# Do childhood measles and DTaP vaccination decrease the mortality rate caused by SARS CoV-2 in OECD countries?

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## Abstract

**Aim:** This study aims to examine the relationship between DTaP (diphtheria, tetanus, pertussis) and measles vaccination rates in the Organization for Economic Co-operation and Development (OECD) countries and the case fatality rate (CFR) caused by SARS CoV-2.

**Methods:** Considering that the COVID-19 pandemic primarily affected the northern hemisphere and due to seasonal effects, OECD countries located in the northern hemisphere were included in this study. 2018 OECD data were used for vaccination rates, while the "Our World in Data" website (https://ourworldindata.org/) was used for CFR and other data. CFR was calculated based on the total mortality count of OECD countries for the 3-month period following the first confirmed SARS CoV-2 case.

**Results:** Based on the correlation between vaccination rates and 3-month CFR in OECD countries, a negative, although not yet significant, correlation (r = -0.264, p = 0.145) was found between CFR and DTaP vaccination rates, and a statistically significant negative correlation (r = -0.479, p = 0.006) between CFR and measles vaccination rates.

**Conclusions:** It was concluded that SARS CoV-2 CFRs are lower in countries with stricter implementation of measles vaccination, a live-attenuated vaccine. Governments should implement stronger vaccination programs to promote widespread immunization.

***Keywords***: *Case fatality rate; SARS CoV-2; vaccination; DTaP; measles*

## 1. Introduction

SARS CoV-2 (severe acute respiratory syndrome coronavirus 2), which emerged in Wuhan province, China, at the end of 2019, has become a pandemic affecting the entire world. While this study focuses on the early phase of the pandemic, prior to the availability of effective vaccines or treatments, COVID-19 mortality rates have varied across countries. Over 500,000 people have died globally. Factors such as government interventions, public compliance, average age of affected individuals, the number of tests conducted, and a country's healthcare infrastructure have all influenced SARS CoV-2 mortality.[1] While children are generally at risk for many contagious diseases, they have been less affected by the SARS CoV-2 pandemic. As of May 12, 2020, data from New York City Health indicated nine deaths in the 0–17 age group, with six involving underlying comorbidities.[2] According to a report by the Center for Evidence-Based Medicine (CEBM), mortality in children under the age of 9 was low, estimated at approximately 1% in China.[3] One explanation is their faster immunological response. Childhood vaccination is considered a primary factor for this rapid response and also plays a key role in maintaining herd immunity.

The pertussis vaccine, an inactivated vaccine, has been administered as a single shot since the 1930s and as part of the DTaP combination (diphtheria-tetanus-pertussis) since the 1990s. Although DTaP vaccination programs have been strictly implemented in OECD countries in recent years, the coverage rate was around 80% during the 2000s.[5] The measles vaccine, first developed in 1963, has been widely used in the USA since the 1980s

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as part of the Centers for Disease Control and Prevention (CDC)'s initiative to eliminate measles among children.[5] The UK introduced the measles vaccine, a live-attenuated vaccine, in 1988, and other OECD countries gradually incorporated it into their immunization schedules. Since its introduction, the incidence of measles has decreased significantly. It is typically administered in combination with mumps and rubella vaccines as the MMR vaccine.[6]

In this study, we aim to examine the relationship between childhood vaccination rates for DTaP and measles and the case fatality rate (CFR) from SARS CoV-2 across OECD countries.

**Table 1**

Data obtained in the first 3 months from the first case in the country

| Country | Case fatality ratio, % | Total number of tests | Total confirmed deaths |
|---|---|---|---|
| France | 18 | 724574 | 21856 |
| Belgium | 16 | 396052 | 7844 |
| United Kingdom | 14 | 2620000 | 37048 |
| Italy | 14 | 1980000 | 27967 |
| Holland | 13 | 344334 | 5856 |
| Sweden | 12 | 119400 | 2586 |
| Spain | 11 | 1350000 | 24824 |
| Slovenia | 7 | 82161 | 108 |
| Ireland | 7 | 325795 | 1639 |
| Greece | 6 | 160991 | 172 |
| Canada | 5 | 717451 | 2560 |
| United States | 5 | 4030000 | 40682 |
| Switzerland | 5 | 376935 | 1641 |
| Denmark | 5 | 480239 | 563 |
| Austria | 5 | 405341 | 8257 |
| Polond | 4 | 967177 | 1092 |
| Portugal | 4 | 840681 | 1424 |
| Finland | 4 | 99090 | 199 |
| Lithuania | 4 | 287982 | 66 |
| Germany | 4 | 2450000 | 5750 |
| Estonia | 4 | 80720 | 65 |
| Czech Republic | 3 | 449356 | 320 |
| Norway | 3 | 234637 | 235 |
| Luxembourg | 3 | 72996 | 110 |
| Japan | 3 | 162816 | 393 |
| Turkey | 3 | 2450000 | 4729 |
| Latvia | 2 | 111404 | 24 |
| Korea | 2 | 563035 | 236 |
| Slovakia | 2 | 185596 | 28 |
| Israel | 2 | 531569 | 279 |
| Hungary | 1 | 195894 | 534 |
| Iceland | 1 | 60450 | 10 |

## 2. Materials and Methods

Considering the fact that the COVID-19 pandemic was mainly observed in the northern hemisphere and due to seasonal effects, OECD countries located in the northern hemisphere (Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States) were included in this study. OECD countries located in the southern hemisphere (Australia, Chile, Colombia, Mexico, New Zealand) were excluded from the study. 2018 OECD data were used for the vaccination rates, while the "Our World in Data" website (https://ourworldindata.org/) was used for CFR and other related data. CFR was calculated based on the total mortality count in OECD countries for the 3-month period starting from the date when the first SARS CoV-2 case was reported.

### 2.1. Statistical Analysis

The data obtained from the study were recorded in SPSS 24.0 (Armonk, NY: IBM Corp.). The data of the patients are expressed as median (quartiles) for distributed data and percentage for categorical variables. Shapiro Wilk test was used to check if the continuous variables were normally distributed. While comparing the vaccination rates between the case fatality groups caused by COVID-19, the Mann-Whitney U test was used. Chi-square test or Fisher test was used to analyze the categorical variables. The correlation analyses for the vaccination rates and CFR were performed using Spearman tests. $P < 0.05$ was considered to be statistically significant.

**Table 2**

Vaccination rates by country

| Country | Diphtheria, tetanus, pertussis, % of children | Measles, % of children |
|---|---|---|
| France | 96.0 | 90.0 |
| Belgium | 98.0 | 96.0 |
| United Kingdom | 94.0 | 92.0 |
| Italy | 93.0 | 93.0 |
| Holland | 93.0 | 93.0 |
| Sweden | 97.0 | 97.0 |
| Spain | 97.0 | 97.0 |
| Slovenia | 93.0 | 93.0 |
| Ireland | 92.0 | 92.0 |
| Greece | 97.0 | 97.0 |
| Canada | 91.0 | 90.0 |
| United States | 92.0 | 92.0 |
| Switzerland | 95.0 | 95.0 |
| Denmark | 95.0 | 95.0 |
| Austria | 95.0 | 95.0 |
| Polond | 93.0 | 93.0 |
| Portugal | 99.0 | 99.0 |
| Finland | 99.0 | 96.0 |
| Lithuania | 92.0 | 92.0 |
| Germany | 95.0 | 97.0 |
| Estonia | 92.0 | 87.0 |
| Czech Republic | 96.0 | 96.0 |
| Norway | 96.0 | 96.0 |
| Luxembourg | 99.0 | 99.0 |
| Japan | 99.0 | 97.0 |
| Turkey | 96.0 | 96.0 |
| Latvia | 96.0 | 98.0 |
| Korea | 98.0 | 98.0 |
| Slovakia | 97.0 | 96.0 |
| Israel | 98.0 | 98.0 |
| Hungary | 99.0 | 99.0 |
| Iceland | 91.0 | 93.0 |

## 3. Results

As per the data obtained from 32 OECD countries included in this study, it has been seen that France is the country with the highest CFR rate (18%) followed by Belgium (16%), UK (14%), Italy (14%), Holland (13%), Sweden (12%) and Spain (11%) while Hungary and Iceland are the countries with the lowest CFR rates (1%) (Table 1).

Considering the DTaP vaccination rates of the countries it has been determined that Japan (99%), Luxemburg (99%), Portugal (99%), Finland (99%) and Hungary (99%) have the highest rates whereas Canada (91%) and Iceland (91%) have the lowest rates. Considering the Measles vaccination rates of the countries it has been determined that Portugal (99%), Luxemburg (99%) and Hungary (99%) have the highest rates whereas Canada (90%) and Estonia (87%) have the lowest rates (Table 2).

As per the vaccination rates of the countries that have been divided into groups (light, medium, heavy) according to the CFR and significance levels between the groups it has been stated that vaccination with DTaP does not create a significant difference between the groups (96.5%, 94.0%, 94.5%; p=0.255) whereas measles vaccination creates a significant difference between the groups (96.0%, 94.0%, 93.0%; p=0.048) (Table 3).

When examined the correlation levels between vaccination rates of OECD countries and 3-month CFR it has been seen that there is negative although not yet significant correlation (r=-264.0, p=0.145) between CFR and DTaP vaccination rates and there is negative correlation at a high level of significance between CFR and measles vaccination rate (r=-0.479, p=0.006) (Table 4, Figure 1).

**Table 3**

Vaccination rates and inter-group significance levels of countries that are divided into groups (low, medium, high) by case fatality rates

| | Low (<% 5), median (quartiles) | Medium (≥5, <10), median (quartiles) | High (≥10), median (quartiles) | p |
|---|---|---|---|---|
| Diphtheria, tetanus, pertussis | 96.5 (95.2-99.0) | 94.0 (92.0-96.0) | 94.5 (93.0-96.2) | 0.255 |
| Measles | 96.0 (94.5-98.0) | 94.0 (92.0-95.0) | 93.0 (92.0-97.0) | 0.048 |

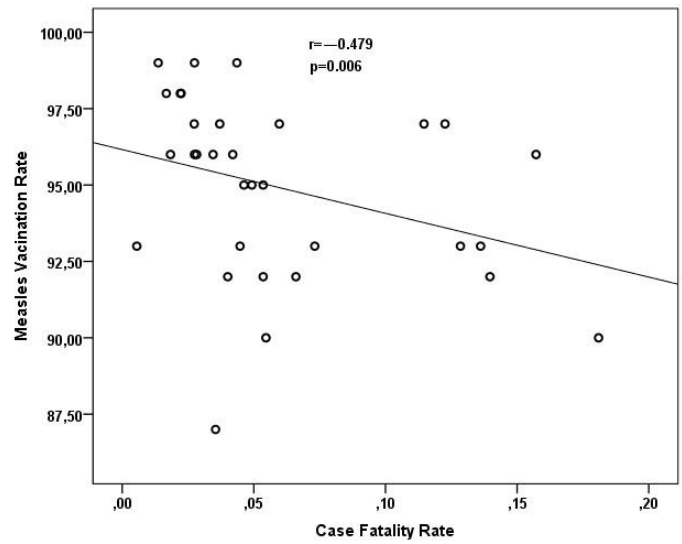
**Table 4**

Vaccination rates and inter-group significance levels of countries that are divided into groups (low, medium, high) by case fatality rates

| | Correlation coefficient | P |
|---|---|---|
| Diphtheria, tetanus, pertussis | -264.0 | 0.145 |
| Measles | -0.479 | 0.006 |

**Figure 1**

The correlation of between case fatality rate and measles vaccination rate.




## 4. Discussion

In the current study, a negative, though not yet statistically significant, correlation was observed between DTaP vaccination rates and SARS CoV-2 CFR, while a significant negative correlation was found between measles vaccination and CFR in OECD countries. One hypothesis for the lower mortality in SARS CoV-2-infected younger individuals is that childhood vaccination programs, which have become increasingly widespread over the past fifty years, may contribute to stronger immune responses.

Gold et al. investigated MMR (measles, mumps, rubella) vaccination rates in Italy, the UK, France, the United States, and Germany in 2002.[7] Their findings showed the highest MMR rate in Germany and the lowest in Italy, the UK, and France. A negative correlation between 2002 MMR rates and SARS CoV-2 CFRs as of 3 May 2020 was reported. Our findings based on 2018 OECD data align with this. Measles vaccination rates in Italy, the UK, and France were below 95% (93%, 92%, and 90%, respectively), while Germany's was 97%. Corresponding CFRs within three months of the first reported case were 14%, 14%, and 18% for Italy, the UK, and France, and 4% for Germany. The article also referenced Madagascar, where a nationwide MMR campaign had just concluded before the pandemic. As of 4 May 2020, the country had reported 1,443 cases and 13 deaths within three months of the first detected case on 20 March 2020. Although climate factors in the southern hemisphere may influence viral transmission, the country's low CFR (0.9%) may also be attributed to the recent mass vaccination campaign.[8]

In a study of 131 countries, BCG vaccination was associated with markedly lower COVID-19 mortality. Countries without BCG programs experienced approximately ten times more deaths (40/million) than those with active programs (4.28/million).[9]

Live-attenuated vaccines such as BCG and measles are thought to provide broad immunological benefits beyond their target pathogens. These vaccines may enhance innate immune training and generate non-specific immune memory, potentially increasing

resistance to unrelated infections such as SARS CoV-2.[10,11] This mechanism might explain the protective association observed between higher measles vaccination rates and lower CFRs in our study. Supporting this, previous research suggested that vaccinated children in China were significantly less affected by COVID-19, likely due to cross-reactivity from rubella or measles immunization.[12]

However, CFR is influenced by multiple factors beyond vaccination, including public health policies, testing strategies, and healthcare infrastructure. For instance, Sweden's CFR is four times higher than Norway's, despite similar vaccination coverage. Iceland, with below-average measles vaccination rates, had the lowest CFR among OECD countries—likely due to rigorous testing and isolation protocols. Iceland had the highest testing rate per capita among OECD nations.[13]

### 4.1. Limitations

The limitation of our study is that situations which may directly affect the CFR, such as the policies followed by countries in preventing the epidemic, health infrastructures, and the number of tests performed during the COVID-19 epidemic, vary from country to country. In addition, the fact that countries differ significantly in terms of population, and that epidemic control in highly populated countries is much more difficult than in low-populated countries such as Iceland, also affects the CFR. These reasons impact the results of the statistical analysis.

## 5. Conclusion

Considering the fact that child patients are less affected than adults, the positive effects of cross-resistances on the immune system formed by live-attenuated vaccines, and the key result of our study, which is the significant negative correlation between the live-attenuated measles vaccine and CFR, it has been stated that live-attenuated vaccines have a decreasing effect on CFR caused by SARS CoV-2. To conclude, healthcare implementers in countries should spread childhood vaccination across the entire society and implement these practices with stricter programmes.

## Statement of ethics

In this research, data obtained from the web was analyzed. For this reason, ethics committee approval was not obtained.

Since our study was planned retrospectively, an informed consent form was not required.

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## Conflict of interest statement

The authors declare that they have no conflict of interest.

## Availability of data and materials

This Data and materials are available to the researchers

## Author contributions

Dr. RG, Dr. AA, Dr. GE, Dr. SYS, Dr. MIS, Dr. BSA: conceptualization, methodology, investigation, and writing – original draft. Dr. RG, Dr. AA, Dr. GE, Dr. SYS, Dr. MIS, Dr. BSA: resources, formal analysis, and writing – review and editing. Dr. RG, Dr. AA, Dr. GE, Dr. SYS, Dr. MIS, Dr. BSA: conceptualization, methodology, and writing – review and editing. All authors read and approved the final version of the manuscript.

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