Distribution of catheterisation laboratories in Indonesia 2017–2022: a nationwide survey

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Summary

Background Geographical terrains of Indonesia pose a major hindrance to transportation. The difficulty of transportation affects the provision of acute time-dependent therapy such as percutaneous coronary intervention (PCI). Also, Indonesia's aging population would have a significant impact on the prevalence of acute coronary syndrome in the next decade. Therefore, the analysis and enhancement of cardiovascular care are crucial. The catheterisation laboratory performs PCI procedures. In the current study, we mapped the number and distribution of catheterisation laboratories in Indonesia.

Methods A direct survey was used to collect data related to catheterisation laboratory locations in July 2022. The population data was sourced from the Ministry of Home Affairs. The recent growth of catheterisation laboratories was examined and evaluated based on geographical areas. The main instruments for comparing regions and changes throughout time are the ratio of catheterisation laboratories per 100,000 population and the Gini index (a measure of economic and healthcare inequality. Gini index ranges from 0 to 1, with greater values indicating more significant levels of inequality). Regression analysis was carried out to see how the number of catheterisation laboratories was affected by health demand (prevalence) and economic capacity (Gross Domestic Regional Product [GDRP] per Capita).

Findings The number of catheterisation laboratories in Indonesia significantly increased from 181 to 310 during 2017–2022, with 44 of the 119 new labs built in an area that did not have one. Java has the most catheterisation laboratories (208, 67%). The catheterisation laboratory ratio in the provinces of Indonesia ranges from 0.0 in West Papua and Maluku to 4.46 in Jakarta; the median is 1.09 (IQR 0.71–1.18). The distribution remains a problem, as shown by the high catheterisation laboratory Gini index (0.48). Regression shows that distribution of catheterisation laboratories was significantly affected by GDRP and the prevalence of heart disease.

Interpretation The number of catheterisation laboratories in Indonesia has increased significantly recently, however, maldistribution remains a concern. To improve Indonesia's cardiovascular emergency services, future development of catheterisation laboratories must be better planned considering the facility's accessibility and density.

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Introduction

Indonesia has entered a new population growth phase, and its demographic distribution will shift to an older population in the next ten years.[1,2] It is estimated that the population will increase by 6–7% from 2020 to 2030, with the elderly population (>45 years old) increasing by

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Research in context

Evidence before this study
According to earlier studies, accessibility to catheterisation laboratories is critical as it reduces the time taken by acute coronary syndrome (ACS) patients to receive care. Indonesia is the fourth-largest nation by population and the largest archipelagic country in the world. Unfortunately, the number of catheterisation laboratories in Indonesia (nationwide) was never examined or mentioned in any previous research articles that we could find. In the current study, we tried to map the catheterisation laboratories in Indonesia to encourage planning of laboratories in strategic locations.

Added value of this study
This study provides data on the number of catheterisation laboratories, primary geographic distribution, catheterisation laboratory-to-population ratio, and evolution over the previous five years in Indonesia. To ensure equity access, Indonesia needs government policies that initiate catheterisation laboratory distribution and strategic placement, especially in areas with lower economic capacity.

Implications of all the available evidence
Our study identified regions in Indonesia with limited access to essential cardiac services. The findings would allow policymakers to strategically direct investments and implement policies in underserved areas, which would thereby decrease the time taken for commencing treatment in ACS patients and potentially reduce mortality rates. Additionally, our findings related to the changes in laboratory distribution over the past five years would help policymakers to evaluate the impact of previous initiatives and plan future resources more effectively. This would ensure equitable access to cardiac care for all citizens regardless of economic status and enhance health outcomes at national level.

up to 30%, a rate four times greater than that of the general population. This will lead to an increase in the incidence of cardiovascular disease, particularly acute coronary syndrome.[3–5]

Acute Coronary Syndrome (ACS) is a life-threatening, noncommunicable disease. Its effective treatment depends upon specific and general infrastructure. Specific infrastructure includes health facilities with specialised equipment (catheterisation laboratories), and public infrastructure (roads, ambulances, referral systems) supports access to these facilities.[6–8] Primary Percutaneous coronary intervention (PCI) is still the gold standard in treating ACS, as evidenced by reduced mortality and morbidity in patients receiving this treatment. However, the efficacy of primary PCI depends upon symptoms-to-needle and door-to-needle time criteria.[9–11]

As the world's largest archipelago country, Indonesia has the burden of a growing population, transportation, and accessibility problems. The sea is a barrier between islands, separating their populations and making it harder for health facilities to cover their people.[12,13] In this paper, we will describe the growth, number, ratio, and distribution of catheterisation laboratories (cath labs) in Indonesia with the expectation of providing a basis for procurement policy.[14–16]

Methods

This cross-sectional study used geospatial information systems (GIS) for descriptive analysis. We gathered the data on the cath lab facilities, road networks, population, and demographic boundaries and analysed them using Network Analysis. This study was conducted in July 2022 divided into two phases: data collection and data analysis. In this research, we focused on infrastructure, such as the road network and cath lab facility. This paper does not discuss other factors that may affect the time needed to reach the nearest facility, such as the cardiac emergency system, human resources available to perform PCI, and the national referral system.

Cath lab facility data

Open-source data for cath labs were unavailable; therefore, we conducted a primary survey from the data of hospital instruments from the Ministry of Health, Indonesia (*Kementerian Kesehatan*). These data were cross-checked using a primary survey of the regional heart association data and online data mining sourced from hospital facilities' websites and news of cath lab openings from trusted media. After the primary data were finished, the data was cross-checked with the data from the Ministry of Health, the Indonesian Heart Association, and the Indonesia National Health Insurance. The data collection process is illustrated in Fig. 1. First, we collected comprehensive data on hospitals in Indonesia and determined whether they offer cath lab. If a hospital did not have a cath lab, we classified it as a "non-eligible hospital" and removed it from our mapping. Data that did not match our sources or was ambiguous was further checked by contacting the hospital or the regional heart association.

The hospital data were excluded if discrepancies occurred during crosschecking. The final data related to cath labs reflected the situation in Indonesia as of June 2022. Some facilities, especially tertiary and referral hospitals, may have more than one cath lab. Information on the cath labs in every hospital was unavailable publicly. Considering this limitation, we counted the number of hospitals with a cath lab. Existing hospital data was also analysed temporally based on when the PCI facility started operating. Data collection ran from February to June 2022. Facilities opening after data collection were not included.

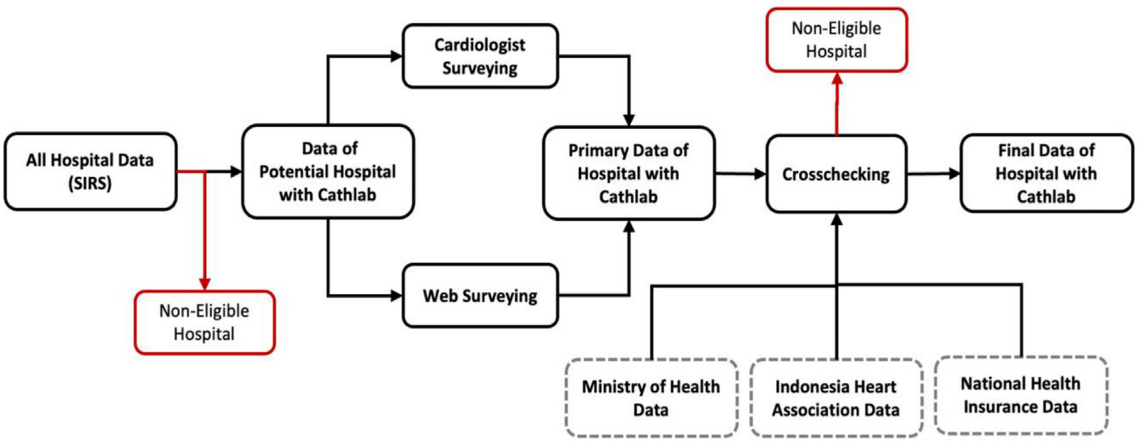

Fig. 1: **Data collection process related to catheterisation laboratories (Cath lab).**

Population and administrative data

The population data were obtained from the geospatial information system (GIS) data of the Ministry of Internal Affairs. The most recent population estimates were from June 30, 2022. GIS data contain both population and administrative data. Indonesia's administration level is divided into provinces, districts, and subdistricts. Province is the first administrative-level term, and Indonesia has 34 provinces. The second administrative level is the district, divided into urban (*Kota*) and rural (*Kabupaten*). Indonesia had 416 rural and 98 urban areas in 2022. In addition, we group the province data into five islands: Sumatra, Java, Kalimantan, Bali-Nusa, Sulawesi, and Maluku-Papua. The cath labs are also grouped into public and privately owned hospitals.

Cath lab ratio and Gini index

To measure and compare the cath lab maldistribution, we compared the ratio of the cath lab per population between areas and used the Gini index as an inequality measurement. The ratio was defined as the number of cath labs per one million population in a designated area. The Gini index is a widely recognised measure of economic and healthcare inequality. The Gini Index ranges from 0 to 1, with greater values indicating more significant levels of inequality. UNICEF defines the Gini index as <0.2 corresponds to ideal income equality, 0.2–0.3 corresponds to relative equality, 0.3–0.4 corresponds to a substantial income gap, 0.4–0.5 corresponds to a high-income disparity, and above 0.5 corresponds to severe income inequality. The Gini index was measured at the inter-province level.

The Lorenz curve plots the cumulative percentages of total income received against the cumulative number of recipients, starting with the poorest individual or household. The Gini coefficient is calculated using the area between the Lorenz curve and the line of perfect equality. The Gini index was calculated using R in RStudio's "dineq" package by René Schulenberg.[17,18] The Gini coefficient can be calculated using the formula:

$$G = 1 - \sum_{i=1}^{n} (Y_{i+1} + Y_i)(X_{i+1} - X_i)$$

Where Y_i and X_i are the cumulative proportions of total income and population, respectively.[19,20]

Inferential analysis

To determine possible variables that might have correlation or causation on the cath lab ratio, we conducted the correlation analysis as an initial step to determine the magnitude and direction of the relationship between the variables of interest. We use the prevalence of heart disease as a predictor of the demand aspect of the population; we controlled with the Gross Domestic Regional Product per Capita (GDRP) purchasing power parity (PPP) as the economic capacity factor supporting the demand. The study employs the prevalence of heart disease from the Indonesia Basic Health Survey 2018 as a substitute for the incidence rate to determine the need for cath lab procurement. The Heart disease definition included all types of heart disease diagnosed by a doctor. The better variable might be the incidence rate of ischemic heart disease. However, incidence data on the population were not available. The incidence data obtained from hospital records in low-income and middle-income countries (LMICs) may not accurately represent the disease burden as it might be under-reporting due to the patient barrier to the hospital.[21] GDRP data were taken from the National Statistic Agency in 2022.

Afterward, we performed multivariate linear regression analysis to ascertain the impact of different predictors on the cath lab ratio. Two models were created: one model utilised 'natural coefficients', and the other utilised 'standardized coefficients'. Standardization was accomplished by converting the variables into z-scores, representing the number of SDs away from the mean of a particular value. This process involved subtracting the mean and dividing by the SD for each independent variable. This approach enables us to discern which predictors have the most substantial relative impact on the cath lab ratio, irrespective of the units of measurement, thus providing a clearer understanding of the predictors' importance in the model.[22] The models are shown below:

$$Cath\ lab\ Ratio = \beta 0 + \beta 1 \times Prevalence\ Rate + \beta 2 \times Cath\ GDRP\ PPP + \in$$

Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and was final responsible for the decision to submit it for publication.

Results

Cardiologist and cath lab distribution

Java boasts the highest number of cardiologists and cath labs in Indonesia, with 981 cardiologists and 208 cath labs. While the regions with the least resources are Maluku, which has only six cardiologists and two cath labs, and Papua, which has four cardiologists and one cath lab (Table 1).

Table 1 shows the number of cardiologists by province. DKI Jakarta has the highest number of cardiologists, with 327, followed by East Java with 229 and West Java with 209. The lowest number is in the provinces of West Papua and North Maluku, with two cardiologists each, followed by Central Sulawesi with three and Maluku with four. The highest density of cardiologists in Indonesia's islands is found in Bali, with 12.1 cardiologist per million, followed by Java Island with 6.47 and Sulawesi with 5.43. According to the density of cardiologists, DKI Jakarta has the most with 29.2, followed by West Sulawesi with 18.7 and DI Jogjakarta with 13.1. Central Sulawesi has one cardiologist, Papua has 0.9, and NTT has 0.6 for the lowest density.

Regarding cath labs, Java, Bali, and Sumatra have the greatest densities of 1.37, 1.17, and 0.96, respectively. The province with the highest cath lab density is DKI Jakarta, with 4.46 cath labs per million, North Kalimantan came in second with 2.93, and The Riau Island came in third with 1.99. The lowest values were recorded in East Lesser Sunda (0.19 cath lab per million), Papua (0.23), West Papua (0), and North Maluku (0).

Cath lab growth

The number of cath labs in Indonesia increased significantly from 2017 to 2022. Within six years, 129 new cath lab facilities were added. Increasing the total cath labs from 181 to 310 further contributed to 71.3% of the total cath lab growth. The owner distribution of the cath lab is still dominated by private hospitals, which own 54% of the facilities. 62 private hospitals have had new cath labs in the last six years, whereas public hospitals added 67 (Table 2). The distribution of the cath lab location are shown in Fig. 2.

In 2018 and 2019, the growth rate was up to 33 cath labs per year. When the COVID-19 pandemic occurred, the cath lab growth in Indonesia decreased, dropping to 19 cath labs in 2020 and 21 in 2021. However, we saw an upward trend in 2022 with 16 new cath labs opening in first half of the year. Java Island still dominates cath lab growth, contributing 81 new facilities (62.3% of the total cath labs). Java was followed by Sumatra with 26 new cath labs (20%), Kalimantan with 10 (7.7%), and Sulawesi with nine (6.9%). There have been no new cath labs in Papua, Bali, and Nusa in the past six years (Table 2).

Table 3 shows that within five years, there were 44 new cath labs in districts that previously had no cath lab at all. That is, one-third of the new cath labs were built in districts that did not have one. This increased the districts covered by cath labs from 83 to 113 (21.9% of the total districts). Public-owned hospitals made up the majority of new cath labs in these areas, with 31 of the 44. Most of the new cath labs in new districts were built in 2018. After that, the number of cath lab additions in new areas decreased (Fig. 3).

Gini index of cath lab distribution

The density of cath labs in Indonesia ranges from 0.0 in West Papua and Maluku to 4.46 in Jakarta; the median is 1.09 (IQR 0.71–1.18) (Fig. 4). The wide range of densities shows area disparities. The wide range of ratios with the Gini index (Fig. 5). Our analysis shows that the Gini index in 2022 was 0.48. Gini index decreased compared to 2017 (0.54 to 0.48), indicating a more equal distribution in the latter year. However, this 0.06 point decrease in Gini index is less synchronized with an increase of up to 72.7% in the number of cath lab.

Impact of heart disease prevalence and regional GDP on cath lab ratio

The Spearman's rho was performed because the cath lab was not normally distributed. Correlation analysis revealed a strong positive association between the prevalence rate of the population with heart disease and the cath lab ratio, with a correlation coefficient (ρ) of 0.59, which is statistically significant ($P < 0.0001$). Correlation with GDRP has shown a higher statistically significant coefficient (0.73, $P < 0.0001$). As shown in the scatter plot (Fig. 6), some areas might be outliers, such as DKI Jakarta and North Kalimantan, with a higher cath lab ratio than the expected prevalence of heart disease; otherwise, central Sulawesi has a lower cath lab ratio than expected prevalence and GDRP.

Island and province	Population	Number		Ratio		
		Cardiologist	Cath labs	Cardiologist[a]	Cath labs[a]	Prevalence of heart disease (%)
National	269,648,234	1446	310	5.36	1.15	1.5
Lesser Sunda	10,713,122	18	4	1.68	0.37	
West Nusa Tenggara	5,308,887	15	3	2.8	0.57	0.9
East Nusa Tenggara	5,404,235	3	1	0.6	0.19	0.7
Bali	4,285,815	52	5	12.1	1.17	1.3
Java	151,629,504	981	208	6.47	1.37	
DKI Jakarta	11,207,822	327	50	29.2	4.46	1.9
Di Yogyakarta	3,671,818	48	7	13.1	1.91	2
Central Java	36,947,166	111	27	3	0.73	1.6
West Java	47,161,961	209	53	4.4	1.12	1.6
East Java	41,002,289	229	49	5.6	1.2	1.5
Banten	11,638,448	57	22	4.9	1.89	1.4
Kalimantan	16,641,765	60	16	3.61	0.96	
North Kalimantan	681,766	2	2	2.9	2.93	2.2
East Kalimantan	3,770,038	24	6	6.4	1.59	1.9
West Kalimantan	5,475,380	17	2	3.1	0.37	1.3
South Kalimantan	4,078,949	12	3	2.9	0.74	1.3
Central Kalimantan	2,635,632	5	3	1.9	1.14	1.3
Maluku	3,167,532	6	2	1.89	0.63	1.5
Maluku	1,870,414	4	2	2.1	1.07	1.5
Maluku Utara	1,297,118	2	0	1.5	0	1.1
Papua	5,419,011	6	1	1.11	0.18	
Papua	4,272,391	4	1	0.9	0.23	0.9
West Papua	1,146,620	2	0	1.7	0	1.2
Sulawesi	19,715,820	107	18	5.43	0.91	
Gorontalo	1,193,241	5	1	4.2	0.84	2
Central Sulawesi	3,012,499	3	1	1	0.33	1.9
North Sulawesi	2,657,940	26	4	9.8	1.5	1.8
South Sulawesi	8,933,926	41	10	4.6	1.12	1.5
West Sulawesi	1,447,712	27	1	18.7	0.69	1.5
Southeast Sulawesi	2,470,502	5	1	2	0.4	1.4
Sumatra	58,075,665	216	56	3.72	0.96	
Riau Island	2,012,496	7	4	3.5	1.99	1.5
Lampung	9,087,213	13	6	1.4	0.66	1.2
Riau	6,015,023	16	7	2.7	1.16	1.1
West Sumatra	5,448,684	41	5	7.5	0.92	1.6
Jambi	3,534,933	12	2	3.4	0.57	0.9
Bengkulu	2,019,339	5	1	2.5	0.5	1.3
Aceh	5,301,202	21	6	4	1.13	1.6
South Sumatra	8,281,587	11	7	1.3	0.85	1.2
North Sumatra	14,938,770	82	16	5.5	1.07	1.3
Bangka Belitung Island	1,436,418	8	2	5.6	1.39	1.5

[a]Ratio per 1,000,0000 population.

Table 1: **The distribution of Indonesian catheterisation laboratories (cath labs) and cardiologists within major islands and provinces.**

The regression analyses were conducted to understand the effect of the prevalence of heart disease and GDRP (PPP) per capita on the Cath lab ratio and controlling both variables to confirm whether independent confounds each other or independently (Table 4). Model 1 yielded an adjusted R-squared of 0.664, explaining approximately 66.4% of the variability in the Cath lab Ratio. Within this model, both Prevalence and GDRP were found to be significantly associated with lab Ratio with $P = 0.003$ and $P < 0.0001$, respectively. Both variables are independently affecting the Cath lab ratio. Standardization furthered this investigation to compare

Island group or region	Cath lab number in the end of the year (+growth in that year)						Percentage[a]
	≤2017	2018	2019	2020	2021	Half 2022	
All cath lab number (Growth)	181	221 (+40)	254 (+33)	273 (+19)	294 (+21)	310 (+16)	71.27%
National insurance-covered	87	108 (+21)	120 (+12)	129 (+9)	135 (+6)	139 (+4)	59.77%
Sector							
Public-owned	80	99 (+19)	115 (+16)	125 (+10)	134 (+9)	142 (+8)	77.5%
Private-owned	101	122 (+21)	139 (+17)	148 (+9)	160 (+12)	168 (+8)	66.34%
Island group							
Bali Nusa	8	8	8	8	8	9 (+1)	12.5%
Java	127	159 (+32)	178 (+19)	188 (+10)	201 (+13)	208 (+7)	63.78%
Kalimantan	6	7 (+1)	11 (+4)	14 (+3)	15 (+1)	16 (+1)	166.67%
Maluku	1	1	1	1	2 (+1)	2	100%
Papua	1	1	1	1	1	1	0%
Sulawesi	9	10 (+1)	13 (+3)	14 (+1)	14	18 (+4)	100%
Sumatra	30	36 (+6)	43 (+7)	47 (+4)	53 (+6)	56 (+3)	86.67%

[a]The percentages shown above depict the increased growth in the quantity of cath labs from 2017 to halfway of 2022.

Table 2: **Indonesia hospital with catheterisation laboratory (cath lab) growth from 2017 to 2022.**

the impact of independent variables. When comparing GDRP to prevalence, GDRP is shown to have a higher standardization coefficient (0.63 vs. 0.34) and low P-value (<0.0001 vs 0.003).

The post-diagnostic showed heteroskedasticity in model 1 (Breusch–Pagan test P value > 0.05). As shown in the correlation plot, both Jakarta and North Kalimantan have been shown as outliers. The explanation

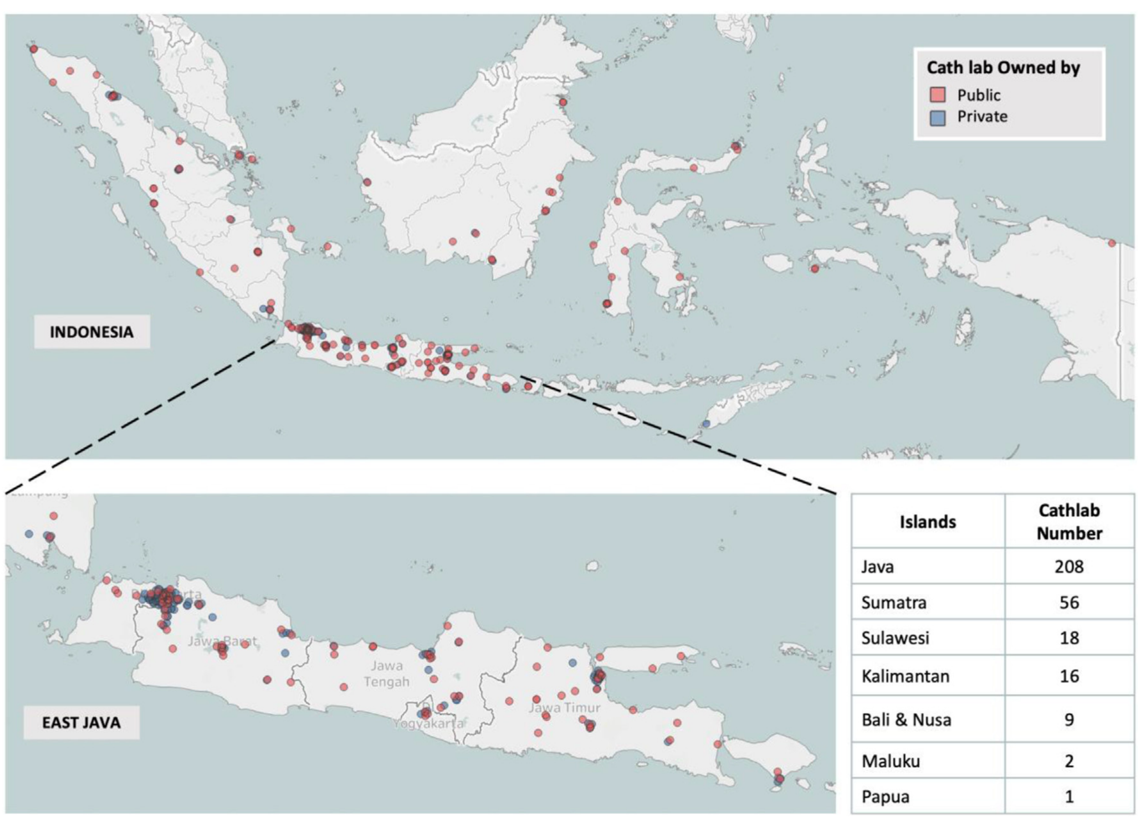

Fig. 2: **The map of catheterisation laboratory (cath labs) distribution in Indonesia, the red dot represents cath lab owned by public hospitals, and blue by private hospitals.** The table in lower right shows the distribution between the major islands in Indonesia.

Hospital sector	Additional cath lab per year					Cumulative addition
	2018	2019	2020	2021	2022	
Public	+9	+7	+5	+4	+6	31
Private	+5	+1	+3	+2	+2	13
Total	+14	+8	+8	+6	+8	44
Cumulative District-covered[a]	83	91	99	105	113	

[a]District-covered refers to the number of districts in Indonesia with at least one hospital with cath lab (among total of 514 districts in the whole country).

Table 3: **Expansion of catheterisation laboratory facilities (cath labs) in previously unserved districts.**

for this outlier is that Jakarta is the capital province of Indonesia. North Kalimantan is a newly expanded province with the smallest population. Areas with very high-density populations concentrated in one place characterise these two provinces. We performed model 2, where both provinces were excluded; model 2 showed higher adjusted R-squared (0.678) and removed heteroscedasticity. In model 2, the P-value of the heart disease prevalence coefficient was changed to borderline (0.07).

Discussion

Acute coronary syndrome in LMICs

According to the Global Burden Disease Study 2019, ischemic heart disease cases have been increasing in almost all provinces, with up to 66% increase in prevalence number and 36.5% in prevalence rate over twenty years.[23,24] The number will continue to rise as the Indonesian population ages. In the next ten years, one-third of the population will be aged over 45, resulting in a higher prevalence of ACS.[25] In LMICs, ST-elevation myocardial infarction (STEMI) is one of the most prevalent presentations of ACS. Over 60% of hospitalisations for ACS are due to STEMI in India, and 80% in China.[26–29]

ACS, particularly STEMI, requires prompt intervention and coordination of systems. Creating efficient systems in resource-constrained contexts is challenging. Successful solutions from more developed countries cannot simply be transferred. The challenges include a lack of accessible PCI facilities in urban areas, a shortage of specialists, and inadequate emergency medical services. These structural issues hinder timely and effective care for ACS patients. Indonesia is lagging in this respect, and cath lab utilisation is suboptimal. Often, the 24-h service is unavailable, and providers do not respond quickly to cardiac emergencies. Most LMICs in the WHO Southeast Asian Region, especially Indonesia, only provide 24-h rescue or primary PCI at the tertiary or national level.[16,25]

A study in Jakarta, the capital of Indonesia, found that between 2007 and 2013, PCI procedures increased from 24% to 35%, and non-reperfusion patients decreased from 67.1% to 62.8%. Maintaining the expansion of PCI procedures is important as the overall STEMI mortality rate has decreased from 11.7% to 7.5%. Increased cath lab utilisation indicates progress. However, the problems in other regions of Indonesia are unquestionably worse than in the capital. Especially in regions with no cath labs or where their number and accessibility are limited.[30,31]

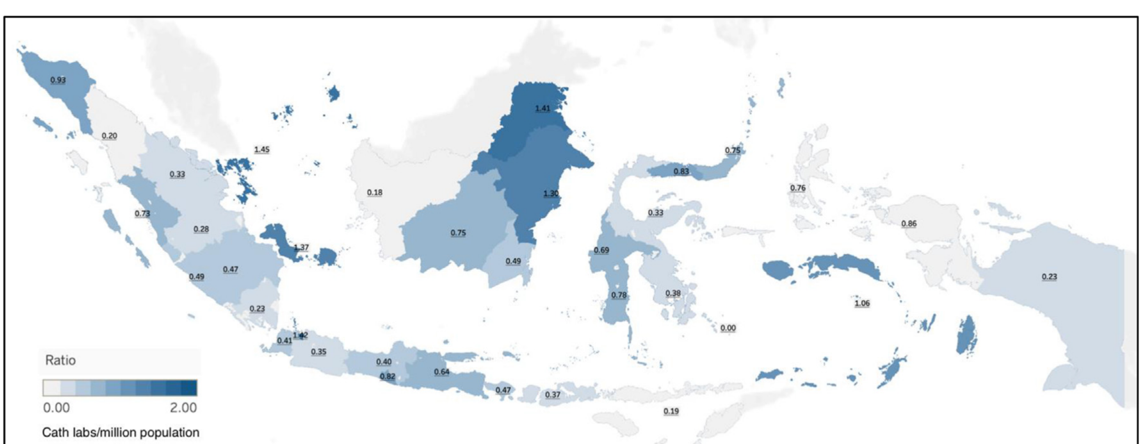

Fig. 3: **The density map of catheterisation laboratories (cath labs) per population in Indonesia in 2022.**

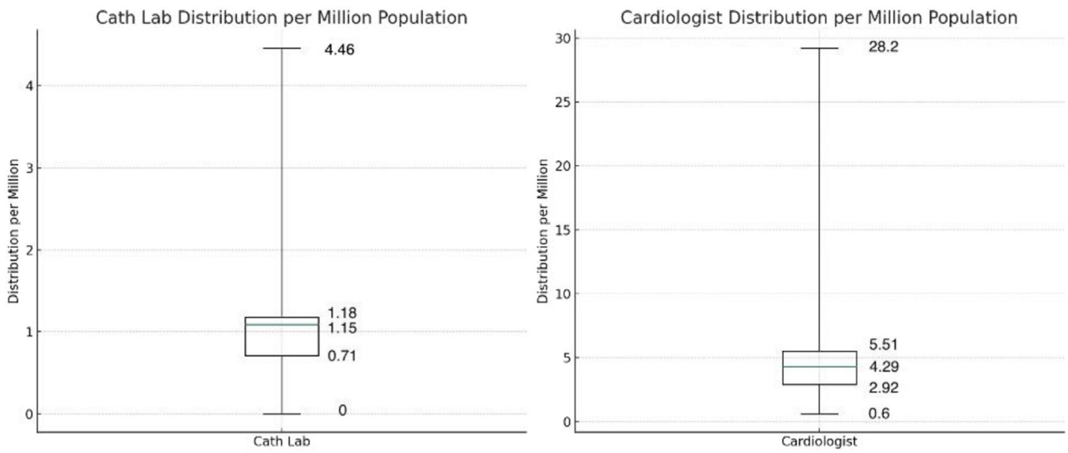

Fig. 4: **Boxplot of catheterisation laboratory (cath lab) and cardiologist ratio distribution among all provinces in Indonesia**.

Number and growth of cath labs in Indonesia

In the last five years, the number of cath labs in Indonesia has increased by up to 40% (129 new cath labs). This impressive progress will help prepare for the population shift expected in the next ten years. Our study found that the pandemic slowed cath lab growth by up to 50% in 2020 and 2021. This is understandable as the fiscal might focus on the pandemic. However, the Ministry of Health must compensate by accelerate cath lab growth over the next decade to meet demand. Java Island has 81 new cath labs, two-thirds of the total. Sumatra Island has 26. Papua Island has one cath lab and has not had a new one in five years. According to "The Inverse Care Law," good medical or social care availability varies inversely with population requirements. The province of West Java, with 53, has the most cath labs in Indonesia, but this is only 1.12 cath labs per million population. The European Association of Percutaneous Cardiovascular Interventions (EAPCI) suggests that there should be one catheterisation laboratory for every 450,000 to 600,000 individuals, or alternatively, 1.67 to 2 cath laboratories for everyone million people. The cath lab ratio in Indonesia increased from 0.68 to 1.14 per million people.[32] However, with a population of 272 million, Indonesia requires a minimum of 450 cath labs to satisfy the recommended standards.[33]

The other concern is 24-h cath lab services, which remain low in Indonesia. We could not extract the data of facilities which provide uninterrupted service (perform

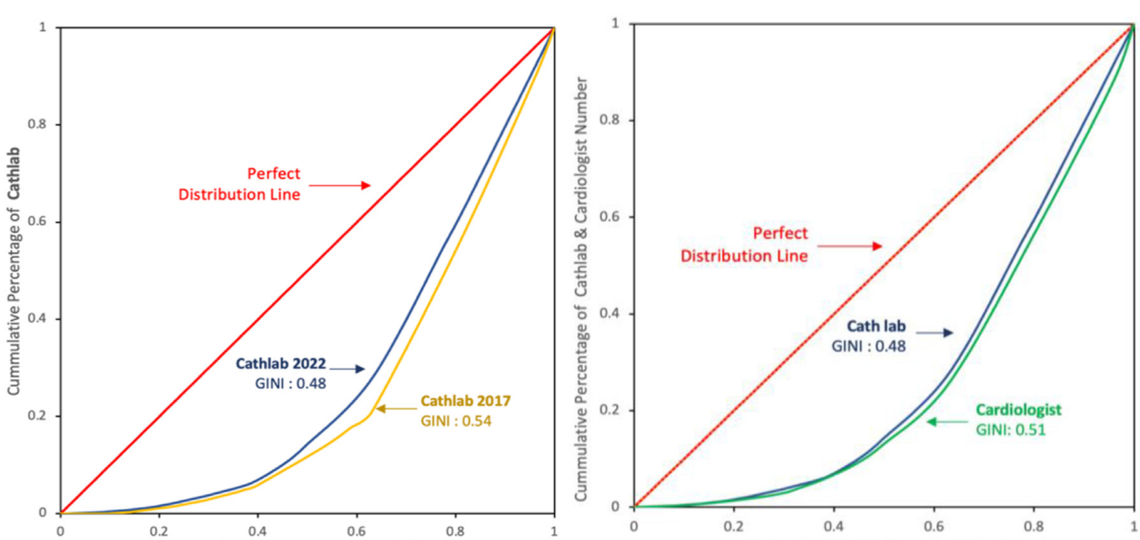

Fig. 5: **The Lorenz Curve and Gini index of the catheterisation laboratory (cath lab) and cardiologist distribution**.

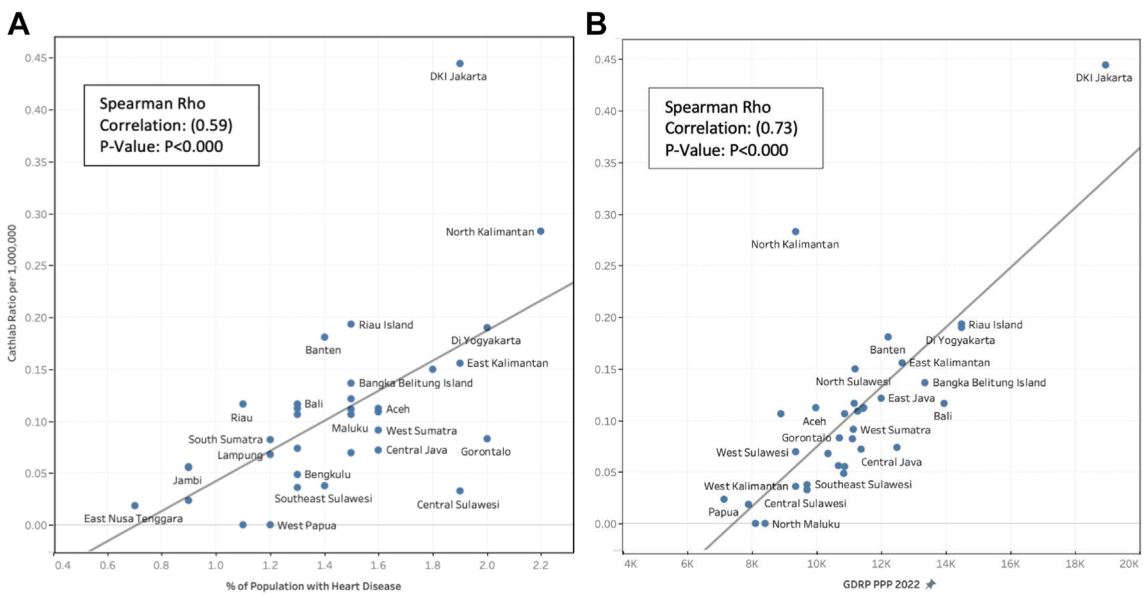

Fig. 6: **The scatterplot of the catheterisation laboratory (cath lab) ratio to the percentage of population with heart disease (panel a) and GDRP per Capita 2022 (panel b)**.

PCI 24 × 7). Previous study from EAPCI showed capacities of different countries on 24-h service catheterisation laboratories, with the lowest rate on their report was Egypt (0.2 per million), and the highest rate in Poland and Belgium (>4 per million). Only a few hospitals in Egypt had cath labs that offer 24-h cardiac emergency care, which further affected the low rates of primary PCI and structural cardiac interventions in Egypt.[33] In 2014, Jakarta had only one national referral hospital that provided 24-h service for primary PCI covered by national health insurance. The data of hospitals that can handle PCI around the clock and the data of hospitals that are covered by national health insurance systems is limited despite the important factors of showing effective coverage both in timeliness and effective coverage when developing the STEMI network.[18,34]

In the aspect of cath lab owner, both public and private hospitals have expanded their numbers and distribution of cath labs. Private hospitals slightly dominated, owning 54% of the cath labs. However, public hospitals are leaders in the procurement process in the new district that previously did not have a cath lab. Among the 44 districts which got covered by a new cath lab in 2022, public hospitals provide service to 31 districts. Private

Independent variable	Cath lab ratio (dependent variable)			
	Model 1 (n = 34)		Model 2 (n = 32)	
	Natural Coefficient (P-value)	Standardized Coefficient (P-value)	Natural Coefficient (P-value)	Standardized Coefficient (P-value)
Percentage of population with heart disease (prevalence) 2018	8.36E-02 (0.00389) **	0.34 (0.00389) **	3.426e-02 (0.0726)	0.21 (0.0726)
Gross Domestic Regional Product (PPP) per capita 2022	2.37E-05 (3.04e-06) ***	0.63 (3.04e-06) ***	2.082e-05 (6.06e-07) ***	0.72 (6.06e-07) ***
Constant	−2.77E-01 (1.98e-06) ***	−7.39E-17 (1.00)	−1.850e-01 (7.33e-06) ***	−5.666e-16 (1.00)
Multiple R-squared	0.6843		0.6989	
Adjusted R-squared:	0.664		0.6782	
F-statistic:	33.6 on 2 and 31 DF		33.66 on 2 and 29 DF	
P-value:	<0.0001		<0.0001	
Residual standard error	0.049 on 31 DF	0.5797 on 31 DF	0.02954 on 29 DF	0.5673 on 29 DF
Shapiro–Wilk normality test	0.92697 (0.0287) *		0.98146 (0.8407)	
Breusch–Pagan test	11.79 (0.002753) **		0.95432 (0.6205)	

Statistical significance codes (P-value): '***' <0.001; '**' <0.01; '*' <0.05. DF: degrees of freedom.

Table 4: **Impact of heart disease prevalence and regional GDP on catheterisation laboratory (cath lab) ratio.**

hospitals have been shown to provide complementary services to districts that have established cath labs before. Construction of new cath labs is important as it will expand the coverage to a greater extent.

Effect of disease demand and economic capacity on cath lab distribution

This study investigated the correlation between the occurrence of heart disease, the per capita regional GDP (GDRP PPP), and the proportion of Cath labs in different regions. The results indicate that areas with a greater incidence of heart disease typically have a higher proportion of cath labs, which is consistent with the logical assumption that healthcare resources, like cath labs, are distributed based on the healthcare requirements of the population. Additional regression models examination further confirmed the influence of both the prevalence of heart disease and the regional GDP per capita on the cath lab ratio. This study confirms the complex nature of healthcare resource allocation, which is influenced both by health needs and economic capacity.[35–37]

The higher standardization coefficient for GDRP, compared to the prevalence of heart disease, indicates that economic factors may have a more significant influence than health needs in determining the allocation of Cath labs.[6,37] It highlights crucial factors to be considered in healthcare policy and planning, underscoring the importance of balancing economic capacity and health requirements to achieve fair distribution of healthcare resources.

Notably, the study identified anomalies such as DKI Jakarta and North Kalimantan, which diverge from the anticipated distribution of Cath labs based on the prevalence of heart disease. These regions, distinguished by distinct demographic and administrative characteristics, indicate that factors other than the prevalence of diseases can impact the allocation of healthcare resources. Further studies are required to explain the outliers that might have other factors affecting cath lab procurement such as easier market entry for private sector to procure cath lab or insurance coverage to DKI Jakarta and North Kalimantan.[38,39]

Our study has few limitations. The analysis is based solely on the presence of cath lab infrastructure without assessing their operational capacity or service provision. Some facilities, especially tertiary and referral hospitals, may have more than one cath lab. Information on the cath labs in every hospital was unavailable publicly. Considering this limitation, we counted the number of hospitals with a cath lab. Patient-level outcomes could not be explored due to data limitations. Furthermore, the reliance on prevalence data rather than incidence rates may not accurately capture the immediate demand for PCI procedures, especially in LMICs where barriers such as limited education may lead to underutilisation of hospital services. These aspects highlight the need for cautious interpretation of the results and suggest areas for more in-depth investigation in future research.

The increase in Indonesia's ACS mortality rate underscores the need for additional cath labs. Poland is an interesting example of how its STEMI patient treatment capacity was enhanced a decade ago, leading to more competent patient outcomes compared to other European countries with similar economic positions.[33] Research conducted by EAPCI indicates no correlation between the number of catheterisation laboratories and economic conditions. Greece, despite having a smaller economy compared to Denmark, possesses a greater number of cath labs. The responsibility for increasing the number of cath labs lies primarily with the government, which acts as a regulatory body overseeing policy and decision-making in the procurement process.[15,19]

Indonesia should consistently monitor and record the locations of hospitals equipped with catheterisation laboratories by utilising a dashboard system. Geospatial analysis conducted in Russia demonstrates positive outcomes by showing the proportion of the population with prompt access to cath labs and identifying regions that still lack such facilities. Indonesia requires an accurate mapping of the proportion of the population that can access existing thrombolytic or PCI treatment within less than 2 h. This information would be highly valuable for procurement planning purposes.[6,40–42]

The ultimate objective of cath lab procurement is to enhance patient outcomes. It is imperative to closely monitor the factors that impact the operational efficiency of cath labs in each hospital.[43] Improved data on cath lab capacity in local regions is necessary for enhancing regulatory policy in the cath lab field.[44] It is important to analyse the healthcare expenses related to cath labs for the regulator to assess the utilisation of cath labs in the population. Care should be regionalised to enhance the interconnectivity of cath labs in areas with limited coverage.[6] Further research might provide information on how existing cath labs cover the population and how future cath lab procurement increases the coverage, service utilisation, and health outcomes.

Indonesian ACS treatment is susceptible to its low cath lab density. There is also significant maldistribution, accumulating at several loci. Increasing the number and distribution of cath labs with strategic placement is needed to increase the capacity of emergency cardiovascular services in Indonesia.

Contributors

FRM: Project Leader, Conceptualisation, Data Curation, Formal Analysis, Methodology, Software, Validation, Funding Acquisition, Visualisation, Writing–original draft; CECZM, WSR: Data Curation, Formal Analysis, Methodology, Visualisation, Writing–original draft; AA: Supervisor, Resource, Data Curation, Data Validation, Funding, Acquisition, Investigation, Writing–Review & Editing; SAS: Investigation, Methodology, Data Curation, Formal Analysis, Visualisation, Project Administration, Writing–original draft; ID, HA, DF, MMM, RP, DA: Supervisor, Data Curation, Data Validation, Investigation, Validation, Writing–Review & Editing.

Data sharing statement
Data related to the study can be procured by sending a request email to the corresponding author.

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