

Covid-19, Vaccination Rates, Infection Rates, Death Rates and Behavioral Interventions: It's Time to Cut the Bull!

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Abstract

Efficacy of SARS-CoV-2 (COVID-19) vaccines was assessed by comparing infection and death rates in the eight most- and eight least-fully-vaccinated German states. Infection and death rates were measured on three dates in fall 2021. Less-vaccinated states had substantially higher infection and death rates than more-vaccinated states. These effects occurred in the context of a time main effect and a vaccination rate x time interaction: Infection and death rates increased substantially over time, particularly in less-vaccinated states. These increased infection and death rates over time may be due to Germany having few measures other than vaccination in place for controlling the spread of COVID-19, despite the high community prevalence of the Delta variant. The results are discussed in the context of anti-vax rhetoric, policy, strategies for quelling the pandemic, the lack of a synergistic research relationship between the social and medical sciences, and issues related to vaccine equity.

Keywords: COVID-19; Vaccination Rates; Death Rates; Behavioral Interventions

Introduction

Whereas clinical trials, which constitute the gold standard for assessing vaccines' efficacy in preventing infection, have shown that COVID-19 vaccines significantly reduce the likelihood of infection, field studies are important for several reasons [1]. First, sample sizes in clinical trials are too small to reliably estimate efficacy for low-frequency outcomes such as hospitalizations and deaths. Second, it is important to examine how vaccines perform in the context of other factors that influence the spread of COVID-19, such as the emergence of new, more infectious variants, differences in the nature of non-pharmaceutical interventions (NPIs) such as mask mandates or physical distancing requirements in different locales, seasonal changes that influence behavior related to viral spread (e.g., cold weather driving people indoors), or relevant demographic features of different countries such as the median age of their populations [2-7]. Even if more highly vaccinated groups retain relative protection compared to less-vaccinated groups as circumstances change, absolute rates of infection or other adverse outcomes may change with those changed circumstances in both the vaccinated and the unvaccinated.

We have shown that the timing and scope of public health measures aimed at limiting COVID-19 infection rates, such as mask mandates, is very strongly associated with COVID-19 infection and death rates, which vary across countries by a

factor of several hundred [7]. In fact, we argued, it is likely that variations in social behavior, including both differences in governmental policy (e.g., border lockdowns, mask mandates, and physical distancing requirements) and differences in individuals' conduct (e.g., compliance with mask mandates), have a greater immediate impact on infectious disease rates than vaccines and, moreover, dropping other policies aimed at controlling the spread of COVID-19 and relying exclusively on vaccines when there is still a very large unvaccinated segment of the population can be expected to backfire and result in infection spikes even with moderately high vaccination rates. Thus, given the fact that the Delta variant of SARS-CoV-2 is more than twice as contagious as the original virus (and the Omicron variant is approximately twice as contagious as Delta), and the exponential nature of viral spread, it is unsurprising that countries that dropped most other protective measures have been hit hard by spikes in cases over the past few months [8]. In fact, several European countries faced their highest infection rates of the entire pandemic during the Omicron wave, despite having the majority of their populations vaccinated.

Given that so many factors other than vaccines have such a substantial impact on COVID-19 case as well as death rates, effects of vaccines may very well be obscured in comparisons of regions differing widely in ways other than their vaccination rates (climate, median age, policy, culture, etc.) that substantially impact

infection or death rates. As our own recent research suggests, that appears to be precisely what happened in a recently published study by Subramanian and Kumar which found no differences in COVID-19 infection rates as a function of vaccination rates across 68 countries [8, 9]. This resulted, unfortunately but predictably, in their study being cherry-picked by anti-vaxxers as “proof” that vaccines do not work [10].

Accordingly, to better assess the role of vaccination rates in rates of COVID-19 infections and deaths, we examined the relationship between the full vaccination rates and infection and death rates of the 16 German states during the current European surge. We expected that, given that we were examining different regions of a single country that does not cover a particularly large geographical area, does not have wide variation in relevant demographic factors such as age, has many of its public health policy decisions made on a national rather than state by state level, and is relatively culturally homogeneous, we would find a substantial relationship between vaccination rates and COVID-19 infection and death rates, even though the difference between the vaccination rate of the most-vaccinated state (Bremen) and the least-vaccinated state (Saxony) was less than 20% at the time of our study.

We split the 16 German states into eight higher and eight lower full vaccination rate groups, and measured infection and death per hundred thousand rates on three dates in the fall of 2021. Given that Germany, like many other European countries, removed most NPIs in the fall and relied almost exclusively on vaccines to limit COVID-19 spread despite the prevalence of the highly infectious Delta variant, we expected a large main effect for time, with infection and death rates increasing for both groups of states [11-14]. However, we expected the higher vaccination rate states to substantially outperform the lower rate states, and expected this difference to increase over time (i.e., a significant vaccination rate x time interaction).

Methods

Patients and Public Involvement

There were no patients involved in the study.

Procedure

We performed a median split on the rates of fully vaccinated people in all 16 German states, resulting in eight less-vaccinated and eight more-vaccinated states [15]. We measured infection and death per hundred thousand rates on October 18, November 18, and December 1, 2021[16].

Results

Two (rate: low, high) x 3 (time) mixed-model *analyses of variance* (ANOVAs) were conducted on the infection and death measures. For infections, there was a main effect for vaccination rate with the higher-rate states ($M = 24.50$, $s = 7.56$) outperforming the lower-rate states ($M = 59.96$, $s = 29.74$), $F(1, 14) = 10.68$, $p < .007$, $\eta_p^2 = .43$. There was also a main effect for time, with all rates increasing over time, $F(2, 28) = 45.46$, $p < .001$, $\eta_p^2 = .76$. Both main effects occurred in the context of a significant vaccination

rate x time interaction, $F(2, 28) = 10.10$, $p < .001$, $\eta_p^2 = .42$. There was a far smaller increase in infection rates over time in the higher ($M_s = 7.25, 24.50$, and 41.75 at times 1, 2, and 3, respectively; $s = 2.71, 8.85$, and 12.90 , respectively) than in the lower rate states ($M_s = 11.50, 60.87$, and 107.50 at times 1, 2, and 3, respectively; $s = 4.69, 32.80$, and 54.53 , respectively). *Fisher's Least Significant Difference (LSD)* tests indicated that all means differed at the $p < .05$ level. In short, the pattern of results shows that less-vaccinated states had much higher infection rates than more-vaccinated states, and this difference increased over time, but all states exhibited substantial increases in infection rates across the three dates [1].

On the death measures, the pattern of effects was similar. There was a main effect for vaccination rate, with the higher-rate states ($M = 0.11$, $s = 0.03$) outperforming the lower-rate states ($M = 0.31$, $s = 0.17$), $F(1, 14) = 10.90$, $p < .005$, $\eta_p^2 = .44$. There was a main effect for time with all rates increasing over time, $F(2, 28) = 21.53$, $p < .001$, $\eta_p^2 = .61$. Both main effects occurred in the context of a significant vaccination rate x time interaction, $F(2, 28) = 8.80$, $p < .001$, $\eta_p^2 = .39$. For the higher-rate states, there was a far smaller increase in deaths over time ($M_s = .05, .10$, and $.16$ for times 1, 2, and 3, respectively; $s = .03, .05$, and $.03$, respectively) than in the lower-rate states ($M_s = 0.07, .28$, and $.58$ for times 1, 2, and 3, respectively; $s = 0.03, 0.14$, and 0.37 , respectively). *LSD* tests indicated that all means differed at the $p < .05$ level except for the higher-rate time 2 and lower-rate time 1 means, which differed at the $p < .10$ level. In short, as was the case with infections, lower-rate states performed significantly more poorly than higher-rate states, and this difference increased over time. At the same time, both higher-rate and lower-rate states exhibited increased death rates over time, consistent with there being few mitigations in place other than vaccines in the context of a prevalent, extremely infectious variant.

Discussion

Our results provided strong evidence that COVID-19 vaccines substantially reduce infection and death rates. We found significant main effects for vaccination rate: The higher-rate states had higher infection ($\eta_p^2 s = .43$) and death ($\eta_p^2 s = .44$) rates than the lower-rate states. We also found a significant rate x time interaction, with the gap between higher-rate and lower-rate states increasing over time for both infections and deaths, providing further evidence of vaccine efficacy. The large effects we obtained are striking given that we only had 16 data points for each date for our dependent variables, and given that the mean vaccination rate of the high-rate group (72%) was less than 9% greater than the low-rate group's (63.7%).

Thus, although a double-blind clinical trial with random assignment is a “cleaner” test of vaccine efficacy than comparing regions differing in vaccination rates, German states are sufficiently similar in terms of demographics, governmental policies, and conduct as well as geographically proximate that the “signal” of vaccines’ impact on infection and death rates generally comes through loud and clear above the “noise.” In contrast, in a previous study that compared countries with higher and lower vaccination

rates, our effect size did not become strong until we covaried out other factors strongly associated with infection rates [7]. There are many variables such as cultural individualism vs. collectivism, obesity, cultural tightness/looseness, the presence or lack of mask mandates, median age, etc. that are related to COVID-19 infection and death rates and differ substantially between countries, making it more difficult to “see” the powerful impact of vaccines than it is in a country like Germany [7].

Although there is considerable evidence on the individual level (i.e., in comparisons of vaccinated and unvaccinated individuals) that COVID-19 vaccinations significantly reduce rates of infection, transmission of the virus by infected individuals, and severe illness or death, there has been comparatively little evidence at the population level (i.e., involving comparisons of regions differing in vaccination rates). Our results are an important addition to that body of evidence [17-19].

We also found significant main effects for time, with states’ infection and death rates increasing substantially between the first and last dates for which we collected infection and death rate data. The implications of this finding are in our view equally as important as our other effects. Germany, like many other countries in Western Europe, eliminated most measures to limit the spread of COVID-19 other than vaccination once it reached a moderately high vaccination rate (65.3% fully vaccinated as of October 18) [1, 11-13, 20]. For instance, masks were not mandated in schools even though few children were vaccinated, and restaurant reservations were running close to pre-pandemic levels throughout the fall [14, 21]. In short, whether because they deemed it better for corporate profits, because they overestimated the capacity of the vaccines to limit spread in the face of more contagious variants of the virus, because they failed to acknowledge that SARS-CoV-2 is an airborne virus, or for some combination of reasons, government officials throughout the West relied almost exclusively on mass vaccination to control the spread of COVID-19, and largely reverted to a “business-as-usual (pre-pandemic)” state of affairs, whereas this is less the case throughout Asia and the Pacific Islands [7, 22]. The dramatic increase in the number of cases that resulted from the dominance of the ultra-contagious Omicron variant, estimated to be the second-most contagious virus in history, has made clear that this approach has failed miserably [23]. Even Spain and Portugal, with more than 80% of their populations vaccinated, have had record numbers of cases.

Of course, community prevalence of infectious diseases depends on vaccination rates, as our data show. We believe that it is an important milestone in the battle against the pandemic that many countries have mandated COVID vaccinations in many public indoor spaces, and some are mandating them for all citizens, because a vital aspect of using vaccines to control the spread of infectious diseases is reaching a very high population level of vaccination, something unlikely to otherwise be achieved in countries with high levels of vaccine hesitancy [24]. That will have to be achieved on a worldwide basis, which has not happened so far because pharmaceutical companies have limited access of poor

countries to vaccines through their patent protections [25]. Steps are being taken to address this issue: Peter Hotez and his team at Baylor University have developed an inexpensive vaccine that is being made available on a not-for-profit basis with no patent protections, and China recently announced that it was making 2 billion vaccines available to other countries cheaply or for free[26, 27].

But vaccines alone are not going to “solve” the pandemic. In fact, behavioral interventions are arguably more important for bringing infectious diseases under control than vaccines are. Evidence suggests that lockdowns (broadly defined as measures to limit public indoor social contact) substantially decrease the number of new confirmed infections, and countries or regions that implemented lockdowns shortly after their first case (i.e., early 2020, prior to the availability of vaccines) had fewer deaths and hospitalizations than those that implemented them later[28-30]. So successful were countries such as China and New Zealand at bringing COVID-19 infection rates under control through border controls and quarantines, effective contact tracing, closures of non-essential businesses (with adequate financial compensation for those affected), and universal, mandatory mask-wearing that they have been able to live relatively normal lives, without fear of the virus, the majority of the time since these early lockdowns[4, 5, 31]. As a result, not only was their economic performance better, but their infection and death rates have been dozens or hundreds of times lower than many Western countries[31, 32].

Ending a pandemic involving a virus as highly contagious as recent SARS-CoV-2 variants is a daunting challenge and will require both the steps toward near-universal vaccination outlined above and a recognition that a panoply of infection control measures will be needed to rein COVID-19 infections in [7, 8, 33-38]. History has shown that highly contagious and deadly diseases such as polio and smallpox can be brought under control. Whether and when we do so with COVID-19 is up to us: Let’s cut the bullshit.

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