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Spatial Disparities in Jakarta's Health and Education Infrastructures: An OpenStreetMap-Based Analysis

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Abstract: Jakarta, as Indonesia's most populous megacity, had a population of 11.14 million in 2024. Covering an area of 661 square kilometers, it is also the country's most densely populated city, with over 16,500 individuals per square kilometer. High population density brings challenges, particularly in access to essential public services like education and healthcare, which are crucial for sustainable urban development. This study examines spatial disparities in the distribution of health and educational infrastructures in Jakarta concerning population density. Through overlay analysis, two models were developed: the Educational Facilities Gaps Map and the Health Facilities Gaps Map, categorizing areas as well-served, moderately served, or underserved. The findings highlight significant disparities across Jakarta's administrative regions. Central Jakarta has the highest accessibility, with 57.43% of its area well-served for education and 65.06% for healthcare. Conversely, North Jakarta and Kepulauan Seribu experience the most severe service gaps, with 51.92% and 100% of their areas underserved in education, and 50.20% and 85.92% in healthcare, respectively. East, South, and West Jakarta exhibit moderate service coverage, though underserved zones remain. These results emphasize the importance of strategic urban planning to improve equitable access to public services. By incorporating geospatial analysis into policymaking, decision-makers can optimize facility distribution and infrastructure development, reducing service disparities, especially in underserved areas.

Keywords: Geospatial analysis; public infrastructures; spatial disparities; sustainable urban development.

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1. Introduction

Jakarta has experienced rapid population growth over the decades. As of 2024, the city's population reached approximately 11.14 million people with over 16,500 people per square kilometer, making it the most densely populated urban area in Indonesia [1]. Its rapid population growth due to urban migration, economic opportunities. Jakarta has one of the highest traffic congestion levels globally. It highlights that private transport dominates the modal share, accounting for 72% of trips, while public transport is used for less than 10%. This has exacerbated congestion, and economic inefficiencies [2].

Some previous study about healthcare and educational disparities reveals inequalities in hospital distribution and accessibility of schools. The study indicates that healthcare facilities and medical staff are mostly concentrated in metropolitan areas, resulting in limited services elsewhere.

Similarly, educational facilities tend to be more accessible in wealthier neighborhoods, while poorer areas face location-based disadvantages [3, 4].

Meanwhile, increased travel time to a health facility is consistently associated with higher mortality rates [5, 6, 7]. There should be a special attention to the travel time aspect regarding how well a public service reaches the community within the city. Travel time could be represented by travel distance, transportation mode and departing time.

In several studies related to facility accessibility in Jakarta, the data used is still limited to the simple radius or the road network length measurements, which do not analyze the complexity of accessibility; as these methods usually use straight-line distances, fail to calculate the actual road network. By utilizing network analysis, this study aims to achieve a more accurate representation of disparities of public infrastructures in spatial perspectives, as it incorporates road network length in the analysis process. This study used OpenStreetMap (OSM) as the main data source for analyzing the disparity of health and education infrastructures in Jakarta due to its accessibility and open nature. Numerous studies have successfully utilized OSM data for analyzing spatial disparities, which mostly in Europe cities [9, 10, 11, 12]. Although OSM data from regions outside Europe may be less comprehensive, the quality of OSM data in Jakarta has been evaluated based on ISO 19157 quality criteria, ensuring its suitability for this study [15]. These factors make OSM a reliable and valuable resource for analyzing the accessibility of health and education infrastructures in Jakarta.

One of the most essential aspects of urban growth and social well-being is ensuring fair access to basic services like healthcare and education. This study aims to analyze the spatial distribution of educational and healthcare infrastructures in Jakarta by examining accessibility in relation to population density. By identifying underserved areas, the findings of this study can provide valuable insights for policy makers in designing strategies to ensure more equitable access to public services. Incorporating geospatial analysis and the use of open data in urban planning can help optimize facility placement, enhance service efficiency, and improve overall urban resilience.

2. Methods

2.1. Research location

The research was carried out from January to March 2024. Jakarta is located in the northwest coast of Java, at the mouth of Ciliwung River on Jakarta Bay, situated at coordinates -6.367812, 106.380137 and -5.131474, 106.972412. The map of the research location is shown in **Figure 1**.

2.2. Tools and data

This study employed QGIS 3.28 and Microsoft Excel as its primary tools. QGIS was used for geospatial analysis and visualization, while Microsoft Excel facilitated data processing. This research utilized OSM datasets, including public infrastructures (educational and healthcare), buildings, roads, and administrative boundaries. All OSM data were obtained from Geofabrik (https://download.geofabrik.de/asia/indonesia.html) and downloaded in January 2025.

2.3. Research procedure

2.3.1 Spatial distribution of health and educational infrastructures

This research starts by mapping the spatial distribution of health and educational infrastructures throughout Jakarta. OSM data is utilized to extract infrastructure locations, including 2,358 health facilities such as hospitals, clinics, and pharmacies, as well as 5,783 educational facilities including schools, kindergartens, and universities, as illustrated in **Figure 2**. In general, most healthcare and educational infrastructures are concentrated in Central Jakarta, while the rest are more evenly spread throughout the city. However, despite the high number of basic infrastructures, the distribution remains uneven, highlighting accessibility challenges in certain areas.

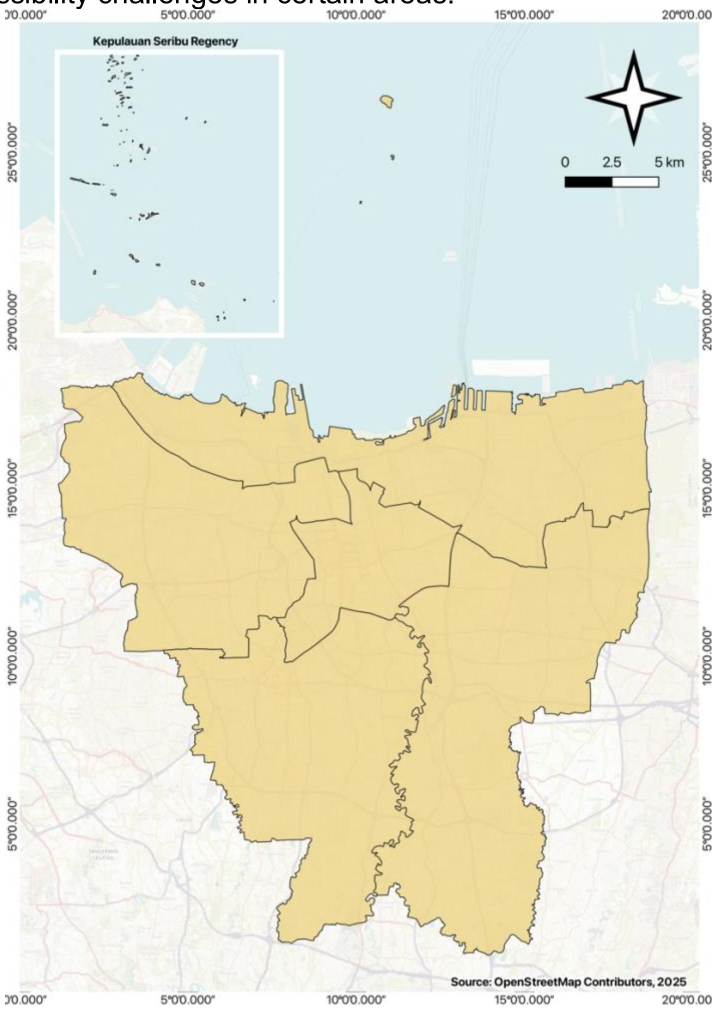

Figure 1. Research Location.

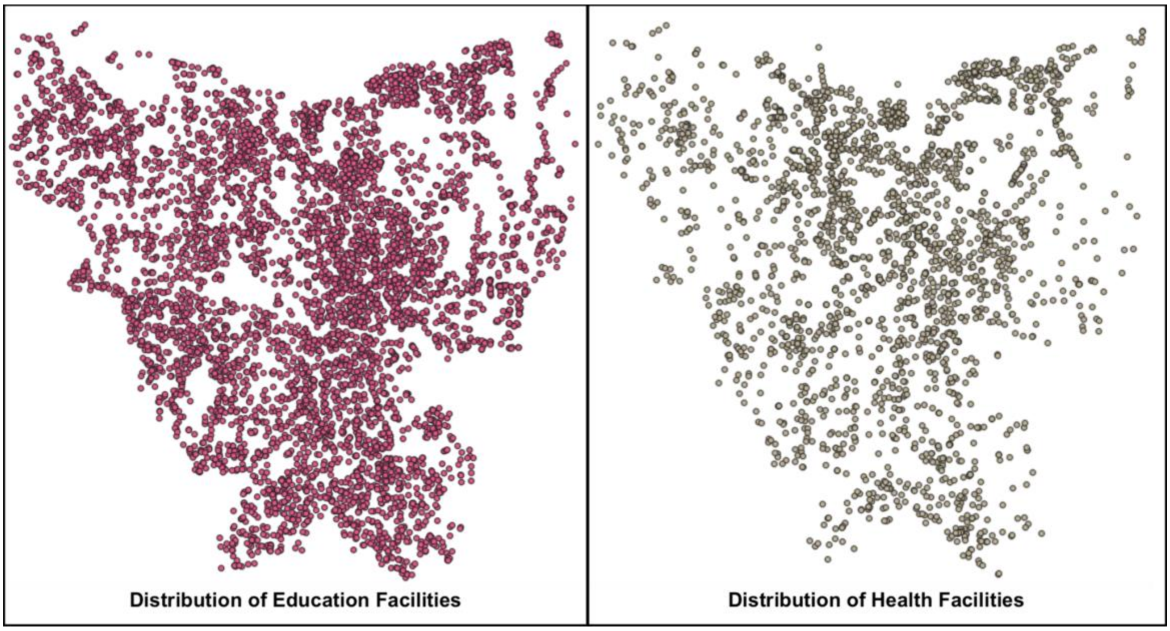

Figure 2. Distribution of data for educational and healthcare facilities.

2.3.2 Network analysis

A network analysis was conducted to evaluate access to public services. This analysis utilized the road network from OSM data and the GRASS GIS module in QGIS to create travel time zones based on distance attributes. However, this study only included the level one and level two road network (motorway, trunk and primary roads) as previous research [15] had evaluated the data quality exclusively for these roads.

The analysis defined four accessibility zones based on distance: 0-500 m, 500-1000 m, 1,000-1,500 m, and beyond 1,500 m. These intervals were chosen considering the average urban walking speed of 4.3 to 5.4 km/h, where a 500 m walk is estimated to take approximately 10 minutes [16]. However, travel time is not calculated in this study. Instead, it provides more realistic analysis using distance measures along the road network rather than straight-line distances.

Figure 3 illustrates the distance interval between the road network and healthcare as well as road network and educational facilities. The 500-1000 m range represents the highest proportion of accessibility, 33.23% of healthcare and 34.52% of educational infrastructures. In contrast, the 1000-1,500 m interval includes 21.04% of healthcare infrastructures, while 18.79% of educational infrastructures are situated more than 1,500 m from the closest road network.

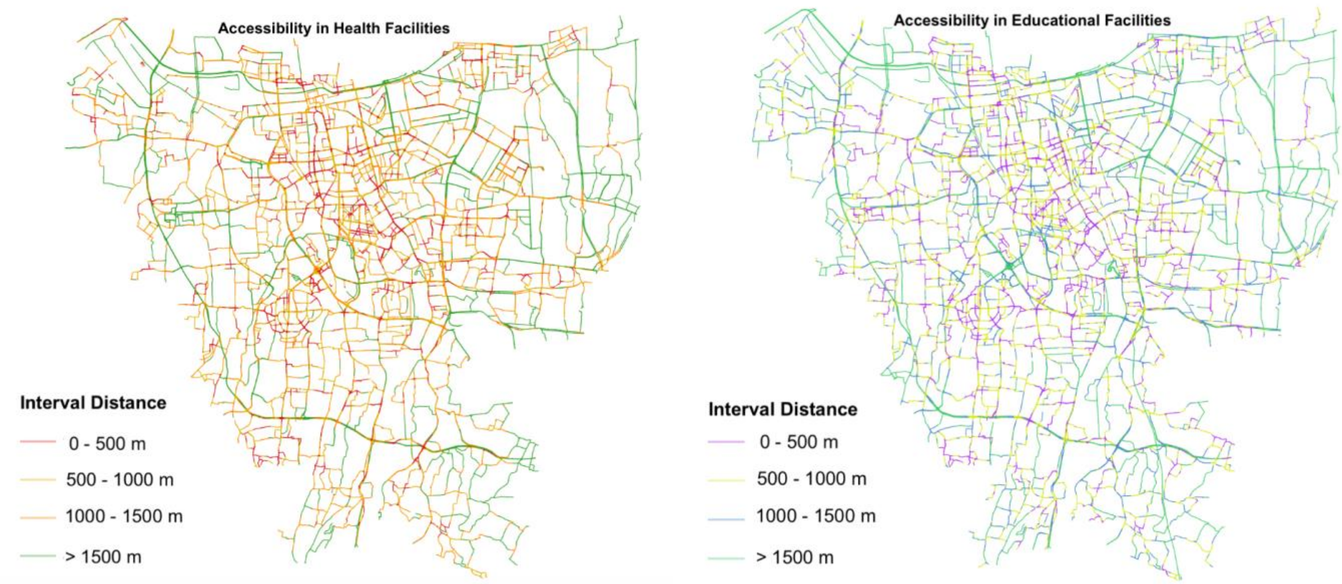

Figure 3. Four types of accessibility education and health facilities

2.3.3 Population density

To estimate population density, this study utilized building footprint data from OSM which was collected from Geofabrik in January 2025. The datasets contained over 1.6 million building footprints across the Jakarta area. Because the detailed demographic data in geospatial file was unavailable, an indirect approach was used, assuming that areas with a higher density of buildings within a one-kilometer radius have higher population densities. Thus, based on this assumption that more buildings represent more house structures, which implies a larger number of populations.

To analyze population distribution, the building footprint polygons were first converted into point features, with each point representing the centroid of an individual building. A Kernel Density Estimation (KDE) method was then applied to generate a heatmap, which provides a spatial representation of population density. This heatmap highlights areas with a high concentration of buildings, assuming as a proxy for densely populated regions.

Figure 4 presents the resulting population density distribution derived from the OSM building footprint data, offering insights into urban population patterns and helping to identify areas with higher residential concentrations.

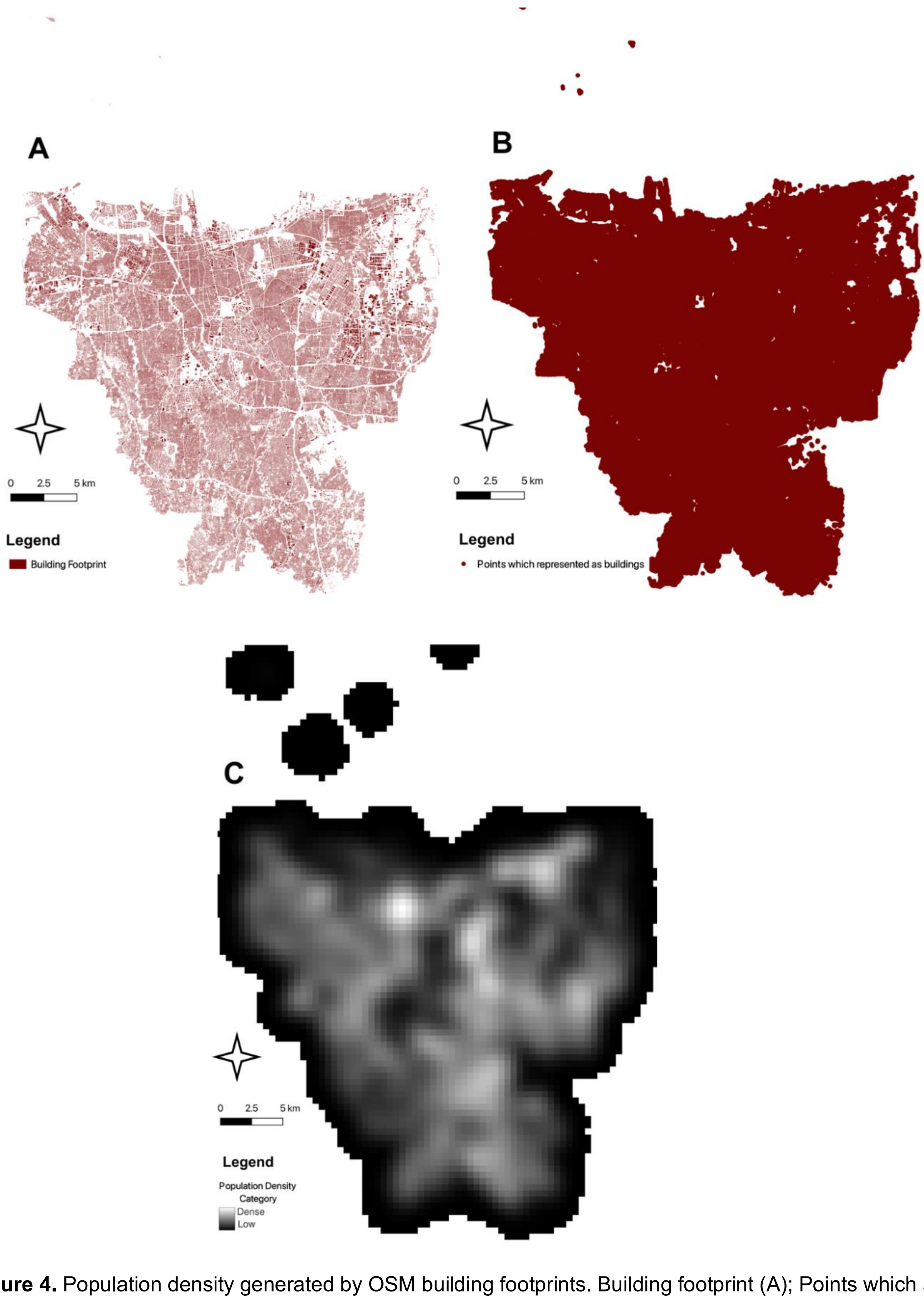

Figure 4. Population density generated by OSM building footprints. Building footprint (A); Points which are represented as buildings (B); Population density (C).

2.3.4 Analysis of spatial disparities

To assess spatial disparities in access to public infrastructures, this study overlays accessibility maps and population density maps. This approach helps in identifying disparities in road access, healthcare, and educational infrastructures based on population distribution.

Spatial disparities occur when accessibility is insufficient in comparison to population density, resulting in bigger disparities in areas with high population density but low accessibility. In this study, accessibility is measured as the average distance travelled to the nearest infrastructure on the road network. To identify these disparities, we assume that a gap score was calculated by dividing accessibility distance by population density, as represented in **Equation (1)**.

$$Gap\ Score = \frac{Accessibility\ Distance}{Population\ Density} \quad (1)$$

where:

- Accessibility Distance refers to the average network-based distance in meters to the nearest healthcare or educational infrastructure
- Population Density is measured as the number of buildings per square kilometer, based on OSM building footprint data

A higher gap score indicates greater disparities and poorer accessibility, meaning that residents in those areas must travel farther to reach essential services despite high population density. On the other hand, a lower gap score implies better service coverage and more equitable infrastructure distribution.

To analyse the results, gap scores were classified into low, moderate, and high disparity categories using natural breaks highlighting areas with the most significant service gaps. The final spatial disparity maps reveal the insights into where infrastructure improvements and new public infrastructure placements are most required.

3. Results and Discussion

The analysis of spatial disparities in healthcare and educational infrastructures reveals similar distribution patterns throughout Jakarta. As illustrated in **Figure 5**, the most underserved areas are characterized by the highest disparities, and are mainly located on the boundaries of Jakarta and Kepulauan Seribu. Despite having high population densities, these regions experience limited access to important public services, including healthcare and educational infrastructures, highlighting the spatial imbalance in service availability. Several factors may have contributed to these disparities, including rapid urbanization, land-use limitations, and uneven infrastructure development, which have affected Jakarta's accessibility to essential services.

Table 1 presents the percentage of the results based on Equation (1), which is divided into three types of disparities in educational and health infrastructures. Central Jakarta possesses the highest accessibility with 57.43% of its area being well-served for education and 65.06% for healthcare. This region advantages from its position as the administrative and economic center of Jakarta, where public investments have resulted in a greater concentration of hospitals and educational infrastructures. The relatively low percentage of underserved areas, at 14.46% for education and 10.44% for healthcare, indicates that existing infrastructure effectively meets the needs of residents. This trend aligns with findings from previous studies, which suggest that urban cores often receive higher public investment, leading to better service coverage and accessibility [17].

On the other hand, North Jakarta and Kepulauan Seribu face the greatest disparities in access to public infrastructures. In North Jakarta, 51.92% of the area lacks adequate educational infrastructures, while 50.20% remains underserved in healthcare services. The swift rate of urbanization in this region has not been matched by sufficient infrastructure development, leading to a mismatch between population density and service availability. Informal settlements and coastal communities in North Jakarta particularly struggle with inadequate access to essential infrastructures, exacerbating existing inequalities.

Kepulauan Seribu experiences even more severe accessibility challenges due to its geographical isolation. The entire region lacks sufficient educational infrastructures, while 85.92% of the area remains underserved in healthcare. Limited infrastructure investment and logistical constraints make it difficult to provide conventional services to the island communities. As previous studies [18] have suggested, geographic isolation poses a major challenge in ensuring equitable access to healthcare and education. We believe that alternative solutions to reduce these disparities could include the enhancement of healthcare infrastructures and physicians [19], the implementation of floating hospitals [20], and the enhancement of Information and Communication Technology (ICT) development to support digital education initiatives [21].

Moreover, East and South Jakarta present a mixed pattern, with large portions of their areas classified as moderately served. In East Jakarta, 39.39% of the area has moderate access to educational infrastructures, while 37.86% falls into the same category for healthcare. South Jakarta exhibits a similar trend, with 39.07% of its area moderately served for education and 40.67% for healthcare. Although these locations do not experience the severe disparities the same as in North Jakarta and Kepulauan Seribu, they still contain areas where access to important services is insufficient. Furthermore, the accessibility of services in these regions could be considerably improved through targeted improvements, such as the establishment of community healthcare centers and localized schools.

West Jakarta, despite being a highly urbanized area, still has 18.87% of its area underserved in education and 17.32% in healthcare. Although the proportion of underserved areas is lower than in other districts, there is still room for improvement. Enhancing access through strategic investments in public infrastructure, particularly in neighborhoods with high population density, would help close the service gaps.

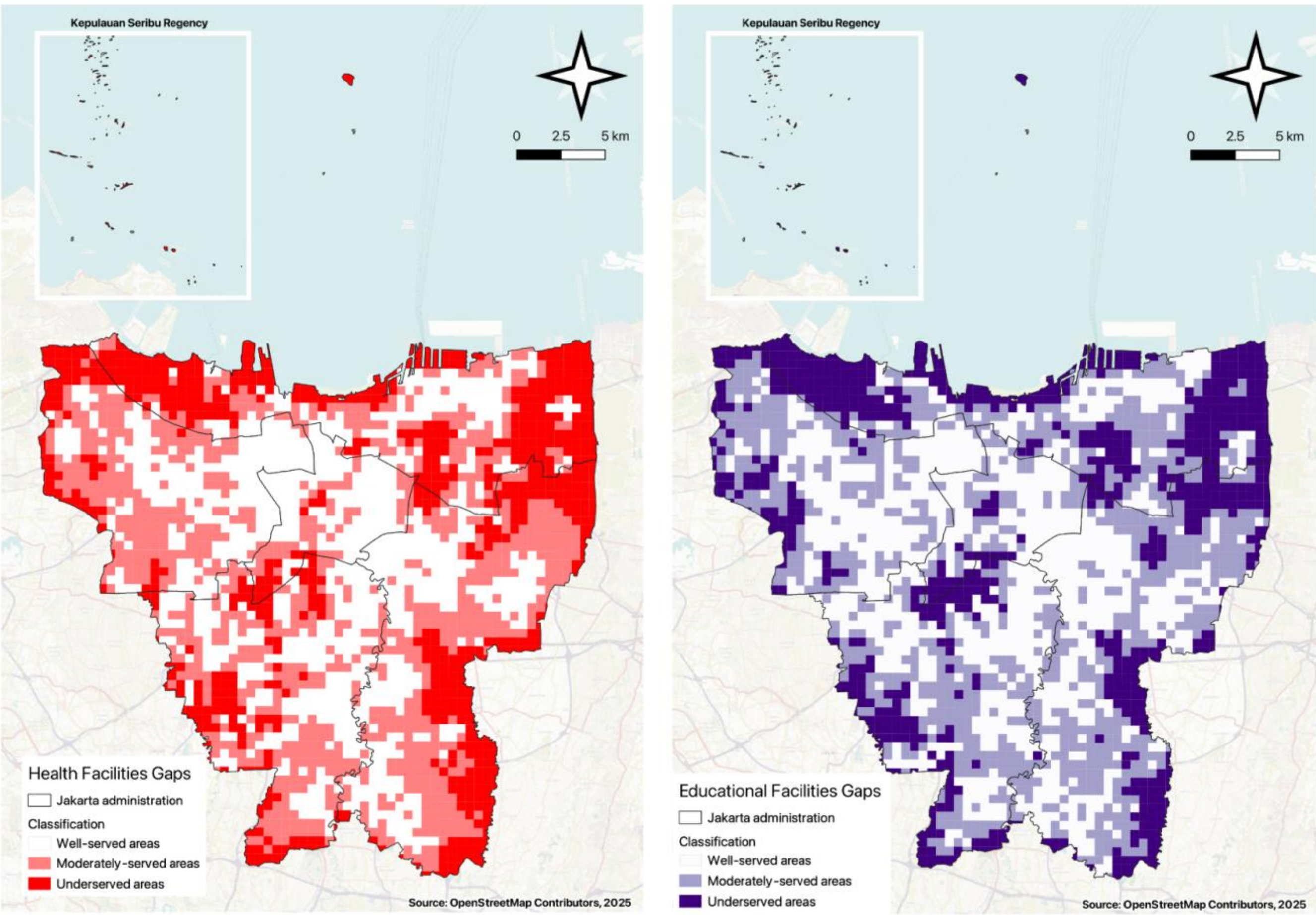

Figure 5. Spatial Disparities of health and educational facilities in Jakarta

The findings of this study highlight clear disparities in Jakarta's public service accessibility. Central Jakarta benefits from concentrated infrastructure investments, ensuring well-distributed facilities. In contrast, North Jakarta and Kepulauan Seribu experience significant service gaps due to urban expansion outpacing infrastructure development and geographic isolation, respectively. East, South, and

West Jakarta have a mix of well-served and moderately served areas, indicating opportunities for future improvement. Addressing these disparities requires targeted interventions, such as expanding healthcare and educational infrastructures in high-density areas, introducing mobile service solutions in isolated regions, and improving community-based infrastructure.

Table 1. Percentage of spatial disparities in educational and health infrastructures.

Cities	Educational Facilities Gaps			Health Facilities Gaps		
	Good	Moderate	Underserved	Good	Moderate	Underserved
Central Jakarta	57.43%	28.11%	14.46%	65.06%	24.50%	10.44%
East Jakarta	34.73%	39.39%	25.78%	31.01%	37.86%	31.13%
North Jakarta	19.62%	28.47%	51.92%	25.07%	24.63%	50.20%
South Jakarta	39.07%	36.44%	24.49%	40.67%	37.17%	22.16%
West Jakarta	42.37%	38.77%	18.87%	41.68%	40.99%	17.32%
Kepulauan Seribu	0%	0%	100%	1.41%	12.68%	85.92%

4. Conclusion and Recommendation

This study reveals significant inequalities in the distribution of healthcare and educational infrastructures throughout Jakarta. The findings show that Central Jakarta shows the best accessibility to these vital services, whereas North Jakarta and Kepulauan Seribu suffer from severe educational and healthcare service gaps. The uneven distribution of public facilities highlights the urgent need for strategic intervention to ensure that all residents have equal access to education and health services. Without targeted efforts, these disparities will persist, further marginalizing communities with limited access to essential services.

Resolving this issue necessitates prioritizing infrastructure advancement in neglected areas. North Jakarta and Kepulauan Seribu are identified as the most crucial regions, where insufficient investment has resulted in inadequate healthcare and educational infrastructures. Enhancing public infrastructure through the establishment of new educational institutions and healthcare infrastructures, along with the advancement of information and communication technology, is crucial for closing the accessibility gap. Moreover, augmenting transportation networks—by expanding public transit routes and upgrading road infrastructure—can further facilitate equal access to services.

Policy actions are essential in mitigating service inequities. Government policies ought to promote the creation of educational and healthcare infrastructures in underserved regions via subsidies, tax incentives, or regulatory assistance. Furthermore, urban planning methodologies must include geospatial research to identify ideal facility locations based on population density and current infrastructure. Utilizing data-driven decision-making, officials can strategically locate new infrastructures to enhance accessibility and benefit the most number of citizens.

However, this study has not yet explored the disparity side comprehensively by involving travel time factors to schools and hospitals. Travel time is one of the main reasons for urban communities to travel. Exploring disparities in terms of travel time will produce more accurate conditions of public service disparities because it will be clearly visible how the dynamics of choosing a mode of transportation and road conditions affect the accessibility of a service.

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References

[1] Dinas Kependudukan dan Pencatatan Sipil Provinsi DKI Jakarta. (2025, January 18). Dashboard. Accessed on https://kependudukancapil.jakarta.go.id/.

[2] Benita, F. (2023). Exploring non-mandatory travel behavior in Jakarta City: Travel time, trip frequency, and socio-demographic influences. Transportation Research Interdisciplinary Perspectives, 21, 100896. https://doi.org/10.1016/j.trip.2023.100896

[3] Setiawan, K. E., Kurniawan, A., Chowanda, A., & Suhartono, D. (2023). Clustering models for hospitals in Jakarta using fuzzy c-means and k-means. Procedia Computer Science, 216, 356–363. DOI10.1016/j.procs.2022.12.146

[4] Muhaimin, A. A., Gamal, A., Setianto, M. A. S., & Larasati, W. L. (2022). The spatial justice of school distribution in Jakarta. Heliyon, 8, e11369. DOI10.1016/j.heliyon.2022.e11369

[5] Avdic D. Improving efficiency or impairing access? Health care consolidation and quality of care: Evidence from emergency hospital closures in Sweden. J Health Econ. 2016;48: 44–60. 10.1016/j.jhealeco.2016.02.002 [published Online First: 2016/04/10].

[6] Berlin C, Panczak R, Hasler R, Zwahlen M, Swiss National Cohort Study Group. Do acute myocardial infarction and stroke mortality vary by distance to hospitals in Switzerland? Results from the Swiss National Cohort Study. BMJ Open. 2016;6(11): e013090. 10.1136/bmjopen-2016-013090 [published Online First: 2016/11/03].

[7] Shen YC, Hsia RY. Association Between Emergency Department Closure and Treatment, Access, and Health Outcomes Among Patients With Acute Myocardial Infarction. Circulation. 2016;134(20): 1595–1597. 10.1161/CIRCULATIONAHA.116.025057 [published Online First: 2016/11/25].

[8] Suaidah, L., Hutagaol, R. R., & Khairunnisa, S. S. (2023). Analisis persebaran rumah sakit umum daerah (RSUD) di Wilayah Jakarta Selatan dengan metode nearest neighbor analysis (NNA). Jurnal Sains Geografi, 1(2), 59–70. https://doi.org/10.2210/jsg.vx1ix.xxx

[9] Teeuwen, R. F. L., Milias, V., Bozzon, A., & Psyllidis, A. (2024). How well do NDVI and OpenStreetMap data capture people's visual perceptions of urban greenspace? Landscape and Urban Planning, 245, Article 105009. https://doi.org/10.1016/j.landurbplan.2024.105009

[10] Feng, Y., & Li, W. (2024). A systematic review of urban green space use and the factors influencing its use. Sustainable Cities and Society, 85, 104463. https://doi.org/10.1016/j.scs.2024.104463

[11] Zhao, J., & Zhang, H. (2022). Evaluating the impact of urban green spaces on residential housing prices in China: Evidence from 35 major cities. Journal of Environmental Management, 320, 115833. https://doi.org/10.1016/j.jenvman.2022.115833

[12] Wang, X., & Liu, Y. (2019). Urban green space accessibility and environmental justice: A case study in Beijing, China. Landscape and Urban Planning, 191, 103625. https://doi.org/10.1016/j.landurbplan.2019.103625

[13] Zielstra, D., & Hochmair, H. H. (2022). Assessing the completeness of OpenStreetMap building data and its application for urban studies: A case study of 13,000 cities globally. Applied Geography, 141, 102676. https://doi.org/10.1016/j.apgeog.2022.102676

[14] Zhou, Q., Zhang, Y., Chang, K., & Brovelli, M. A. (2023). Assessing OSM building completeness for almost 13,000 cities globally. International Journal of Digital Earth, 16(1), 1–22. https://doi.org/10.1080/17538947.2022.2159550

[15] Ramadhanis, Z., & Hong, J. H. (2022). Towards the Quality Assessment of Volunteered Geographic Information. Taiwan Geographic Information Society Annual Meeting and Academic Symposium.

[16] Fitzpatrick, K., Brewer, M. A., & Turner, S. (2006). Another look at pedestrian walking speed. Transportation research record, 1982(1), 21-29.

[17] Seto, K. C., Reenberg, A., Boone, C. G., et al. (2017). Urban land teleconnections and sustainability. Proceedings of the National Academy of Sciences, 114(34), 8937-8942.

[18] Craig, A. T., Beek, K., Gilbert, K., Soakai, T. S., Liaw, S. T., & Hall, J. J. (2022). Universal health coverage and the Pacific islands: an overview of senior leaders' discussions, challenges, priorities and solutions, 2015–2020. International journal of environmental research and public health, 19(7), 4108.

[19] Sivakumar, I., Manimekalai, K., & Ranjithkumar, A. (2020). Accessing public health facilities: rural and urban disparities. Journal of Critical Reviews, 7(3), 382-388.

[20] Abdillah, H. N., Masroeri, A. A., Artana, K. B., & Edfi, R. D. (2020, August). Hospital ship design for public health services in the foremost, outermost, and remote (FOR) areas in Indonesia. In IOP Conference Series: Earth and Environmental Science (Vol. 557, No. 1, p. 012011). IOP Publishing.
[21] Hudson, H. E. (2009, June). Overcoming the barriers of isolation: Strategies for small and isolated developing states. In 2009 Global Information Infrastructure Symposium (pp. 1-7). IEEE.