A geospatial study of the coverage of catheterization laboratory facilities (cath labs) and the travel time required to reach them in East Java, Indonesia

by Achmad Chusnu Romdhoni

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Andrianto Andrianto,[1] Farizal Rizky Muharram,[1] Chaq El Chaq Zamzam Multazam,[1] Wigaviola Socha,[1] Doni Firman,[2] Ahmad Chusnu Romdhoni,[1] Senitza Anisa Salsabilla[3]

[1]Faculty of Medicine Universitas Airlangga, Surabaya, East Java; [2]Department of Cardiology and Vascular Medicine, Faculty of Medicine, University of Indonesia, National Cardiovascular Centre Harapan Kita, West Jakarta; [3]Faculty of Dental Medicine, Universitas Airlangga, Surabaya Indonesia

Abstract

Coronary heart disease is a non-communicable disease whose treatment is closely related to infrastructure, such as diagnostic imaging equipment visualizing arteries and chambers of the heart (cath lab) and infrastructure that supports access to healthcare. This research is intended as a preliminary geospatial study to carry out initial measurements of health facility coverage at the regional level, survey available supporting data and provide input on problems in future research. Data on cath lab presence was gathered through direct survey, while population data was taken from an open-source geospatial system. The cath lab service coverage was obtained by analysis based on a Geographical Information System (GIS) specific tool to evaluate travel time from the sub-district centre to the nearest cath lab facility. The number of cath labs in East Java has increased from 16 to 33 in the last six years and the 1-hour access time increased from 24.2% to 53.8%. However, accessibility remains a problem as16.5% of the total population of East Java cannot access a cath lab even within 2 hours. Thus, additional cath lab facilities are required to provide ideal healthcare coverage. Geospatial analysis is the tool to determine the optimal cath lab distribution.

Correspondence: Andrianto Andrianto, Faculty of Medicine Universitas Airlangga, Surabaya Indonesia Jl. Mayjen. Prof. Dr. Moestopo No. 47 Surabaya, East Java, 60132 Indonesia.
Tel.: +62.85334403303.
E-mail: andrianto@fk.unair.ac.id

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Introduction

The burden of Cardiovascular Disease (CVD) has been increasing, especially in developing countries, Indonesia. According to Indonesia Basic Health Research data provided by the Agency of Health Research and Development, almost all the provinces in Indonesia showed a growing prevalence of Ischemic Heart Disease (IHD), which has increased by 87%in the last ten years. In 2018, about 1.5% of the population in East Java (around 570,000 people), suffered from this medical disorder. Based on disability-adjusted life years (DALY), a statistical method to measure the overall disease burden, IHD is the leading cause of disability and years of life lost globally, moving from the fourth position in 1990 to the first in 2017 (Aminorroaya *et al.*, 2021). Consequently, IHD has become a severe challenge in Indonesia.

East Java is the province with the second largest population in Indonesia, with a total population of 46 million people in 2020 and the population aged >45 years in 2020 amounted to 34% of the total population (Results of the 2020 Population Census, 2021), a growth predicted to continuously increase until 2035 to then reach 39% of the total population. The increase in the population number will impact the prevalence of patients with degenerative diseases, especially CVD. The incidence of IHD generally starts to increase from the fourth decade of life reflecting the role of age as a risk factor. Due to the high proportion at cardiovascular riskin the Indonesian population that will further rise sharply, the management of IHD emerges as an essential issue (Baumgartner *et al.*, 2017; Timmis *et al.*, 2020).

Acute Coronary Syndrome (ACS), commonly known as a heart attack, is the most lethal form of IHD. Primary Percutaneous Coronary Intervention (PCI) remains the gold standard in the reperfusion management, but this procedure must be performed within 2 hours to improve a patient's survival. Therefore, accessibility to the healthcare facility is essential to optimize the treatment and consequently save a patient's life. Furthermore, the man-

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agement of ACS significantly depends on the infrastructure, particularly a catheterization laboratory (cath lab), *i.e.*, an examination room in a hospital or clinic with diagnostic imaging equipment that can be used to visualize the arteries of the heart and its chambers and treat any abnormality found. While the presence of a cath lab is a necessity for the PCI procedure, is of limited value without supporting infrastructure, such as roads, ambulances, and referral systems (Gabb & Arnolda, 2017; Timonin *et al.*, 2018).

Geospatial analysis shows differences in locations and distances on a map and can be used to provide a broader view of geographic issues, such as the distribution of health facilities and travel time from the patient's location to a suitable facility. Hence, it is a powerful tool for estimating the healthcare facility's coverage to meet the population needs. Studies in the United States, Australia and Russia have reported on the geospatial coverage of cath lab facilities for ACS disease. Since there is only rudimentary information on cath lab locations in Indonesia, this research is intended as a preliminary study to survey the health facility coverage at the regional level, and to provide information on possible problems encountered. We discuss two main aspects, on the one hand the ratio between the number of cath lab facilities and the population in a particular area, and the duration of time required to travel to the nearest cath lab on the other.

Materials and Methods

We chose the province of East Java as the basis for our initial study because of its geographical proximity, large number of residents and diverse population density. The population of East Java is scattered and concentrated in metropolitan, urban, suburban, rural areas as well as located on different islands. Our analysis was carried out in three stages: data collection, data analysis and data visualization to map cath lab coverage in Indonesia.

Data collection

Four primary data are needed to produce this research: i) data on cath lab facilities and geocoding; ii) data on regional boundaries at the sub-district level in East Java locations; iii) population data at the sub-district level; and iv) data on highway connections in East Java.

Cath lab geocoding data

We discovered that Indonesia does not yet have an open public data system that shows the availability of existing cath labs; thus, the data had to be collected through a primary survey of hospitals that potentially have cath labs based on the criteria of being accredited as a referral hospital and having at least one cardiologist. Then the survey results are compared to data owned by the Surabaya and Malang branches of the Indonesian Heart Association.

Regional boundary data

The second type of data concerned the regional sub-district boundaries (level 2). The data are available in GADM, a high-resolution database of country administrative areas (https://gadm.org/), and the Indonesian Ministry of Home Affairs. These are open-source data that can be fully accessed and updated regularly. We used the latest data available on the Ministry of Home Affairs GIS website when we conducted this research. While collecting the data on the boundaries of the East Java region from the Ministry of Home Affairs dataset in December 2021, we discovered that East Java has 666 sub-districts spread across 34 districts and cities. The last update was done in December 2021. At each sub-district boundary, data transformation was carried out changing area data to point data that was selected as the midpoint within each boundary region. Point data was used to represent the distance between the mid-point of the sub-district to the nearest cath lab facility.

East Java population data

Data on the population development from 2015 to 2035 were gathered through the Indonesia Central Agency on Statistics. Table 1 displays the development of population numbers in East Java between 2015 and 2020 and the prediction of population until 2035. Overall, population in East Java has been increasing significantly in the past five years, e.g., the number of 45-year-olds increased from 12 million to 13.7 million or about 15% and those estimated to be at high risk of developing ACS is predicted to increase to 17.5 million (42% total population) in the next 15 years.

Road network data

We used the road access data available in the ArcGIS Pro (Redlands, CA, USA) subscription for our geospatial analysis. The highway access data were divided into various types of highways based on the capacity and average speed used.

Data analysis

To determine the travel time and cath lab service coverage, the analysis was carried out using the 'closest facility network tool' in ArcGIS Pro. The travel time in this study was estimated by calculating the time required from the midpoint (representing the average residence) of a sub-district to the nearest cath lab facility based on the available network. Figure 1 illustrates how this is done. We measured the speed of travel time by considering the type of road in the network data.

The results of each sub-district analysis were then aggregated at the district level. Subsequently, at the district level, we obtained the number of residents who can access the nearest cath lab facility and calculated their travel times expressed as the number of 30 min intervals. The percentage of travel times needed for each district was estimated by measuring the total population in each sub-district belonging to the district.

Data visualization

The analysis aimed at comparing the cath lab change between years as well as highlighting the location of cath labs in relation to the centre of the sub-districts. The travel time analysis was visualized in a choropleth map, which has the advantage of showing the data in two dimensions which visualize the presence of cath labs and thus contributes to finding areas needing, but lacking, a cath lab.

Table 1. Growth of East Java population.

Population	2015	2020	2025	2030	2035
Total (no. x 1,000)	38,784	39,955	40,866	41,401	41,830
Age (>45 years)	12,074	13,768	15,281	16,322	17,493
Part of the total population (%)	31	34	37	39	42
Increase from 2015 (%)	0	14	27	35	45

Results

Number of cath labs

The number of Cath labs in East Java has increased from 16 to 33 in the last seven years. Details of this growth are shown in Table 2. Public and private hospitals added 8 new cath labs each so the increases are balance. With a total of seven cath lab facilities, the most significant increase occurred in 2018. We also found that he pandemic in 2020-2021didnot inhibit the growth of the number of cath labs in East Java.

Figure 2 shows the population distribution in East Java, with each sub-district represented by blue dot, the size of which indicates the relative number of people. As can be seen in the figure, the population is evenly distributed over East Java with exception of urban areas, such as Surabaya and Malang where the population is more strongly concentrated. The figure also shows the location of cath labs represented by red dots. As is obvious from the map, the location of the cath labs was unevenly distributed in 2021. Surabaya has the highest number of cath labs, while Madura did not have any cath labs at all. With 3 million inhabitants Surabaya

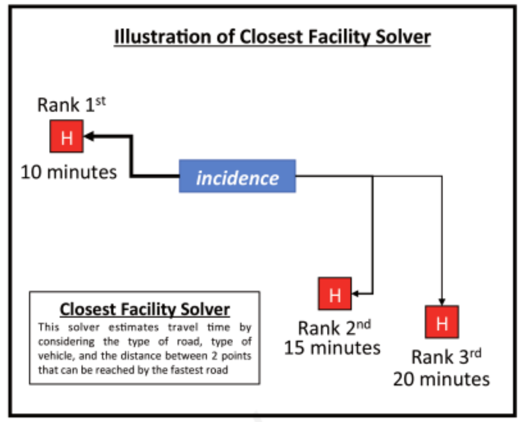

Figure 1. Finding the closest access to healthcare centres (H) in the study area.

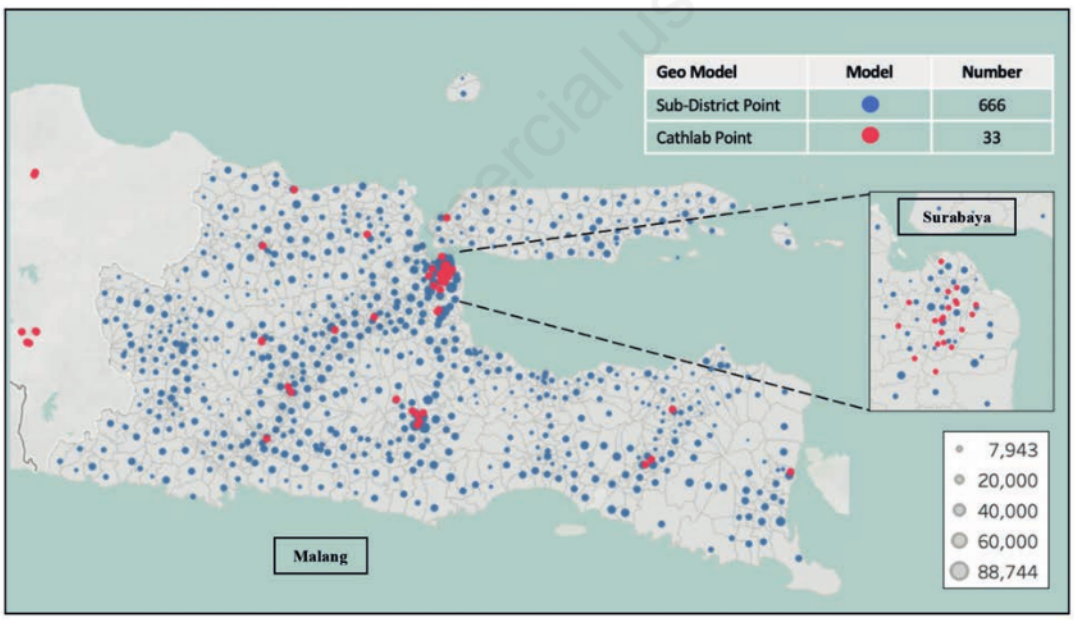

Figure 2. Sub-District and cath lab distribution in East Java.

Table 2. The number of cath labs in East Java 2015-2021.

Cat lab (no.)/Year	2015	2016	2017	2018	2019	2020	2021	Total
Total	16	18	21	26	27	29	33	33
New	-	+2	+3	+5	+1	+2	+4	17
Public	-	-	+3	+2	+1	+1	+2	9
Private	-	+2	-	+3	-	+1	+2	8

would need five cath labs but has in fact 12, a surplus may be due to the fact that Surabaya is the capital city of East Java. We also noted also some cath labs near the border but outside East Java. These three cath labs may also contribute to the coverage as some sub-districts in the western part of East Java are closer to them than their own cath labs.

Change in travel time coverage

The travel time to cath labs in East Java has decreased significantly in last six years. The travel time for the years 2025, 2019 and 2021 labs are shown in Table 3. In 2015, cities in East Java already had so many cath labs that 78% of the population were able to reach a cath lab within 30 minutes and 85% within 1 hour. Only 8% of the city population had travel times exceeding 2 hours. However, there were contrasts between urban, suburban and rural areas; only 7.7% could access a cath lab within 30 minutes and only 26% in less than 1 hour. Half the population in the districts could not access a cath lab within 2 hours. However, progressive changes occurred within the six years. Now, the number of people without access to a cath lab within 2 hours has decreased from 50.0% to 18.3%. Cath lab facilities growth has significantly reduced travel time in the districts. Access in cities has also changed but less than in other places. In general, East Java increased the percentage of those who could reach a cath lab in less than 1 hour from 33.1% in 2015 to 53.0% in 2021.

Cath lab coverage at the district level

The detailed data for every district is given in Table 4. We can see the districts of Malang, Kediri, Mojokerto and Surabaya can offer cath lab access within 30 min for almost their whole populations. Surabaya metropolitan areas (including Sidoarjo and Gresik) take advantage of a good road network and many cath lab facilities. In the centre of East Java, the Malang District acts the cath lab center for nearby districts, such as Batu and Kediri. Further south, Tulungagung District is the centre for the south coast of East Java.

Table 3. East Java cath lab travel time distribution.

Area by min	2015 (%)	2019 (%)	2021 (%)	Change
Kabupaten[a]				
0-30	7.7	18.2	22.5	+14.8
30-60	18.9	24.1	26.3	+7.4
60-120	22.9	34.6	32.9	+10.2
>120	50.7	23.0	18.3	-32.4
Kota[b]				
0-30	78.4	78.4	81.1	+2.6
30-60	7.2	9.3	6.7	-0.6
60-120	6.0	7.7	7.7	+1.8
>120	8.4	4.6	4.6	-3.9
East Java[c]				
0-30	16.8	26.0	30.0	+13.2
30-60	17.4	22.2	23.8	+6.4
60-120	20.6	31.1	29.7	+9.1
>120	45.3	20.7	16.5	-28.7

[a]District; [b]City; [c]Province.

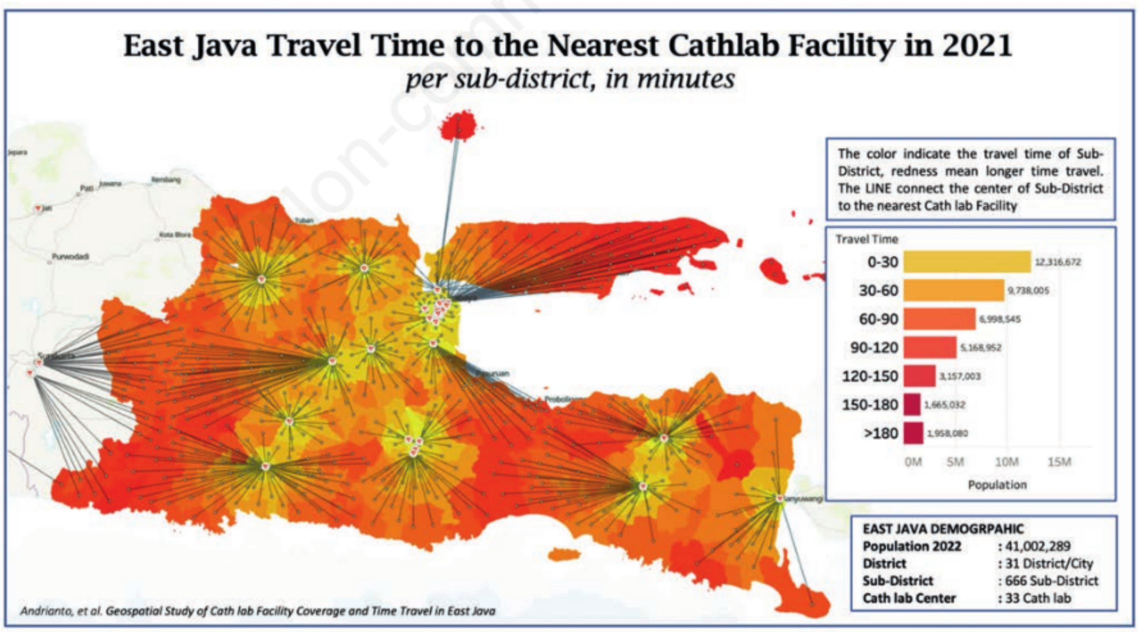

Figure 3. Choropleth map of East Java cath lab coverage. The colour gradation shows the difference of time needed to the nearest cath lab. The lines show the connection between each sub-district to the nearest cath lab location.

From the Table 4, we can see which areas cannot access cath labs and also have large populations that need to be covered, e.g., Ponorogo, Probolinggo, Sampang and Sumenep. There more than 50% of the population in the district cannot access a cath lab within 2 hours, and these districts have populations around one million.

Visualization of cath lab coverage

Visualisation of the cath lab coverage area is given in Figure 3. We can see the locations of the longest travel times to the nearest cath lab. Many people need over 2 hours to go to nearest cath lab. The area with huge portions of long travel times is the eastern part of Madura Island and the south-western part of East Java in a region, called Mataraman. The Choropleth approach visualize the areas that are in the highest need of better cath lab access.

Discussion

With a total population near 40 million people in 2021, East Java has the second largest population in Indonesia. In the next 15 years, the population will increase considerably and there will be a demographic shift to older ages. The number of those aged >45 years is already 12 million people, and it is projected that this number will be 17 million in 2035, a 45% increase. This figure accompanied by high smoking rates in the Indonesian population is of concern because these two factors will greatly increase the incidence of ACS. It is therefore necessary to make sure that adequate health facilities for handling ACS critical patients will be available.

A study previously conducted by European Association of PCI showed an inverse correlation between the number of cath lab

Table 4. Travel times to reach a cath lab in East Java.

Area	Travel time									
	0-60 min		60-120 min		120-180 min		180+ min		Total population	
	n	%	n	%	n	%	n	%	n	%
District										
Sidoarjo	1,941,485	100	-	-	-	-	-	-	1,941,485	100
Mojokerto	1,100,914	97	31,488	3	-	-	-	-	1,132,402	100
Tulungagung	1,091,553	97	-	-	32,452	2.9	-	-	1,124,005	100
Jombang	1,254,744	93	96,133	7	-	-	-	-	1,350,877	100
Kediri	1,522,824	91	149,208	9	-	-	-	-	1,672,032	100
Bondowoso	656,651	82	100,783	13	-	-	43,146	5	800,580	100
Gresik	1,038,018	81	162,247	13	-	-	82,418	6	1,282,683	100
Malang	1,907,872	74	679,526	26	-	-	-	-	2,587,398	100
Nganjuk	697,306	62	430,076	38	-	-	-	-	1,127,382	100
Bojonegoro	827,948	62	420,019	31	93,357	7.-	-	-	1,341,324	100
Jember	1,514,955	59	1,063,145	41	-	-	-	-	2,578,100	100
Banyuwangi	951,683	54	679,914	39	124,356	7.1	-	-	1,755,953	100
Lamongan	703,141	51	672,996	49	-	-	-	-	1,376,137	100
Pasuruan	681,764	43	833,990	52	81,452	5.1	-	-	1,597,206	100
Bangkalan	460,422	42	491,179	45	131,767	12.2	-	-	1,083,368	100
Trenggalek	276,667	37	340,415	45	135,510	18.-	-	-	752,592	100
Tuban	412,117	34	805,962	66	-	-	-	-	1,218,079	100
Situbondo	143,245	21	456,434	66	94,639	13.6	-	-	694,318	100
Blitar	229,556	18	932,438	75	85,038	6.8	-	-	1,247,032	100
Lumajang	-	-	690,624	62	429,278	38.3	-	-	1,119,902	100
Madiun	-	-	596,377	79	155,980	20.7	-	-	752,357	100
Magetan	-	-	459,746	67	228,932	33.2	-	-	688,678	100
Ngawi	-	-	859,015	94	53,525	5.9	-	-	912,540	100
Pacitan	-	-	-	-	364,990	61.2	231,118	39	596,108	100
Pamekasan	-	-	-	-	433,686	52.-	400,306	48	833,992	100
Ponorogo	-	-	96,104	1-	815,134	83.6	63,521	7	974,759	100
Probolinggo	-	-	481,561	42	666,641	58.1	-	-	1,148,202	100
Sampang	-	-	229,650	26	653,304	74.-	-	-	882,954	100
Sumenep	-	-	-	-	-	-	1,137,571	100	1,137,571	100
City										
Kota surabaya	2,971,377	100	-	-	-	-	-	-	2,971,377	100
Kota malang	866,547	100	-	-	-	-	-	-	866,547	100
Kota kediri	285,762	100	-	-	-	-	-	-	285,762	100
Kota batu	213,861	100	-	-	-	-	-	-	213,861	100
Kota mojokerto	139,773	100	-	-	-	-	-	-	139,773	100
Kota pasuruan	110,400	52	99,889	48	-	-	-	-	210,289	100
Kota blitar	54,092	34	104,349	66	-	-	-	-	158,441	100
Kota madiun	-	-	204,229	100	-	-	-	-	204,229	100
Kota probolinggo	-	-	-	-	241,994	10	-	-	241,994	100
Total	22,054,677	54	12,167,497	3	4,822,035	11.8	1,958,080	5	41,002,289	100

facilities and the number of deaths due to IHD. A lower number of cath labs in an area leads toa higher cardiovascular death rate in that area. The number of cath-labs must be sufficient to meet the need of the existing population. Therefore, the population volume in an area decides the number of cath labs needed. Egypt, with a cath lab ratio of 0.2 per million population, has a CVD death rate of 1,311 per 100,000 population, a remarkably high value when compared to France, where the CVD deaths is only 197 per 100,000 population with a total cath lab ratio of 3.1 per million population (Barbato *et al.*, 2020).

Based on the European Association of Percutaneous Cardiovascular Interventions (EAPCI), the ideal ratio is one cath lab per 600,000 inhabitants (Barbato *et al.*, 2020). Currently, there are 33 cath labs spread across cities and districts in East Java Province, which means that one cath lab serves 1.33 million people. With an expected 45 million population in 2035, as many as 80 cath labs are needed. In addition, we notice that several cath lab facilities are located close together in one city, *e.g.*, in Kota Surabaya and Kota Malang. This has resulted in an uneven distribution between cities and districts. This situation is caused by many factors and cost influences the rate of increase in the number of cath labs. We need to consider the volume ratio and distance factor in allocating the cath lab development in the future (Oliver & Mossialos, 2004). Moreover, not all cath-labs operate optimally, *e.g.*, some are closed due to the absence of interventionists. However, East Java has made satisfactory progress in increasing the number of cath-lab from 16 to 33 in the last six years, a positive change that augmented the percentage in the region from 26% to 48%. It is a good sign, but it will require an additional eight cath labs per year to reach the ideal conditions in 2030.

Both state and private hospitals have a vital role in increasing the number of cath lab facilities. In this study, we noted that both increased equally thereby playing an essential role in increasing the number of cath labs. In the last seven years, private and public hospitals contributed eight additional cath lab facilities. In Indonesia, the difference between Cath lab facilities in public and private hospitals is due to the insurance coverage. In contrast to the private sector, almost all cath labs operated by the public sector receive coverage from the National Health Insurance (BPJS). In further research, it is necessary to look at the coverage of BPJS as an insurance provider for Cath lab facilities in Indonesia.

Geospatial analysis research shows a significant increase in the number of people having access to the cath labs in East Java over the last six years. Currently, the majority of the population in East Java can access the Cath lab within the time limit of 2 hours, which is in accordance with the ACS guideline recommendations. In 2015 34.5% of people could access the cath lab within 1 hour. This number increased in 2021, with 46% of people accessing the Cath-lab in less than1 hour. However, more than 50% of the population in some districts with populations around one million, *e.g.*, Ponorogo, Probolinggo, Sampang and Sumenep, cannot access a cath lab within 2 hours. It should be a priority to provide cath labs for these districts.

Timewise the accessibility of the Cath lab in the city contrasts with that in the district areas as a whole, which means that city dwellers have much better cath lab accessibility than those elsewhere. Cities on the island of Madura represent an extreme example of inequality with respect to travel time, as the average travel time can be as long as 4 hours. However, this inequality has diminished compared to 2015. This is a good intervention by the government as it reduces the equity imbalance across the region. However, more attention is needed with regard to remote areas. A similar study has been conducted in the United States where the majority of citizens in that country can access the Cath lab within 1 hour (Concanon *et al.*, 2012). The same thing has been done by Russia using geospatial analysis, where most of the population can access the Cath lab in less than 2 hours (Timonim *et al.*, 2018). This differs from Indonesia, especially in this study, East Java, where the population density is high and where the presence of archipelago areas makes the situation particularly difficult.

Not all existing cath labs have human resources capable of providing PCI around the clock. Some hospitals do not even have any human resources operating their cath labs, so the cath lab facilities are idle. Further research is needed on the factors that govern the continuous operation of available cath lab (Januś *et al.*, 2015; Neumann *et al.*, 2019).

Insurance coverage is another important consideration. The cath lab procedures are expensive and not all can finance this out-of-pocket cost. Several hospitals do not collaborate with BPJS, which can cover the financing for cath lab installations. Insurance is one of the obstacles to the coverage of the cath lab action (Peters *et al.*, 2008; Ahmat *et al.*, 2021). A referral system can be made based on the nearest referral facility for patients who need PCI facilities based on guidelines. Areas where patients cannot reach the Cath lab in less than 2 hours require alternative measures such as availability of fibrinolytic injections.

In this research, we focused on the infrastructure aspect such as road network and cath lab facility. Other factors that may also affect the travel time are: i) cardiac emergency system, ii) human resources and iii) referral system was not discussed in sufficient detail. Future research is needed to include these factors to further evaluate the capabilities of cardiovascular referral system in Indonesia (Larson *et al.*, 2016; Barbato *et al.*, 2020).

Conclusions

The number of cath labs in East Java has increased from 16 to 33 in the last six years. However, only 6 of 39 cities/districts could access the Cath lab facilities within 1 hour, leaving nearly 50% of the population in East Java without this medical support. Moreover, six districts require an average travel time exceeding 2 hours. Geospatial analysis can be a tool for assessing current conditions, predicting future needs and evaluating the results of the procurement of health facilities. Indonesia, which has many geographical barriers making this type of analysis fundamental for the production of data-driven policies.

Recommendations

Our recommendation is to increase the number of cath labs prioritising the areas where they are lacking. The ratio of facilities per population and the travel time needed to access the facilities are the two most important factors to measure the need for healthcare facilities such as cath labs, therefore, a geospatial study at the national level is the next target for analysing the coverage of cath labs in Indonesia

References

Ahmat A, Asamani JA, Abdou Illou MM, Millogo JJS, Okoroafor SC, Nabyonga-Orem J, Karamagi HC, Nyoni J. 2021. Estimating the threshold of health workforce densities towards universal health coverage in Africa. BMJ Glob Health 7:e008310.

Aminorroaya A, Yoosefi M, Rezaei N, Shabani M, Mohammadi E, Fattahi N, Azadnajafabad S, Nasserinejad M, Rezaei N, Naderimagham S, Ahmadi N, Ebrahimi H, Mirbolouk M, Blaha MJ, Larijani B, Farzadfar F. 2022. Global, regional, and national quality of care of ischaemic heart disease from 1990 to 2017: a systematic analysis for the Global Burden of Disease Study 2017. Eur J Prev Card 29:371-9.

Barbato E, Noc M, Baumbach A, Dudek D, Bunc M, Skalidis E, Banning A, Legutko J, Witt N, Pan M, Tilsted HH, Nef H, Tarantini G, Kazakiewicz D, Huculeci R, Cook S, Magdy A, Desmet W, Cayla G, Vinereanu D, Voskuil M, Goktekin O, Vardas P, Timmis A, Haude M. 2020. Mapping interventional cardiology in Europe: the European Association of Percutaneous Cardiovascular Interventions (EAPCI) Atlas Project. Eur Heart J 41:2579-88.

Baumgartner H, Falk V, Bax J, Bonis M, Hamm C, Holm P, Kung B, Lancellotti P, Lansac E, Munoz D, Rosenhek P, Sjorgen J, Mas P, Vahanian A, Walther T, Wendler O, Windecker S, Zamorano J. 2017. 2017 ESC/EACTS Guidelines for the management of valvular heart disease. Eur Heart J 38:2739–2786.

Concannon T, Nelson J, Goetz, Griffith J. 2012. A Percoutaneous Coronary Intervention Lab in Every Hospital? Circulation Cardiovascular Quality Outcomes 5:14-20.

Gabb G, Arnolda L. 2017. Geographic location as a modifiable cardiac risk factor. Canad Med Assoc J 189:E482.

Januś B, Rakowski T, Dziewierz A, Fljorek K, Sokolowski A, Dudek D. 2015. Effect of introducing a regional 24/7 primary percutaneous coronary intervention service network on treatment outcomes in patients with ST segment elevation myocardial infarction. Kardiologia Polska 73:323-30.

Larson D, McKavanagh P, Henry T, Cantor W. 2016. Reperfusion options for ST elevation myocardial infarction patients with expected delays to percutaneous coronary intervention. Interventional Cardiol Clinics 5:439-50.

Neumann F, Sousa-Uva M, Ahlsson A, Alfonso F, Banning A, Benedetto U, Byrne R, Collet J, Falk V, Head S, Juni P, Kastrati A, Koller A, Kristensen S, Niebauer J, Richter D, Seferovic P, Sibbing D, Stefanini G, Windecker S, Yadav R, Zembala M. 2019. 2018 ESC/EACTS Guidelines on myocardial revascularization. Eur Heart J 55:87-165.

Oliver A, Mossialos E. 2004. Equity of access to health care: outlining the foundations for action. J Epidemiol Comm Health 58:655-8.

Peters D, Garg A, Bloom G, Walker D, Brieger W, Rahman MH. 2008. Poverty and access to health care in developing countries. Ann New York Acad Sci 1136:161-71.

Results of the 2020 Population Census. 2021. BPS East Java Province. Statistical Rummy News. No 07/01/35/ th. XIX. Available at: https://jatim.bps.go.id/pressrelease/2021/01/21/1224/jumlah-penduduk-jawa-timur-hasil-sensus-penduduk-2020—sp2020—sebesar-40-67-juta-orang.html

Timmis A, Townsend N, Gale C, Torbica A, Lettino M, Petersen S, Mossialos E, Maggioni A, Kazakiewicz D, May H, Smedt D, Flather M, Zuhlke L, Beltrame J, Huculeci R, Tavazzi, Hindricks G, Baz J, Casadei B, Achenbach S, Wright L, Vardas P, 2020. European society of cardiology: Cardiovascular disease statistics 2019. Eur Heart J 41:12-85.

Timonin S, Kontsevaya A, McKee M, Leon D., 2018. Reducing geographic inequalities in access times for acute treatment of myocardial infarction in a large country: The example of Russia. Int J Epidemiol 47:1594-602.

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