Accessibility of Healthcare Services of COVID-19 and Its Impact on Fatalities in Jakarta, Indonesia

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Abstract. The COVID-19 pandemic began in late December 2019 and quickly spread over the planet. It began in Jakarta, Indonesia, in the beginning of March 2020. Jakarta saw the greatest number of confirmed cases during the initial pandemic year due to its dense population. This has sparked concerns about the responsiveness of the city's healthcare systems and accessibility to healthcare, which is crucial for regulating the dynamics of illness and death. To address the need for hospital beds, a number of hospitals in Jakarta have been designated COVID-19 healthcare centers. Studies on healthcare accessibility are generally accessible, however there is a dearth of studies examining the effects of healthcare accessibility given the severity of the COVID-19 epidemic. In the first year of the COVID-19 pandemic, this study intends to analyze the spatiotemporal dynamics of healthcare accessibility in relation to COVID-19 cases and its impact on case fatality rate (CFR). In order to compare the accessibility of COVID-19 healthcare with the monthly statistics of the COVID-19 infected population, two stages floating catchment area was adopted. Following these investigations, the accessibility scores are analyzed using Product Moment Pearson correlation with the CFR to look at the relationship. This study's findings indicate that there is only a weak negative link between healthcare accessibility and CFR, which is not statistically significant.

1 Introduction

COVID-19 was first detected in late December 2019 in Wuhan City, Hubei Province, China [1, 2]. Within a matter of weeks, the disease had spread to 20 countries worldwide [3, 4]. On January 30, 2020, the World Health Organization (WHO) declared the COVID-19 outbreak a Public Health Emergency of International Concern (PHEIC) [4]. To stop the disease's geographic spread, a number of measures have been implemented, from local to nationwide lockdowns [5–7], vaccination [8, 9], social distancing [10, 11], personal protection [11], etc. However, the illness expanded to 215 nations by early of May 2020 [12].
Jakarta, Indonesia’s capital and the most densely populated city (with 15,907 inhabitants per square kilometer as of 2020 [13], experienced the highest number of confirmed COVID-19 cases during the initial year of the pandemic (as depicted in Fig. 1). The graph illustrates a consistent upward trend in COVID-19 cases in Jakarta throughout the observation period (March 2020 - March 2021). Initially, the number of cases remained below 50,000 from March to July 2020. However, it steadily increased thereafter, reaching 50,000 cases in September and doubling to 150,000 by the end of 2020. Subsequently, the number of positive cases continued to rise, reaching approximately 350,000 by March 2021.

Concerns have been raised regarding the ability of healthcare systems across the city to respond effectively, despite the crucial role of access to healthcare facilities in managing disease dynamics and mortality [15]. In Jakarta, several hospitals have been designated as COVID-19 treatment centers to meet the increasing demand [16]. Spatial analysis assessing the accessibility of these designated hospitals for COVID-19 patients has been conducted using an Origin-Destination matrix since the early stages of the pandemic [17]. Similar studies have been carried out globally using various methods such as the two-step floating catchment area (2SFCA) and enhanced two-step floating catchment area in Florida (USA) [18], enhanced two-step floating catchment area in Illinois (USA) [19], and new balanced floating catchment area in Brazil [20]. However, research exploring the impact of spatial accessibility to COVID-19 healthcare on the severity of the pandemic remains scarce in the literature.

This paper aims to analyze the spatiotemporal dynamics of healthcare services accessibility concerning COVID-19 cases and its influence on the severity of the pandemic, as indicated by the case fatality rate (CFR), during the first year of the COVID-19 pandemic period. The subsequent sections of this paper are structured as follows: Section 2 covers the information and methodologies utilized in this study, while Section 3 presents the findings. The discussion section is presented in Section 4, followed by concluding remarks.

2 Materials and methods

2.1 Study area

The research region has been chosen to be the Province of Jakarta (DKI Jakarta), which serves as the capital of Indonesia. It is situated between 6 12' South and 106 48' East in Java’s
western region (Fig. 2). With a total size of 664.01 km² and a population of 10,562,088 in 2020, Jakarta has a population density of 14,555 per km² [13] making it the most populous province in Indonesia.

Fig 2. Location of study area [21]

2.2 Research framework

This study is divided into four main parts. Firstly, spatial data of population and monthly COVID-19 data were used to analyse the spatiotemporal trend of COVID-19 cases. Secondly, CFR calculation was conducted based on data of population, monthly COVID-19 cases, and its fatalities. In the next step, spatiotemporal accessibility was analysed, and for this purpose 2SFCA method was implemented using location of COVID-19 hospitals as the inputs. Finally, following the analysis on COVID-19 cases, CFR, and hospital accessibility, the correlation of accessibility and CFR was then investigated. These entire processes are depicted in a research framework in Fig. 3.

2.3 Datasets and processing

Data are derived from (1) daily COVID-19 data releases [21], and (2) appointed hospitals for COVID-19 [22]. Then, to determine the overall number each month, data on confirmed illnesses and fatalities from daily reports were combined. Equation 1 was used to analyze the monthly CFR data, which was divided by the number of confirmed cases to get the CFR [22]. Furthermore, a total list of 101 designated hospital were obtained and their locations were mapped for the accessibility measurement in the next step.

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\text{Case Fatality rate}_{(\text{CFR}, \text{in} \%)} = \frac{\text{number of deaths from disease}}{\text{Number of confirmed cases from disease}} \times 100
\]  

(1)
The analysis of COVID-19 healthcare accessibility was conducted using the two-step floating catchment area (2SFCA) method, which was compared to monthly data on the COVID-19 affected population [23]. Equation 2 illustrates the two-step search process employed by the 2SFCA technique. In this process, the capacity of a COVID-19 referral hospital (the supply), denoted as $S_j$, is divided by the total COVID-19 infected population (the demand) within a specified distance threshold of 0. This calculation yields the supply-to-demand ratio ($R_j$), representing the catchment size. This step evaluates the capacity of the supply to meet the demands of the COVID-19-infected population within its service radius. Subsequently, according to Equation 3, the accessibility index ($A_i$) for each demand point ($I$) is determined in the second stage as the sum of all $R_j$ values obtained in the first stage. This sum is based on all service providers within the catchment area, conceptualizing the population’s activity space at site $i$. The resulting accessibility indices from the analyses are then examined through Pearson’s correlation with the case fatality rate (CFR) to explore the correlation (Equation 3).

$$R_j = \frac{S_j}{\sum_{k \in \{d_k \leq d_0\}} P_k}$$  \hspace{1cm} (2)$$

$$A_i = \sum_{j \in \{d_{ij} \leq d_0\}} R_j = \sum_{j \in \{d_{ij} \leq d_0\}} \frac{S_j}{\sum_{k \in \{d_k \leq d_0\}} P_k}$$  \hspace{1cm} (3)$$

$$r = \frac{\Sigma(x - m_x)(y - m_y)}{\sqrt{\Sigma(x - m_x)^2 \Sigma(y - m_y)^2}}$$  \hspace{1cm} (4)$$

3 Results

3.1 Case fatality rate in Jakarta during the first year of pandemic

The first COVID-19 cases in Indonesia were officially declared to have been transmitted after two Indonesian citizens were confirmed to be infected by the virus on March 2, 2020 [24]. Because of the high risk of virus transmission, the Government of Jakarta has stopped issuing crowd gathering permits and began reviewing permits that have already been issued.
government of Jakarta also officially announced Large Scale Social Restriction (PSBB) on April 9, 2020 [25]. Various efforts have been made to reduce the number of cases, but the data of COVID-19 cases continue to show an increase.

**Fig. 4** demonstrates the rise in COVID-19 cases from March 2020 to February 2021. By February 2021, about 350,000 cases had been confirmed. A high incidence of COVID-19 patient recovery thereafter occurred, nevertheless. Based on information from January 2021, DKI Jakarta joined the 16 provinces in Indonesia that had recovery rates of >80%. [26]. The death rate from COVID-19 has also occasionally increased in the meanwhile. The graph shows parallel rising trends in the number of patients, the pace of recovery, and the death rate attributable to COVID-19. According to **Fig. 4**, the geographical distribution of COVID-19 patients in DKI Jakarta has affected every part of the hospital. Because the COVID-19 transmission pathway is predicated on population movement, this disease may manifest. [26, 27], so that the number of cases of COVID-19 in DKI Jakarta can spread to all regions as a result of DKI Jakarta, as the capital of the country, exhibiting very large population movements. **Fig. 5** also shows the growth in the number of COVID-19 cases in DKI Jakarta happens randomly every month in each region. The growth of COVID-19 cases in the last 1 year reached the peak of growth in almost every region in January 2021.

![Fig. 4. A year spatiotemporal dynamic of COVID-19 confirmed cases [28]](image)

**Fig. 4** provides a year in the development of COVID-19 CFR with the red zone indicates the high CFR. Overall, as opposed to the COVID-19 cases (**Fig. 5**), the CFR value in Jakarta shows a decreasing trend. CFR was high in the early time of observation from March to June 2020. In March 2020, the high CFR was identified randomly located. High to moderate fatalities of COVID-19 was then distributed to almost all part of Jakarta with the high CFR in southwestern area. In July 2020, the red regions started to disappear, and then at the end of observation period (February 2021), the CFR value in all regions of Jakarta was in the low level.

In more detail, the distribution data of CFR are presented in **Fig. 5**. It is observed that there was a greater variability for CFR in the beginning than in the late period of observation
(exceptionally for Mach 2020). Broader distribution values of CFR were shown between April and August 2020. Then, starting from September 2020, the range of CFR value looked less dispersed indicating the more homogenous fatalities condition throughout Jakarta regions.

3.2 Spatiotemporal dynamics of healthcare accessibility

Regarding the accessibility of healthcare against the infected COVID-19 population (Fig. 6), the condition was better in the early time of observation. In March 2020, Jakarta was found in the green level. In the next months, between April and August 2020, the accessibility value was lower but still in the moderate level. However, the condition got worse as from September 2020 until February 2021 Jakarta was almost covered entirely with the red zone meaning high difficulties in accessing healthcare during that period.

3.3 Correlation of Healthcare Accessibility to CFR

By incorporating all multi-temporal datasets, a low negative correlation between accessibility to healthcare and CFR ($r = -0.026$) were found (Fig. 7). The gradient of the relationship between the two variables is gentle. In other words, the lower accessibility of particular place from healthcare facilities, the higher the CFR. However, the degree of association was not statistically significant in both 0.01 and 0.05 level. Most of the time, the accessibility score was concentrated below 70 or more than 100 whilst CFR was dominantly below 5%.
Discussion

The death rate has increased from time to time in Jakarta. In general, healthcare accessibility and CFR were low during the beginning of pandemic and then getting higher and higher over time. Logically, the better accessibility, people are high likely easier to reach healthcare facilities, thereby reducing the rate of CFR. However, a low negative correlation between healthcare accessibility and CFR was found to be not statistically significant in this study. It might be due to several reasons namely 1) incoming patients from surrounding regions, 2) method of extracting the distance from healthcare, and 3) catchment size.
Jakarta, as the capital city of Indonesia, has a strong appeal to various aspects of life, especially to its surrounding regions namely Bogor City, Bogor Regency, Depok City, Tangerang City, Bekasi Regency, and Bekasi City. The reason that people from areas around Jakarta travel to Jakarta is not only for economic reasons but also for getting adequate health facilities [29]. Adequate health facilities in Jakarta can be a place for treatment for people from around Jakarta. However, the accessibility model made was only based on supply and demand in Jakarta, thus making the model less representative of the actual conditions due to many incoming patients from the surrounding regions.

The distance extraction method from healthcare which only considered the Euclidean distance based on a buffer to calculate accessibility can potentially lead to a model that is not representative of the actual conditions in the field. For example, there may be a location where the Euclidean distance to healthcare is near, but the actual condition may indicate that the road conditions are inadequate, making it difficult to reach healthcare. In addition, Jakarta is one of the most congested cities in comparison to other cities in Indonesia [30] and in the world [31], therefore, accessibility modelling using only Euclidean distance without involving road network conditions make the accessibility model less representative to the actual conditions in the field.

The catchment size which is 15 km away for all types of healthcare also has the potential to cause a low positive correlation between healthcare accessibility and CFR. The service area radius of 15 km is quite far to go. Especially with the congested conditions in Jakarta and the large number of patients from neighbouring regions of Jakarta. In addition, each hospital has a different capacity depending on the type of hospital.

In order to improve the agreement between the model and the actual condition, some future works needed such as 1) applying variations of catchment size to investigate the best radius in describing healthcare accessibility impact on CFR, 2) to conduct additional correlation analysis in monthly basis, since the severity of COVID-19 in Jakarta and surrounding regions have changed over time, and 3) road network should be incorporated since involving Euclidean distance only is not adequate in describing the actual conditions.

5 Conclusion

In Jakarta, the mortality rate has occasionally risen. Access to healthcare and CFR were generally poor at the start of the epidemic but increased steadily over time. It makes sense that improved accessibility would make it simpler for individuals to get to healthcare services and lower CFR. However, this study indicated that a little negative connection between CFR and healthcare accessibility was not statistically significant. It might be because of a number of factors, including 1) the influx of patients from nearby areas, 2) the technique used to calculate the distance to healthcare, and 3) the size of the catchment area.

References


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