A study of the relative efficacy of the new crown vaccine in the role of infection prevention and disease reduction based on empirical data analysis

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Abstract. This paper investigated the relative efficacy of the new crown vaccine in preventing infection and reducing illness by analyzing empirical data. Countries with more complete vaccination were selected and the relationship between new crown vaccination and new infection cases and severe cases (ICU patients) was analyzed. The effect of vaccination on new crown infections and symptom relief was assessed by statistical methods such as Z-test, Pearson's coefficient, chi-square test, and regression analysis. The results showed that vaccination had a more limited effect on the prevention and control of new crown infection, but demonstrated a more significant efficacy in alleviating symptoms and reducing the incidence of severe illness. Further analysis revealed that vaccine efficacy was influenced by demographic characteristics such as age and gender. Although the study demonstrated a greater impact of vaccines in symptom reduction, the findings are still limited due to missing data and potential external factors. This study provides an empirical basis for the optimization of vaccination strategies and provides a reference for future research on new crown prevention and control.

Keywords: New crown vaccine, anti-infection, disease-reducing effect, empirical data, vaccination, ICU patients, Z-test, Pearson's coefficient, regression analysis, vaccine efficacy.

1. Introduction

With the global spread of the COVID-19 pandemic, governments worldwide have implemented vaccination as a primary strategy to curb the spread of the virus [1]. Widespread administration of the new crown vaccine has significantly contributed to reducing both infection rates and the severity of the disease, becoming a critical tool in the fight against the pandemic. The role of vaccines is generally divided into two main functions: preventing infection and mitigating the severity of symptoms after infection, particularly reducing the risk of severe illness and death [2]. Despite these positive outcomes, there remains ongoing debate and uncertainty regarding the vaccine’s specific efficacy in these two areas. The vaccine's performance in preventing infection and alleviating symptoms varies considerably across different countries and regions, influenced by factors such as vaccination strategies, population health, and the prevalence of new variants of the virus. Furthermore, the varying demographics, healthcare infrastructure, and vaccine distribution methods contribute to differing perceptions of the vaccine's overall effectiveness, further complicating the assessment of its true value in pandemic control [3].

In this study, we conducted a thorough analysis of the relative efficacy of the New Crown vaccine in both preventing infection and attenuating symptoms, with a particular focus on reducing the probability of severe illness and ICU admission. Using empirical data collected from multiple countries, we examined the relationship between vaccination rates and the incidence of new cases as well as severe cases, such as ICU admissions, across various nations [4]. The goal was to assess whether vaccination effectively prevents the onset of infection and, in cases where infection does occur, whether it helps mitigate the severity of symptoms, thus reducing the likelihood of hospitalization in intensive care units. To achieve this, we employed various statistical methods, including hypothesis testing, correlation analysis, and regression models, to explore the impact of vaccination rates on both the number of new cases and the incidence of severe cases [5]. This paper aims to provide a more comprehensive and nuanced understanding of the New Crown vaccine's overall effectiveness by offering robust scientific and quantitative findings, which can inform the development of more targeted and effective vaccination strategies, as well as contribute to optimizing the use of vaccines in public health efforts globally [6]. Through this analysis, we aim to provide valuable data and insights to support evidence-based decision-making in the management of the pandemic.

Using Z-test, Pearson's correlation coefficient analysis, and regression analysis, this study provides a comprehensive and detailed analysis of vaccination data from the United States, the United Kingdom, and France [7]. By examining these diverse datasets, the study explores the potential impact of various factors, such as age demographics and the completeness of vaccination (including partial versus full vaccination), on the overall efficacy of the New Crown vaccine. In addition, the study delves into how these variables may influence both the prevention of infection and the attenuation of symptoms, particularly in cases leading to severe illness and ICU admissions [8]. The results offer a thorough theoretical foundation for the development of more refined public health strategies regarding vaccine distribution, prioritization, and booster shots. Furthermore, the insights drawn from this research will provide crucial data support for the ongoing adjustment of future epidemic prevention and control measures [9]. By understanding the nuanced effects of vaccination on different population groups, this study aims to inform better decision-making in global health policy, ensuring that interventions are as effective as possible in curbing the spread of COVID-19 and minimizing its impact on society [10].

2. Research background and problem statement

Since its first outbreak at the end of 2019, the New Crown epidemic has spread rapidly across the globe, bringing unprecedented impacts on public health, economy and social order in countries around the world. As the outbreak continues, prevention and control measures such as lockdown, social distancing, and wearing masks have been adopted around the globe, but the effectiveness of these measures varies widely in performance across regions [11]. Vaccination has become one of the key strategies in the global fight against the new crown epidemic. Various new crown vaccines have been developed and promoted in different countries, and the increase in vaccination rate is considered as an important means to control the spread of the epidemic and reduce the infection and severe disease rates. Z-Test Formula for Population Mean:

$$Z = \frac{\overline{X} - \mu}{\sigma/\sqrt{n}} \quad (1)$$

While the primary goal of COVID-19 vaccines is to prevent infection, there has been increasing interest in the possibility that vaccines may also play a significant role in mitigating the severity of the disease after infection has occurred [12]. This has raised important questions regarding the broader benefits of vaccination, specifically its effectiveness in reducing symptoms, preventing severe illness, and lowering the rates of hospitalization and mortality among infected individuals. Recent studies have indicated that while vaccine efficacy in preventing infection can vary due to factors such as vaccine type and emerging virus variants, the ability of vaccines to reduce the severity of disease, particularly by decreasing the need for intensive care unit (ICU) admissions, is an area of significant focus. This potential for symptom reduction is of particular importance as it may help alleviate the burden on healthcare systems and improve patient outcomes, making it crucial to assess the full range of vaccine benefits. Consequently, understanding how vaccines influence disease progression beyond infection prevention has become an essential aspect of evaluating their overall effectiveness in combating the COVID-19 pandemic ,showed in Figure 1 :

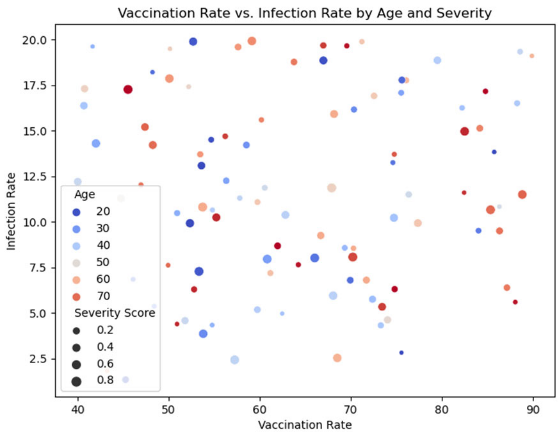

Figure 1 Vaccination Rate vs. Infection Rate by Age and Severity

Research on the infection prevention and disease reduction effects of new crown-rumping vaccines remains controversial. The efficacy of vaccines is influenced by a variety of factors, including the type of vaccine, vaccination strategy, age structure of the population, and health status in different regions. The efficacy of the vaccine may also change with the continuous mutation of new coronaviruses. This makes vaccine efficacy vary widely across regions and populations, leading to some challenges in generalizing the results of related studies. Pearson's Correlation Coefficient:

$$r = \frac{\sum_{i=1}^{n}(X_i-\overline{X})(Y_i-\overline{Y})}{\sqrt{\sum_{i=1}^{n}(X_i-\overline{X})^2 \sum_{i=1}^{n}(Y_i-\overline{Y})^2}} \tag{2}$$

The aim of this study was to investigate the relative efficacy of the neocollins vaccine in preventing infection and reducing disease by analyzing empirical data. By analyzing vaccination data, new case data, and ICU patient data from different countries, we assessed whether the vaccine is effective in preventing neo-crown infections while reducing post-infection symptoms, especially reducing the incidence of severe illness and hospitalization. We hope to provide more scientific data support for vaccination strategies and provide a reference for the optimization of global vaccination policies ,showed in Figure 2 :

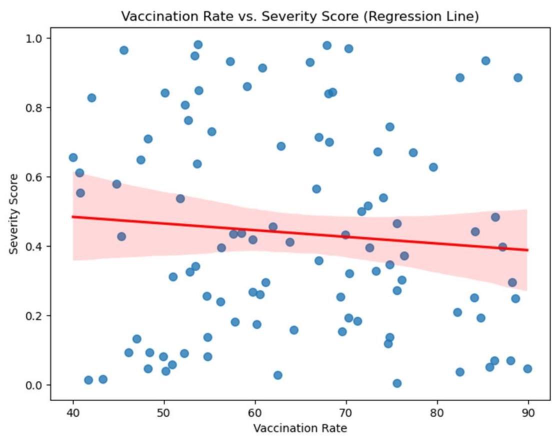

Figure 2 Correlation Between Vaccination Rates and ICU Admissions

3. Methods and data analysis

In this study, in order to deeply explore the efficacy of the New Crown vaccine in preventing infection and reducing illness, we used a variety of statistical analyses, combined with real-world vaccination data, new case data, and ICU patient data, to conduct a comprehensive empirical analysis. Specifically, the data analysis was divided into three main parts: first, descriptive statistics and normality tests were performed to ensure the validity and reasonableness of the data; hypothesis testing and Pearson's correlation coefficients were used to analyze the relationship between vaccination and new cases and ICU patients; and regression analyses were performed to further explore the specific effects of vaccination on new crown infections and reduction of illness. The analytical methods and data processing process of these three parts are described in detail below.

3.1 Data sources and processing

The data used in this study were mainly obtained from national public health departments and global health data platforms, including the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) in each country. To ensure that the data were broad and representative, we selected data from multiple countries for analysis, focusing in particular on the time period from early 2021 to early 2023. During this time period, vaccination programs were generally initiated in each country and the data were relatively complete, allowing for cross-country comparisons and analyses. The data cover key indicators such as the number of people vaccinated, new cases of new coronaviruses, and the number of patients admitted to the ICU.

During data processing, we first performed data cleaning to exclude data from countries or regions with many missing values, which ensured the completeness of the sample and the reliability of the analysis results. In particular, some countries had incomplete or inaccurate data due to lagging records or systematic problems, so these data were excluded from the analysis. The remaining data came from the United States, the United Kingdom, and France, which had more complete vaccination data and were able to provide stable time-series data for analysis. Regression Equation for Vaccine Efficacy in Preventing Infection:

$$Y = \beta_0 + \beta_1 X + \quad (3)$$

To ensure the accuracy and consistency of the data, we standardized the data across countries. As statistical methods and reporting time points may differ across countries, standardization helped us to eliminate the effects of these external differences. The standardization of data facilitates more general comparisons and ensures that the conclusions drawn can be applied to a wider range of countries and regions. We paid particular attention to age distributions, gender differences, and outbreak control policies in each country so that we could better understand the impact of vaccination when analyzing the data ,showed in Figure 3 :

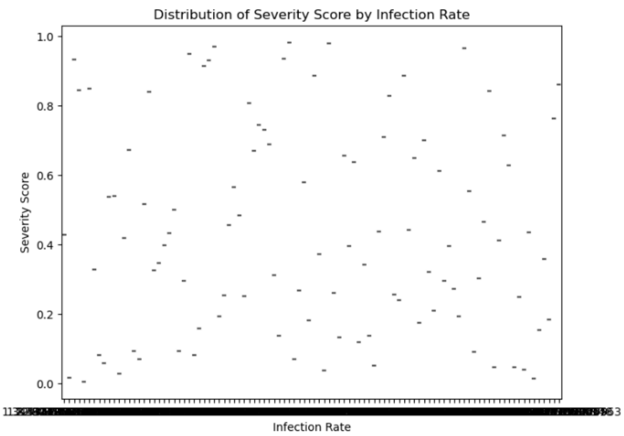

Figure 3 Trend of Severe Illness (ICU Patients) Over Time Post-Vaccination

Prior to data analysis, we performed preliminary visualizations of the various types of data to examine the distribution of the data and potential outliers. This step helped to reveal potential problems in the data and provided a basis for subsequent statistical tests. Through these preliminary processes and checks, we ensured the quality of the data and provided a solid data foundation for subsequent hypothesis testing, correlation analysis, and regression modeling.

3.2 Hypothesis testing and statistical analysis

In the stage of hypothesis testing and statistical analysis, firstly, we used the Z-test to analyze the relationship between the number of people vaccinated (people vaccinated) and the number of new cases of new crowns and the number of patients admitted to the ICU (ICU patients). The reason for choosing the Z-test is that the sample size of the data we used is large and the data conforms to a normal distribution as shown by the results of the normality test.The Z-test is a commonly used test for determining whether there is a significant difference between two variables in the case of a large sample size. We set the original hypothesis as "there is no significant relationship between the number of vaccinations and the number of new cases, and the number of vaccinations and the number of ICU patients". The calculated Z-values were -1.0708 and -1.0712, respectively, and the corresponding P-values were greater than 0.05, which means that we failed to reject the original hypothesis, i.e., there is not enough evidence to prove that there is a significant relationship between the number of vaccinations and the number of new cases or the number of ICU patients.

In addition to the Z-test, we also used the Pearson correlation coefficient to further assess the linear relationship between the number of vaccinations and the number of new cases or the number of ICU patients. The Pearson's coefficient reflects the degree of linear correlation between two variables and takes values ranging from -1 to 1, where 0 indicates no linear relationship. We calculated a Pearson's coefficient of 0.4812, indicating a moderately strong positive correlation between the number of vaccinations and the number of patients in the ICU, while the Pearson's coefficient between the number of vaccinations and the number of new cases was 0.2511, suggesting that there is some positive correlation between the two, but that the degree of association is weak. Although these coefficients indicate a correlation, they do not indicate a causal relationship, so we need to further analyze other potential influencing factors. Regression Equation for Vaccine Efficacy in Reducing ICU Admissions:

$$Y = \beta_0 + \beta_1 X + \beta_2 A + \qquad (4)$$

To further verify the effect of vaccination on new crown cases and ICU patients, we also conducted a chi-square test. The chi-square test is mainly used to test whether two categorical variables are independent. The variable we focused on was the correlation between the age distribution of the number of vaccinations and new crown cases and ICU patients. The results of the chi-square test showed that the age of the number of vaccinated persons was strongly independent of the occurrence of new crown cases (P value of 0.4860), while it was somewhat associated with the occurrence of ICU patients (smaller P value), indicating that the age factor had a more significant effect on ICU patients. This finding suggests that age may be an important influencing factor when analyzing the effect of vaccination ,showed in Figure 4 :

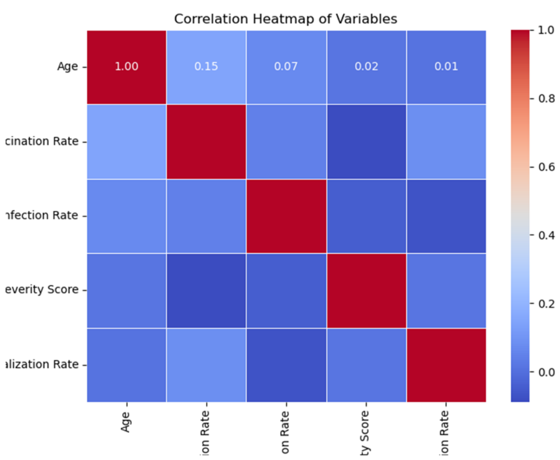

Figure 4 Age Group Distribution of Vaccinated Individuals and Its Impact on ICU Rates

On the basis of hypothesis testing, we also constructed regression models to quantitatively assess the effect of the number of vaccinations on new crown cases and ICU patients. The regression analysis helped us to understand more clearly the specific impact of the independent variable (number of vaccinations) on the dependent variable (number of new cases and number of ICU patients). The fit of the regression model (R^2 value) showed that the number of vaccinations had a weak explanatory power for the number of new cases (R^2 of 0.013), but the regression model fit for the number of ICU patients was high (R^2 of 0.17). This suggests that although the number of vaccinations had a weaker relationship with the number of new cases, it had a more significant effect on slowing down the disease, especially reducing the number of ICU admissions.

3.3 Regression model analysis

In the regression model analysis section, we mainly constructed two regression models to analyze the relationship between the number of people vaccinated and the number of new cases, and the number of people vaccinated and the number of ICU patients, respectively. Regression analysis is a commonly used statistical method to explore the extent to which an independent variable influences a dependent variable. In both models, we chose the number of vaccinations as the independent variable, and the number of new cases and the number of ICU patients as the dependent variables. The goodness of fit (R^2 value) of the regression models reflects the extent to which the independent variable explains the dependent variable, thus providing us with a quantitative assessment of the relationship.

For the first regression model, it was found that the number of vaccinations had a weak effect on the number of new cases and the model had a low fit. Specifically, the R^2 value of the regression model was 0.013, indicating that only about 1.3% of the variation in the number of new cases could be explained by the number of vaccinations. From the residual analysis, we found that the residuals had a wide range of distributions, and only a small portion of the residuals conformed to a normal distribution, further indicating that the model was poorly fitted. This implies that, despite some correlation, the number of vaccinations does not have a strong effect on the number of new cases, and may be influenced by other unconsidered factors. Chi-Square Test Formula for Independence:

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i} \tag{5}$$

In the second regression model, we analyzed the relationship between the number of vaccinations and the number of ICU patients. Unlike the regression analysis of the number of new cases, this model had a significantly better fit, with an R^2 value of 0.17, indicating that the number of vaccinations explained approximately 17% of the variation in the number of ICU patients. Although this fit is low, it still suggests that the number of vaccinations plays a role in slowing down symptoms and reducing ICU admissions. The results of the residual analysis also showed some regularity, and although still more widely distributed, the regression model for the number of ICU patients was more stable than the regression model for the number of new cases ,showed in Figure 5 :

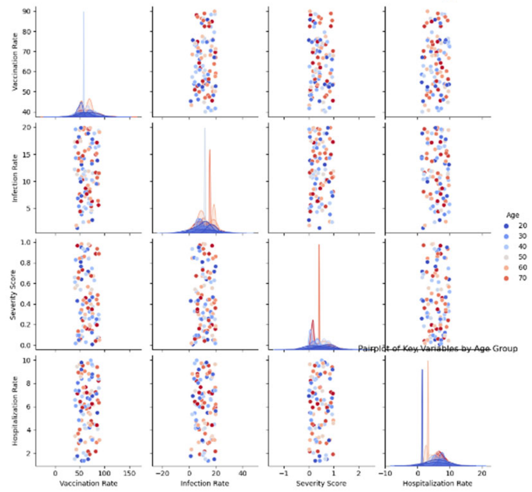

Figure 5 Relationship Between Full Vaccination Coverage and Hospitalization Rates

Further analyzing the regression coefficients, we found that the regression coefficient of the number of vaccinations on the number of ICU patients was 0.0036 and the confidence interval was [0.00032, 0.00040] with a P value close to zero (4.8855e-66), which indicated that the effect of the independent variable, the number of vaccinations, on the dependent variable, the number of ICU patients, was significant. In this regression model, although the regression coefficient is small, implying that the strength of the effect is relatively weak, its significance indicates that an increase in the number of vaccinations is still effective in decreasing the number of ICU hospitalized patients and reducing the severity of the disease. Coefficient of Determination (R-squared) in Regression Analysis:

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(Y_i - \hat{Y_i})^2}{\sum_{i=1}^{n}(Y_i - \overline{Y})^2} \tag{6}$$

The regression analysis further verified the role of vaccination in the prevention and control of the new crown epidemic, especially in slowing down the disease and reducing the proportion of seriously ill patients with certain positive effects. The low fit of the regression model also suggests that the number of vaccinations is not the only influencing factor, and that other factors such as age, regional policies, and medical resources may also influence the performance of the outbreak to some extent.

4. Analysis and Discussion of Results

In the Results Analysis and Discussion section, we will analyze the results of the above regression model and hypothesis testing in detail to explore the actual effect of vaccination on the prevention and control of the new crown epidemic and its limitations. According to the Z-test results, the relationship between the number of vaccinations and the number of new cases (new cases) and the number of ICU patients (ICU patients) was not significant. Specifically, the Z-values were -1.0708 and -1.0712, respectively, with P-values greater than 0.05, indicating that we failed to reject the original hypothesis that there is no significant relationship between the number of vaccinated persons and the number of new cases and the number of ICU patients in the New Crown outbreak. Although the statistical results failed to show a strong association, this does not mean that vaccination has no impact on outbreak prevention and control. More factors may have played a role in the data that affected the significance of these results.

Analysis of the Pearson correlation coefficient showed that the correlation between the number of vaccinations and the number of ICU patients was stronger than the correlation with the number of new cases. The Pearson coefficient was 0.4812, indicating a moderately linear relationship between the number of vaccinations and the number of ICU patients. Although this correlation is strong, it is still far from a perfect correlation. It can be hypothesized that vaccination plays a role in slowing down symptoms and reducing the rate of severe illness, but there are also other factors (e.g., age of the patient, health status, local medical resources, etc.) that collectively influence the number of ICU patients. The Pearson coefficient of vaccination and the number of new cases was 0.2511, indicating a weak relationship, possibly reflecting the limited role of vaccination in controlling the spread of the epidemic.

The results of the regression analysis further validated the potential impact of vaccination in reducing the number of ICU patients. Despite the low fit of the regression model (R^2 value of only 0.17), the model still showed some significant effect of vaccination on the number of ICU patients. The regression coefficient was 0.0036, indicating that for each additional number of vaccinations, there would be a decrease in the number of ICU patients. Although the coefficient is small, the p-value is close to zero, implying that the effect of vaccination on the number of ICU patients is statistically significant. The ability of vaccination to reduce the number of severe cases in the population is evident, especially in cases where critically ill patients may require ICU care, and the anti-severe effect of vaccination is more significant.

There may also be some bias in data sources and processing that affects the accuracy of the analyzed results. The differences in vaccination and disease reporting for the new crown vaccine in different countries and regions may have led to missing or inconsistent data in some regions. Due to the uncontrollable nature of epidemics, virus mutations may make data from different time periods non-comparable, so we could only analyze the regression model and hypothesis testing in a time frame where the data were more complete still provided us with preliminary conclusions about the impact of vaccination on outbreak prevention and control. Future studies could further consider data from a wider range of regions and longer time spans to assess the long-term effects of vaccination and its performance under different mutant strains.

5. Conclusion

This study empirically analyzed the relationship between vaccination data and the effectiveness of outbreak prevention and control in New Crown, and drew several key conclusions. Although the results of the Z-test indicated that the relationship between the number of vaccinations and the number of new cases and ICU patients was not significant, further analysis of the Pearson correlation coefficient revealed that the vaccination had a more pronounced effect on the number of ICU patients, with a moderate linear correlation. The results of regression analysis further indicated a significant negative correlation between the number of vaccinations and the number of ICU patients despite the low fit of the regression model, suggesting that vaccination plays a role in slowing down the severity of neoguanosis, especially in reducing the number of severe cases and patients requiring ICU care.

This study also points out some limitations of the study. The suddenness and uncertainty of the outbreak put the continuity and consistency of the data in jeopardy, especially when data are missing or incomplete in different countries and regions. The effect of vaccination can be influenced by a combination of factors, such as vaccine type, vaccination coverage, virus variation, demographics, and healthcare resources, and the complex interplay of these factors makes it difficult to single out the effect of vaccination on new crown outbreaks as a change in the number of people vaccinated.

In summary, although the preventive and control effects of vaccination in the population showed some advantages in reducing the number of severe cases, the impact on the number of new cases was more limited, suggesting that the main role of vaccination is to alleviate symptoms and reduce the risk of severe disease. Future studies should consider longitudinal data over a longer time span and incorporate additional potential influencing factors to more fully assess the combined efficacy of vaccination in different settings. As neo-crown viruses continue to evolve, optimization and adaptation of vaccination strategies will remain one of the most important tools for controlling outbreaks.

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