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THE IMPACT OF VACCINATION STATUS ON COVID-19 CASES: A CASE STUDY IN PAHANG

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Abstract
COVID-19 refers to the infectious disease known as coronavirus disease, distinguished by its transmission within the environment and attributed to the viral variant SARS-CoV-2. The aforementioned illness has resulted in significant levels of morbidity and mortality. Despite the implementation of diverse regional and national non-pharmaceutical interventions, including travel restrictions, social distancing measures, stay-at-home orders, and lockdowns, numerous countries are still grappling with the escalated situation of COVID-19 cases. The vulnerability of the global population to COVID-19 is widespread, emphasising the imperative of developing and deploying a potent vaccine. Several countries have highlighted the significance of vaccinations and their association with the daily incidence and mortality rates of COVID-19. Therefore, this study aimed to identify the association between the documented count of individuals who have not received vaccinations and the daily incidence of COVID-19 cases in Pahang, Malaysia. Based on the Spearman rank correlation analysis, its revealed that the use of vaccinations plays a pivotal role in mitigating the likelihood of contracting COVID-19 within the region of Pahang. The increase in reported cases of individuals in the state of Pahang who have not been vaccinated correlates with an increase in the daily incidence of COVID-19 cases. The results obtained from this study offer valuable insights into the epidemiological patterns of COVID-19 in the Pahang region. Also, these emphasis the significance of COVID-19 vaccination in mitigating the incidence of outbreaks and fatalities.

Keywords: COVID-19, Vaccination Status, Spearman Rank Correlation Analysis, Unvaccinated cases

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Introduction
The etiology of COVID-19, also known as coronavirus disease 2019, can be attributed to the emergence of a novel coronavirus named SARSCoV-2. The emergence of this novel disease was purportedly observed in Wuhan City, located in Hubei Province, China, during the month of December in the year 2019. The World Health Organization (WHO) declared COVID-19 to be a pandemic on March 11, 2020 (World Health Organization, 2020). The global outbreak of the novel coronavirus (COVID-19) has had an extensive and detrimental effect on public health and general well-being. By early June 2021, the World Health Organization (2020) reported that there were over 1.7 million confirmed cases and 3 million fatalities attributed to COVID-19, spanning across more than 200 nations. The typical COVID-19 symptoms are fatigue, a dry cough, and a fever. Mild symptoms like headaches, muscle pain, a runny nose, a sore throat, or diarrhea may be experienced by some infected people. According to Huang et al. (2020), individuals afflicted with COVID-19 may experience severe pneumonia, organ failure such as kidney dysfunction, acute respiratory tract infection, and septic shock, all of which can ultimately result in mortality. Nevertheless, there exists a subset of infected persons who remain asymptomatic and do not experience any apparent symptoms or feelings of illness. These individuals are commonly referred to as asymptomatic carriers. The demographic groups that exhibit a heightened susceptibility to

COVID-19 include the elderly population, young children, pregnant individuals, and individuals afflicted with chronic diseases such as hypertension, diabetes, heart conditions, kidney disorders, and other related conditions (Elengoe, 2020).

Despite the implementation of many non-pharmaceutical interventions at regional and national levels, including travel limitations, social distancing measures, stay-at-home orders, and lockdowns, numerous nations are still grappling with the escalation of COVID-19 cases (Pinto Neto et al., 2021; Hsiang et al., 2020; Lancet, 2020). Nevertheless, it is noteworthy that a significant portion of the world's population still lacks immunity to COVID-19, underscoring the imperative for the development and deployment of an effective vaccine. In order to address the increasing challenges posed by the COVID-19 pandemic, there has been accelerated progress in the creation of vaccines, exceeding previous rates (Le et al., 2020).

In light of the recent outbreak of the COVID-19 pandemic, global efforts have been undertaken to implement several strategies aimed at mitigating the transmission of the virus. The utilization of vaccination as a means of immunization has emerged as a highly significant advancement in the field of public health during the course of the previous century. This breakthrough has played an essential part in the substantial reduction of vaccine-preventable diseases on a global scale (Pollard and Bijker, 2021). The consistent decrease in global COVID-19 cases and fatalities following its implementation has supported the importance of the COVID-19 vaccination as a public health intervention in putting an end to the COVID-19 pandemic (Liang et al., 2021). The United Kingdom was one of the early adopters of widespread immunization against the COVID-19 virus (Mathieu et al., 2021). In addition to the utilization of mRNA as the primary active material by Moderna and Pfizer, alternative vaccines employ diverse antigen types, including viral vectors, attenuated viruses, and inactivated viruses (Kaur & Gupta, 2020).

Numerous countries have emphasized the significance of immunizations and their correlation with daily COVID-19 incidence and fatality rates. According to Liang et al. (2021), specific studies have suggested a correlation between COVID-19 vaccines and a decrease in mortality rates. In the context of the United States, a simulation study conducted by Moghadas et al. (2021) indicated that the implementation of COVID-19 immunization programs would result in a 69.3% reduction in COVID-19 mortality. Furthermore, it has been observed that immunizations had a significant impact on reducing symptomatic COVID-19 cases among older individuals in England (Bernal et al., 2021) and decreasing the likelihood of COVID-19 hospitalization in Scotland (Vasileiou et al., 2021). In contrast, Brazil had widespread dissemination of the COVID-19 virus throughout its various regions and endured the most significant impact from the global health crisis (Ranzani et al., 2021; Castro et al., 2021). According to Zimmermann et al. (2021), a total of 200,000 deaths attributed to COVID-19 were documented in the year 2020. The initiation of COVID-19 immunization campaigns in the country occurred on January 17, 2021. The prioritization of vaccine distribution was based on certain demographic groupings, including health workers, elderly adults (beginning at age 85 and progressively encompassing younger age cohorts), indigenous communities, and institutionalized individuals (Victora et al., 2021). According to research conducted in Pakistan, it has been shown that individuals who have received the COVID-19 vaccination can still experience the development of severe and critical infections. However, it is important to note that the occurrence of such cases is relatively uncommon when compared to the unvaccinated population (Fatima et al., 2022).

Based on current comprehension, there is an insufficient amount of research available from Asian nations, including Malaysia, that specifically examines the link between COVID-19 vaccination and the reported number of cases. Therefore, it is imperative to investigate these interconnected matters in the context of Malaysia. The objective of this study was to investigate the association between the daily incidence of COVID-19 cases and the number of unvaccinated individuals in the region of Pahang, Malaysia. The primary objective of this study is to ascertain the patterns of COVID-19 cases in Malaysia, with a specific focus on the Pahang region. The initial investigation only concentrated on the region of Pahang due to its significant population and geographical characteristics in Peninsular Malaysia. The results of this study offer valuable insights into the epidemic patterns of COVID-19 in Pahang, shedding light on the significance of the COVID-19 vaccine in mitigating the spread of the disease and minimizing mortality rates.

Methods

COVID-19 in Malaysia

The initial case of COVID-19 in Malaysia was identified on January 25th, 2020. This case was linked to three individuals from China who had prior direct interaction with an individual affected in Singapore. On January 24, 2020, they embarked on a journey to Malaysia by crossing the border from Singapore. The individuals received medical care at Sungai Buloh Hospital, located in Selangor, Malaysia, as reported by the New Straits Times (2020). The first Malaysian was confirmed with COVID-19 on February 4, 2020. According to a report by Bernama (2020a), the individual, aged 41, exhibited symptoms of fever and cough shortly after returning from Singapore. On the aforementioned date, a 4-year-old girl of Chinese nationality who had been placed in isolation at Sultanah Maliha Hospital in Langkawi since January 29, 2020, successfully recuperated and was subsequently released from the hospital, thereby permitting her to return to China (Bernama, 2020b).

According to the Ministry of Health Malaysia (2020), Malaysia documented its initial isolated instance of COVID-19 on March 12, 2020. This case involved an individual who had not traveled to a region afflicted by the virus nor had any contact with an infected person. The reported cases of COVID-19 had a gradual increase in March 2020 until a religious gathering occurred in Sri Petaling, Kuala Lumpur. This event subsequently resulted in a rapid and exponential surge in the number of cases (Barker, 2020). According to Barker (2020), Malaysia experienced the largest number of confirmed COVID-19 cases in the Southeast Asian region a few weeks following the occurrence. The transmission of COVID-19 to several states within Malaysia and neighboring nations, including Brunei, Cambodia, Indonesia, Thailand, Singapore, the Philippines, and Vietnam, has been documented in several academic sources (Yasmin, 2020; Ferdinandh, 2020; Le, 2020; Sukumaran, 2020).

On March 16, 2020, the total number of confirmed positive cases exceeded 553, prompting the Prime Minister of Malaysia to declare the implementation of a Movement Control Order (MCO). The implementation of social distancing measures, spanning from the 18th of March to the 31st of March 2020, aimed to mitigate the accelerated transmission of the COVID-19 virus. Since the commencement of the 18th of March, 2020, the government has implemented restrictions on individuals' ability to travel to regions beyond their own state or locations that have been impacted by the COVID-19 pandemic. According to Jus (2020), a single individual per household is permitted to venture outside the residence for the purpose of procuring needed commodities. During the implementation of the Movement Control Order (MCO), the government observed the imposition of six restrictions. According to the New Straits Times (2020b), the limits are as follows.

a) Mass meetings, encompassing religious, physically fit, social, and cultural events, were subject to prohibition, thereby restricting individuals from attending such gatherings. Temporarily, all places of worship and businesses were shuttered. Nevertheless, individuals have the option to purchase necessary commodities from various establishments such as markets, grocery stores, supermarkets, and convenience stores.
b) Individuals were required to undergo health screening procedures to identify potential cases of COVID-19 and thereafter engage in self-isolation upon their return from international travel.
c) Foreign tourists and visitors were prohibited from entering Malaysia.
d) Various educational institutions, such as kindergartens, government schools, and private schools encompassing daily schools, boarding schools, international schools, tahfiz centers, as well as other primary, secondary, and pre-university establishments, were all subjected to closure.
e) Public and higher education institutions, as well as skill training institutes, across the nation were temporarily shut down.
f) Both government and private establishments were required to cease operations, with the exception of essential services. These essential services encompassed a range of sectors, including water,

electricity, energy, telecommunications, postal services, transportation, irrigation, oil and gas, fuel and lubricants, broadcasting, finance, banking, healthcare, pharmacy, fire services, prison facilities, port operations, airport services, safety services, defense, cleaning services, retail, and food supply.

Study Area

Pahang, alternatively referred to as Pahang Darul Makmur, is a Malaysian state that holds the distinction of being the third-biggest in terms of geographical size and the largest on the peninsular. Furthermore, it ranks ninth in terms of population size. Pahang is geographically situated at coordinates 3º45'N 102º30'E, sharing borders with the State of Kelantan to the north, Perak, Selangor, and Negeri Sembilan to the west, the State of Johor to the south, and the State of Terengganu and the Southern China Sea to the east. The geographical expanse of Pahang State spans 35,965 square kilometres (km^2) and is partitioned into 11 distinct administrative districts, namely Pekan, Kuantan, Rompin, Maran, Bera, Jerantut, Temerloh, Raub, Bentong, Lipis, and Cameron Highlands. According to the most recent census conducted in 2021, the state's total population stands at approximately 1,684,700 individuals, with a population density of 47 individuals per square kilometer. The research area's geographical location is depicted in Figure 1.

Figure 1. Map of Pahang, Malaysia

Data Collection

Data on daily reported COVID-19 cases in Pahang, Malaysia, from March 17th, 2020, to April 1st, 2023, were obtained from the Ministry of Health, Malaysia. The datasets comprise information regarding the vaccination status, age category, age interval, ethnicity of the patients, and the daily reported count of unvaccinated cases, along with the daily reported count of COVID-19 cases.

Statistical Method

Descriptive Statistics

The pattern of COVID-19 disease in Malaysia and in Pahang from March 17, 2020, to April 1, 2023, was initially analysed using descriptive statistics such as mean, standard deviation, minimum, maximum, and skewness of the data. The dependent variable employed in the present study is the daily incidence of COVID-19, while the independent variable is the daily counts of unvaccinated cases reported in the region of Pahang.

Normality Testing

The pattern of COVID-19 disease in Malaysia and in Pahang from March 17, 2020, to April 1, 2023, was initially analysed using descriptive statistics such as mean, standard deviation, minimum, maximum, and skewness of the data. The dependent variable employed in the present study is the daily incidence of COVID-19, while the independent variable is the daily counts of unvaccinated cases reported in the region of Pahang.Several statistical techniques used for data analysis rely on the fundamental assumption of data normality, such as correlation analysis. There exist two main methodologies for evaluating the normality of data, namely graphical and numerical techniques, which encompass statistical test methodologies (Bland, 2015; Campbell et al., 2007). The statistical test for normality offers the benefit of providing an unbiased assessment of normality, whereas graphical interpretation allows for subjective evaluation of normality in cases where the numerical test may exhibit excessive sensitivity or insensitivity (Mishra et al., 2019). Several methods can be employed to assess the normality of data, such as the Shapiro-Wilk test, the Kolmogorov-Smirnov test, evaluating skewness, looking at histograms, Q-Q plots, box plots, and other similar approaches. However, in this work, the Shapiro-Wilk test and normal Q-Q plot were employed, representing the numerical and graphical techniques, respectively, for evaluating the normality of the data.

The Shapiro-Wilk test is used in order to assess the normality of the data in the present study. The Shapiro-Wilk test, devised by Shapiro and Wilk in 1965, is widely regarded as the most robust and comprehensive approach for determining if a given sample comes from a distribution that is not normal (Shapiro & Wilk, 1965). The methodology relies on establishing the relationship between the data and the related normal scores (Thode, 2002). The formal hypothesis for the Shapiro-Wilk test can be stated as follows:

H_0: The errors follow a normal distribution
H_1: The errors do not follow a normal distribution

The Equation 1 below displays the test statistic used in the Shapiro-Wilk test:

$$W = \frac{\left(\sum_{i=1}^{n} a_i e_{(i)}\right)^2}{\sum_{i=1}^{n}(e_i - \bar{e})^2} \tag{1}$$

where e_i represents the i^{th} largest value of the error terms, and the values of a_i are calculated using the means, variances, and covariances of e_i. The symbol n is the number of observations. The value of the test statistic, W, is compared with the tabulated values. The null hypothesis of this test will be rejected when the p-value is less than α or $W < W_0(\alpha, n)$, where $W_0(\alpha, n)$ is the critical value at the significance level of $\alpha = 0.05$.

The Q-Q plot, also known as the quantile-quantile plot, displays the standardised residuals in ascending order, paired with an estimation of their expected values (Lindsey, 2000). The present study employs the normal Q-Q plot as a graphical tool to assess the normality of the dataset. The Q-Q plot is a graphical tool used to assess the normality of a distribution. In this plot, all data points are expected to fall along or in close proximity to a straight line that is drawn across the central half of the points. This line represents the expected values of a sample selected from a normal distribution.

Correlation Analysis

Data on daily reported COVID-19 cases in Pahang, Malaysia, from March 17th, 2020, to April 1st, 2023, were obtained from the Ministry of Health, Malaysia. The datasets comprise information regarding the vaccination status, age category, age interval, ethnicity of the patients, and the daily reported count of unvaccinated cases, along with the daily reported count of COVID-19 cases. Correlation analysis is employed to identify the extent of the relationship between two or more quantitative variables. Several studies have utilised Pearson and Spearman's rank correlation analysis to examine medical health and disease data (Huang et al., 2022; Guo et al., 2016; Kim et al., 2016; Ma et al., 2013). This study performed Spearman's rank correlation analysis to establish an initial association between COVID-19 cases and the daily reported count of individuals who had not received vaccination. The Spearman's rank correlation coefficient, denoted as ρ in Greek (ρ), is commonly used in the analysis of statistics. The correlation approach utilised in this study is a variant of Pearson's correlation coefficient that is predicated on rank. The Spearman's rank correlation coefficient, which is named after Charles Spearman, is a statistical measure that quantifies the correlation between variables by utilising their ranks. It is a non-parametric method, meaning it does not make assumptions about the underlying distribution of the data. This approach is suitable for analysing continuous data that does not follow a normal distribution, ordinal data, or data that includes outliers of significance (Schober et al., 2018). The correlation method employed in this study assesses the association between two variables by utilising a monotonic function. The following Equation 2 can be used to determine the Spearman's rank correlation coefficient, abbreviated as ρ (Liebetrau, 1983):

$$\rho = \frac{\sum_{i=1}^{n}\left[\left(r(x_i) - r(\bar{x})\right)\left(r(y_i) - r(\bar{y})\right)\right]}{\sqrt{\sum_{i=1}^{n}\left(r(x_i) - r(\bar{x})\right)^2 \sum_{i=1}^{n}\left(r(y_i) - r(\bar{y})\right)^2}} \tag{2}$$

where $r(x_i)$ and $r(y_i)$ represent the ranks assigned to the observations in the sample. The $r(\bar{x})$ and $r(\bar{y})$ represent the average values of respective variables. The Spearman's rank correlation coefficient has limits between -1 and 1, with the value of the coefficient representing the intensity of the monotonic association. A smaller absolute value of ρ indicates a weaker monotonic relationship between the two variables. In contrast, Spearman's correlation coefficient can assume a value of zero when variables are not monotonically related, whereas it can take a value of one when variables exhibit monotonic relationships (Liebetrau, 1983).

Result and Discussion

The Pattern of COVID-19 Cases in Malaysia

Figure 2 displays the cumulative number of COVID-19 cases in Malaysia during the time period between March 17th, 2020, and April 1st, 2023. The state of Selangor exhibited the highest prevalence of this particular disease, with a total of 1,553,401 documented cases. Following this were Wilayah Persekutuan Kuala Lumpur, which recorded 472,220 cases, Sabah with 406,980 cases, and Johor with 399,000 cases. The state of Perlis recorded the lowest number of reported cases, specifically 19,061.

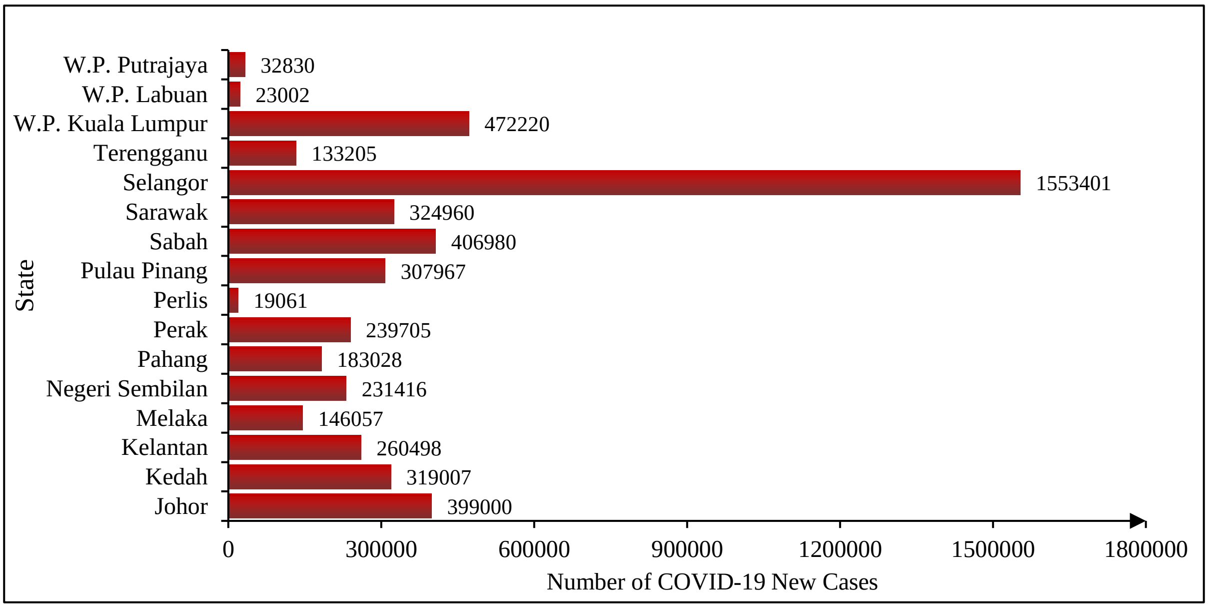


Figure 2. The total number of COVID-19 cases in Malaysia, from March 17th, 2020, to April 1st, 2023

Furthermore, Figure 3 illustrates the cumulative number of fatalities attributed to COVID-19 in Malaysia. Once more, the results indicate that Selangor state exhibited the highest incidence of fatalities attributed to COVID-19, with a total of 10,990 recorded cases. This was followed by Johor with 4,717 cases, Wilayah Persekutuan Kuala Lumpur with 2,866 cases, and Sabah with 3,202 cases. In contrast to the other states, Wilayah Persekutuan Putrajaya has the lowest death rate, with only 32 cases. This finding suggests that the total number of new cases and fatalities could potentially be impacted by the entire population, population density, and geographical location.

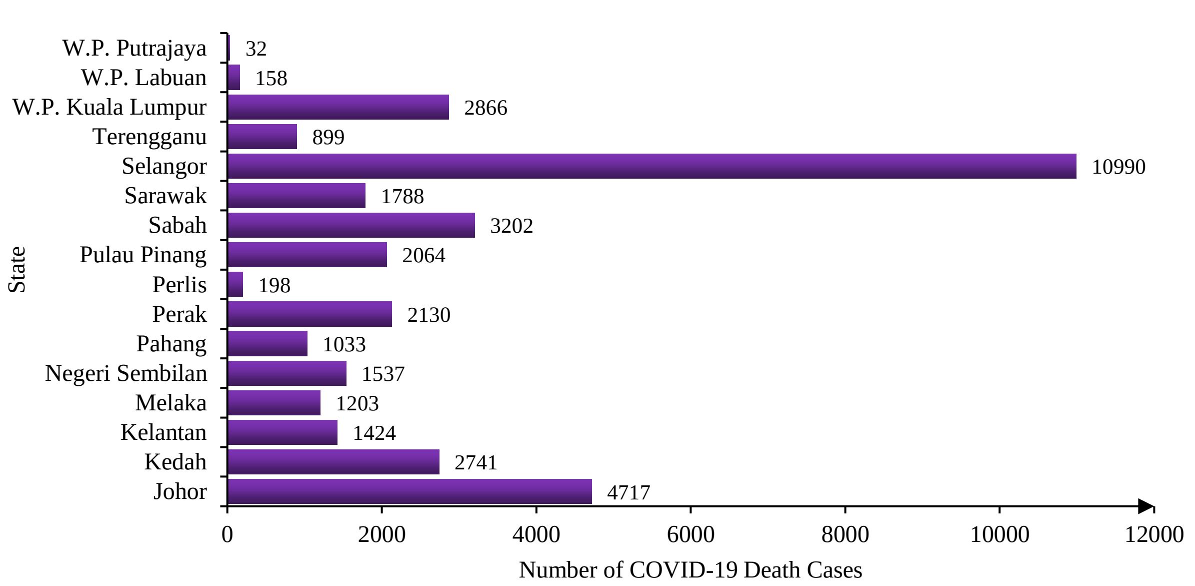


Figure 3. The total number of COVID-19 death cases in Malaysia, from March 17th, 2020, to April 1st, 2023

According to the findings of Segovia-Juarez et al. (2020), there is a negative correlation between altitude and the incidence of COVID-19 infection in Peru. Sun et al. (2020) observed the same results in China, where the cumulative incidence of COVID-19 infections exhibited a decrease in correspondence with increasing altitude. Nevertheless, the results of this study appear to be inconsistent with the findings of Wu et al. (2021), who observed a positive correlation between the average altitude at the city level in China and the incidence of COVID-19. According to Zu et al. (2020), COVID-19 has been established as a respiratory infection that is transmitted between humans. Consequently, the density of the population is a significant factor in the dissemination of the virus. The hypothesis that higher population density contributes to increased transmission of COVID-19 has been supported by empirical evidence from many studies conducted in Iran (Ahmadi et al., 2020), Turkey (Sahin, 2020), and China (Zu et al., 2020). According to Lin et al. (2020), an investigation conducted in the plains region of China revealed that a higher population density may increase the chance of COVID-19 transmission. The study established that this association follows a non-linear pattern.

Summary Statistics for the Reported COVID-19 Cases and Vaccination Status in Pahang

The following table, Table 1, gives a comprehensive analysis of the reported COVID-19 and unvaccinated individuals in Pahang between March 17th, 2020, and April 1st, 2023. Based on the findings, the average number of reported COVID-19 cases in Pahang is estimated to be around 165, with a standard deviation of 301.190. In the present context, it is evident that the reported cases of COVID-19 display a range of values, ranging from a minimum of 0 to a maximum of 2006. Furthermore, it has been noted that the average number of individuals who have not had vaccinations is approximately 65, exhibiting a standard deviation of 114.014. In addition, it is noteworthy that the least and maximum reported cases of individuals who have not had vaccinations are 0 and 693, respectively. The skewness values suggest that the distribution of reported COVID-19 cases and unvaccinated cases in Pahang exhibits positive skewness, with values of 2.964 and 2.252, respectively. This suggests that the distributions of both datasets do not follow a normal distribution.

Table 1. Summary of the reported COVID-19 and unvaccinated cases in Pahang, from March 17th, 2020, to April 1st, 2023

Variables	Mean	Standard Deviation	Minimum	Maximum	Skewness
COVID-19 cases	164.72	301.190	0	2006	2.964
Unvaccinated Cases	64.96	114.014	0	693	2.252

Figure 4 represents the distribution of COVID-19 cases in the state of Pahang, categorised by age groups. The data demonstrates a notable prevalence of COVID-19 infections among individuals in the adult age category, accounting for 66.2% of the total. Subsequently, the child and elderly age categories exhibit infection rates of 17.2% and 9.4%, respectively. The age group of adolescents shows the smallest proportion of COVID-19 cases, accounting for about 7.2%.

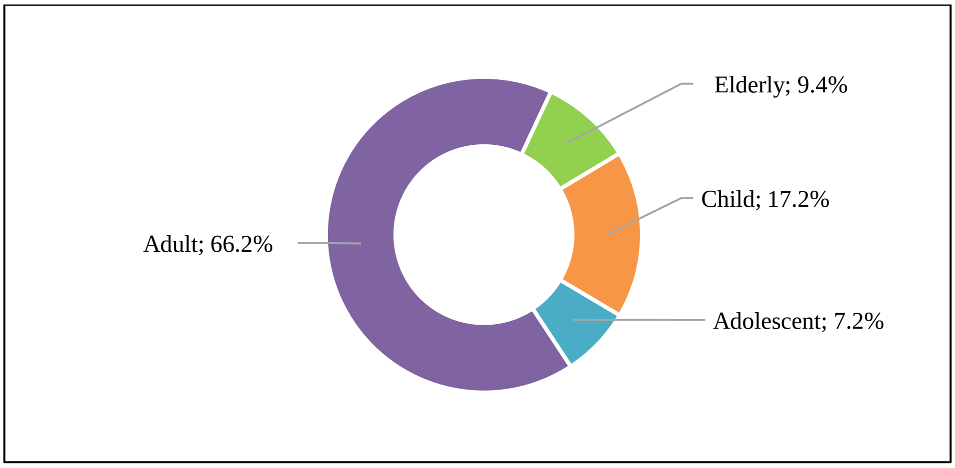


Figure 4. The percentage of COVID-19 cases in Pahang based on age category

Figure 5 illustrates the distribution of COVID-19 cases in Pahang according to age intervals. The age group consisting of individuals aged 18 to 29 exhibits the greatest percentage, accounting for 24.2% of the total. This is followed by the age groups of 30 to 39, 40 to 49, and 5 to 11 years old, which account for 21.2%, 12.2%, and 10.2%, respectively. Individuals in the age group of 80 years and older exhibited the lowest percentage, specifically amounting to a mere 1%. Therefore, the impact of age is expected to influence both the incidence and fatality rates of COVID-19 throughout an extensive range.

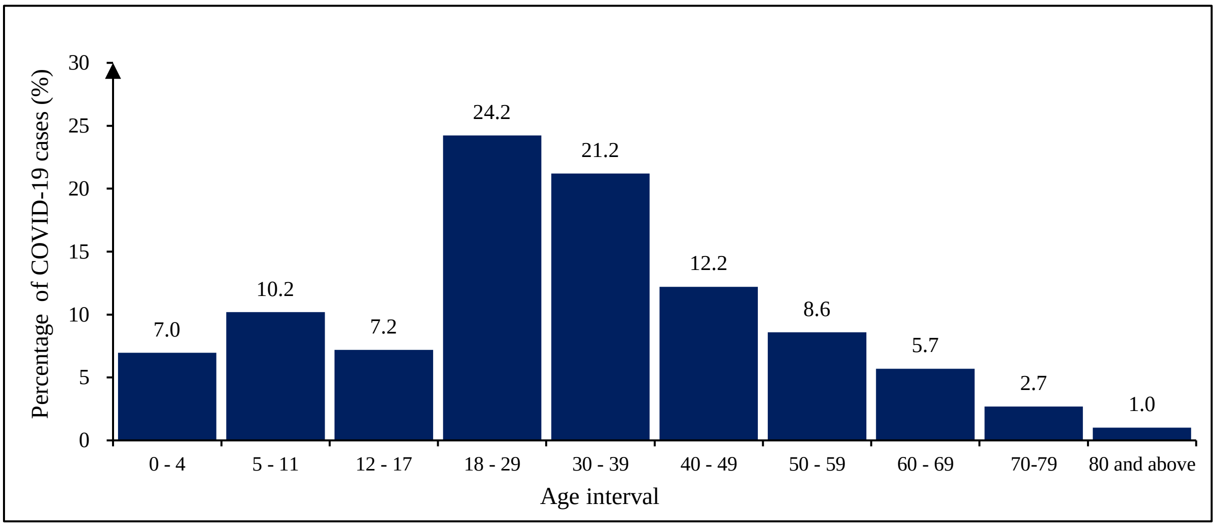


Figure 5. The percentage of COVID-19 cases in Pahang based on age interval

Several global investigations have demonstrated that there is an age-related distribution in both the incidence and severity of COVID-19 infection. The study conducted by Chen et al. (2020) revealed that the average age of patients among infected healthcare professionals at Jintanshan Hospital in Wuhan, China, was 55.5 years. Similarly, Berenguer et al. (2020) reported a mean age of 70 years for patients in Spain, while the CDC COVID-19 Response Team (2020) discovered that the average age of patients in the United States was 42 years. Furthermore, a number of studies have examined individuals who tested positive for the virus, highlighting the heightened vulnerability and increased mortality risk in older adults compared to younger individuals, necessitating enhanced protective measures (Calderon-Larranaga et al., 2020; Verity et al., 2020).

The pie chart shown in Figure 6 above presents the distribution of COVID-19 vaccination status in the area of Pahang. In the area of Pahang, only 39.5% of the population has received full immunisation, while 20% have concluded their vaccination regimen with a dose of booster 1. A mere 0.5% of individuals have successfully completed their vaccination by receiving booster 2. In contrast, a significant percentage of individuals (40%) had received partial immunisation, which is the highest rate among the various vaccination statuses.

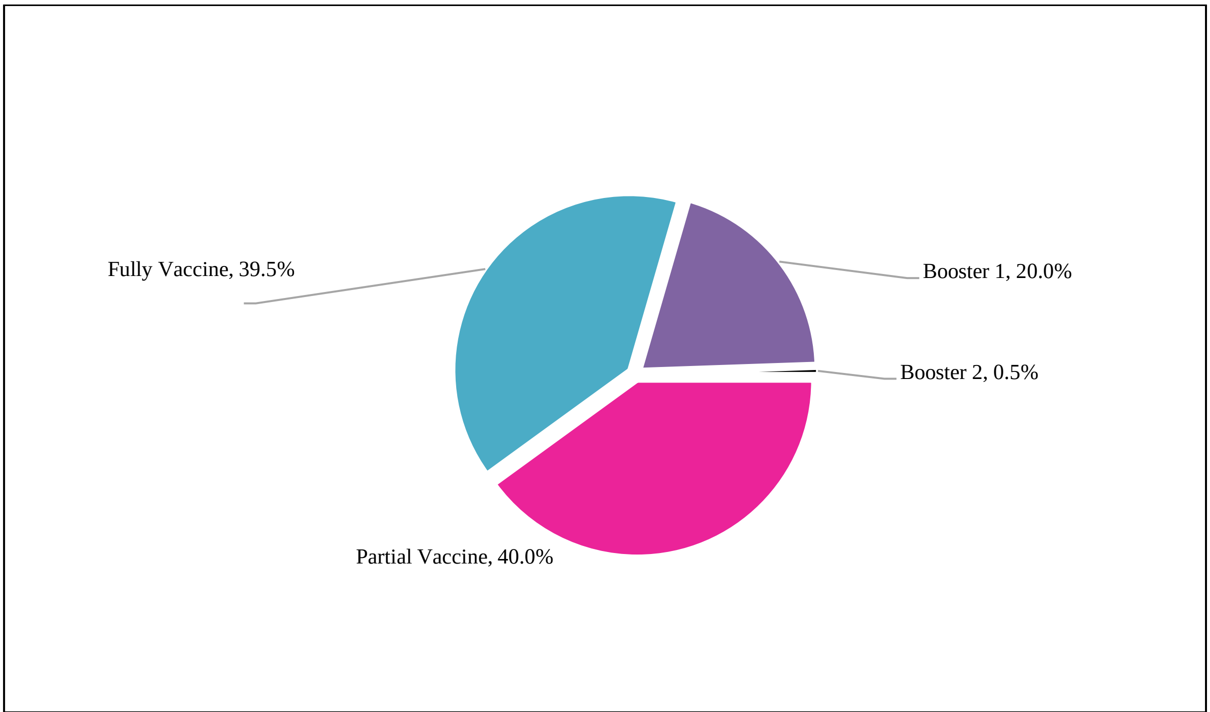
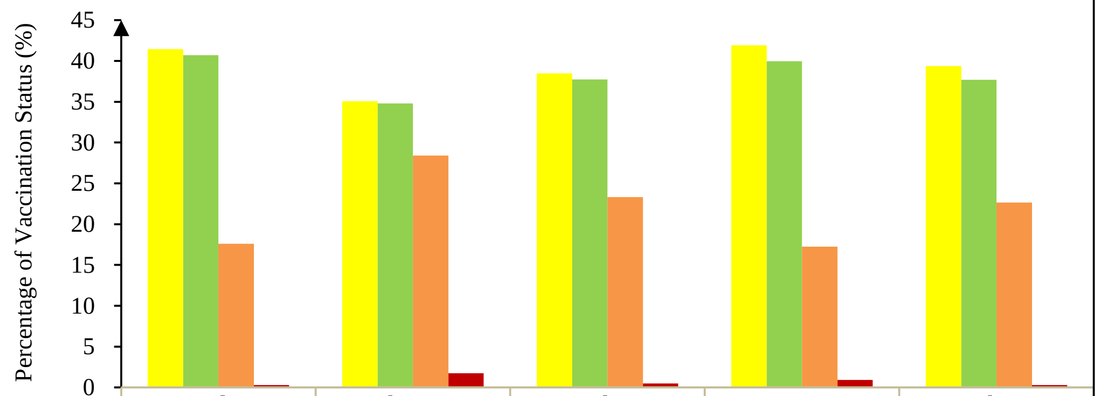


Figure 6. The percentage of COVID-19 vaccination status in Pahang

Figure 7 depicts the distribution of COVID-19 vaccination status in the state of Pahang, categorised by ethnicity. In general, the results indicate that individuals of Native ethnicity show the greatest number of completed or partially completed vaccinations, with an overall prevalence of 41.9%. Conversely, individuals of Chinese ethnicity have the lowest percentage at 35.1%. The data reveals that those of Malay ethnicity exhibit the largest proportion, accounting for 40.7%, in terms of being fully vaccinated. On the other hand, individuals of Chinese ethnicity demonstrate the lowest percentage, with just 34.8% having attained full vaccination status. In addition, it is noteworthy that those of Chinese ethnicity exhibit the largest proportion of completion for the booster 1 vaccine, amounting to 28.4%. On the contrary, individuals of Native ethnicity demonstrate the lowest completion rate, standing at 17.2%. The data reveals that those of Chinese ethnicity exhibit the largest proportion, at 1.7%, of completed vaccinations with the second booster in comparison to individuals of other ethnicity. Meanwhile, individuals of Malay and other ethnicity display the lowest percentage, at a mere 0.3%.

Journal of Academia Vol. 12, Issue 1 (2024) 49 – 64



	Malay	Chinese	Indian	Native	Others
Partial Vaccine	41.4	35.1	38.5	41.9	39.4
Fully Vaccine	40.7	34.8	37.7	40.0	37.7
Booster 1	17.6	28.4	23.3	17.2	22.6
Booster 2	0.3	1.7	0.5	0.9	0.3

Figure 7. The percentage of COVID-19 vaccination status in Pahang based on ethnicity

Figure 8 illustrates the number of newly reported COVID-19 cases and the number of individuals who remain unvaccinated in the state of Pahang, covering the time period from March 17th, 2020, to April 1st, 2023. The colour red is employed to symbolise the reported cases of COVID-19 among patients who have not received the vaccination, while the colour blue is used to represent the newly reported cases of COVID-19. The frequency of newly reported cases has demonstrated a significant increase since March 2020, commencing with a modest total of one case and subsequently rising to a big total of 119 cases by December 9, 2020. All newly reported outbreaks have been attributed to individuals who have not undergone injection of the COVID-19 vaccine (the number of new cases aligns with the number of individuals who have not gotten vaccination). The study demonstrates a noticeable correlation between the reported cases of COVID-19 and the number of individuals who have not received vaccination. Based on the results mentioned above, it can be hypothesised that vaccination status has a substantial influence on the increasing prevalence of COVID-19 cases.

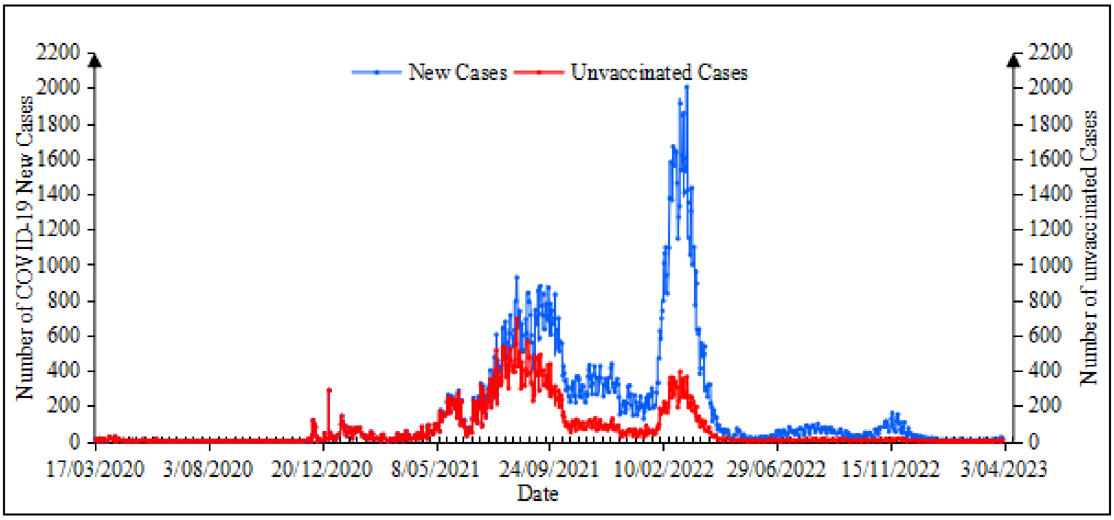


Figure 8. The pattern of the reported COVID-19 and unvaccinated cases in Pahang

Moreover, there were two notable peaks in COVID-19 cases documented between the dates of March 17 and April 1, 2023. A large peak of COVID-19 cases was observed in Pahang in March 2022 during the intermoonson season and a smaller peak in August 2021 during the southwest moonson season (May to August). Based on the occurrence of two notable peaks, it is expected that there is a correlation between climate variables and the number of COVID-19 cases. These peaks were seen between August 2021 and March 2022. Numerous earlier studies supported this claim. For instance, a study conducted in Dhaka City, Bangladesh, revealed a positive association between meteorological variables and air quality indicators. This correlation implies that the relationship between these factors has implications for the incidence of COVID-19 cases (Rahman et al., 2020). In addition, it has been observed that in China, the presence of low relative humidity has heightened the influence of the Air Quality Index (AQI) on the transmission of COVID-19. According to Xu et al. (2020), there was a significant influence of air pollution on the incidence of COVID-19 during periods when the temperature ranged from 10ºC to 20ºC or the relative humidity was between 10% and 20%.

Normality Test

In the present study, a combination of graphical and numerical techniques was utilised to assess the normality of the dataset. The graphical method employed the Q-Q plot, while the numerical method used the Shapiro-Wilk normality tests.

a) Graphical Method: Normal Q-Q Plo

The graphical methods, including the Q-Q plot, used to assess the normality of reported cases of COVID-19 and unvaccinated individuals are shown in Figure 9. Based on the provided figure, it can be observed that the usual quantile-quantile (Q-Q) plot for both datasets indicates a deviation from the expected diagonal line. This observation suggests that the data distribution exhibits non-normality.

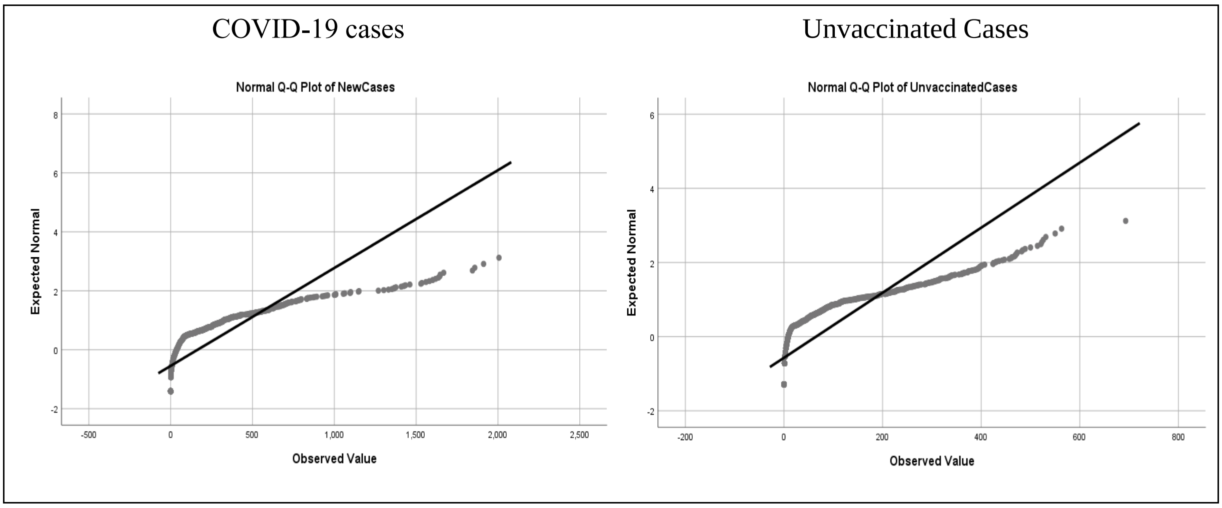


Figure 9. Graphical Method for Normality Test Using Normal Q-Q Plot

b) Numerical Method: Normality Test

To ascertain the presence of concrete evidence regarding the normality of the data, the analysis proceeds by using numerical methods, such as the Shapiro-Wilk normality test, following the graphical method discussed in the preceding section. The outcome of the test can be seen in Table 2. Based on the obtained results, it is evident that the p-value is below the predetermined significance level of 0.05 for both datasets. This suggests that the distributions of reported COVID-19 cases and unvaccinated patients do not adhere to a normal distribution.

Table 2. Shapiro-Wilk Normality Test

Normality Test	Test statistic, W	df	p-value
COVID-19 cases	0.593	1111	0.000***
Unvaccinated Cases	0.629	1111	0.000***

Spearman Rank Correlation Analysis Between the Reported COVID-19 and Unvaccinated Cases
As stated in the methodology section, due to the absence of normal distribution in both sets of data, the Spearman rank correlation approach was employed to examine the association between the two sets of data. This particular approach can be used for continuous data that does not follow a normal distribution. The analytical stages encompassed doing a correlation study to examine the relationship between the reported cases of COVID-19 and the number of individuals who have not had vaccinations in the region of Pahang. The outcomes of the Spearman rank correlation analysis between reported COVID-19 and unvaccinated cases are presented in Table 3. The results suggest a statistically significant correlation between reported cases of COVID-19 and individuals who have not received vaccination. The statistical significance of this link is shown by a p-value of 0.000, which falls below the commonly accepted threshold of 0.05. Furthermore, the correlation coefficient, symbolised as ρ, exhibits a value of 0.923, indicating a highly strong association between the variables mentioned above.

Table 3. Spearman rank correlation analysis

Variables	Values	COVID-19 cases	Unvaccinated Cases
COVID-19 cases	Correlation Coefficient, ρ	1	0.923
	p-value	-	0.000***
Unvaccinated Cases	Correlation Coefficient, ρ	0.923	1
	p-value	0.000***	-

Significant codes: 0.05 '***'

Additionally, the coefficient of determination value, R^2, is presented in Table 4. According to the coefficient of determination, which is 0.852, the number of reported unvaccinated cases accounts for about 85.2% of the overall variability in the reported COVID-19 cases in Pahang. Conversely, the remaining 14.8% of the difference can be attributed to a range of additional factors, including climate factors, population density, and socio-demographic factors.

Table 4. Correlation coefficient and coefficient of determination

Statistical Analysis	
Correlation Coefficient, ρ	Coefficient of Determination, R^2
0.923	0.852

The advantages of immunization greatly exceed the associated risks, and there is ample evidence to support the high level of protection exhibited by COVID-19 immunizations. Multiple previous studies have yielded comparable results. For instance, a study conducted in England revealed a significant correlation between vaccines and notable decreases in symptomatic cases of COVID-19 among older individuals (Bernal et al., 2021). According to Vasileiou et al. (2021), the use of vaccines in Scotland has been linked to significant decreases in the risk of hospitalization due to COVID-19. Besides, Liang et al. (2021) have stated that there is an association between COVID-19 vaccines and decreased fatality rates. According to Moghadas et al. (2021), empirical evidence suggests that the implementation of COVID-19 immunization programs in the United States would result in a significant reduction of 69.3% in COVID-19 mortality rates.

Conclusion

COVID-19 is currently recognized as an emerging infectious disease that exhibits a worldwide influence on people. The emergence of this disease outbreak has become an important concern in the context of global public health, impacting diverse geographical areas. It is a worldwide pandemic that exerts significant impacts on the physical and mental well-being of people on a global scale. The immunisation programme is an organised campaign led by healthcare professionals aimed at mitigating the prevalence of COVID infection and reinstating social balance. Hence, the main aim of the study was to determine the association between the daily incidence of COVID-19 cases and the number of unvaccinated individuals in the region of Pahang, Malaysia. Next, this study also aimed to look into the profile pattern of COVID-19 cases in the state of Pahang. The study findings suggest that the use of vaccines is of crucial significance in mitigating the risk of contracting COVID-19 in the region of Pahang. An increase in the prevalence of individuals who have not received vaccinations in Pahang is associated with a corresponding increase in the number of daily reported cases of COVID-19. Consequently, this study proposes prioritizing the extensive adoption of vaccination, effectively addressing vaccine hesitancy, and continuously monitoring the enduring effects of immunization. These findings possess the capacity to support public health policies and provide significant contributions to the broader effort to limit the spread of COVID-19. Several limitations were identified in the current research. It is imperative to employ advanced statistical techniques in order to examine the association between COVID-19 cases and people who have not been vaccinated. These may encompass the application of sophisticated statistical models, such as the generalized linear model and the generalized additive model. This may potentially enhance the scope of research pertaining to the association between unvaccinated individuals and the incidence of COVID-19 cases in Malaysia. Moreover, it is advisable for forthcoming research endeavors to consider additional variables, such as the population density of states and climate-related factors, in order to determine the potential influence of these factors on the prevalence of COVID-19 cases.

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Author Contribution

All authors contributed to the design of the research, including data collection, data cleaning, data analysis and the write-up. All authors have read and approved the final manuscript.

Conflict of Interest

Authors declare no conflict of interest.

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