COVID-19 Impact Analysis: Cases, Deaths, and Vaccination Rates Across Six Countries

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1 Executive Summary

This report details a study of COVID-19 confirmed cases, deaths, and vaccination rates across Canada, France, Germany, India, the UK, and the US from February 2020 to July 2023. It shows the impact of vaccination on pandemic outcomes. Studies state that countries, including the US and UK, saw a decrease in both cases and deaths when vaccination uptake began at the onset of the pandemic. This analysis shows how vaccination has a proportionately large effect relative to decreasing pandemic numbers.

2 Introduction

Since early 2020, countries around the globe have experienced COVID-19 to different extents. Governments responded with measures like testing, lockdowns, and mass vaccination, but the outcomes varied signifi-

cantly. This study compares Canada, France, Germany, India, the UK, and the US to understand the contrast in outcomes. It researches time series data on confirmed cases, deaths, and vaccination rates from 2020 to 2023. The primary question focuses on the role of vaccination in decreasing case numbers and mortality rates. Vaccination programs started at varying times, with richer nations beginning earlier. For example, Canada and the United States started vaccinations in December 2020, while India began in January 2021. This study aims to provide insight into successful responses to the pandemic. It highlights the importance of vaccination in reducing the spread and severity of the virus.

3 Methodology

Data Source:

We used publicly available datasets from Our World in Data, including:

- Confirmed COVID-19 case numbers (Ritchie et al. 2020a)
- COVID-19 death data (Ritchie et al. 2020b)
- COVID-19 vaccination data (Ritchie et al. 2020c)

Time Range Validation:

- Confirmed Cases: February 1, 2020 - February 1, 2023
- Death Rates: February 1, 2020 - February 1, 2023
- Vaccination Data::

The vaccination dataset was obtained from Our World in Data. We observed that different countries had different vaccination start and end dates. For example, Canada and the US began recording vaccinations in December 2020, while India started in mid-January 2021. These differences are likely due to unequal access to vaccines and different national data reporting schedules.

To ensure fair comparisons, we limited our analysis to the overlapping period across all six countries: from January 16, 2021 to September 4, 2022. This allows for consistent visualization and avoids bias caused by missing early or late-stage data in certain countries.

Data Cleaning and Preprocessing:

Data cleaning was performed in R using the tidyverse and lubridate packages. First, records with missing

vaccination rates (doses per million) were excluded using filter(!is.na(…)) to keep consistency in the analysis. Column names were standardized, and all datasets were reshaped from wide to long format via pivot_longer() to facilitate merging.

Dates were parsed using ymd() to create uniform date objects. Death data, initially provided per 100,000 people, was converted to per million by multiplying by 10 to align with the scale of other variables.

The confirmed case and vaccination datasets were merged by country and date. This combined data was further joined with the cleaned death dataset to form a unified, time-aligned dataset with complete metrics for each country.

Data Analysis Strategy:

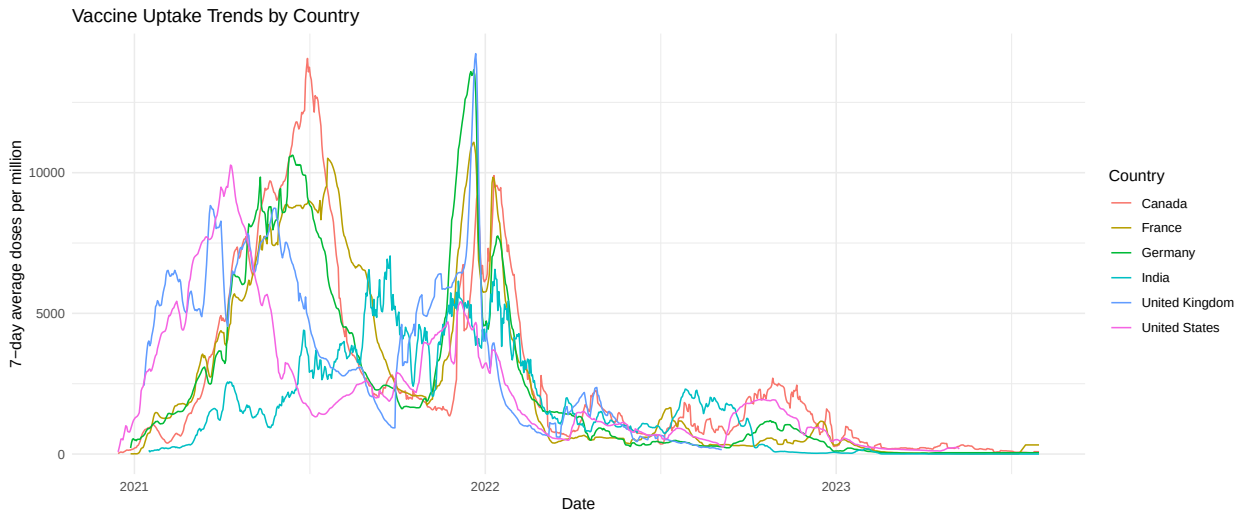

Figure 1: Figure: COVID-19 vaccine: 7-day average doses per million (by country)

Table 1: Table: Summary of vaccination data coverage (start-end date by country)

Country	Start	End
Canada	2020-12-15	2023-07-31
France	2020-12-28	2023-07-31
Germany	2020-12-28	2023-07-31
India	2021-01-16	2023-07-31
United Kingdom	2021-01-11	2022-09-04
United States	2020-12-15	2023-05-09

The resulting dataset was used to explore trends in vaccination coverage and pandemic progression through visualizations and a 7-day lag analysis. Figure 1 illustrates the 7-day average vaccination rate per million, highlighting varied rollout speeds. Table 1 summarizes the vaccination data coverage period for each country, confirming early rollout in high-income countries and delayed coverage in others.

These preprocessing steps ensured data quality, consistency, and meaningful cross-country comparisons throughout the analysis.

4 Results

The analysis across six countries shows key patterns in the relationship between COVID-19 cases, deaths, and vaccination. The daily changes in COVID-19 case and vaccination rates in Figure 2 shows that large outbreaks triggered spikes in vaccination, indicating reactive public health responses. Similarly, Figure 3, shows that vaccines were often given after case numbers had already started rising.

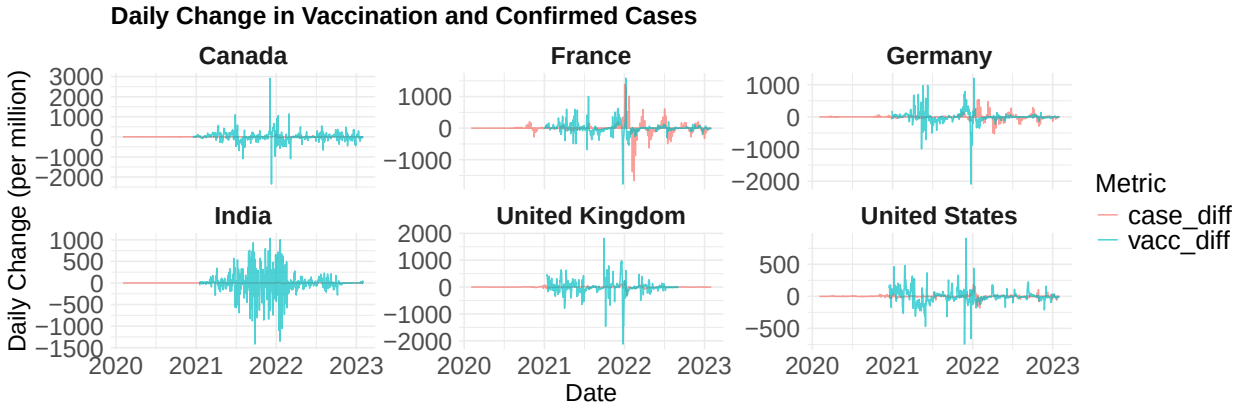

Figure 2: Figure: Daily changes in confirmed cases and vaccine doses per million

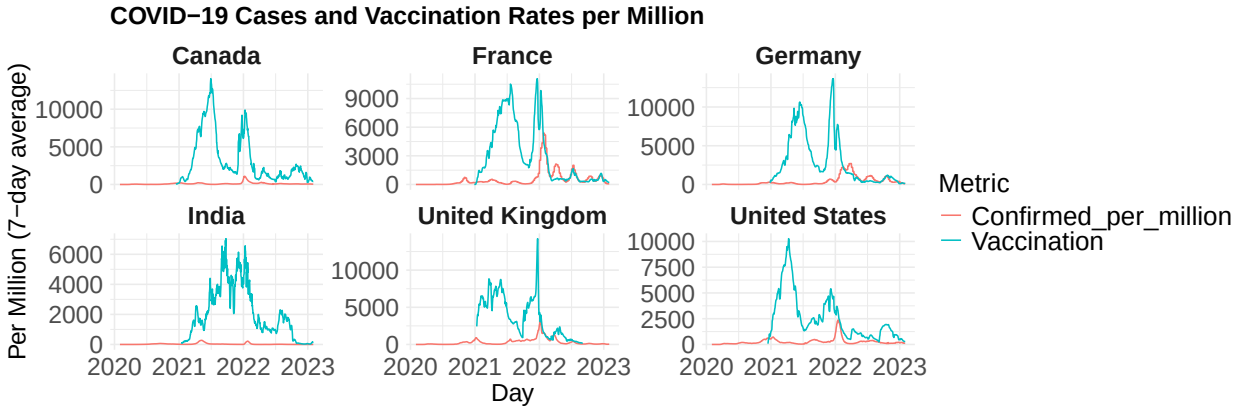

Figure 3: Figure: Comparison of confirmed cases and vaccination rates per million (by country)

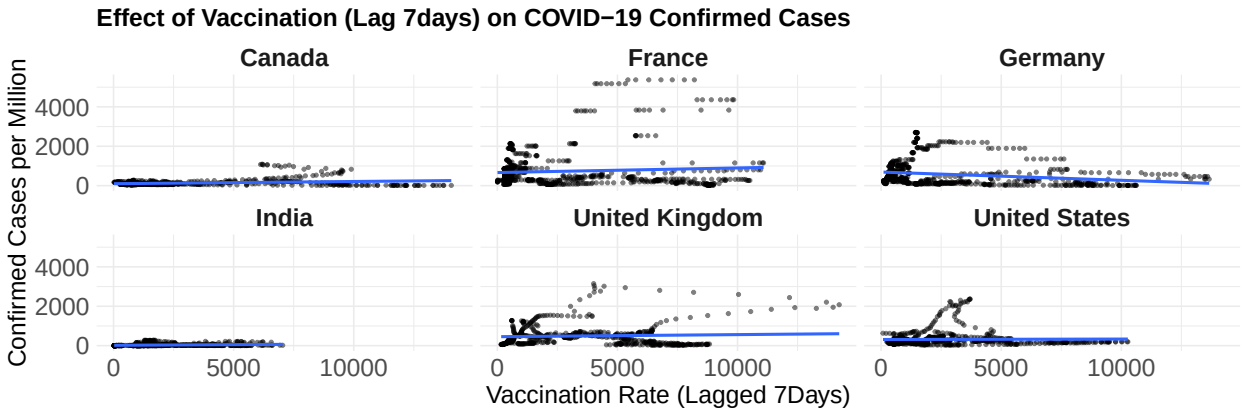

Figure 4: Figure: Lagged vaccination rate vs confirmed cases (7-day lag, by country)

A 7-day lag analysis Figure 4 shows that higher vaccination rates were followed by declines in new case numbers, particularly in countries like the US and UK. This suggests that vaccines helped slow the spread of the virus.

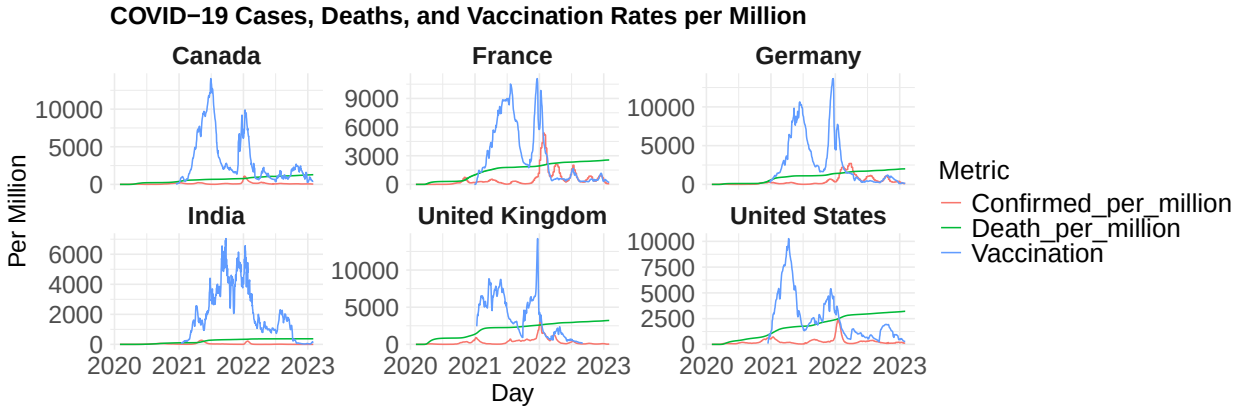

Figure 5: Figure: COVID-19 confirmed case-death rates-vaccination by country)

Figure 5 illustrates the trends in confirmed COVID-19 cases, deaths, and vaccination rates per million across six countries. In the early stages of the pandemic, when vaccines were not yet available, the number of deaths closely followed confirmed cases. However, in later waves, as vaccination coverage expanded, deaths did not rise in proportion to case numbers. This growing gap suggests that vaccines played a key role in reducing the severity of outcomes, even when transmission rates remained high.

The overall findings show that vaccination contributed to lower death rates and reduced the impact of major outbreaks when implemented early and consistently.

5 Discussion

1. Case rates depend heavily on how much testing was available and how consistently it was used. Some countries, particularly in early stages of the pandemic, had limited testing capacity, meaning many infections may have gone unrecorded. In contrast, countries with widespread and frequent testing likely reported more cases, even among people with mild or no symptoms.
2. The differences in how countries report COVID-19 deaths may affect the accuracy of comparisons. For example, some countries may only record deaths that occur in hospitals, while others include deaths that happen at home. This means that countries with more limited reporting systems could appear to have lower death rates, even if the actual impact was higher.

6 Conclusion

During the project, we analyzed numbers of confirmed cases, deaths and vaccinations in Canada, France, Germany, India, the UK and the US.

Our findings highlight three key observations:

1. In most countries, the number of cases increased quite a bit before widespread vaccination took place.
2. During major outbreaks, both case numbers and vaccine doses administered showed significant daily fluctuations.
3. A 7-day lag analysis indicated that rising vaccination rates were followed by a reduction in new case numbers. Areas where vaccination started early and was kept up showed the strongest impact.

These insights suggest that timely and sustained vaccination campaigns played a crucial role in reducing transmission and saving lives. Future public health responses should prioritize early vaccine deployment during pandemics.

7 Recommendations

Given the findings, we suggest that further pandemic responses concentrate on spreading vaccinations quickly, especially in lower-income parts of the world like India, in order to reduce chances for breaks in case numbers. As seen in Figure 2, rather than waiting for a surge, Governments should consider establishing proactive vaccination schemes, ensuring vaccines are deployed before a high number of cases

occur. Having comparable ways of reporting data in different nations allows for better assessment and guides effective policy creation. Finally such campaigns need to make sure vaccination efforts continue, because sustained work in the US and UK greatly reduced the number of people affected and the death rate, as shown in Figure 5.

8 References

Ritchie, Hannah, Edouard Mathieu, Lucas Rodés-Guirao, Cameron Appel, Charlie Giattino, Esteban Ortiz-Ospina, Joe Hasell, Bobbie Macdonald, Diana Beltekian, and Max Roser. 2020a. "COVID-19 Confirmed Cases." https://ourworldindata.org/covid-cases; Our World in Data.

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