Beyond Obstetricians Density: The Dominant Role of Road Quality in Maternal Mortality-an Ecological Study from Indonesia

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Abstract. Maternal mortality remains a significant public health issue in Indonesia, with wide disparities across provinces. While national strategies have focused on expanding health insurance coverage and increasing the number of skilled birth attendants, the role of infrastructure, particularly road conditions, has received less attention. This study aimed to examine the relationship between maternal mortality and three key factors: the number of obstetricians, road quality, and health insurance coverage. An ecological cross-sectional study was conducted using secondary data from 34 Indonesian provinces. Maternal mortality ratio (MMR) data were sourced from the 2020 Long Form Population Census, while data on obstetricians, road conditions, and BPJS health insurance coverage were obtained from national government reports (2021–2025). Pearson correlation and multiple linear regression analyses were performed. Results showed that road quality had the strongest and most statistically significant inverse relationship with MMR ($\beta = -3.58$, $p = 0.005$), while the number of obstetricians and insurance coverage were not significant predictors in the multivariate model. These findings highlight the importance of integrating transportation infrastructure development into maternal health policies, particularly in underserved regions, to accelerate progress toward achieving national and global maternal mortality reduction targets.

Keywords: Maternal Mortality, Road Quality, Doctor Density, Obstetrician, Transportation.

1 Introduction

Maternal mortality continues to pose a significant public health challenge in Indonesia. As of 2020, Indonesia ranked third among Southeast Asian countries with the highest maternal mortality ratio (MMR), reporting 189 deaths per 100,000 live births [1]. This figure remains well above the Sustainable Development Goal (SDG) target 3.1, which aims to reduce the global MMR to fewer than 70 per 100,000 live births by 2030 [2].

Although there have been notable improvements in antenatal care coverage, institutional deliveries, and the availability of healthcare professionals, maternal mortality in various regions of the country remains alarmingly high [1].

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While national strategies have largely focused on promoting deliveries at Basic and Comprehensive Emergency Obstetric and Neonatal Care (BEmONC/CEmONC) facilities [3], [4], ensuring the availability of high-quality and accessible healthcare services [5], and mandating that childbirth be attended by skilled health personnel [6], emerging evidence indicates that structural and infrastructural factors, particularly physical access to healthcare facilities such as road conditions, may play an equally, if not more, critical role in reducing maternal mortality [7], [8].

When discussing access to healthcare facilities, most existing studies have concentrated on geographic barriers and travel time from home to health services. Evidence consistently shows that longer travel times are associated with an increased risk of obstetric complications [7], [8]. However, limited research has explored the role of road conditions and transportation infrastructure in maternal and child health outcomes. This is a critical gap, considering that transportation systems are essential for ensuring timely access to appropriate levels of care for pregnant women. Well-functioning maternal transport systems have been shown to reduce neonatal, perinatal, and maternal morbidity and mortality by enabling timely referral to higher-level facilities when complications arise [9].

In addition to health workforce availability and physical access, financial accessibility plays a crucial role in determining maternal health outcomes. Health insurance schemes, particularly those that reduce out-of-pocket costs, are increasingly recognized as a key strategy to improve the utilization of maternal health services in low- and lower-middle-income countries. A recent systematic review found that the introduction or expansion of health insurance was associated with increased antenatal care attendance (at least four visits), higher rates of facility-based deliveries, and greater use of skilled birth attendants, all interventions known to reduce maternal mortality [10]. As Indonesia continues to pursue universal health coverage through its national health insurance system (BPJS Kesehatan), assessing the relationship between insurance coverage rates and maternal mortality becomes essential for understanding the effectiveness of financial protection mechanisms in advancing maternal health equity.

This study explores the hypothesis that multiple factors, including the number of obstetricians, the quality of road infrastructure, and the level of health insurance coverage, collectively influence maternal mortality at the provincial level. It aims to examine how each of these variables contributes to variations in maternal mortality ratios across different regions in Indonesia, offering insights into the broader determinants of maternal health outcomes.

2 Methods

2.1 Study Design and Setting

This study employed an ecological cross-sectional design using province-level secondary data from Indonesia. The unit of analysis was the province, encompassing all 34 provinces as administratively defined prior to the 2022 expansion in Papua. An ecological approach was selected to examine system-level and spatial determinants of maternal mortality that operate beyond individual-level risk factors, consistent with health geography perspectives on access, infrastructure, and inequality.

Indonesia provides a relevant analytical setting due to its archipelagic geography, substantial regional disparities in infrastructure development, and ongoing national efforts to expand health system coverage. These characteristics make it well suited for examining how spatial and structural conditions shape maternal health outcomes.

2.2 Data Sources

Maternal mortality data were obtained from the 2020 Long Form Population Census conducted by Statistics Indonesia [1]. This source provides the most comprehensive and nationally comparable estimates of maternal mortality across Indonesian provinces.

Data on obstetrician availability were drawn from the 2025 national report on the distribution of medical specialists published by the Ministry of Health [11]. Road infrastructure data were sourced from the 2023 dataset released by the Ministry of Public Works and Housing [12], which reports the proportion of district and municipal roads classified as being in good or fair condition. Health insurance coverage data were obtained from the 2021 BPJS Kesehatan dataset compiled by BPS, reflecting the percentage of the provincial population enrolled in Indonesia's national health insurance scheme [13].

Although the datasets were drawn from different years, the variables of interest represent relatively stable structural characteristics—particularly road infrastructure and specialist distribution—rather than short-term fluctuations. As such, they were treated as system-level exposures shaping spatial access to maternal healthcare.

2.3 Variables

The dependent variable in this study was the Maternal Mortality Ratio (MMR), measured as the number of maternal deaths per 100,000 live births. The independent variables included: (1) the number of obstetricians, presented as the absolute count per province (2025); (2) road quality, defined as the percentage of district and municipal roads classified in good condition (2023); and (3) health insurance coverage was measured as the percentage of the provincial population enrolled in the national health insurance program (BPJS Kesehatan) as of 2021.

For maternal mortality, the number of maternal deaths refers to deaths among women caused by pregnancy, childbirth, miscarriage, or abortion, occurring up to 42

days after delivery, miscarriage, or abortion within a given geographic area. The number of live births refers to the total number of infants born alive in that same area [1].

Roads classified as having good service conditions refer to segments that are in good or fair condition based on their planned service life and adherence to established standards. The condition of a road segment categorized as good, fair, lightly damaged, or severely damaged, is determined using thresholds for the International Roughness Index (IRI) and the Road Condition Index (RCI), in conjunction with traffic volume data. The IRI quantifies the unevenness of a road surface and is calculated as the cumulative vertical displacement of the surface per unit length. Mathematically, the IRI represents the ratio of the total length of damaged or potholed road sections (in meters) to the total road length (in kilometers). A higher IRI value (expressed in m/km) indicates a rougher and more deteriorated road surface [12].

Data on health insurance coverage includes both government-subsidized members (Penerima Bantuan Iuran, or PBI) and non-subsidized members. Individuals enrolled in regional health insurance schemes, private health insurance plans, or employer-sponsored insurance programs were excluded from this measurement. The naming and classification of provinces in this study follow the administrative standards set by BPS.

Although Indonesia currently has more than 34 provinces, this study is limited to 34 due to the use of datasets published prior to the 2022 administrative expansion in Papua. Similarly, the 2025 data on obstetrician distribution have been adjusted to match the pre-division provincial structure to maintain consistency across datasets.

2.4 Statistical Analysis

Data were analysed using Pearson correlation to assess the bivariate relationships between variables. Multiple linear regression was employed to examine the independent contribution of each predictor to maternal mortality. Variance Inflation Factor (VIF) scores were calculated to evaluate multicollinearity among predictors. Residual plots were examined to ensure the assumptions of linear regression were adequately met.

Additionally, subgroup analyses were conducted by stratifying provinces into major island regions: Sumatra, Java, Bali–Nusa Tenggara, Kalimantan, Sulawesi, Maluku, and Papua. This grouping follows the international geographic classification defined by ISO 3166-2:ID [14], which reflects administrative and spatial divisions of the Indonesian archipelago. To ensure a minimum of four provinces per subgroup for analytical stability, Bali was added to Java regional units, while Nusa Tenggara, Maluku and Papua were combined, resulting in five regional units used in the subgroup analysis: Sumatra, Java-Bali, Kalimantan, Sulawesi, and Nusa Tenggara-Maluku–Papua. Separate regression models were run for each subgroup to explore whether the relationships between predictors and maternal mortality differed across geographic regions.

2.5 Ethical Consideration

This study used publicly available, aggregated secondary data and did not involve human participants. Ethical approval was therefore not required.

3 Result

3.1 Descriptive Statistics

Table 1. Descriptive statistics

Variables	Mean	Min	Max
MMR[1)]	189	48	565
No of Obstetricians[2)]	314.2	17	1740
Road quality[3)]	57.58%	30.96%	98.47%
Health insurance coverage[4)]	63.80%	39.7%	95.15%

[1)] Long Form SP2020; [2)] 2025 report on the Distribution of Doctors in Indonesia published by the Ministry of Health; [3)] percentage of district and municipal roads classified in good condition 2023 dataset released by the Ministry of Public Works; [4)] from the 2021 BPJS dataset compiled by BPS

Substantial spatial variation in maternal mortality and system-level characteristics was observed across Indonesian provinces (Table 1). The mean maternal mortality ratio (MMR) was 189 deaths per 100,000 live births, with marked disparities ranging from 48 in DKI Jakarta to 565 in Papua. These differences reflect pronounced regional inequalities in maternal health outcomes.

The distribution of obstetricians varied considerably, with a mean of 314.2 obstetricians per province. Provinces in western Indonesia, particularly Java, had substantially higher concentrations of specialists compared with eastern regions. Road infrastructure quality, measured as the proportion of district and municipal roads in good or fair condition, also showed wide geographic variation, ranging from 30.96 % in Papua to 98.47 % in DKI Jakarta. Health insurance coverage similarly varied across provinces, from 39.7 % to 95.15 %, indicating uneven financial access to health services nationwide.

3.2 Bivariate Analysis

Bivariate analyses revealed statistically significant inverse associations between maternal mortality and each of the examined system-level variables (Table 2). Higher obstetrician availability was moderately associated with lower maternal mortality ($r = –0.369$, $p = 0.032$). Health insurance coverage also demonstrated a moderate negative correlation with maternal mortality ($r = –0.400$, $p = 0.019$).

Road infrastructure quality exhibited the strongest bivariate association with maternal mortality ($r = –0.629$, $p < 0.001$), indicating that provinces with better road conditions tended to experience substantially lower maternal mortality ratios. These findings suggest that multiple dimensions of access—service availability, financial

protection, and physical connectivity—are related to maternal mortality at the ecological level.

Table 2. Pearson Correlation Matrix Between Variable Pairs

Variable pair	Correlation coefficient (r)	p-value
Number of Obstetricians – MMR	-0.369	0.032
Road Quality – MMR	-0.629	<0.001
BPJS Coverage – MMR	-0.400	0.019

3.3 Multivariate Analysis

The results of the multiple linear regression analysis with maternal mortality ratio (MMR) as the dependent variable are presented in Table 3.

Table 3. Multivariate Analysis

Independent variable	Coefficient (β)	p-value
Number of Obstetricians	+0.018	0.675
Road Quality	-3.582	0.005
BPJS Coverage	-1.883	0.090

The overall model was significant ($F(3,30) = 8.785$, $p < 0.001$), explaining 46.8 % of the variance in MMR ($R^2 = 0.468$). Road quality remained a statistically significant predictor ($\beta = -3.582$, $p = 0.005$), while the number of obstetricians ($\beta = 0.018$, $p = 0.675$) and BPJS Coverage ($\beta = -1.883$, $p = 0.090$) did not.

Based on the results of the multicollinearity test using the Variance Inflation Factor (VIF), conducted to rule out potential correlations among predictor variables, all independent variables were found to have VIF values below 5. This indicates the absence of problematic multicollinearity, allowing the regression coefficients to be interpreted reliably without bias due to high intercorrelations among the predictors.

3.4 Subgroup Analysis

Subgroup regression analyses across five major island regions revealed notable geographic variations. In Sumatra, none of the predictors were statistically significant and model fit was weak ($R^2 = 0.174$), suggesting other unmeasured factors may

influence maternal mortality. Java–Bali ($R^2 = 0.908$) and Kalimantan ($R^2 = 0.968$), showed strong model performance but individual predictors remained nonsignificant. Sulawesi demonstrated moderate explanatory power ($R^2 = 0.826$), with obstetrician density approaching significance. The Nusa Tenggara–Maluku–Papua region stood out, with all three predictors: obstetrician density ($\beta = 2.09$, $p = 0.014$), road quality ($\beta = -10.45$, $p = 0.007$), and health insurance coverage ($\beta = -4.23$, $p = 0.047$) significantly associated with maternal mortality ($R^2 = 0.99$), highlighting the critical role of infrastructure and health access in eastern Indonesia (Table 4).

Table 4. Subgroup Analysis

Island group	R-squared	Significant predictor
Sumatera	0.174	None
Java-Bali	0.908	None
Kalimantan	0.968	None
Sulawesi	0.826	None
Nusa Tenggara-Maluku-Papua	0.990	All

4 Discussion

4.1 Overview of Main Findings

This study aimed to investigate the relative influence of healthcare access indicators including road quality, the number of obstetricians, and health insurance coverage on provincial maternal mortality ratios (MMR) in Indonesia. The results revealed that road quality had the strongest and most statistically significant inverse association with maternal mortality. Although both the number of obstetricians and BPJS health insurance coverage demonstrated moderate negative correlations with MMR, only road quality remained a significant predictor in the multivariate regression model. These findings suggest that beyond the expansion of the health workforce and insurance programs, improvements in physical infrastructure may be a more immediate and impactful strategy for reducing maternal deaths in the Indonesian context.

4.2 Interpretation of Key Predictors

Maternal mortality is a multifactorial issue influenced by a complex interplay of individual, household, and systemic determinants. In low- and lower-middle-income countries, key individual-level risk factors include place of birth, maternal education, delays in seeking care, lack of prenatal services, and absence of skilled birth attendants. At the household level, poor housing conditions, inadequate water and sanitation, low socioeconomic status, and limited education of partners also contribute significantly to adverse maternal outcomes. Ecological-level determinants such as inadequate health workforce availability, limited access to health infrastructure, high fertility rates, weak health financing systems, and broader social factors including poverty, governance, and gender inequality are also strongly associated with maternal mortality [15].

In Indonesia, these structural vulnerabilities manifest in clinical causes such as non-obstetric complications (29 %), obstetric hemorrhage (25 %), and hypertensive disorders (23 %), with many of these deaths resulting from delayed or insufficient care, especially in areas with poor service accessibility [16].

These established determinants align with the key variables examined in this study: the availability of obstetricians, the quality of road infrastructure, and the extent of health insurance coverage. The number of obstetricians reflects the adequacy of human resources in maternal care, while road quality functions as a proxy for physical

accessibility to emergency obstetric services. Health insurance coverage, in turn, represents financial accessibility to care.

The strong inverse association between road quality and maternal mortality underscores the critical role of transportation infrastructure in facilitating timely access to obstetric care. A study conducted in Ghana reported that inadequate road conditions significantly impede access to maternal healthcare services by making travel physically challenging. As a result, many women are forced to walk long distances or depend on unsafe and unreliable modes of transportation. These geographic barriers contribute to substantial delays in obtaining timely medical care, which in turn negatively affect both maternal and child health outcomes [17]. A systematic review conducted in Africa found that long distances to health facilities and limited transportation access significantly increased the risk of maternal near-miss (MNM), defined as a woman who nearly died but survived a life-threatening complication during pregnancy, childbirth, or within 42 days of pregnancy termination, either due to receiving quality care or by chance. Although MNM is not a direct measure of maternal mortality, these factors are closely linked to delays in receiving adequate care, which ultimately influence maternal health outcomes [18].

A study conducted in India demonstrated that improved access to paved roads enhances access to healthcare facilities, which can indirectly influence maternal health outcomes. By facilitating greater access to health services, better road conditions may contribute to reductions in maternal mortality, similar to the observed declines in infant mortality attributed to improved healthcare access and increased immunization coverage following road infrastructure development [19].

Previous studies have also emphasized that distance and travel time to health facilities are significant predictors of maternal outcomes [20]. This may reflect broader disparities in geographic accessibility, particularly in underdeveloped or remote provinces such as Papua, where road infrastructure is often inadequate. Therefore, road quality serves not only as a transportation indicator but also as a proxy for regional inequality in health service accessibility.

Although the number of obstetricians per province showed a moderate negative correlation with maternal mortality, it was not statistically significant in the multivariate model. This finding contrasts with previous studies which have shown that a higher density of health workers, particularly the combined density of skilled health professionals, including nurses and midwives, is significantly associated with improved health outcomes, including lower maternal mortality rates [21]. However, this may be due to the fact that maternal mortality is more strongly associated with the overall density of health workers and physicians, rather than specifically with the number of obstetricians [21], [22]. One possible explanation is the maldistribution of specialists, where a large proportion are concentrated in urban or Java-based provinces, leaving rural and remote areas underserved [11].

Another possible explanation relates to the scale of the available data, which is aggregated at the provincial level rather than at smaller administrative units such as districts or municipalities. This limits the ability to capture disparities in the distribution of obstetricians. According to the 2025 data on the distribution of obstetricians, there are 33 districts or cities in Indonesia with no obstetricians available. Unfortunately,

maternal mortality data are only available at the provincial level, preventing more detailed analysis at the district level.

Moreover, the presence of obstetricians does not automatically guarantee quality care if health facilities are under-resourced or inaccessible. Similarly, BPJS health insurance coverage showed a marginally significant negative association with maternal mortality. While insurance improves financial access to care, it may have limited impact when physical access is constrained. These findings align with previous research indicating that financial coverage must be accompanied by service availability and geographic accessibility to produce substantial improvements in maternal health outcomes [23].

This interpretation is also supported by evidence from Indonesia showing that the quality of antenatal care services is associated with maternal mortality outcomes, particularly during periods of health system strain such as the COVID-19 pandemic. Previous research from East Java reported that poorer access and quality of antenatal care were correlated with higher maternal mortality, underscoring that the effectiveness of maternal health services depends not only on service provision itself, but also on broader access conditions that enable timely utilisation of care [24].

4.3 Geographic Variations

Given Indonesia's vast and diverse geography, comprising more than 17,000 islands with varying levels of infrastructure, health workforce availability, and healthcare access, this study conducted subgroup analyses by major island groups to explore whether regional differences affect the relationship between maternal mortality and its predictors. Such geographic disaggregation is essential, as national averages may obscure critical inequalities across regions, particularly in resource distribution and health outcomes.

While the overall model showed road quality as the most dominant predictor nationally, the subgroup analyses revealed that this pattern is not uniform. In Sumatra, none of the examined predictors were statistically significant, indicating that maternal mortality in this region may be driven by other structural or sociocultural factors not captured in the model. Java–Bali and Kalimantan demonstrated strong model fit, but predictor effects did not reach significance, possibly due to homogeneity in healthcare infrastructure or sample limitations. In Sulawesi, the number of obstetricians was negatively associated with maternal mortality and nearly significant, supporting the notion that skilled birth attendance remains vital. Notably, the eastern region, Nusa Tenggara, Maluku, and Papua, showed statistically significant associations for all predictors, with road infrastructure having the largest effect. This underscores the compounded barriers faced by underserved provinces, where geographic isolation, inadequate roads, and uneven healthcare coverage jointly contribute to persistently high maternal mortality. These findings emphasize the need for regionally tailored interventions that go beyond healthcare facility availability, incorporating broader infrastructural and equity-focused strategies.

These disparities are consistent with prior studies that document significant health infrastructure inequalities across Indonesian provinces. The Public Health

Development Index (PHDI), a composite measure of infrastructure, service availability, behavioural risk factors, and health outcomes, shows stark inequality across provinces, ranging from 43.9 in Papua to 65.0 in Bali. Provinces in western Indonesia consistently scored higher than those in the east, reflecting longstanding gaps in public health investment and access [25]. These disparities are mirrored in maternal and newborn health indicators. For example, antenatal care coverage varies by as much as 44.4 percentage points, from 85.5 % in Yogyakarta to just 41.1 % in Maluku. Moreover, Maluku, North Maluku, Papua, and West Papua all report less than 50 % coverage for both antenatal and postnatal care services, critical interventions for preventing maternal deaths [26]. In contrast, Bali and Yogyakarta, which perform better on both health infrastructure and service coverage, consistently report lower maternal mortality ratios. As such, addressing maternal mortality in Indonesia requires context-specific strategies that account for regional disparities in infrastructure, healthcare distribution, and population density.

4.4 Policy Implications

These findings underscore the necessity of integrating health and infrastructure policy to effectively reduce maternal mortality in Indonesia. While national strategies have appropriately prioritized antenatal care, skilled birth attendance, and insurance expansion, the absence of reliable transport infrastructure remains a critical bottleneck. Maternal health interventions must therefore include investment in district and provincial road improvements, particularly in regions with high mortality and poor road performance. This approach requires coordinated action between the Ministry of Health and other sectors such as the Ministry of Public Works and regional planning agencies. Prioritizing provinces with low road quality can help address inequities and accelerate progress toward achieving Sustainable Development Goal (SDG) 3.1 [2].

4.5 Strength and Limitations

This study offers several notable strengths. It leverages comprehensive and publicly accessible national datasets, enabling an ecological-level analysis across all 34 provinces in Indonesia. By incorporating three key predictors: obstetrician density, road infrastructure quality, and health insurance coverage, the study captures both health system and structural determinants of maternal mortality. The inclusion of subgroup analysis by major island regions further enhances the study's relevance by accounting for Indonesia’s geographical diversity, offering insights into regional disparities that are often masked in national-level analyses.

However, several limitations must be acknowledged. As an ecological analysis, the findings reflect associations at the population level and cannot be interpreted as causal relationships at the individual level. Additionally, the use of datasets from different years (2020–2025) may introduce temporal discrepancies, although care was taken to use the most recent and relevant data available.

The use of proxy indicators (such as road quality as a surrogate for access) may not fully capture the complexities of maternal health service utilization. The study also did

not include other important determinants of maternal mortality such as place of birth, maternal education level, poor housing conditions, inadequate water and sanitation, low socioeconomic status, health facility density, or travel time, which may offer additional explanatory power.

Despite these limitations, the study provides valuable evidence for prioritizing infrastructure and access as critical components in maternal mortality reduction strategies, especially in underserved regions. Future research should consider mixed-methods or spatial approaches that incorporate both quantitative and qualitative data to explore how infrastructure interacts with social, cultural, and systemic factors to influence maternal health outcomes across diverse Indonesian contexts.

5 Conclusions

Improving road quality should be prioritized alongside medical workforce expansion in strategies to reduce maternal mortality in Indonesia. Future research may explore how specific geographic barriers interact with social and economic determinants to influence maternal outcomes.

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