

Understanding the Interplay of Demographics and Health Compliance of COVID-19 Management in Indonesian Communities

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Abstract. The COVID-19 pandemic has posed unprecedented challenges worldwide, with varying transmission patterns influenced by demographic and behavioral factors. This study explores the relationship between population density, demographic characteristics, and adherence to public health protocols across Indonesian provinces. By utilizing COVID-19 case data alongside demographic information, the study identifies significant patterns that reveal the impact of social and regional factors on virus transmission. The analysis indicates that population density plays a crucial role in determining case numbers, with densely populated areas exhibiting higher transmission rates. Additionally, compliance with preventive measures, such as mask-wearing and social distancing, varies significantly based on educational attainment and regional characteristics. The study underscores the importance of public health interventions tailored to these demographic factors to enhance compliance and curb virus spread. The findings contribute to the existing body of knowledge on pandemic dynamics, providing practical implications for public health policy and community-based interventions. Understanding these relationships can guide future responses to similar health crises, emphasizing the need for adaptive, evidence-based strategies to protect public health effectively.

1 Introduction

In the current digital media era, the popularity of photojournalism continues to rise alongside the demand for rapid information [1]. Images in modern news articles no longer. The COVID-19 pandemic has significantly disrupted societies worldwide, affecting public health systems, economies, and social structures. Since the first

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confirmed case in early 2020, Indonesia has faced immense challenges in controlling the spread of the virus while balancing economic stability and social welfare. With over 4.2 million confirmed cases and more than 140,000 deaths by mid-2022, the country experienced one of the most severe outbreaks in Southeast Asia. The highly contagious nature of the SARS-CoV-2 virus overwhelmed healthcare systems, particularly in densely populated urban areas such as Jakarta, Surabaya, and Bandung [1]. As the pandemic progressed, its impact extended beyond health concerns, affecting employment rates, education accessibility, and overall quality of life. The Indonesian government implemented various strategies, including large-scale social restrictions (Pembatasan Sosial Berskala Besar, PSBB), lockdowns, and mass vaccination programs to mitigate the crisis [2].

Understanding the transmission dynamics of COVID-19 has been a focal point in global epidemiological research, with studies conducted in different countries highlighting unique patterns of virus spread. In China, where the outbreak first emerged, studies by Cheng et al. demonstrated that early detection and strict quarantine measures were critical in curbing transmission [3]. In contrast, studies in countries like Singapore by previous study underscored the effectiveness of swift governmental action and rigorous contact tracing in minimizing case numbers [4]. Moreover, several demographic and socioeconomic factors have been identified as key determinants of COVID-19 transmission in Indonesia. Population density, age distribution, mobility patterns, and economic disparities have all contributed to the uneven spread of the virus [5]. For instance, densely populated urban areas, where social distancing is difficult to maintain, reported significantly higher case numbers than rural regions [6]. Additionally, underlying health conditions and disparities in healthcare access further exacerbated infection severity and mortality rates [7]. In response, the Indonesian government adopted multiple intervention strategies, including large-scale social restrictions, remote working policies, school closures, and an accelerated vaccination campaign.

Although many studies have examined COVID-19 management and compliance, few have specifically explored how demographic factors (such as age, education, income, or cultural background) interact with compliance behaviors in Indonesian communities [8]. Existing research often treats compliance as a uniform phenomenon, without considering how diverse demographic profiles may shape attitudes, practices, and barriers to health protocol adherence. This leaves a gap in understanding the nuanced interplay between population characteristics and compliance patterns, particularly in the Indonesian context where cultural and social diversity is significant.

2 Method

2.1 Data sources and study period

This study utilized COVID-19 case data from February 2022, which was obtained from the Indonesian Ministry of Health's COVID-19 Dashboard (<https://dashboardcovid19.kemkes.go.id/on>). February 2022 was selected as the study period due to its epidemiological significance, as it marked a phase dominated by the Omicron variant with substantial variations in transmission patterns across Indonesian

provinces. Analyzing this period allowed for the assessment of demographic and public health influences on COVID-19 spread during a phase of heightened infection rates. Further, provincial-level population and demographic data were retrieved from Statistics Indonesia (BPS) (<https://web-api.bps.go.id/>) on the same date. This data provided key demographic parameters necessary for analyzing COVID-19 transmission in relation to population characteristics.

2.2 Studying variables and data processing

The dataset incorporated multiple variables at the provincial level to capture various aspects of COVID-19 transmission and demographic characteristics. COVID-19-related variables included the total number of confirmed cases, recovered cases, deaths, and vaccination coverage rates, which were further categorized into first, second, and booster dose coverage. In addition to COVID-19 case data, demographic attributes were incorporated into the analysis. Population density, a key variable in transmission studies, was computed by dividing the total population by the land area for each province. This metric was used to assess the influence of spatial distribution on disease transmission.

2.3 Statistical analysis

All statistical analyses were performed using R version 1.4.1743, a widely used programming environment for epidemiological and statistical research. The statistical analysis included descriptive statistics, correlation analysis, and network visualization.

3 Results and discussion

3.1 Results

3.1.1 Correlation between covid-19 cases, mortality, and recovery rates in Indonesia

Understanding the relationship between the number of COVID-19 cases, mortality, and recovery rates is crucial for assessing the pandemic's impact and guiding public health interventions. The analysis of COVID-19 transmission dynamics in Indonesia reveals a strong and significant relationship between the number of confirmed cases and both mortality and recovery rates. The first scatter plot **Fig. 1a** shows a strong positive correlation (Pearson correlation = 0.974) between COVID-19 cases and deaths. This suggests that as the number of confirmed cases increases, the number of fatalities also rises proportionally. The linear regression line, with a narrow confidence interval, further confirms this trend, indicating a direct and consistent relationship between infection severity and mortality. These findings align with previous studies, which demonstrated that areas with higher case counts also exhibited higher mortality rates due to overwhelmed healthcare systems, comorbidities, and delays in medical intervention [9]. Similarly, the second scatter plot **Fig. 1b** illustrates a strong positive correlation (Pearson correlation = 0.978) between COVID-19 cases and the number of recovered patients. This suggests that as infections increase, the number of recoveries also rises

proportionally. This pattern can be attributed to the natural course of the disease, where a significant portion of infected individuals eventually recover, particularly with access to adequate medical treatment and supportive care.

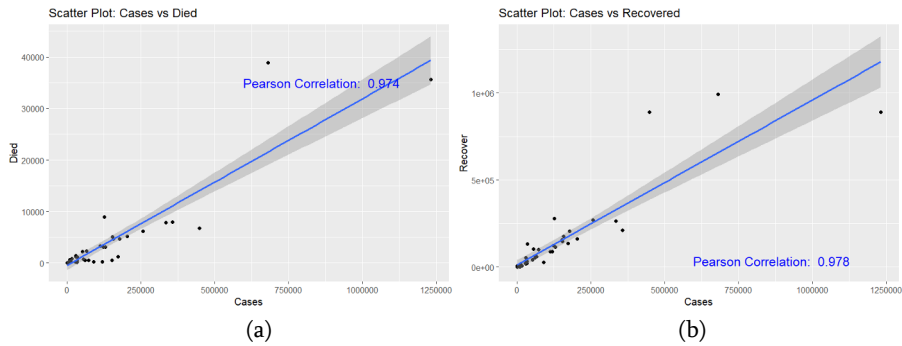


Fig. 1. a) Graph depicting the correlation between COVID-19 cases and related outcomes, showing a strong positive relationship (Pearson Correlation: 0.97) between the number of cases and fatalities. This highlights the impact of increasing cases on mortality rates during the pandemic. b) Graph illustrating the relationship between COVID-19 cases and recoveries, demonstrating a very high positive correlation (Pearson Correlation: 0.99). This indicates that as cases rise, the number of recoveries also increases, reflecting the effectiveness of healthcare responses over time.

3.1.2 The impact of population density on covid-19 case numbers

Examining the relationship between population density and the spread of COVID-19 is essential for identifying the factors that influence variations in case numbers across different regions. Population density, defined as the number of individuals residing within a given area, has been recognized in epidemiological studies as a significant determinant of infectious disease transmission [10]. In densely populated areas, the increased frequency of human interactions creates more opportunities for viral spread, especially in communal spaces and during social activities. Further, the **Fig. 2a** with a linear regression line visually depicts the relationship between COVID-19 cases and population density in Indonesian provinces. The red regression line represents the predicted relationship, with the surrounding grey shaded area indicating the 95% confidence interval. The positive slope of the line supports the findings of the regression equation:

$$\text{Cases} = 1092.32 + (0.6566 \times \text{Density})$$

This equation indicates that for every one-unit increase in population density (people/km²), the predicted number of COVID-19 cases increases by 0.6566 cases. The intercept value (1092.32) suggests that even with zero population density, there is a baseline of estimated cases, although this scenario is not practically meaningful. The strong positive trend observed in the plot reflects the positive correlation between density and case numbers, implying that provinces with higher population density tend to experience higher infection rates. Further, the statistical significance of the model is supported by a t-value of 5.013 and a p-value of 1.91e-05, indicating that the relationship between population density and case numbers is highly unlikely to have occurred by

chance. Additionally, the Multiple R-squared value (0.4398) indicates that 43.98% of the variance in case numbers can be explained by population density alone, suggesting that other demographic and behavioral factors may also influence case distribution.

Despite the clear positive relationship, the plot also reveals variability around the regression line, with several data points deviating from the predicted trend, indicating provincial differences in case patterns. This variability is further reflected in the residual analysis, which shows a Residual Standard Error (RSE) of 2062 and residuals ranging from -1574.1 to 9841.4 cases (**Fig. 2b**). These results emphasize the importance of targeted health interventions in densely populated areas, where the risk of virus transmission is naturally higher due to increased human interaction. This finding is consistent with previous research from urban centers globally, where higher density often correlates with elevated case counts due to proximity, shared facilities, and limited social distancing capacity [11]. Overall, these findings indicate that higher population density is associated with an increase in COVID-19 cases, implying that densely populated areas tend to experience higher infection rates.

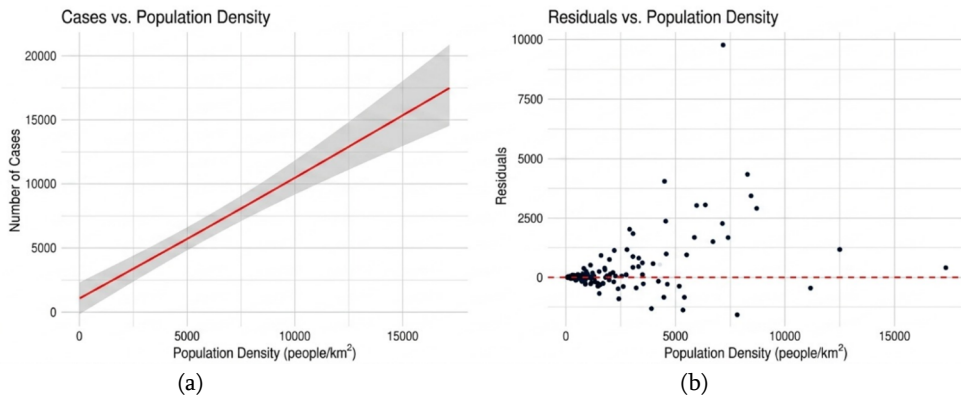


Fig. 2. a) Linear Regression Analysis of COVID-19 Cases and Population Density. b) Residual Standard Error (RSE). Regional Distribution of COVID-19 Cases in Relation to Population Density

The **Fig. 3** illustrates the relationship between COVID-19 cases and population density across Indonesian provinces. The distribution indicates that most provinces are clustered in the lower-left quadrant, suggesting relatively low case numbers in areas with moderate to low population density. However, two notable outliers deviate from this trend: Jakarta (marked in red) and Central Java (marked in green). Jakarta exhibits exceptionally high case numbers despite its small geographical area, which can be attributed to its high population density, intense social interactions, and substantial human mobility patterns as the country's capital. In contrast, Central Java presents a different pattern, with high case numbers despite comparatively lower density. This anomaly might reflect high inter-regional mobility, dense urban centers like Semarang and Solo, and population size that collectively contribute to the elevated transmission rates. The remaining provinces (depicted in blue) show lower case numbers corresponding to lower density, with some variations potentially linked to localized outbreaks, differences in testing capacity, and healthcare infrastructure. This pattern underscores the significant influence of population density on COVID-19 transmission,

highlighting the need for targeted public health measures in high-density regions like Jakarta and Central Java to curtail future outbreaks and mitigate the pandemic's impact.

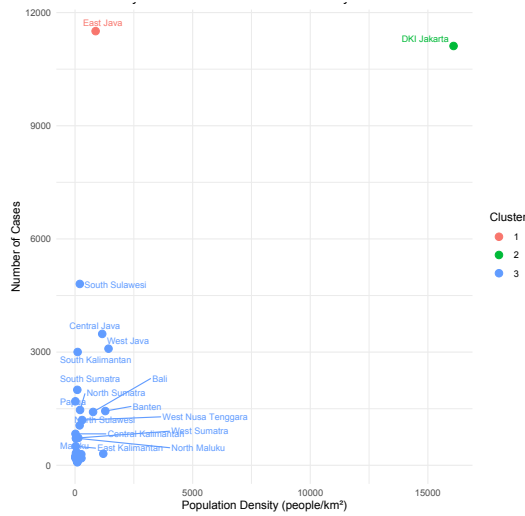


Fig. 3. Scatter Plot of COVID-19 Cases and Population Density Across Indonesian Provinces. The figure demonstrates the relationship between COVID-19 cases and population density across Indonesian provinces.

3.1.3 Regional and provincial variability in compliance with covid-19 health protocols across Indonesia

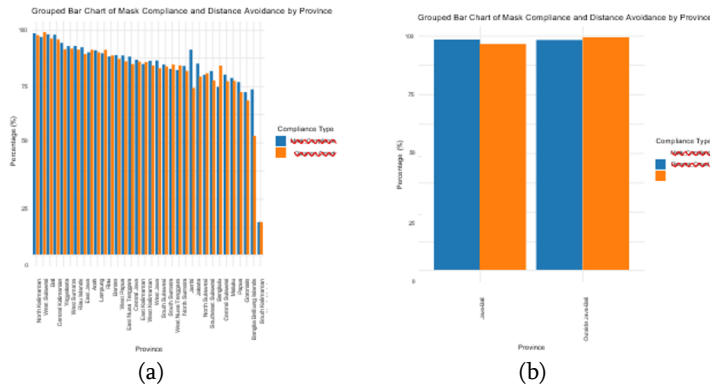


Fig. 4. a) Grouped bar chart illustrating compliance with mask-wearing and physical distancing across Indonesian provinces. b) Comparison of compliance rates between Java-Bali and non-Java-Bali regions. The chart indicates similar overall patterns, with Java-Bali regions demonstrating slightly higher adherence to COVID-19 health protocols compared to non-Java-Bali regions.

The visual representation of compliance with mask-wearing and physical distancing practices across Indonesian provinces highlights significant variability. The grouped bar chart on the left illustrates the percentage of compliance with mask-wearing (blue bars) and distance-avoidance (orange bars) for each province. Provinces such as Kalimantan

Utara, Bali, and Sulawesi Barat show high compliance rates exceeding 95%, suggesting strong adherence to public health protocols. In contrast, Maluku Utara demonstrates the lowest compliance rates, with figures below 20%, indicating potential challenges in community engagement or logistical barriers that are shown in **Fig. 4a**. Moreover, **Fig. 4b** presents aggregated compliance levels by regional classification, differentiating between Java-Bali and non-Java-Bali regions. The data indicates relatively consistent compliance patterns across these regions, though Java-Bali exhibits slightly higher adherence rates. This suggests the effectiveness of more concentrated public health campaigns in these densely populated regions.

3.1.4 Demographic variations in compliance with health protocols

The demographic analysis of compliance with health protocols presents significant variations across multiple sociodemographic categories, including age group, gender, education level, marital status, occupation, and regional location **Fig. 5a**. In terms of age distribution, younger individuals in the 17-24 and 25-39 age groups exhibited a lower level of compliance compared to older adults. This trend aligns with previous studies indicating that younger populations tend to have higher mobility rates and lower perceived risks, potentially contributing to reduced adherence to preventive measures. Conversely, individuals in the 40-59 and 60+ age groups demonstrated relatively higher compliance, likely due to greater health awareness and higher risk perception regarding severe COVID-19 outcomes. Regarding gender differences, females displayed higher compliance rates compared to males. This finding is consistent with previous research highlighting that women are generally more risk-averse and more likely to adopt preventive health behaviors than men. The higher compliance among women may also be attributed to their roles in caregiving and household management, which often require greater adherence to health protocols.

Education level also played a crucial role in compliance behavior. Individuals with higher education levels (bachelor's degrees and above) exhibited greater adherence to health measures, whereas those with lower education levels (elementary and junior high school) showed lower compliance. This trend suggests that health literacy and awareness campaigns should be tailored towards individuals with lower educational backgrounds to improve their understanding and adherence to public health guidelines. Further, examining marital status, married individuals demonstrated higher compliance rates, likely due to the responsibility of protecting family members, especially children and elderly relatives. In contrast, single and divorced individuals exhibited lower adherence, potentially influenced by lifestyle factors such as increased mobility and social interactions.

Lastly, regional differences were evident, with individuals residing in Java-Bali demonstrating higher compliance rates compared to those in regions outside Java-Bali. This discrepancy may be due to differences in public health infrastructure, enforcement of COVID-19 policies, and access to health-related information. Urban areas, particularly in Java-Bali, benefited from more stringent government policies and better healthcare access, contributing to higher compliance levels. These findings emphasize the need for

targeted health policies and public awareness campaigns that account for demographic differences in compliance behavior.

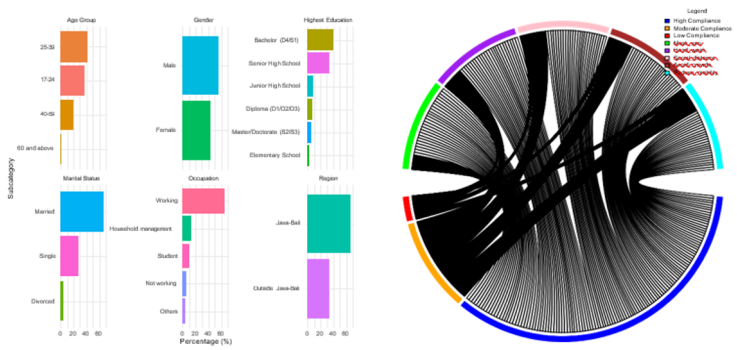


Fig. 5 a). The figure illustrates variations in compliance with health protocols based on age group, gender, education level, marital status, occupation, and regional location. The data reveal that older individuals, females, higher-educated individuals, and those residing in Java- Bali exhibit higher compliance levels, whereas younger individuals, males, lower-educated groups, and working individuals show lower adherence. These findings suggest that public health interventions should be tailored to specific demographic groups to improve compliance and reduce the next transmission-disease. **b)** The figure illustrates the relationship between different compliance levels (high, moderate, and low) and various health behaviors, including mask use, handwashing, social distancing, distance-avoidance, and mobility reduction.

3.1.5 Insights into the relationship between compliance levels and health behaviors

Fig. 5b illustrates the interconnections between compliance levels and various health behaviors, including mask use, handwashing, social distancing, distance-avoidance, and mobility reduction. The arcs around the circumference represent distinct compliance categories, while the lines connecting these arcs demonstrate the relationships and interactions between compliance levels and corresponding health behaviors. From the visualization, it is evident that individuals with high compliance levels are strongly associated with mask use and handwashing practices. This suggests that these behaviors were prioritized by individuals who adhered to health protocols consistently. Additionally, high compliance is also linked to social distancing and avoiding crowds, reflecting the effectiveness of public health messaging emphasizing these practices during peak transmission periods. Conversely, individuals in the moderate and low compliance categories exhibit weaker connections to these behaviors, particularly regarding reducing mobility and maintaining social distance. The reduced line density between these categories and health behaviors implies lower adherence to preventive measures among these groups.

3.2 Discussion

This study investigates the relationship between population density and COVID-19 cases, alongside public compliance with health protocols across various regions in Indonesia. The analysis draws attention to the interplay of demographic factors and their influence

on pandemic dynamics, providing a broader context for understanding transmission patterns and adherence behaviors. Public health behavior, particularly compliance with preventive measures like mask-wearing and social distancing, is shaped by multiple factors. Education, for instance, has consistently been identified as a key determinant. Regions with better access to educational resources tend to exhibit higher levels of compliance, suggesting the importance of educational campaigns in promoting health-protective behaviors. This finding aligns with previous research that highlights education's role in fostering better understanding and implementation of health guidelines [12]. Moreover, population density has been recognized as a significant factor in infectious disease transmission. Densely populated areas pose challenges for maintaining physical distance, thereby increasing the likelihood of virus spread. Historical data from past pandemics and studies in other countries reinforce this relationship [13]. In Indonesia, the varying population densities across provinces provide a natural context for observing these dynamics, emphasizing the need for tailored interventions in more crowded regions.

The social and demographic characteristics of communities further contribute to differences in health behavior adherence. Occupational status, marital status, and age group distinctions influence perceptions of risk and responsibility. Behavioral studies, including those by Bish and Michie, suggest that individuals with higher perceived susceptibility and responsibility tend to comply more with health protocols [14]. This perspective provides a framework for interpreting the observed compliance patterns and tailoring interventions accordingly. Furthermore, policy implications derived from these findings emphasize the need for context-specific strategies. Educational programs targeting populations with lower compliance rates, especially in regions with limited access to formal education, are essential. Community-based initiatives, leveraging the influence of local leaders and trusted figures, may enhance public trust and participation. The integration of social behavior theories, like the Health Belief Model, could further refine intervention strategies by addressing perceived risks and benefits effectively.

Indonesia's experience with COVID-19 resonates with international observations. Countries that implemented early testing, transparent communication, and strict health protocol enforcement, such as South Korea and Germany, managed to mitigate transmission more successfully [15]. Comparative analysis suggests that policy consistency and public engagement are critical factors in pandemic response. While direct adoption of foreign strategies may be challenging due to socio-political and economic differences, lessons from these countries indicate the importance of early intervention, data-driven decision-making, and public cooperation. Policymakers in Indonesia can use these insights to refine strategies for future outbreak preparedness. Beyond the COVID-19 pandemic, understanding the interaction between demographic factors and public health behaviors can inform strategies for future infectious disease management. Preparedness plans should incorporate population density considerations, educational outreach programs, and community engagement strategies as foundational components for strengthening resilience against future outbreaks. Future research should expand on these findings by investigating the impact of vaccination coverage, mobility patterns, and misinformation on public health compliance. Additionally, studies on

digital literacy and its role in disseminating accurate health information could provide valuable insights into enhancing public engagement during health crises.

4 Conclusion

This study highlights the interplay between population density, education levels, and adherence to preventive measures, providing a nuanced understanding of pandemic dynamics in Indonesia. The findings emphasize the critical role of education in shaping public health behaviors, underscoring the need for targeted health literacy initiatives. Regions with lower adherence rates should be prioritized for digital and community-based educational interventions to improve compliance with health protocols. Moreover, the study reinforces the significance of population density as a determinant of infection risk, necessitating tailored strategies for densely populated areas. Measures such as crowd management, improved ventilation in public spaces, and localized risk communication should be integral to future public health policies. To strengthen outbreak preparedness, policymakers should adopt evidence-based, community-driven approaches. Collaborating with local leaders, religious figures, and trusted institutions can enhance public trust and engagement, fostering long-term resilience.

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