Income Group)	
	Statistic	Prob	Statistic	Prob	Statistic	Prob
Breusch-Pagan LM	447.18	0.000	854.34	0.000	12971.27	0.000
Pesaran Scaled LM	173.35	0.000	58.16	0.000	517.76	0.000
Pesaran CD	12.19	0.000	4.07	0.000	16.13	0.000

In Table 7, horizontal cross-section dependency test results are given for all three models. When the test results are examined, the H0 hypothesis, established as there is no horizontal cross-section dependence, is rejected and it is seen that there is a horizontal cross-section dependence in all three models. Driscoll and Kraay resistance estimators were used to eliminate the problems encountered as a result of basic assumption tests of the models. Applying the resistive estimator in question to the models allowed the estimator values to be more accurate.

Table 8. Driscoll and Kraay Standard Error Model 1 Panel Data Results

Dependet Variable: DLNTDEATH **Term:** 01/03/2021-8/08/2021 **Horizontal Section:** 5 **Total Number of Observations:** 774				
Variable	**Coefficient**	**Drisc/Kraay Standard Error**	**t-statistics**	**Probability Value**
DLNTTEST	0.141	0.055	2.52	0.011
DLNTCASE	7.265	1.154	6.29	0.000
VACRATE	-2.100	0.090	23.22	0.000
BED	-0.839	0.013	-61.84	0.000
AGE65	1.718	0.023	71.71	0.000
AGE70	2.054	0.037	54.98	0.000
C	7.776	0.026	29.23	0.000
R^2 : 67.69	F-statistic: 282.02		Prob (F-Statistic): 0.000	

The findings of Model 1 are shown in Table 8. In Model 1, the Covid-19 deaths of countries in the low-income group were examined. While the dependent variable is the total number of deaths caused by Covid-19, the independent variables are the number of Covid-19 tests performed, the total number of cases encountered, the number of people who received at least one dose of vaccine, the number of beds per thousand people, the proportion of the population aged 65 and over in the total population and is the proportion of the population aged 70 and over in the total population.

It has been determined that among the panel data approaches, the fixed effects approach is the most suitable for model 1. As a result of the basic assumption tests on Model 1, problems of autocorrelation, varying variance, and cross-section dependence were encountered. Resistant Driscoll and Kraay estimators were used to eliminating the effects of these problems on Model 1. In addition, when the holistic significance indicator F probability value of model 1 is examined, it is seen that the model is significant at the 1% significance level. When the R2 value, which shows the explanatory power of the dependent variable, of the independent variables, is examined, it is seen that it is 67.69% and the explanatory power of the model is sufficient.

When the findings of the variables belonging to Model 1 are examined, firstly, the findings of the variables with natural logarithmic transformation will be interpreted as percentages. When the findings of Model 1 are examined, it is predicted that in the case of a 1% increase in the number of tests performed, 0.14% more deaths due to Covid-19 can be detected. On the other hand, if there is an increase of 1% in the total number of cases, it is predicted that there may be an increase of 7.26% in deaths caused by Covid-19. In case of an increase of 1% in the number of vaccinated population in a society, it is predicted that there may be a decrease of 2.10% in deaths caused by Covid-19. In case of an increase of 1 unit in the number of beds per thousand people, it is predicted that there may be a decrease of 0.83% in deaths caused by Covid-19. In the case of a 1-unit increase in the population aged 65 and over in the total population, it is predicted that there may be an increase of 1.71% in deaths caused by Covid-19. On the other hand, if the population aged 70 and over increases by 1 unit in the total population, it is predicted that there may be an increase of 2.05% in deaths caused by Covid-19. It is predicted that if the proportion of the elderly population in the population increases, the number of deaths will increase even more.

Table 9. Driscoll and Kraay Standard Faulty Model 2 Panel Data Results

Dependet Variable: DLNTDEATH **Term:** 01/03/2021-8/08/2021 **Horizontal Section:** 14 **Total Number of Observations:** 2209				
Variable	**Coefficient**	**Drisc/Kraay Standard Error**	**t-statistics value**	**Probability Value**
DLNTTEST	0.392312	0.028539	13.74630	0.000
DLNTCASE	18.97408	4.945882	-17.98953	0.000
VACRATE	-0.573359	0.143329	-4.000306	0.000
BED	-0.324239	0.029707	-10.91464	0.000
AGE65	0.641460	0.071856	8.926993	0.000
AGE70	0.680541	0.104344	6.522119	0.000
C	5.227937	0.455335	11.48152	0.000
R^2 : 0.41	F-statistic: 259.4396		Prob (F-Statistic): 0.000	

The findings of Model 2 are shown in Table 9. In Model 2, deaths caused by Covid-19 in countries in the middle-income group were examined. While the dependent variable is the total number of deaths caused by Covid-19, the independent variables are the number of Covid-19 tests performed, the total number of cases encountered, the number of people who received at least one dose of vaccine, the number of beds per thousand people, the proportion of the population aged 65 and over in the total population and the proportion of the population aged 70 and over in the total population.

As a result of the tests, it was determined that the most appropriate panel data approach for Model 2 was fixed effects. As a result of the basic assumption tests on Model 2, it was seen that there are problems of autocorrelation, varying variance, and cross-section dependence. Driscoll and Kraay estimators, one of the resistant estimators, were used to eliminate the effects of the mentioned problems on Model 2. The fact that the F probability value of Model 2 is 0.000 indicates that the model is significant as a whole at the 1% significance level. The fact that the R2 value of Model 2 is 41% indicates the percentage of the independent variables explaining the dependent variable.

When the findings of the variables used for Model 2 are examined, the results of the variables to which the natural logarithmic transformation is applied will be interpreted as a percentage change. When the findings of the variables are examined, it is predicted that in the case of a 1% increase in the number of tests performed, 0.39% more Covid-19-related deaths can be detected. In case of an increase of 1% in the number of cases, it is predicted that deaths from Covid-19 may cause an increase of 18.97%. On the other hand, if there is a one-unit increase in the number of the population exceeded, it is predicted that there will be a 0.57% decrease in deaths caused by Covid-19. In case of an increase of 1 unit in the number of beds per thousand people, it is predicted that there may be a decrease of 0.32% in deaths caused by Covid-19. In countries in the middle-income group, it is seen that the increase in the elderly population in the total population causes an increase in deaths caused by Covid-19. In the event that the rate of the population aged 65 and over increases by 1 unit in the total population, it is predicted that there may be an increase of 0.64% in deaths caused by Covid-19. If the population aged 70 and over increases by 1 unit in the total population, it is predicted that there may be an increase of 0.68% in deaths caused by Covid-19. After examining the model developed for developed country groups, a general evaluation will be made.

Table 10. Driscoll and Kraay Standard Faulty Model 3 Panel Data Results

Dependet Variable: LNTDEATH **Term:** 01/03/2021-8/08/2021 **Horizontal Section:** 24 **Total Number of Observations:** 3839				
Variable	**Coefficient**	**Drisc/Kraay Standard Error**	**t-statistics value**	**Probability Value**
LNTTEST	0.101032	0.003153	32.04318	0.000
LNTCASE	1.337990	0.099773	44.4733	0.000
VACRATE	-13.07612	0.147570	39.60961	0.000
BED	-0.93089	0.010472	-18.87862	0.000
AGE65	0.1724835	0.001086	22.86384	0.000
AGE70	0.298030	0.001262	77.69223	0.000
C	-11.10533	0.074067	-149.9369	0.000
R^2 :0.63	F-statistic:3478.7		Prob (F-Statistic): 0.000	

The findings of Model 3 are shown in Table 10. In Model 3, deaths from Covid-19 in high-income countries were examined. While the dependent variable is the total number of deaths caused by Covid-19, the independent variables are the number of Covid-19 tests performed, the total number of cases encountered, the number of people who received at least one dose of vaccine, the number of beds per thousand people, the proportion of the population aged 65 and over in the total population and the proportion of the population aged 70 and over in the total population. As a result of the tests, it was determined that the most suitable approach for Model 3 was fixed effects. When the basic assumptions of Model 3 are checked, it is seen that there are problems of autocorrelation, varying variance, and cross-section dependence. In order to get more accurate results, Driscoll and Kraay were used in resistant estimators to eliminate the effects of the problems in question. When the F probability value of the model is examined, it is seen that it is significant at the 1% significance level as a whole. When the percentage of independent variables explaining the dependent variable is examined, it is seen that it is 78% and the said value is sufficient.

Among the variables in Model 3, the results of the variables to which logarithmic transformation was applied will be interpreted as percentages. It is predicted that in case of an increase of 1% in the number of tests performed first, 0.10% more deaths from Covid-19 will be detected. In the case of an increase of 1% in detected cases, it is predicted that there may be an increase of 1.33% in deaths caused by Covid-19. In case of an increase of 1 unit in the number of vaccinated population in developed countries, it is predicted that there may be a decrease of 0.13% in Covid-19 deaths. In the case of a one-unit increase in the number of beds per thousand people, it is predicted that there may be a decrease of 0.93% in deaths caused by Covid-19. It has been determined that the increase in the elderly population in the total population in countries within the developed country groups may cause an increase in deaths caused by Covid-19. In the case of a 1-unit increase in the population aged 65 and over in the total population, it is predicted that there may be an increase of 0.17% in deaths caused by Covid-19. On the other hand, if the population aged 70 and over increases by 1 unit in the total population, it is predicted that there will be an increase of 0.29% in deaths caused by Covid-19.

4. CONCLUSION AND EVALUATION

In this research, countries are divided into three basic income levels, taking into account the World Bank income classification. For the countries in each country group, deaths from Covid-19 were examined using econometric models. To find the most accurate results for all models, basic assumption tests were applied and the problems encountered were corrected with the help of resistant estimators. When all three country groups are evaluated in general, it has been determined that as the income level of the countries decreases, the probability of an increase in deaths caused by the case increases. On the other hand, it has been determined that as the income level of the countries increases, the deaths as a result of vaccination decrease. Due to the high-income level of the countries, it is thought that more vaccinations are also a factor in this situation. On the other hand, as the income level in the countries decreases, it has been determined that the elderly population in the total population causes more problems. It has been determined that the increase in the elderly population in the total population in low-income countries causes more deaths than in high-income countries. On the other hand, it has been determined that the increase in the number of patient beds per thousand people has a positive effect on the fight against Covid-19 for all three countries and has a reducing effect on deaths.

It is an undeniable fact that the vaccine has an impact on both the reduction in the rate of Covid-19 transmission and the deaths. In this study, the importance of the vaccine was once again demonstrated and the reducing effect of the vaccine on deaths was examined by panel data analysis. The effect of a 1 unit increase in vaccination rates on deaths in each country group shows itself with the increasing rate from high-income countries to low-income countries. Mortality rates decrease as vaccination increases. This rate is particularly high in low-income countries. The main way out of the Covid-19 pandemic worldwide is through vaccination. This vaccination should not be limited to high-income countries but should be equally distributed to the rest of the world. With the increase in vaccination in all countries of the world, especially in low-income countries, there is a serious decrease in both Covid-19 transmission rates and death rates. In this context, vaccine studies should be continued without slowing down around the world.

Before moving on to suggestions in line with the research, there are situations that should be mentioned about the limitations of the research. The biggest limitation of the study was the countries whose data could be accessed. A secondary limitation of the study is that the types of vaccines were not considered separately and were evaluated in general. Separate data types specific to each vaccine type could not be reached. As a suggestion within the scope of the research, modeling studies can be done again by expanding the time dimension with current data. As a secondary suggestion, different models can be produced by adding different indicators related to Covid-19.

Statements and Declarations

- We declare that no funding was received for this article.
- Authors have no potential conflict of interest.
- This article does not contain any studies with human participants or animals performed by any of the authors.
- All authors have equally contributed to this article.

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