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Regional and Demographic Patterns of Covid-19 in Malaysia: A State and Federal Territory Analysis of Cases, Mortality, Age and Vaccination Status, 2020–2025

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ABSTRACT

This study analyses the burden of COVID-19 in Malaysia at the regional and demographic levels based on an aggregated dataset at the state level comprising 16 states and federal territories. Analysis is based on reported cases, reported deaths, age group composition, vaccination status, and will attempt to place the COVID-19 surveillance data in a population and social-science context. Descriptive statistics were used to compare burden on a state-by-state basis, to calculate crude case-fatality ratios, and to look at characteristics of cases and deaths by vaccination status and age. There were 5,330,305 reported case and 37,351 deaths reported. Selangor reported the highest number of cases, 30.69%, and deaths, 29.63%, while the five largest state level contributors together reported 62.42% of the cases. For cases with known age, adults accounted for 71.62%, the children for 12.36%, the adolescents for 6.31% and elderly for 9.71%. When broken down by vaccination status, 38.41% of reported cases were unvaccinated, 8.20% were partially vaccinated, 26.67% were fully vaccinated and 26.72% had been boosted. On the other hand, 60.34% of reported deaths were among unvaccinated individuals; 16.91% among those who were partially vaccinated; 18.74% among those fully and 4.01% among those who were boosted. The results indicate significant geographic and demographic variation in the reported burden of COVID-19 in Malaysia. The difference in the vaccination status of cases and deaths indicates that vaccination status is an important factor to consider in pandemic analysis at the population level, where vaccination status cannot be used to determine person-to-person vaccine effectiveness or cause-and-effect. The study calls for geographically-based health communications, for targeted age-based protection and for the maintenance of clear disaggregated surveillance data in future public-health crises.

Keywords: COVID-19; Malaysia; regional inequality; vaccination status; population studies

INTRODUCTION

COVID-19 was a biomedical, social and spatial event. Population density, mobility, economic activity, access to services, public health interventions, and communications and the ability of institutions to reach various populations influenced patterns of infection and mortality. The first COVID-19 case in Malaysia was identified in January 2020, followed by successive waves, movement restrictions, vaccination programs, and gradual shift to the endemic phase of COVID-19. The pandemic is thus a useful platform to explore regional and demographic variations in population vulnerability.

Previous studies in Malaysia have shown that COVID-19 is a spatiotemporally heterogeneous disease. However, through the use of spatial and temporal approaches, Cheong et al (2022) demonstrated that high-risk areas shifted over time and that there was a lack of uniform spatial distribution of transmission across the Malaysian states. Their work points to the significance of looking at geography and spatial concentration in understanding national COVID-19 statistics. Likewise, Teh et al. (2024) discovered significant variations in

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COVID-19 deaths across the states and regions of Malaysia with several areas such as Kelantan, Perlis, Sabah and Sarawak being considered at high risk at certain times. These studies reinforce the idea that it is insufficient to capture social distribution of pandemic burden by a national level.

There is an additional population dimension in the vaccination. Starting from February 2021, Malaysia launched a national COVID-19 immunisation program, with vaccination increasingly linked to public communication, public trust, and individual behaviour – and the organisation of health services. The research conducted among the Malaysian population revealed high acceptability of COVID-19 vaccination, and concerns regarding safety, side effects, information and trust were also found among groups of hesitance. (Syed Alwi et al., 2021) Subsequent studies also showed that vaccine hesitancy was related to behavioral beliefs, perceived risks, conspiracy beliefs and social influences (Vaithilingam et al., 2023). The results show that vaccination cannot only be viewed as a medical act, but also as a social process, with communication, trust, access and population behaviour as important elements. The present study aims to explore the distribution of COVID-19 cases and deaths at the state level in Malaysia and to analyse the age and vaccination disparity in the burden of the pandemic. The study is intentionally designed as a population and social-science rather than a clinical vaccine-effectiveness study. The goal is not to find out if vaccination led to a decrease in either infection or death rates. However, the goal is to report on the social distribution of outcomes, and to find commonalities that are relevant for planning, communication, and allocation of resources at the population level.

This study aims to answer four research questions. First, what was the distribution of COVID-19 burden across Malaysian states and federal territories? Secondly, what age group made up the biggest percentage of reported cases? Thirdly, what is the distribution of reported cases and deaths by vaccination status? Third, what are the population-level implications of the observed regional, demographic and vaccination patterns without individual level causal claims?

LITERATURE REVIEW

COVID-19 as a Social and Spatial Phenomenon

Public-health emergencies are socially patterned because exposures are related to the ways people live, work, travel and interact with institutions. The COVID-19 pandemic altered everyday habits as a result of mobility and gathering restrictions, and found new ways to spread as activities resumed in the economy and society. The shift from strict control to reopening in Malaysia coincided with the emergence of new viral strains and increased vaccination rates. The transition from strict controls to reopening coincided with the viral variants' changes and the increase in vaccination rates in Malaysia. Thus, reported case numbers for a specific site were not only related to biological transmission, but to population structure, mobility, testing policies, reporting policies and timing of interventions. Spatial research provides evidence for this interpretation. Cheong et al. (2022) were able to identify high-risk clusters and showed the spatial distribution of the spread of COVID-19 was dynamic. The authors reported early concentration at Selangor/KL and later spread to other places. Ganasegeran et al. (2021) also studied population density and suggested that population density is a factor in the spread of COVID-19 in Malaysia. This means that the distribution across states can be compared for social research because there are differences in states' population density, urbanization, "connectivity", and economic activity.

Age and Population Vulnerability

One of the most significant criteria for population vulnerability in the event of a pandemic is age. Infection can take place at any time in the lifespan, but the impact of infection is not consistent throughout. Children and adolescents have frequently been a smaller proportion of the severely affected and have not been the main risk group for severe cases and fatalities, whereas older individuals have been more likely to be severely affected and to die. Teh et al. (2024) showed significant variation in the case-fatality rates by age group in Malaysia and between states. According to their analysis, the population of senior citizens tend to have the higher fatality, while for parts of the pandemic, the population of children in Sabah recorded the

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comparatively higher fatality. This is an illustration of the need for geographically disaggregated analysis in addition to national age totals. The age structure also has a social-policy dimension. The communication and workforce strategies should be different in a state where elderly people are a larger proportion of the severe cases in contrast to a state with a relatively high number of adult cases. Age-specific patterns can thus help to guide risk communication, community outreach, vaccination prioritisation, and allocation of health and social-care resources.

Vaccination, Trust and Social Behaviour

Vaccination is a health and social phenomenon. Uptake varies with access, information, perceived risk, trust in institutions, and social norms and beliefs about vaccine safety and effectiveness. Syed Alwi et al. (2021) noted that the overall acceptance was high compared to the concern on side-effects, safety, information and effectiveness among the Malaysian respondents. A group of Malaysian respondents was found to exhibit vaccine hesitancy, with behavioral and social factors such as vaccine risks and conspiracy beliefs associated with it, according to Vaithilingam et al., (2023). These studies are relevant to the present analysis because vaccination status is provided in the data set and cases and deaths are recorded for vaccination status. This data can be analyzed to determine if there were differences in reported outcomes by vaccination status (unvaccinated, partially vaccinated, fully vaccinated and boosted). But the right interpretation is descriptive. The denominator (the number of people who were in each vaccination category at risk during the period analysed) is missing from the analytical file and thus a count of vaccinated cases cannot itself be used to estimate vaccine effectiveness. Furthermore, there may be systematic differences in age, timing of vaccination, variant circulation, health status and testing behaviour among vaccination groups.

Research Gap

Research on aspects of COVID-19 in Malaysia has largely focused on epidemiology, spatial dynamics, deaths, clinical complications, or vaccine uptake. These strands are useful but tend to focus on one dimension and at a time. The present study is a compact population-level synthesis that considers concentration in regions together with age composition, and with vaccination-status composition, in the same state-level analytical framework. The contribution then is not a new clinical effect, but rather, an identification of a new mechanism of action. Instead, it is a combination of geographically and demographically disaggregated surveillance markers and a social-science-based approach to population vulnerability and pandemic governance.

METHODOLOGY

Research Design

The method used in this study was quantitative descriptive research with secondary data. The unit of analysis was a state or a federal territory in Malaysia. Sixteen geographical units have been analysed namely Perlis, Kedah, Kelantan, Perak, Pahang, Pulau Pinang, Melaka, Terengganu, Johor, Negeri Sembilan, Selangor, Sabah, Sarawak, Wilayah Persekutuan Kuala Lumpur, Wilayah Persekutuan Labuan and Wilayah Persekutuan Putrajaya.

Data Source and Variables

This study analysed Malaysian COVID-19 surveillance data covering the period from 25 January 2020 to 31 May 2025. The dataset was derived from COVID-19 data published by the Ministry of Health Malaysia through the KKMNOW data platform and included state-level cases and deaths, with additional information on age group and vaccination status. The dataset includes several variables such as newly reported cases, imported cases, recovered cases, active cases, cluster cases, vaccination status categories, age categories, and mortality (Ministry of Health Malaysia, 2025). The Ministry of Health classification of state-level case data as surveillance data with counts being reported as per the reporting date. Vaccination-status data is created by correlating COVID-19 case data with vaccination status records, and categorizes cases according to whether they are unvaccinated, partially vaccinated, fully vaccinated and boosted. Reported cases (cases_new) and

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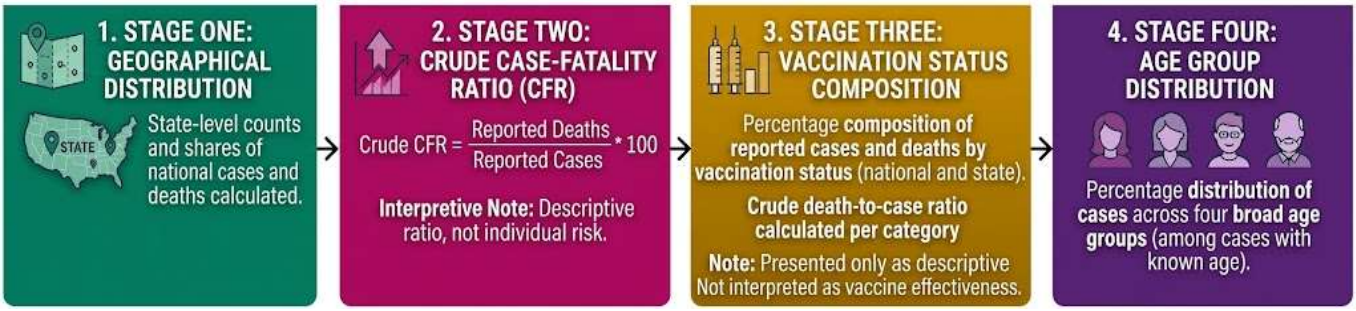
reported deaths (deaths_new) were the main outcome variables. Secondary variables: imported cases, cluster related cases, age groups (children, adolescents, adults and elderly) and vaccination status (unvaccinated, partially vaccinated, fully vaccinated and boosted). The working file also includes much more granular age bands ranging from 0–4 years to 80 years and over, which were employed in checking data but the analysis provided in the main paper employs the four overall age groups as these matched the overall age banding used by the source.

Measures and Analysis

There were four stages of descriptive analysis. Counting and sharing of national cases and deaths at the state level was first conducted. Second, a basic case fatality ratio (CFR) was computed by dividing the reported number of deaths by the number of reported cases and multiplying by 100. This measure is seen as a very simple descriptive ratio and not an estimate of individual risk since the data is aggregated and not followed up at the individual level. Finally, national and state-level percentages of reported cases and deaths by vaccination status were computed. Fourthly, the distribution of cases by four broad age groups was calculated for the cases for which information on age was available. A simple ratio of crude deaths to crude cases was also computed by vaccination category. This latter is only a descriptive ratio and not a vaccine effectiveness measurement. No causal inference model was used to assert causality. Moreover, the study does not regress deaths on vaccination status since the number of people in each vaccination category, denominators (age-adjusted), timing of vaccination and individual-level covariates are not provided in the provided file. The goal of the study is to describe population patterns, as is the analytical plan. Analytical framework of measures and analysis in this study is presented below.

Figure 1. Analytical Framework for Measures and Analysis



RESULTS

Overall State-Level Distribution

The analytical dataset comprises the reported number of COVID-19 cases of 5,330,305 and deaths reported in 16 Malaysian states and federal territories of 37,351. This gives a national crude case-fatality ratio of approximately 0.70%. Selangor recorded the largest number of reported cases (1,635,718), followed by Wilayah Persekutuan Kuala Lumpur (524,421), Johor (418,235), Sabah (414,352) and Sarawak (334,325). These five geographical units combined made up 62.42% of all reported cases. The concentration is especially high in Selangor with 30.69% of the national reported cases.

The distribution of deaths generally matched the distribution of cases, but there were significant differences in relative burden. The Selangor state had 11,066 deaths, accounting for 29.63% of the total deaths in the country. Johor recorded 4,770 deaths, followed by Sabah (3,216), Kuala Lumpur (2,872) and Kedah (2,775). The top five causes of death together made up 63.54% of all deaths in the country. The state with the highest crude state level case fatality ratio (CFR) in the data supplied was Johor at 1.14%, followed by Perlis with 0.95% and Kedah with 0.83%. Putrajaya was the lowest with a crude ratio of 0.08% but in very small populations, the ratio must be viewed with caution.

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Table 1. State-level distribution of reported COVID-19 cases and deaths

State / federal territory	Cases	Case share	Deaths	Death share	Crude CFR
Selangor	1,635,718	30.69%	11,066	29.63%	0.68%
Wilayah Persekutuan Kuala Lumpur	524,421	9.84%	2,872	7.69%	0.55%
Johor	418,235	7.85%	4,770	12.77%	1.14%
Sabah	414,352	7.77%	3,216	8.61%	0.78%
Sarawak	334,325	6.27%	1,807	4.84%	0.54%
Kedah	332,579	6.24%	2,775	7.43%	0.83%
Pulau Pinang	323,921	6.08%	2,101	5.63%	0.65%
Kelantan	268,987	5.05%	1,430	3.83%	0.53%
Perak	251,164	4.71%	2,190	5.86%	0.87%
Negeri Sembilan	244,089	4.58%	1,552	4.16%	0.64%
Pahang	190,938	3.58%	1,042	2.79%	0.55%
Melaka	163,965	3.08%	1,227	3.29%	0.75%
Terengganu	143,187	2.69%	909	2.43%	0.63%
Wilayah Persekutuan Putrajaya	39,151	0.73%	32	0.09%	0.08%
Wilayah Persekutuan Labuan	24,006	0.45%	160	0.43%	0.67%
Perlis	21,267	0.40%	202	0.54%	0.95%

Figure 2. Reported COVID-19 cases by Malaysian state/federal territory

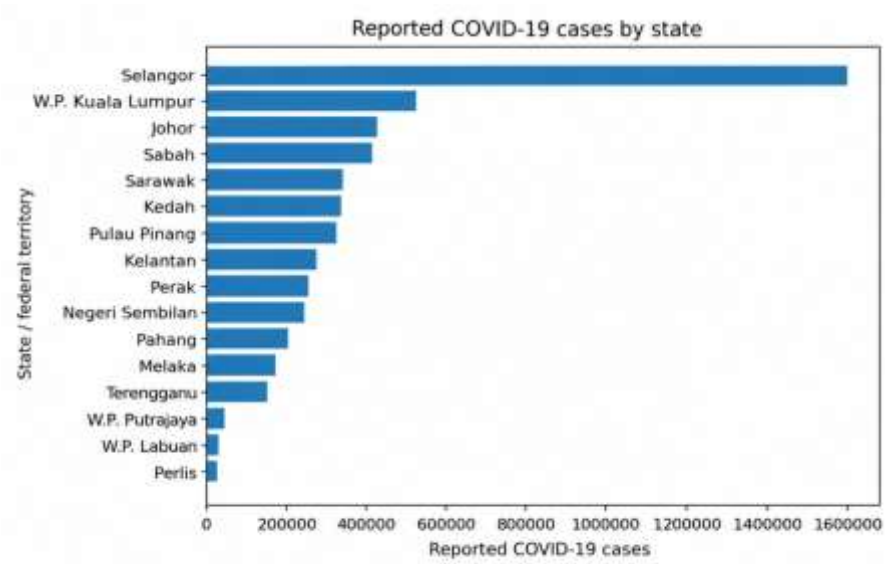

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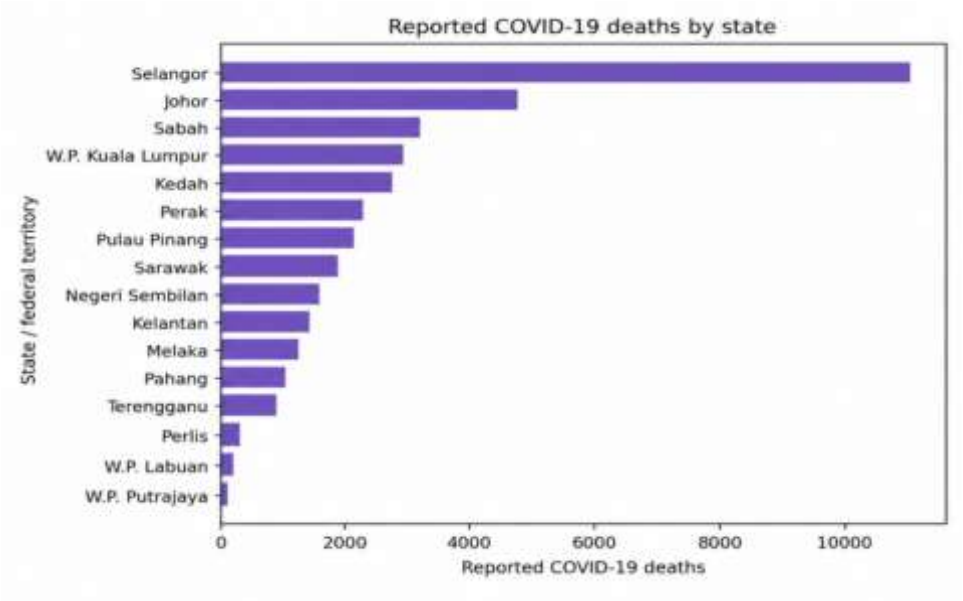
Figure 3. Reported COVID-19 deaths by Malaysian state/federal territory



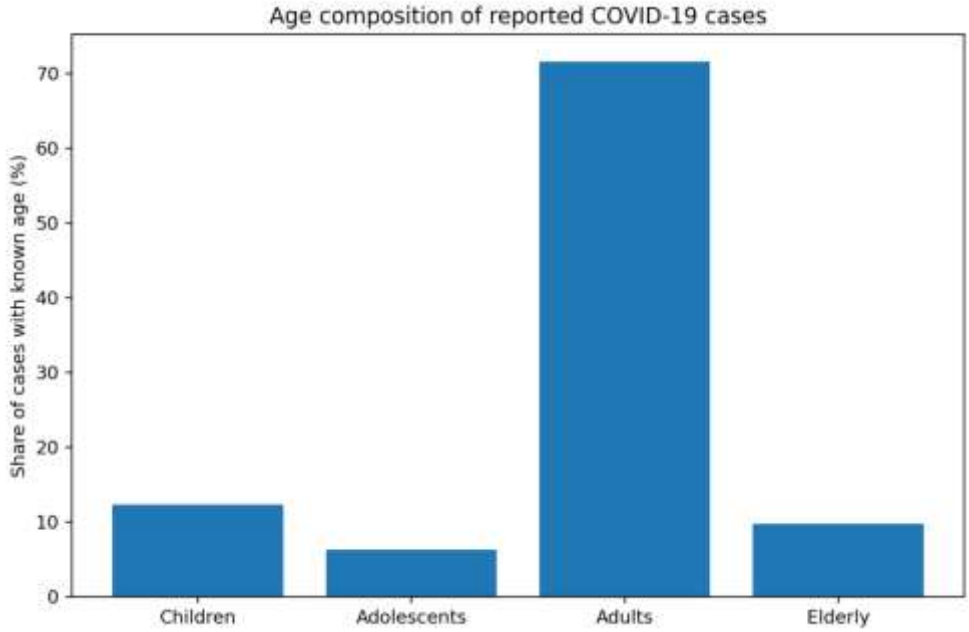
Age Composition of Reported Cases

In Malaysia, there were 3,215,422 cases with known age distributed across the four broad age categories. The largest proportion was adults (71.62%), followed by children (12.36%), elderly persons (9.71%) and adolescents (6.31%). The four categories do not add up to the total number of cases due to the fact that 45,682 (or about 1.42%) of the cases reported in the aggregate data were not assigned to a usable broad age category.

Table 2. National age composition of reported cases

Age group	Cases	Percentage
Children	648,498	12.36%
Adolescents	330,814	6.31%
Adults	3,756,406	71.62%
Elderly	509,554	9.71%

Figure 4. Age composition of reported COVID-19 cases among cases with known age



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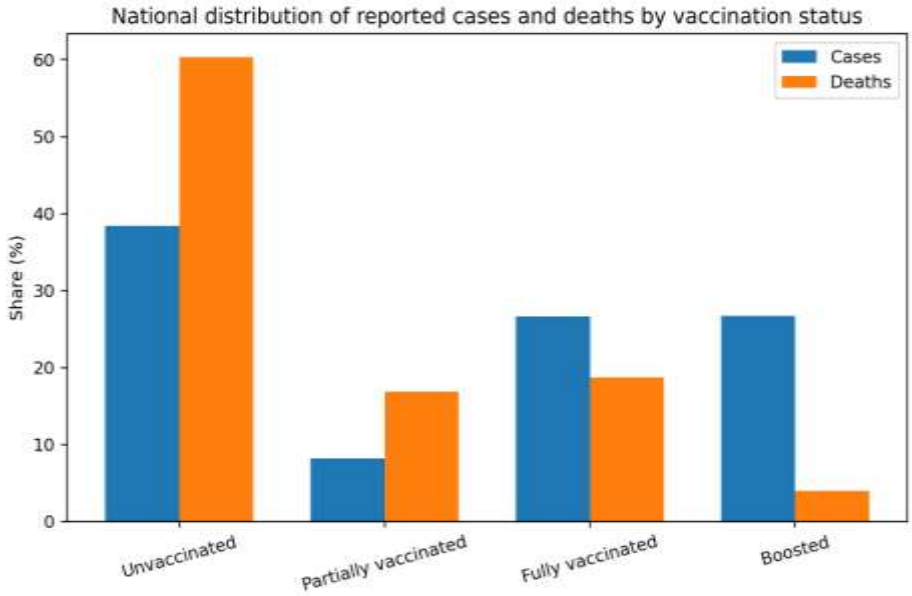
Vaccination Status and Reported Cases

The vaccination status gives rise to a more complex pattern compared to age. Of the 5,330,305 reported cases, 2,047,211 (38.41%) were unvaccinated, 436,918 (8.20%) were partially vaccinated, 1,421,807 (26.67%) were fully vaccinated and 1,424,369 (26.72%) were boosted. So, 53.39% of reported cases were among fully vaccinated and boosted people and 46.61% were among unvaccinated and partially vaccinated people. There were significant differences between the composition of the state-level groups. Johor and Sabah did not perform well in terms of unvaccinated cases, with 44.33% and 44.35%, respectively, of cases, while Wilayah Persekutuan Labuan had 47.14%. Wilayah Persekutuan Kuala Lumpur had a relatively high boosted case share of 42.58%, while Putrajaya had a boosted case share of 47.04%, by contrast. Perlis had the highest proportion of cases that were fully vaccinated (50.24%). These are not vaccine effectiveness differences, as the populations of different states varied, vaccination coverage also varied, and age structure and timing of vaccination vary.

Vaccination Status and Reported Deaths

The composition of deaths was very different from that of cases. Of the 37,351 reported deaths, 22,539 (60.34%) were among unvaccinated individuals, 6,315 (16.91%) among partially vaccinated individuals, 7,000 (18.74%) among fully vaccinated individuals and 1,497 (4.01%) among boosted individuals. The most prominent descriptive difference is that unvaccinated persons have made up 38.41% of the reported cases and 60.34% of reported deaths. The contrast is relevant for the interpretation on the population level since it indicates that the distribution of deaths was not proportional to the distribution of reported infections at the vaccination level. However, the difference is not equivalent to a direct estimate of the vaccine protection. People who have not been vaccinated can be older or younger than vaccinated, have different underlying health conditions, have different access to care, when they get sick, and more. Vaccination status also evolved over time and there were different variants, different population immunity levels in the pandemic.

Figure 5. National composition of reported cases and deaths by vaccination status



Crude Death-To-Case Ratios by Vaccination Status

The crude death-to-case ratios were around 1.10%, 1.45%, 0.49% and 0.11% for cases who were not vaccinated, partially vaccinated, fully vaccinated and boosted, respectively. The increased ratio for the partially vaccinated group should not be interpreted as a sign of higher mortality rates in this group. Partial vaccination was a stage between full vaccination and full vaccination, which could be targeted at certain time periods, such as implementation of vaccination programmes or when population risk and circulating variants were fluctuating.

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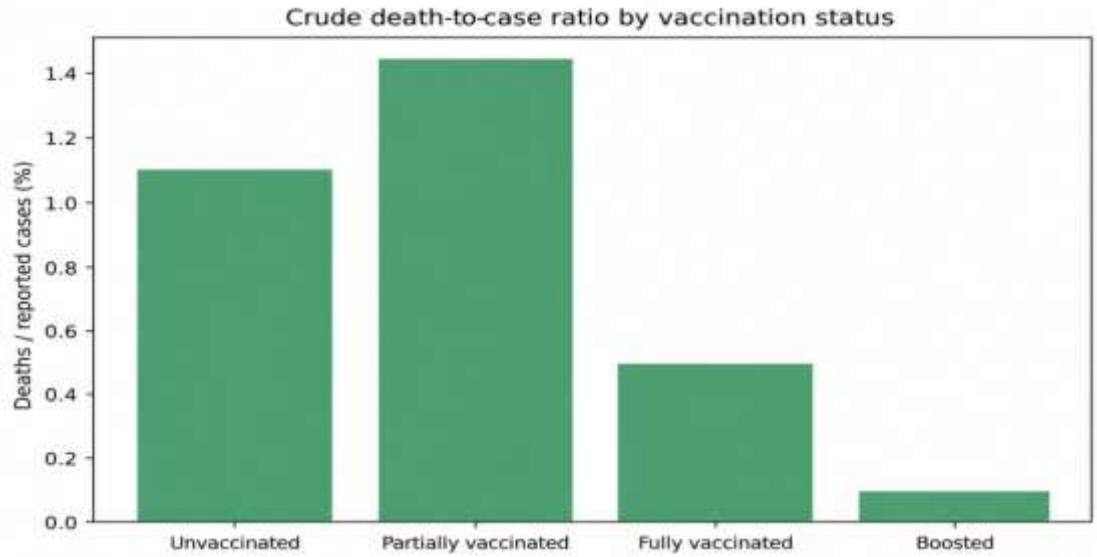
Table 3. Descriptive death-to-case ratios by vaccination status

Vaccination status	Cases	Deaths	Crude death-to-case ratio
Unvaccinated	2,047,211	22,539	1.10%
Partially vaccinated	436,918	6,315	1.45%
Fully vaccinated	1,421,807	7,000	0.49%
Boosted	1,424,369	1,497	0.11%

Figure 6. Crude death-to-case ratio by vaccination status



DISCUSSION

Regional Concentration and Social Vulnerability

The first significant result is that there is a high density of reported COVID-19 cases and deaths in a relatively small number of geographical units. Selangor had reported nearly one-third of cases, with the top 5 states reporting over three-fifths of the national cases. This trend is in line with previous studies conducted in Malaysia which indicated that population density, connectivity and mobility were significant factors in the spatiotemporal distribution of COVID-19 (Cheong et al., 2022; Ganasegeran et al., 2021). From a social-science point of view, concentration is not necessarily a reflection of the poor performance of a given state. If not higher, individual risk is higher in large and well-connected populations, which produce larger absolute numbers. The city of Selangor and Kuala Lumpur are the economic and transportation hubs with huge population movements every day. The right policy conclusion is therefore not that states should be ranked, but that there are different approaches to surveillance and communication that are needed in different places. High-volume urban areas might need immediate information sharing, work site and travel modifications, and strict surveillance of identified clusters.

Meanwhile, smaller absolute rates can have comparatively high crude case-fatality ratios in states with smaller absolute numbers. The absolute numbers of cases and the relative level of severity should be considered together, as shown by Johor and Perlis. The COVID-19 mortality data also showed significant variation across the states and time by COVID-19 status, as was shown by Teh et al. (2024). This implies the vulnerability of the population is multidimensional, that is, a state can have a high level of transmission burden, relative mortality burden, or both.

Age as a Dimension of Population Vulnerability

The high proportion of adults in cases was not unexpected, since adults make up a significant share of the population and were over-represented in economically and socially active environments. This was not to be taken as a sign that adults were more vulnerable than other age groups in general. Case counts are influenced

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by population composition, exposure opportunities, testing/reporting and biological susceptibility. Especially noteworthy is the relatively low proportion of elderly cases. Low vulnerability does not mean a low number of elderly infections. Although the elderly may have a lower proportion of infected individuals, they may be more affected. Across multiple periods, Teh et al. (2024) discovered significantly greater mortality rates in the senior groups. Hence, pandemic preparedness should differentiate those who are most likely to spread the disease and those who are most likely to suffer from the most serious consequences. Communication needs should be adapted accordingly by age. Adults can be addressed in the workplace, via digital tools and community networks, whilst elderly people need family-mediated communication, primary-care community engagement and accessible immunisation provision. Children and adolescents require communication strategies involving schools, parents and caregivers. This sort of differentiation illustrates how the epidemiological data can inform social policy, instead of just reporting counts of disease

Vaccination status as a Social-Policy Indicator

The vaccination results are of particular interest for a social-science journal as they illustrate the intersection of a population intervention with outcomes of disease observed. Although more than half of the cases reported in the data were fully vaccinated or boosted, the proportion of unvaccinated was significantly higher among deaths than it was among cases. The descriptive contrast aligns with the overall body of evidence that vaccination and booster programmes came into play for the reduction of COVID-19 mortality and also highlights that breakthrough infections were observed. But the social interpretation should be directed to the protection of population and not the individual blame. The proportion of unvaccinated deaths may be large due to unequal access or uptake, or trust and differences in demographic composition, or in the access or timing of healthcare services. The concerns about safety, side effects and information, as well as social and behavioural factors, have been documented in the context of vaccine hesitancy in the Malaysian research context (Syed Alwi et al., 2021; Vaithilingam et al., 2023). These results further underscore the need for communication and institutional trust in formulating vaccination strategies. Communication implications also exist when considering the different compositions of vaccinations by state. For instance, states with relatively high rates of unvaccinated cases could target information campaigns and increase vaccination access, while states with high booster uptake could focus on communication to ensure continued trust and rebut misinformation about breakthrough infections. Such targeting is not to stigmatise communities, but to target interventions in line with identified population patterns.

Implications for Public-Health Governance

Findings support the development of three governance implications. First, surveillance needs to continue to be disaggregated by geography, age and vaccination status. There may be significant regional variations within one national total. Second, the public communication must be varied based on the needs of the population and not be based on a national message. Third, clear denominators and time stamps should be retained in data systems to allow for more robust causal or quasi-experimental analyses in future through descriptive surveillance.

Lastly, the present study could describe vaccination-status pattern due to having counts of cases and deaths by vaccination status. It lacked an ability to calculate vaccine effectiveness as it did not have the numbers of people at risk in each category over time. Vaccination coverage should therefore be coupled with population denominators, age, sex, comorbidity, testing and outcomes in a privacy-preserving way in future surveillance systems. This integration would enable the identification of changes in population risk and composition.

Comparison with Previous Malaysian Research

The present results complement rather than contradict previous Malaysian studies. The spatial approaches by Cheong et al. (2022) were used for spatial analysis to identify changing geographical clusters, while Teh et al. (2024) applied the period-specific CFRs and principal component analysis to study age and sex differentials in mortality. The present study is different in that it combines age with vaccination composition into a single descriptive framework along with cases and deaths by state. Existing studies on vaccine acceptance and

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hesitancy have largely focused on attitudes and behavioural factors, such as those by Syed Alwi et al. (2021) and Vaithilingam et al. (2023). There is no direct measure of attitudes in this dataset; this is an outcome measure at the population level for behaviors that can be interpreted in the context of the attitudes.

LIMITATIONS

There are some restrictions to be considered. Firstly, the data provided from the Ministry of Health are date-based and accurate temporal information is critical for interpreting vaccination status and variants and policy changes. Secondly, the analysis is ecological. Patterns at the state-level do not imply relationships at the individual level. High unvaccinated deaths do not necessarily mean all unvaccinated people had a higher risk of death and high vaccinated case share does not mean low performance with vaccines.

Third, the current study does not contain population denominators by vaccination category, thus the vaccine effectiveness cannot be estimated. Lastly, reported cases are not an accurate reflection of all infections. In addition to varying by time and place, testing behaviour, as well as health care-seeking behaviour and reporting, may vary by population group. This is also consistent with what Teh et al. (2024) reported, where they suggested that the actual number of infections might be higher than official figures.

CONCLUSION

This study shows a high geographical, age and vaccination status-specific COVID-19 burden in Malaysia. Case burden was reported in a limited number of states that are well connected and highly populated with 30.69% of cases reported in Selangor. With known age, adults made up 71.62% of cases, and elderly persons made up a smaller proportion of cases, but they are an important vulnerable group due to their increased risk for severe cases. A significant contrast was observed between the vaccination status: unvaccinated accounted for 38.41% of the reported cases and 60.34% of the reported deaths.

The results of this research justify a population-centered approach to pandemic governance. The figures and trends presented in the COVID-19 surveillance should not be seen in isolation or only in terms of national numbers or clinical outcomes; they should take into account the regional context, age structure, social behaviour, and vaccination coverage. Vaccination data is not just a measure of a biomedical intervention, as vaccination is also linked to public trust, communication, access and collective behaviour.

At the same time, the study emphasises the limits of aggregate descriptive evidence. The identified patterns do not provide any causal information nor do they explain the reasons for the regional differences. Future studies should integrate the data from state-level surveillance with population denominators, vaccination coverage data, socioeconomic indicators, mobility indicators and time-varying indicators. This would enable more robust measurement of health inequalities and social determinants of pandemic outcomes. In general, the study recommends the future preparedness for pandemics in Malaysia to be done through the integration of three main aspects which are geographically targeted surveillance, age-sensitive protection strategies and equitable access to vaccines together with sustained public communication.

ACKNOWLEDGMENTS

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Data Availability

The analytical file used in this manuscript was supplied by the author and was derived from Malaysia's publicly available Ministry of Health Malaysia COVID-19 surveillance data. The underlying public datasets include state-level cases, age-group cases and vaccination-status cases.

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