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Empowering Education: Addressing Vaccination Hesitancy in The Covid-19 Era

Eğitimin Güçlendirilmesi: Covid-19 Döneminde Aşı Tereddüdünün Ele Alınması

Muhammed Tümay[a]

[a] Dr. Öğr. Üyesi, Gümüşhane Üniversitesi, İktisadi, İdari ve Sosyal Bilimler Fakültesi, İktisat Bölümü, Gümüşhane/Türkiye, mtumay@gumushane.edu.tr, ORCID: 0000-0002-3226-3898 *(Sorumlu Yazar/Corresponding Author)*

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ABSTRACT

The COVID-19 pandemic started in 2019 with the emergence of a new coronavirus and has greatly affected societies worldwide. It has led to an increase in mortality rates, disturbed pre-existing health conditions, disrupted educational systems, and reduced global workforce productivity and production. The scientific community has expedited vaccine development to combat the pandemic. However, the emergence of various vaccines has paradoxically resulted in a decline in public confidence, contributing to anti-vaccine sentiments. This study explores the pivotal role of education in fortifying vaccination rates and seeks to identify effective strategies to address hesitancy and strengthen public health measures. This research uses the two-stage least squares (2SLS) methodology to analyze the "*Learning Loss Covid-19*" cross-sectional dataset, which the World Bank published on January 4, 2023. The investigation focuses on the relationship between "Vaccination rate (per person)" and "*Year of Education*" across 41 countries. The empirical findings show that education has a significant impact on vaccination rates. An increase of one year in educational attainment leads to an approximate 14% increase in doses administered per person and a substantial 23% surge in the average dosage across nations. Therefore, education plays a crucial role in fortifying and elevating vaccination rates, demonstrating its significance as a potent tool in global public health endeavours.

MAKALE BİLGİSİ

Makale Türü
Araştırma Makalesi

Anahtar Kelimeler
Sağlık Ekonomisi
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ÖZ

2019 yılında yeni bir korona virüsün ortaya çıkmasıyla başlayan COVİD-19 salgını, dünya çapında toplumlar üzerinde derin etkiler yarattı. Bununla birlikte, çeşitli aşıların ortaya çıkması, paradoksal olarak halkın güveninin azalmasına yol açarak aşı karşıtlığının artmasına neden oldu. Bu çalışma, aşılama oranlarının artırılmasında, tereddütlerin gidermesinde ve halk sağlığı önlemlerini güçlendirmede eğitimin rolünü belirlemeyi amaçlıyor. Araştırmada, Dünya Bankası tarafından yayınlanan 41 ülkenin yer aldığı "*Learning Loss Covid-19*" yatay kesit veri setinden yararlanılmıştır. Ayrıca, "Aşılama oranı (kişi başına)" ile "*Eğitim Yılı*" arasındaki ilişkiyi analiz etmek için iki aşamalı en küçük kareler (2SLS) yöntemini kullanılmıştır. Ampirik bulgular, eğitim düzeyindeki bir yıllık artış, kişi başına uygulanan dozlarda yaklaşık %14'lük bir artışa ve ülkeler genelinde ortalama dozda %23'lük bir artışa yol açmaktadır. Bu nedenle eğitim, aşılama oranlarının güçlendirilmesinde ve artırılmasında önemli bir rol oynamakta ve küresel halk sağlığı çalışmalarında güçlü bir araç olarak önemini ortaya koymaktadır.

1. Introduction

Vaccination, hailed as one of the most successful public health interventions in history, has played a pivotal role in preventing and controlling infectious diseases worldwide. It is important to remember that the history of vaccines goes back further than Edward Jenner's smallpox vaccine, which was developed in the late 18th century. In fact, as far back as the 7th century, some Buddhists used snake venom to increase immunity. In the 10th century, the concept of variolation

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or inoculation was used in China. However, Jenner's smallpox vaccine marked a significant turning point in the fight against deadly pathogens as it was the first successful vaccine developed (Plotkin, S. L., & Plotkin, S. A., 2012: 1). Over the years, vaccines have led to the near-eradication of devastating diseases like polio, measles, smallpox, and diphtheria (Orenstein, W. A., & Ahmed, R., 2017: 4031). However, despite these remarkable achievements, the acceptance and uptake of vaccines have not been uniform across populations.

Delaying acceptance or refusing vaccination despite its availability, known as vaccination hesitancy, presents a major obstacle to public health efforts. (Dubé, E. et al., 2013: 1763). This hesitancy is not a recent phenomenon but rather a complex interplay of historical, cultural, and socio-political factors that have evolved over centuries.

In the early 19th century, establishing the Anti-Vaccination League in England highlighted the emergence of organized opposition. Concerns about vaccine safety and efficacy, as well as apprehensions about government interference in personal health decisions, were pivotal in driving this early resistance (Blume, S., 2006: 628-632). These concerns were further compounded by religious and philosophical objections (in the Netherlands), as some groups held steadfast beliefs against vaccination.

In the 20th century, we have witnessed unprecedented successes in vaccination programs. The near-eradication of smallpox, a monumental feat achieved through widespread vaccination campaigns (like the Expanded Programme on Immunization), demonstrated the immense potential of immunization efforts (Fine, P. E., 1993: 265). Similarly, dramatic reductions in diseases like polio and measles were achieved, leading to the belief that many of these once-devastating illnesses could be consigned to the annals of history.

However, even amidst these triumphs, pockets of vaccine resistance persisted. Religious or philosophical objections presented unique challenges to vaccination efforts. Their beliefs often conflicted with the principles of vaccination, leading to pockets of under-immunized populations (Salmon, D. A. et al., 1999). Additionally, concerns about vaccine safety, while largely unfounded, continued to influence public perception.

The advent of the internet and social media platforms ushered in a new era in disseminating health information, including vaccine-related content. While these platforms offer unprecedented opportunities for communication and information-sharing, they also provide fertile ground for the rapid spread of misinformation. The proliferation of anti-vaccine rhetoric and the amplification of unfounded claims contributed to a resurgence of vaccine hesitancy in the latter half of the 20th century and into the 21st century (Nuzhath, T. et al., 2020, Puri, N. et al., 2020, and Wilson, S. L., & Wiysonge, C., 2020).

This resurgence was further exacerbated by the infamous MMR-autism controversy, where a discredited study, Wakefield, A. J. et al. (1998), falsely linked the MMR vaccine to autism. Despite extensive scientific evidence debunking this claim, its impact on public perception of vaccine safety was enduring, leading to declining vaccination rates and subsequent outbreaks of preventable diseases.

Understanding the historical context of vaccine hesitancy is crucial for developing effective strategies to combat this persistent public health challenge. By acknowledging the factors that have contributed to vaccine skepticism over time, public health authorities can tailor interventions to promote vaccine acceptance.

2. Literature Review

Vaccination is an indispensable cornerstone of primary healthcare and a fundamental human right, pivotal in upholding global health standards, as the World Health Organization (WHO) asserted. Vaccination significantly diminishes the susceptibility to a spectrum of diseases by fortifying the immune system. WHO reports that vaccination has been instrumental in averting over 20 life-threatening maladies, resulting in the annual preservation of 3.5 to 5 million lives (WHO, 2020). Nevertheless, the global vaccination landscape faced unprecedented upheaval in 2020-2021 due to the onset of the COVID-19 pandemic. Persistent endeavours are underway to rectify these disruptions and ensure the seamless resumption of vaccination services.

Several studies conducted in different countries prior to the COVID-19 pandemic have highlighted the connection between education and vaccination hesitancy, particularly between the education level of parents and the immunization of their children. For instance, Danis et al. (2010) discovered that low parental education was associated with low immunization rates in Greece. Educating women has a strong correlation with increased vaccination rates at both individual and community levels in Nigeria (Burroway, R., & Hargrove, A., 2018). In the USA, Bobo et al. (1993) found that children of mothers with higher levels of education were less likely to be under-immunized at any stage of their childhood. However, Wei et al. (2009: 1) found that vaccination refusers in the USA were more likely to reside in higher-income and well-educated areas compared to non-refusers. Moreover, the likelihood of a child being vaccinated was found to be lower if their caregiver had received some formal education compared to those caregivers without any formal education (Zhang, S. et al., 2011: 82). A high level of education among Dutch parents leads to a negative attitude towards child vaccination (Hak, E. et al., 2005: 3105).

Delving into the intricacies of vaccination hesitancy mandates a thorough recognition of its multifaceted origins. Scholarly investigations have illuminated that disparities in ethnicity, religion, gender, age, education, political affiliation, and income substantially contribute to COVID-19 vaccine hesitancy (Troiano, G. & Nardi, A., 2021: 246-249). Notably, among these findings, Olagoke et al. (2021) elucidate an inverse correlation between religiosity and the inclination to receive the COVID-19 vaccine. A comprehensive study conducted by Kreps et al. (2020) in the United States, involving 1971 adults, unravels a complex interplay of factors influencing vaccine selection. These encompass considerations of vaccine effectiveness, side effects, duration of protection, political nuances, vaccine origin, ethnicity, age, education, and income. The study underscores that women, individuals of black ethnicity, those with lower educational levels, and younger age groups exhibit lower proclivities towards vaccination. Intriguingly, a heightened propensity for vaccination is observed among individuals aligning with the Democratic Party.

Moreover, health engagement emerges as a significant factor positively correlated with the willingness to vaccinate, particularly among Italian adults (Graffigna et al., 2020: 4). Fisher et al. (2020) discern that females, young individuals, those from black or Hispanic backgrounds, individuals with lower educational and income levels, and those who did not receive the influenza vaccine were less likely to express intent to accept vaccination. Vaccine hesitancy may emanate from various sources, including specific concerns about the vaccine, informational gaps, anti-vaccine attitudes, or deep-seated mistrust (Detoc, 2020: 7005). Studies further underscore the impact of perceived safety and prevailing myths concerning the COVID-19 vaccine on acceptance rates. Individuals perceiving the vaccine as unsafe are less inclined to receive it, often owing to limited knowledge about the virus and susceptibility to misinformation (Kricorian et al., 2022: 1). Educational programs have emerged as a pivotal tool in enhancing attitudes toward vaccine acceptability (Kaim et al., 2021: 6).

Furthermore, demographic factors consistently play a role in vaccine acceptance across different countries. For instance, older females with higher educational qualifications in France and Germany are more likely to accept the vaccine. Similar patterns are observed in Poland, the UK,

and Russia. In Ecuador, India, and the US, individuals with high educational qualifications are more likely to accept the vaccine (Lazarus et al., 2020: 800). Abdulah (2021) conducted a study in Iraq Kurdistan, unveiling elevated rates of COVID-19 vaccine hesitancy associated with lower education levels and concerns about potential side effects. These insights emphasize the complex interplay of factors influencing vaccine hesitancy, providing valuable knowledge for formulating targeted public health interventions.

Conversely, Lazarus et al. (2020) suggest that higher education levels may be related to lower vaccine acceptance rates in Canada, Spain, and the UK. Dror et al. (2020) found that vaccine acceptance rates were similar between healthcare and non-healthcare workers. Similarly, Barello et al. (2020) discovered no significant differences in vaccine acceptance rates among healthcare students. Pogue et al. (2020) demonstrated that income had no noticeable correlation with attitudes toward vaccination. Palamenghi et al. (2020) reported that individuals in the middle age group were less willing to get vaccinated as compared to those between the ages of 18-34 and individuals above 60 years of age. Salali, G. D., & Uysal, M. S. (2022) reveal that having a graduate degree and children decreased the odds of vaccine acceptance in Turkey but not in the UK.

The Covid-19 pandemic has thrust vaccination hesitancy into the spotlight of public discourse. One potential determinant of vaccination hesitancy is education. Existing research indicates that individuals with higher levels of education are more likely to trust scientific information and possess a better understanding of the benefits of vaccinations. Hence, it is imperative to investigate the impact of education on vaccination hesitancy during the COVID-19 pandemic.

3. Data and Variables

This study examines the effects of education on vaccination rates to identify effective strategies for increasing vaccination rates and promoting public health using the "*Learning Loss Covid-19*" cross-sectional data published by the World Bank (World Bank, 2023). This dataset encompasses observations from 41 countries. The investigation zeroes in on the association between "*Vaccination rate (per person)*" as the dependent variable, and "*Years of Education*," "*Stringency of Lockdowns Index*," "*Democracy*," and "*Deaths*" as the independent variables. The instrumental variables enlisted encompass "*School Quality*," "*Weeks in which Schools were closed*," and "*Proportion of Private Schools*." Table 1 shows the definition and sources of variables.

Table 1: Variables Used in The Model

Variable	Definition	Source
Vac	Vaccination rate (doses per capita), includes all doses and boosters, average 2021	Our World in Data
Schooling	Years of education	Barro-Lee Educational Attainment Dataset
Stringency	Stringency lockdown index (2021 average)	Our World in Data
Polity	Democracy, polity2 variable, 2018	Center for Systemic Peace – Polity5 Dataset
Deaths	Death rate due to COVID, average 2021	Our World in Data
Hlo	School quality	WB - Harmonized Learning Outcomes (HLO) Database
Weeks	Weeks schools closed on average 2021	WB - Learning Loss Covid-19
Private	Proportion of private schools in country, primary, 2019	WB - World Development Indicators

Sources: World Bank-Learning Loss Covid-19 dataset. Access address: https://microdata.worldbank.org/index.php/catalog/5367

Table 2: Descriptive Statistics

Variables	Mean	Std. Dev.	Min	Max
Vac	59.769	32.171	1.905	115
Schooling	9.438	2.756	2.3	13.18
Stringency	56.294	8.901	42.254	72
Polity	7.024	4.757	-7	10
Deaths	152.359	125.558	1.09	492.49
Hlo	462.083	89.969	229.175	569.013
Weeks	20.78	18.206	0	93
Private	14.843	14.097	0.385	62.633

Descriptive statistics for the variables under consideration are presented in Table 2. The vaccination rate ranges from 1.9 to 115, with the highest education level being 13.2 years and the lowest at 2.3 years. When examining countries based on the stringency lockdown index, Greece boasts the highest index at 72, while Malawi exhibits the lowest at 42.3. Notably, the polity, indicative of democratic governance, attains its highest values in advanced economies, except for Turkey. The death rate spans from 1.1 to 492.5, and the school quality metric reaches its zenith in Japan at 569, contrasting with the lowest value of 229.2 in Ghana. India records the most prolonged duration of school closures, with 93 weeks, while Sweden, in contrast, has not closed schools throughout the observed period. Based on the proportion of private schools in countries, Chile has the highest index at 63, while the Netherlands exhibits the lowest at 0.4.

4. Estimation Strategy

This study employs Two-Stage Least Squares (2SLS) regression analysis to investigate the effects of education on vaccination rates using the "*Learning Loss Covid-19*" cross-sectional data from the World Bank. The dataset spans observations from 41 countries. The primary focus is on understanding the relationship between "*Vaccination rate*" as the dependent variable and several independent variables, namely "*Years of Education*," "*Stringency of Lockdowns Index*," "*Democracy*," and "*Deaths*" (Newbold, S. C. et al., 2020).

Instrumental variables are introduced in the model to address potential endogeneity issues. The chosen instrumental variables include "*School Quality*," "*Weeks in which Schools were closed*," and "*Proportion of Private Schools*." These instruments are selected based on their relevance and assumed exogeneity to the endogenous variable, mitigating the impact of potential omitted variable bias.

The 2SLS methodology is implemented through a two-step process (Basmann, R. L., 1957, 1959). In the first stage, the endogenous variable, "*Years of Education*," is regressed on the instrumental variables:

$$\text{Years of Education}_i = \pi_0 + \pi_1 \text{School Quality}_i + \pi_2 \text{Weeks}_i + \pi_3 \text{Private Schools}_i + \eta_i \quad (1)$$

Where π_0 is the intercept, π_1 to π_4 are the coefficients associated with the instrumental variables, "*School Quality$_i$*," "*Weeks in which Schools were closed$_i$*," and "*Proportion of Private Schools$_i$*" are the instrumental variables, η_i is the error term.

The results from this stage provide the predicted values of "*Years of Education*," denoted as $\widehat{Years\ of\ Education}_i$, which are then utilized in the second stage.

In the second stage, the original regression model is estimated using the predicted values obtained from the first stage:

$$\text{Vaccination Rate}_i = \beta_0 + \beta_1 \widehat{\text{Years of Education}}_i + \beta_2 \text{Stringency}_i + \beta_3 \text{Democracy}_i + \beta_4 \text{Deaths}_i + \epsilon_i \quad (2)$$

Where $\widehat{Years\ of\ Education}_i$ represents the predicted values of "*Years of Education*" from the first stage, β_0 is the intercept, and β_1 to β_4 are the coefficients of interest.

To assess and address potential endogeneity concerns in this study, two sets of tests are employed after the 2SLS estimation. Initially, the Durbin (1954) and Wu–Hausman (Wu, 1974; Hausman, 1978) statistics tests are applied to analyze the 2SLS estimation without a robust Variance-Covariance Matrix (VCE). Subsequently, to further fortify the analysis against endogeneity issues, Wooldridge's (1995) robust regression-based test are conducted on the 2SLS estimation with a robust VCE. This comprehensive approach ensures a rigorous examination of potential endogeneity, enhancing the reliability and validity of the results. For assessing the validity of the instrumental variables used in the analysis, Sargan's (1958) and Basmann's (1960) tests (overidentification) are employed after 2SLS estimation. Additionally, Wooldridge's (1995) robust score test is utilized to ensure the reliability of the instruments. Also, GMM estimation is applied to calculate Hansen's (1982) J statistic for the overidentification test.

This two-stage approach allows for a comprehensive examination of the impact of education on vaccination rates while systematically addressing potential endogeneity concerns associated with the "*Years of Education*" variable.

The analysis accounts for the potential influence of "*School Quality*," "*Weeks in which Schools were closed*," and "*Proportion of Private Schools*" on education and, consequently, on vaccination rates. By utilizing instrumental variables and 2SLS regression, the study aims to provide a robust analysis that addresses endogeneity concerns, offering insights into the effectiveness of education-related strategies in increasing vaccination rates and promoting public health across diverse countries during the specified timeframe.

5. Results

The study employs instrumental variable (IV) estimators to calculate the effects of education on vaccination rates. Table 3 shows estimation results of 2SLS without a robust VCE, 2SLS with a robust VCE, and GMM (Overidentification) with a robust VCE. Table 4 indicates the test results of IV estimators.

Table 3: Estimation Results of 2SLS and GMM (Overidentification)

Variables	(1) 2SLS without a robust VCE	(2) 2SLS with a robust VCE	(3) GMM with a robust VCE
Schooling	13.914*** [2.687]	13.914*** [2.297]	12.579*** [2.032]
Stringency	0.973** [0.468]	0.973** [0.475]	0.746* [0.409]
Polity	-2.532** [1.177]	-2.532** [1.096]	-2.155** [1.036]
Deaths	-0.020 [0.038]	-0.020 [0.035]	-0.021 [0.032]
R-squared	0.382	0.382	0.433
Observations	41	41	41

Notes: Models use three control/covariate variables. These are stringency of lockdowns index, democracy, and deaths. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively. [ ] are standard error terms.

The first column of Table 3 shows the results of 2SLS without a robust VCE, representing the effect of schooling on the vaccination rate. The positive and highly significant impact of schooling of 14% on the vaccination rate indicates that an additional year of educational attainment leads to a 14% increase in doses administered per person. The third column of Table 3 shows the results of GMM with a robust VCE, representing the effect of years of education on the vaccination rate. The positive and highly significant impact of education of approximately 13% on the vaccination rate reveals that an increase of one year in educational attainment leads to a 13% increase in doses administered per person. It has been observed that the Stringency lockdown measures have a

positive and significant impact on the rate of vaccination. On the other hand, the polity variable, commonly known as Democracy, has a negative and significant impact on the vaccination rate. Additionally, the death rate due to the COVID-19 has a negative impact on the vaccination rate, but it is not significant.

Table 4: Test Results of IV Estimators

Tests	(1)	(2)	(3)
	2SLS without a robust VCE	**2SLS with a robust VCE**	**GMM with a robust VCE**
Endogeneity		**Robust Score**	**GMM C statistic chi2(1)**
Durbin (score) chi2(1)	9.262 (0.0023)	7.859 (0.0051)	4.717 (0.0299)
Wu-Hausman F(1,35)	10.213 (0.0030)	10.684 (0.0024)	
Weak IV			
F(3,34)	9.607	16.185	16.185
Minimum Eigenvalue	9.607	-	-
	{9.08}		
Adjusted R-squared	0.6052	0.6052	0.6052
R-squared	0.4588	0.4588	0.4588
Overidentification		**Robust Score chi2(2)**	**Hansen's J chi2(2)**
Sargan (score) chi2(2)	4.312 (0.1158)	3.843 (0.1464)	3.843 (0.1464)
Basmann chi2(2)	3.996 (0.1356)		

Notes: The table indicates tests of the coefficients. There are two types of parentheses. () are p-value of test scores. { } is the critical value of 2SLS relative bias at 10% levels.

In Table 4, The Durbin and Wu-Hausman tests reveal that the schooling variable is endogenous, and the p-values of the test scores are highly significant, which means that we can reject the null hypothesis that schooling is an exogenous variable. To solve the endogeneity issue, we examined the test scores and found that the variables we used (school quality, weeks in which schools are closed, and proportion of private schools) were not weak. Moreover, the adjusted R-squared and R-squared values indicate that the instruments used highly correlate with the endogenous variable, making the instrumental-variables estimators confirm less bias. However, the F statistic value should also be checked, and the F statistic should be greater than the critical value at the 10% level to ensure the reliability of inference based on the 2SLS estimator if there is one endogenous regressor (Stock, J. H. et. Al., 2002). The test statistic in the results is 9.607, which is significant at the 10% level, and the model contains one endogenous regressor, so we can conclude that the instrumental variables are not weak.

When we look at the overidentification test scores in Table 4, both test statistics are insignificant, which means we can reject that the instruments are invalid or that the structural model is specified incorrectly. The second column of Table 4 shows the results of 2SLS with a robust VCE, which are almost identical to column 1. Finally, The GMM C statistic can reject the null hypothesis that schooling is exogenous at the 5% level, and other test results are almost identical to the 2SLS models in columns 1 and 2.

It is clear that the study's findings align with the existing literature, specifically regarding the relationship between education and vaccination hesitancy during the COVID-19 pandemic. The study supports previous research emphasizing the multifaceted origins of vaccine hesitancy. Similar to the results of Lazarus et al. (2020), Fisher et al. (2020), Kreps et al. (2020), and Kaim et al. (2021), the study highlights the positive interplay of factors, such as education, in shaping attitudes towards COVID-19 vaccination. These parallel findings strengthen the collective understanding of

the intricate dynamics surrounding vaccine acceptance and hesitancy, providing valuable insights for public health interventions.

6. Conclusion

The examination of the impact of education on vaccination rates through a comprehensive analysis using instrumental variable (IV) estimators has revealed compelling insights. The findings from this study, based on the "*Learning Loss Covid-19*" dataset spanning observations from 41 countries, highlight the crucial role of education in bolstering vaccination rates.

The results indicate a significant positive correlation between educational attainment and vaccination rates. Specifically, an increase of one year in educational attainment leads to a substantial rise in doses administered per person, 14% and approximately 13%, according to 2SLS and GMM estimations, respectively. Moreover, the analysis shows a remarkable increase of approximately 23% in the average dosage across nations associated with a one-year rise in educational attainment. These findings emphasize the profound impact of education in promoting vaccination rates, highlighting its significance as a potent tool in global public health endeavors during the specified timeframe.

Addressing potential endogeneity concerns through appropriate tests and robust estimations, the study confirms the endogenous of the schooling variable. However, the instrumental variables employed in the analysis demonstrate strength and relevance, showcasing solid correlations with the endogenous variable and mitigating potential biases in the estimators.

Furthermore, the comprehensive overidentification tests indicate the validity of the instrumental variables used in the analysis, reinforcing the robustness and reliability of the findings. Despite the complexity associated with vaccination hesitancy and the multifaceted determinants influencing public attitudes toward vaccines, this study emphasizes the pivotal role of education as a promising tool for promoting vaccine acceptance and enhancing public health outcomes across diverse countries.

These results hold significant implications for policymakers, public health authorities, and education stakeholders. The findings have shed light on the complex interaction of various factors that affect vaccination rates. The study shows that strict lockdown measures have a positive and significant impact on increasing vaccination rates. This suggests that strong public health measures can help to improve the vaccination rates. However, the study also indicates a negative and significant effect of democracy on vaccination rates. This calls for a closer examination of the socio-political dynamics that may be hindering effective vaccine distribution and uptake. Policymakers should pay special attention to potential barriers within democratic systems that may prevent people from vaccinating.

Although the COVID-19 death rate seems to have a negative impact on vaccination rates, it is important to interpret this cautiously because its lack of significance suggests that this relationship may be more complex. Further research could provide a more nuanced understanding of the interplay between mortality rates and vaccination efforts.

In light of these findings, it is recommended that policymakers prioritize educational efforts as a crucial part of comprehensive vaccination strategies. Improving access to education and ensuring its quality can have a significant impact on public health outcomes. Additionally, it is important to carefully examine democratic structures and potential barriers within these systems to optimize vaccination campaigns. By acknowledging and addressing these factors, policymakers can contribute to the development of robust and effective vaccination policies that align with broader public health goals.

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Appendix

Table A1. Countries

Countries	Region Codes	Vaccination Rate	Population
Argentina	Latin America and the Caribbean	65,1	45.000.000
Australia	Advanced Economies	64,0	26.000.000
Bangladesh	South Asia	17,0	170.000.000
Belgium	Advanced Economies	87,0	11.000.000
Botswana	Sub-Saharan Africa	12,0	2.300.000
Brazil	Latin America and the Caribbean	64,0	210.000.000
Cambodia	East Asia and the Pacific	82,0	16.000.000
Canada	Advanced Economies	87,4	37.000.000
Chile	Latin America and the Caribbean	115,0	19.000.000
China	East Asia and the Pacific	105,0	1.400.000.000
Colombia	Latin America and the Caribbean	49,0	50.000.000
Czech	Europe and Central Asia	70,0	11.000.000
Denmark	Advanced Economies	88,0	5.800.000
England	Advanced Economies	104,0	55.000.000
Ethiopia	Sub-Saharan Africa	3,0	110.000.000
Finland	Advanced Economies	89,0	5.500.000
France	Advanced Economies	82,0	67.000.000
Germany	Advanced Economies	81,0	83.000.000
Ghana	Sub-Saharan Africa	5,0	31.000.000
Greece	Advanced Economies	76,0	11.000.000
Hungary	Europe and Central Asia	42,0	9.800.000
India	South Asia	36,0	1.400.000.000
Indonesia	East Asia and the Pacific	33,0	270.000.000
Italy	Advanced Economies	85,0	60.000.000
Japan	Advanced Economies	80,0	130.000.000
Kenya	Sub-Saharan Africa	6,0	53.000.000
Korea	East Asia and the Pacific	73,0	19.000.000
Malawi	Sub-Saharan Africa	4,2	130.000.000
Mexico	Latin America and the Caribbean	41,0	29.000.000
Nepal	South Asia	24,0	17.000.000
Netherlands	Advanced Economies	78,0	5.300.000
Norway	Advanced Economies	82,0	38.000.000
Poland	Europe and Central Asia	62,0	140.000.000
Russia	Europe and Central Asia	44,0	59.000.000
South Africa	Sub-Saharan Africa	16,0	52.000.000
Spain	Advanced Economies	82,0	47.000.000
Sweden	Advanced Economies	79,0	10.000.000
Switzerland	Advanced Economies	75,0	8.600.000
Turkey	Advanced Economies	72,0	83.000.000
Uganda	Sub-Saharan Africa	1,9	44.000.000
United States	Advanced Economies	89,0	330.000.000

Notes: The table provides information on the region codes, vaccination rates, and population for 41 countries. There are 6 types of regions. These are “Sub-Saharan Africa,” “Latin America and the Caribbean,” “South Asia,” “East Asia and the Pacific,” “Europe and Central Asia,” and “Advanced Economies”. With the exception of Turkey, the term "Advanced Economies" refers to high-income countries. Generally, education and vaccination rates are higher in high-income countries, while lower-income countries tend to have lower education and vaccination rates. Given this information, it has been decided to use data from different country groups to measure the relationship between education and vaccination.