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A Framework for Sociodemographic Analysis and Disease Severity among Children during COVID-19

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Abstract
Rapidly spreading infectious diseases pose a significant public health risk, necessitating immediate action to prevent the disease at the societal level. Regardless of the disease phases, both pandemics and endemics transition threatened children's health. The complex interactions between social health determinants and urbanization may impact new and reemerging infectious diseases, which necessitates specific intervention and management. Post-COVID-19 communities reported infected children with mild or severe symptoms in developed and developing countries. This research proposed a conceptual framework and structured analysis for determining the sociodemographic characteristics and severity of COVID-19 among children in Melaka during pandemic and endemic transition phases.

Keywords: Children; Sociodemographic analysis; Disease severity; COVID-19

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1.0 Introduction

The COVID-19 pandemic has profoundly impacted global public health and affected different age groups in various ways. Understanding the implications of COVID-19 among children is critical due to their role in transmission and the potential for severe outcomes. Globally, the pandemic has emphasized the need for focused research on the unique vulnerabilities and responses of children to COVID-19, considering the heterogeneity in disease presentation, severity, and outcomes across different regions and demographic groups (Ludvigsson, 2020; Dong et al., 2020). The effect of COVID-19 severity on children in developed and developing countries has consistently shown that specific sociodemographic characteristics including, age, gender, ethnicity, comorbidities, and vaccine status, play significant roles in determining the severity of COVID-19 in children (Shen et al., 2020; Young June Choe et al., 2021; Rodríguez-Barranco et al., 2021). While most cases among children are mild, a small proportion developed severe symptoms, requiring hospital

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admission and prolonged ventilation. However, while various ongoing studies focus on the prevalence and severity of the disease in various population groups, research on the relationship between sociodemographic factors and the severity of disease in children, particularly in Asian settings, is limited (Jin et al., 2020).

Malaysia has had approximately 5,271,889 COVID-19 cases and imported cases around 40,000 (Malaysia Ministry of Health, 2024). While most children with COVID-19 have mild symptoms, research indicates that age, comorbidities, vaccination status, and gender significantly influence the outcomes among children (Ludvigsson, 2020; Ng et al., 2021; Abd Rahman et al., 2024). Even worse, data indicates that COVID-19 may even increase the severity of type 1 diabetes in children (Ahangar Davoodi et. al., 2024). Prior research also demonstrated that children are more susceptible to infection, mainly if they reside in urban areas (Jiang et al., 2021; Levin et al., 2022). This situation highlights the need for deeper research focusing on a diverse group of populations such as Melaka. As a famous historical and tourism destination, an estimated 20 million local and international tourists travel to Melaka annually. In fact, Melaka is one of the hardest-hit states due to the high tourist movement during the height of the pandemic, despite still having a large number of local tourists visiting the historical city (Fauzi & Paiman, 2021). Therefore, this study aims to produce a conceptual framework that focuses on children's sociodemographic and disease severity during the COVID-19 pandemic and endemic phases.

2.0 Literature Review

By the end of 2019, the COVID-19 pandemic expanded globally, impacting more than 200 countries and territories. On January 31, 2020, the World Health Organization (WHO) designated the COVID-19 outbreak to be a public health emergency of international concern (PHEIC), and on March 11, it was categorized as a pandemic (WHO, 2020). In the United States, more than 2.72 million cases have been confirmed, with an additional number of cases being reported daily and nearly 127 thousand deaths. In addition, Brazil, Russia, India, the United Kingdom, Spain, Peru, and Chile have diagnosed more than 250,000 people, and more than 15 nations have diagnosed more than 100,000 people. As of May 2022, there have been about 500 million confirmed cases of COVID-19 globally (Adamec et al., 2022). Although the pandemic has now transitioned into an endemic phase, it is still essential to understand the epidemiology of infectious disease outbreaks because they can vary depending on the season, year, location, and country. For example, the National Institute of Infectious Diseases (NIID) reported children infectious disease trends in Japan, including influenza, respiratory syncytial virus (RSV), and infectious gastroenteritis (Fukuda et al., 2021). Infectious disease cases among children continue to rise due to their immune systems not being fully developed (Xu et al., 2023). Previous studies have also demonstrated that the impacts of infectious disease outbreaks on children, parents, and family distress are stressful and emotional (Bloxham et al., 2023).

The severe pandemic and endemic COVID-19 issues have led to a global wave of research, focusing on understanding its diverse impacts across various populations. Children's health status, in particular, is greatly affected. Generally, children with medical conditions are at higher risk of COVID-19 affecting numerous bodily systems, restricting function, requiring intense care, and costing more (Pérez-Ardanaz et al., 2024). Therefore, sociodemographic parameters, including age, gender, and vaccination, are crucial in identifying the elements that directly contribute to COVID-19 cases. For instance, the most common COVID-19 patients' comorbidities are diabetes, hypertension, respiratory disease, cardiovascular disease, and malignancy, among others (Barek et al., 2020). Age is also considered a risk factor, with those older deemed at higher risk of getting severe symptoms. While there are numerous COVID-19 research in Malaysia, there are still limited insights into the specific sociodemographic dynamics that influence disease severity outcomes among children. Ng et al. (2021) reported that the median age of cases was six years (IQR 3–10 years; range 72 days–12 years), and the male-to-female ratio was 0.95 in Negeri Sembilan, Malaysia. Ethnicity impacts research is subject to numerous constraints that have not been addressed and remain primarily ambiguous. However, for many individuals, the neurological symptom served as the initial manifestation of COVID-19 (Paterson et al., 2020). Data from private and government hospitals in Malaysia revealed that during the COVID-19 pandemic, more than 50% of male children admitted to hospitals were diagnosed with the virus. According to Feldstein et al. (2021), the severity of this illness may be categorized based on specific demographic characteristics and clinical manifestations that result in significant cardiovascular or mucocutaneous involvement and more severe inflammation. Patients with COVID-19 can classified into five phases according to their severity: asymptomatic, symptomatic but without pneumonia, symptomatic with pneumonia, symptomatic with pneumonia and needing supplementary oxygen, and critically sick with multi-organ involvement (MOH, 2024). Additionally, further functional investigations have provided compelling evidence that spike-positive individuals with comorbidities are mainly associated with compromised immune function and organ failure, increasing severity and susceptibility to COVID-19 infection (Biswas et al., 2021). Patients with comorbidity status in both situations exhibit more severe symptoms of COVID-19, and symptomatic COVID-19 patients are more contagious, irrespective of the existence of close contacts (Bee Aw et al., 2021).

One such dynamic most frequently neglected is population movement, a factor that may contribute to the transmission and movement patterns of COVID-19. In general, local or international transmission of COVID-19 disease including clusters of cases occurred in schools, kindergartens, churches, and hospitals (Southall et al., 2023; Aiano et al., 2021). Additionally, many countries, including Malaysia, first detected the onset of positive COVID-19 cases in densely populated cities, which had an increased tendency to experience higher rates of human mobility. COVID-19 infections in Malaysia have also been attributed to crowded areas, including children's learning institutions such as preschool, kindergarten, and daycare centers (Bee Aw et al., 2021). The differences between urban and rural areas can highly determine the influence of a viral pandemic on viral transmission, diagnostics, morbidity, and mortality. However, whether introduced cases are associated with place, area, activity, density, and other factors remains unclear.

Apart from that, the benefits of COVID-19 vaccination have also been evaluated to identify the potential risks in children. Due to the increase in pediatric cases, the COVID-19 vaccination in young children may have to be considered. Currently, the only approved vaccine mRNA platform vaccine in children seems to be sustainable. However, the recombinant protein platform COVID-19 vaccines

were evaluated as better options (Young June Choe et al., 2021). Nonetheless, the pandemic of COVID-19 has influenced the number of children receiving other types of common vaccinations at health clinics with parents reportedly opting out of standard vaccinations, thus posing a threat to public health (Amira et al., 2023). Clearly, this is an issue that may contribute to long-term impact.

The COVID-19 pandemic is spread through the simple mechanism of human-to-human contact and this infection is mainly transmitted through large respiratory droplets of affected local people and tourists, especially during traveling (Fauzi & Paiman, 2021). Children with a travel or residence history and neighbouring areas or other areas with persistent local transmission can also cause an increase in COVID-19 cases. Nevertheless, the existing research on COVID-19 cases has just presented data on the number of cases categorized by age group. Limited studies have shown an association between children's sociodemographic profile and COVID-19 disease severity, mainly based on geographical areas, traveling, vaccine, and health status related to the Malaysian population. Hence, the public health community must initiate more comprehensive investigations on pediatric populations.

3.0 Methodology

This study will investigate two phases involving the pandemic and endemic transition of COVID-19 and its analysis applied (see Fig. 1 below). The conceptual framework shows how children's health status from the sociodemographic factors such as age, gender, ethnic and vaccination status, geographical location like urban and rural, tourism and traveling cases involving local and import cases may impact their disease severity during both phase situations.

3.1 Study location

The study will be conducted in Melaka which is a state in Malaysia that lies on the western coast of Peninsular Malaysia. It borders Negeri Sembilan to the north and the east and Johor to the south. Melaka has three districts: Melaka Tengah, Jasin, and Alor Gajah. Melaka was chosen as the study location based on the high total population and high tourist movement during the pandemic, including having many local tourists visiting the historical city (Fauzi & Paiman, 2021).

3.2 Study design

This cross-sectional study uses data obtained between the years 2020 and 2023 from the Melaka State Health Department, Malaysia Ministry of Health. The data will be divided into two phases: pandemic and endemic transition. The duration of the pandemic in Malaysia is between January 2020 and March 2022 (Bee Aw et al., 2021), while the endemic transition is between April 2022 and December 2023 (Amira et al., 2023).

3.3 Sample populations

All children registered COVID-19 cases in government and private hospitals will be used as sample populations. A total sample of 32290 cases was collected in both phases. The pandemic phase is 25010 cases, and endemic was achieved out of 7,280 cases.

3.4 Individual data

All registered cases of children sociodemographics will be analyzed based on factors such as age that will be categorized into six groups, which are <1, 1-3, 4- 6, 7-12, 13-17, and 18. Gender will involve males and females, whereas ethics has four groups: Malay, Chinese, Indian, and others. There are three categories of vaccination status: completed with booster, completed without booster, and none. All of these criteria will be looked at for a better perspective on the health status of individual children populations. Discarded and death cases among children will be excluded.

3.5 Geographical location

The geographical location in this study is two areas: urban and rural. Urban areas in this research context can be described as well-developed cities and transport linkages within and beyond urban centers that also tend to have better-developed facilities and amenities per capita with easier access to healthcare (Bee Aw et al., 2021). It differs from the rural areas, which have limited access to quality healthcare and are far from the city (Callaghan et al., 2021).

3.6 Tourism and traveling cases

Imported and local cases will be defined as when a tourist comes into close contact with someone infected with COVID-19 or at tourist attractions. The verification of the type cases will make an early warning that tourists may be exposed to local transmission of COVID-19, and the chances of encountering an infected person increase.

3.7 Disease severity

In this study context, the disease severity among children can range widely from no symptoms to mild to severe illness. Children with underlying comorbidities like asthma and other factors and having symptoms of the COVID-19 infection will be affected severely. Early identification of the risk factors of severe COVID-19 disease requiring intensive care in hospitals would help manage hospital admissions.

3.8 Ethical approval

Ethical approval will be obtained from the UiTM Research Ethic Committee and Medical Research & Ethics Committee (MREC) with the National Medical Research Registry (NMRR). The secondary data from the public domain that contains no information on human

subjects will be collected from the Communicable Disease Control (CDC) of the Health Department of Melaka for the COVID-19 confirmed cases among children. Permission to access the data will be obtained from the organization through formal application and presentation.

3.9 Data analysis

All data will be analyzed using three types of structured analysis that consists of descriptive analysis, bivariate analysis, and multivariate analysis. This analysis will be used Statistical Package Social Sciences (SPSS) statistical software version 29 as a tool.

3.9.1 Descriptive analysis

The sociodemographic characteristics (individual, geographical location, tourism, and traveling cases, disease severity) of COVID-19 among children in Melaka during the pandemic and endemic phases will be examined through descriptive analysis. This analysis will be presented in table form consisting of total cases and percentages.

3.9.2 Bivariate analysis

In sociodemographic analysis of COVID-19 among children, bivariate analysis will determine the correlation between sociodemographic factors and disease severity and find specific significant factors. A Chi-square test will assess the relationship between sociodemographic factors and disease severity. Two-sided P values < 0.05 were considered statistically significant. Variables with P values < 0.05, based on Wald $\chi 2$ statistics in this analysis, and those variables considered clinically plausible were selected in multivariate analysis.

3.9.3 Multivariate analysis

Further investigation of the significant effect of sociodemographic factors and disease severity and logistic regression analysis will be applied. This finding will show how the main significant factors impact the severity of COVID-19 among children during the pandemic and endemic transition phases. This type of analysis is particularly useful in complex datasets where multiple factors might be interrelated and affect the outcome. The multivariate analysis will yield robust and insightful results, which could contribute to a deeper understanding of the factors influencing the severity of COVID-19 among children in Melaka. However, this analysis differed from the study conducted by Hasani et al. (2021), which was not presented in the table format because the small sample sizes did not give significant ORs and CIs. Besides, based on the p-value and r-value, the model specification will be prepared by selecting the appropriate multivariate analysis method.

3.9.4 Prediction model

Significant findings from multivariate analysis will be continued with specific factors to predict the risk of getting COVID-19 disease. This result is crucial to produce a model of prediction that can be performed using equation (1). This model predicts the probability of a binary outcome (e.g., severe vs. mild COVID-19) based on predictor variables. It examines the impact of each predictor and the strength and direction of their relationships with the outcome. Starting with all independent variables, the least significant effect for the model was removed, and the process was repeated until no further variables could be deleted without a statistically significant loss of fit. After this process, only the significant variables remain in this model. To avoid overfitting the model, only significant variables were included. Possible multicollinearity and two-way interaction terms were checked individually with the main effect. Goodness-of-fit statistics were used to assess the fit of the regression model against actual outcomes. The study follows this Logistic Regression Model analysis step in Biostatistics 202 (Chan, 2004). A prediction model will be developed based on the results and produce a new equation. The overall accuracy and the final model will predict factors contributing to the COVID-19 severity.

The logistic regression model can be represented as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \in \quad (1)$$

Where:
Y is the probability of severe COVID-19
β0 is the intercept of the model
β1, β2,..., are the coefficients associated with each independent variable
X1, X2,..., are the predictor or independent variables
E is an error term that captures the variation in Y that cannot be explained by the independent variables

This model's validation process will also be suggested to ensure its generalizability. This process can be done through cross-validation, which splits the data into multiple subsets and repeatedly training and testing the model on these subsets or equations. Another option is bootstrapping, which will resample the data with the replacement to estimate the model's accuracy.

3.9.5 Interpret result

The result will be interpreted by examining the estimated coefficients and their statistical significance. It will involve the odds ratios (OR) to understand the impact of each predictor variable on the likelihood of severe COVID-19. Besides, the confidence intervals (CI) were also used to determine the reliability of the estimated odds ratios and p-values will be used to assess the statistical significance of each predictor. The results will systematically explore relationships between variables to derive meaningful insights. This interpretation will

contribute to a deeper understanding of the factors affecting health outcomes in specific children populations and highlight the significant sociodemographic factors influencing disease severity.

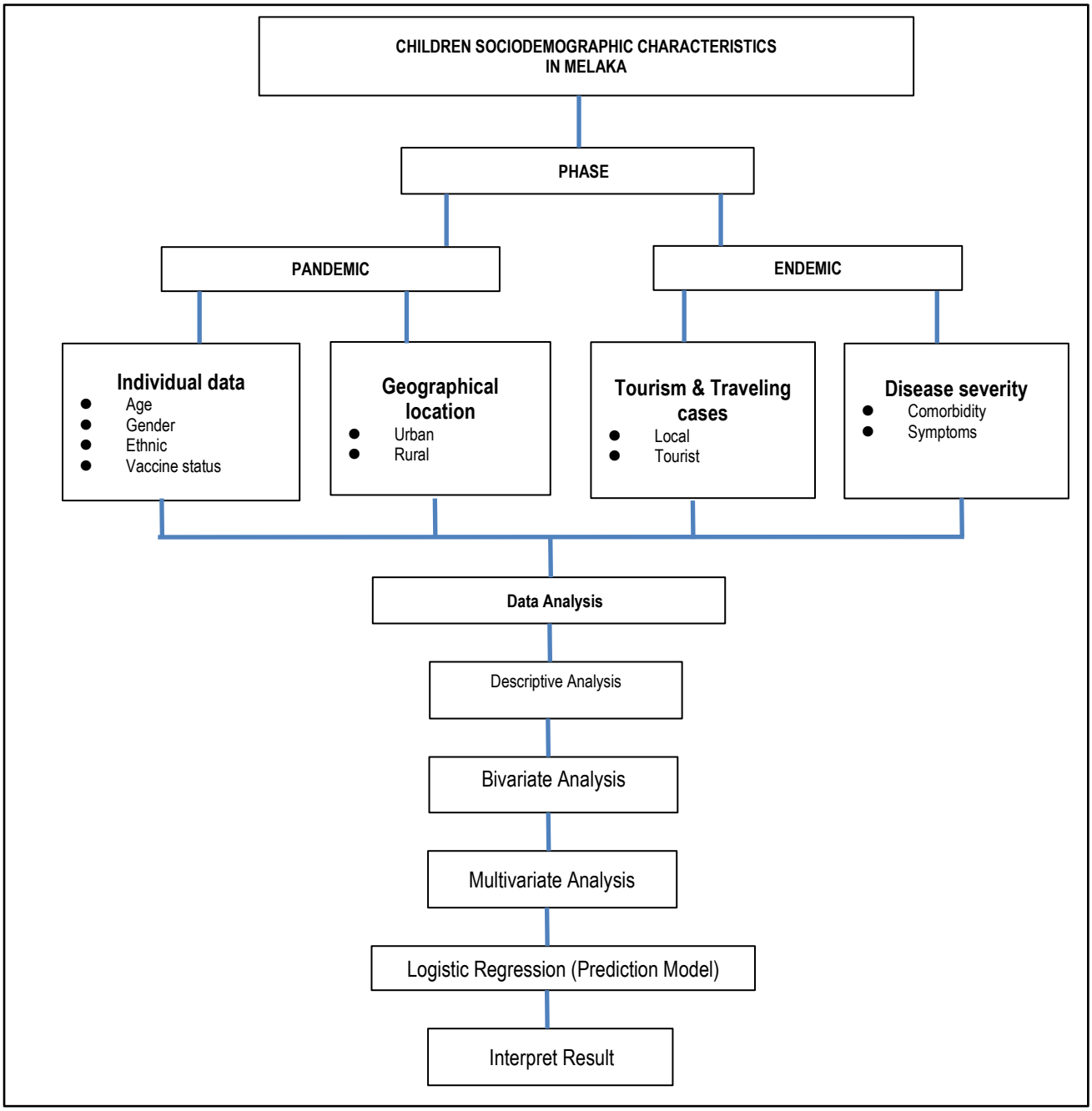

Fig. 1: Framework on children's sociodemographic characteristics in Melaka using specific analysis

4.0 Discussion

The conceptual framework for this study is summarized in Figure 1. This study focuses on sociodemographic factors and disease severity among children during the COVID-19 pandemic and endemic transition phases in Melaka by using three analysis approaches. The significant elements and risk factors that can cause COVID-19 infection and transmission can be detected. The general distribution of patient and disease severity such as age, gender, ethnicity, geographical location, health status, symptoms, infection types, and vaccination status was prepared based on the data year from 2020 to 2023. All of these factors contributed to COVID-19 infection. The objective is to observe and identify the sociodemographic factors that may influence COVID-19 cases among children in Melaka. This conceptual framework is presently in the research phase. Specific results will be provided upon completion of the final research process. Potentially this will assist in a prediction model to forecast and predict the cycle pattern of COVID-19 transmission. The final description of this risk prediction modeling will benefit the health authorities in disease management and targeted preventive strategies.

5.0 Conclusion

This conceptual framework analyzes sociodemographic factors and disease severity among children during the COVID-19 pandemic and endemic phase. Examining sociodemographic factors such as age, gender, ethnicity, geographical location, vaccination status, symptoms, tourism or traveling cases, and underlying health conditions background may play a role in determining their potential impact on the health outcomes of children. In fact, understanding sociodemographic characteristics and disease severity in Malaysia will assist local authorities and public health agencies in managing the next pandemic and endemic of another infectious disease. The framework could also prevent infection or reduce severe cases of COVID-19 or other infectious diseases and limit disease transmission among children in the community. Thus, further research is suggested to be conducted in various populations, states, or geographical locations. Future research may include other factors such as activity, socioeconomic family, hygiene, and diet.

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Paper Contribution to Related Field of Study

This paper contributes to the field of environmental health in Malaysia by establishing the fundamental factors of sociodemographic to be used by the Ministry of Health Malaysia and local authorities to solve children's COVID-19 or other disease outbreaks.

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