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ORIGINAL RESEARCH REPORT

Geographic distribution of ophthalmologists in East Java in 2023

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ABSTRACT

Background: Based on the results of the Rapid Assessment of Avoidable Blindness conducted across 15 provinces in Indonesia, East Java has the greatest prevalence rate of blindness in Indonesia with 4.4% of the population affected and 81.1% of cases attributed to cataracts. Enhancing the human resource capacity is essential for managing visual impairment. It is necessary to ensure the strategic distribution of ophthalmologists in accordance with the needs and healthcare accessibility of the population. **Objectives**: This study aims to determine the geographic distribution of ophthalmologists in East Java and to investigate the correlation between the geographic distribution and various socio-economic indicators. **Materials and Methods**: This study was conducted from December 2023 to January 2024. The researchers used hospital websites and social media platforms to collect data on ophthalmologists at each hospital in East Java, with a ratio of one ophthalmologist per 20,000 population. The Pearson correlation test in SPSS version 27 was used to analyze the correlation between the ratio of ophthalmologists per 20,000 population and the human development index, health index, purchase power index, and education index of each region. **Results**: In this study, the estimated number of ophthalmologists in East Java in 2023 was 505, which ranged from one in Sampang Regency to 142 in Surabaya City. The regions with the highest ratio of ophthalmologists were Mojokerto, Surabaya, and Malang Cities. The ophthalmologists were concentrated in major urban centers, with a notable absence in rural areas. A significant correlation was identified between the ratio of ophthalmologists and the human development index, education index, purchase power index, health index, and regional minimum wage. **Conclusion**: The distribution of ophthalmologists in East Java remains imbalanced, with a concentration in major urban centers and a scarcity in rural areas. The ratio of ophthalmologists showed a significant correlation with socio-economic factors, including the human development index, education index, health index, purchase power index, and regional minimum wage.

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Surabaya Medical Journal (SMJ IDI Surabaya)
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Highlights

1. Ophthalmologists were concentrated in major urban centers with a scarcity in rural areas.
2. A significant correlation was identified between the ratio of ophthalmologists and the human development index, health index, purchase power index, education index, and regional minimum wage.

INTRODUCTION

Visual impairment is a significant public health issue in Indonesia. The Rapid Assessment of Avoidable Blindness (RAAB) conducted across 15 provinces in Indonesia revealed that the prevalence of blindness among Indonesians aged 50 or older ranged from 1.7% to 4.4%. East Java has the highest prevalence rate of 4.4%, followed by South Sumatra with a rate of 3.6%, and West Nusa Tenggara with a rate of 4%. In Indonesia, cataracts accounts for 70–80% of cases of blindness and severe visual impairment. Refractive errors account for 10–15% of cases of severe visual impairment, while posterior segment disease accounts for 1.9–10.9% of cases of blindness. East Java has an estimated population of 371,599 individuals aged over 50 years with blindness, with 81.1% of cases attributable to cataracts (Rif'Ati et al., 2021).

One of the objectives of the Roadmap of Visual Impairment Control Program in Indonesia for 2017-2030 is to reduce the prevalence of preventable vision impairment by 25%. To substantially reduce the incidence of blindness in East Java, measures should be implemented to enhance the availability of cataract surgery. These entail engaging ophthalmologists at regional hospitals to perform significant cataract procedures, involving community informants to identify visual impairments and tasking primary healthcare doctors with determining the underlying causes of blindness. Enhancing the human resource capacity is essential for managing visual impairment. Therefore, it is necessary to ensure the strategic distribution of ophthalmologists in accordance with the needs and healthcare accessibility of the population (Kemenkes RI, 2018).

The World Health Organization (WHO) has determined that the ratio of physicians per 20,000 population is appropriate for North America and Western Europe (Carvalho et al., 2012; Wang et al., 2022). However, there is a lack of comprehensive study regarding the distribution of ophthalmologists in Indonesia, especially in East Java.

OBJECTIVE

This study aims to determine the geographic distribution of ophthalmologists in East Java and to determine the correlation between the geographic distribution and various socio-economic indicators, such as the human development index, health index, purchase power index, and education index of each region. The human development index (HDI) was used in this study to enhance indicators of inequality stratification, as it includes both social and economic aspects of human capital.

MATERIALS AND METHODS

This study was conducted from December 2023 to January 2024. The researchers obtained data on the number of ophthalmologists in Indonesia from the Indonesian Ophthalmologist Association and hospital data in East Java from the Indonesian Ministry of Health. The researchers used hospital websites and social media platforms to collect information regarding ophthalmologists at each hospital in East Java. If the data were insufficient or suspicious, the researchers would reach out to the hospital operator to validate them. All active ophthalmologists and fellows were included, while residents and ophthalmologists who could not be located were excluded.

The independent variables of this study consisted of the human development index, health index, purchasing power index, and education index of each region. In 2010, the United Nations Development Program (UNDP) established the three domains of the human development index (HDI), which has a

scale from 0 to 1, namely health, education, and income (United Nations Development Programme, 2020). To evaluate the impact of the disease on social development and resource utilization, we categorized the predetermined indices established by the UNDP into four groups: low (less than 0.550), medium (0.700-0.799), high (0.700-0.799), and extremely high (0.800 or greater) (Sun et al., 2022). The dependent variable of this study was the ratio of ophthalmologists. A choropleth map was used to illustrate the distribution of ophthalmologists in each regency and city of East Java.

The choropleth map was created using Tableau Public. The data were subsequently analyzed using SPSS version 27. In previous studies, the ratio of one ophthalmologist per 20,000 population has been employed. Additionally, we consulted this source for this study.[4] The researchers used a Pearson correlation test to analyze the correlation between the ratio of ophthalmologists per 20,000 population and the human development index, health index, purchase power index, and education index of each region.

RESULTS

The number of ophthalmologists was estimated based on the ratio of the number of individual ophthalmologists to the total number of hospitals/clinics/private practices in each regency/city. Ophthalmologists practicing in different locations within the same regency or city were considered as one individual in the calculation. An individual ophthalmologist practicing in a different city was considered as a different calculation. The number of ophthalmologists was estimated by categorizing them according to their affiliation with hospitals, eye care facilities, and private practices. The population figures by region in the following table were obtained from the Indonesian Central Bureau of Statistics (Badan Pusat Statistik, 2017).

Table 1. The number of ophthalmologists, ratio of ophthalmologists, and total population

No	City/Regency	Number of Ophthalmologists	Ratio of Ophthalmologists per 20,000 Population	Number of population per Ophthalmologist	Total Population 2023
1	Bangkalan Regency	7	0.13	157,365	110,1556
2	Banyuwangi Regency	6	0.07	290,802	1,744,814
3	Batu City	5	0.46	43,760	218,802
4	Blitar City	6	0.78	25,590	153,541
5	Blitar Regency	6	0.10	208,250	1,249,497
6	Bojonegoro Regency	9	0.14	146,942	1,322,474
7	Bondowoso Regency	4	0.10	196,048	784,192
8	Gresik Regency	29	0.43	46,367	1,344,648
9	Jember Regency	11	0.09	234,979	2,584,771
10	Jombang Regency	13	0.19	103,530	1,345,886
11	Kediri City	12	0.83	24,236	290,836
12	Kediri Regency	13	0.16	128,265	1,667,450
13	Lamongan Regency	16	0.23	86,684	1,386,941
14	Lumajang Regency	3	0.05	382,420	1,147,261
15	Madiun City	10	0.99	20,146	201,460
16	Madiun Regency	4	0.10	191,284	765,135
17	Magetan Regency	6	0.18	113,744	682,466
18	Malang City	42	0.99	20,171	847,182
19	Malang Regency	24	0.18	112,632	2,703,175
20	Mojokerto City	8	1.18	16,927	135414
21	Mojokerto Regency	12	0.21	95,126	1,141,516
22	Nganjuk Regency	13	0.23	86,481	1,124,247

Surabaya Medical Journal (SMJ IDI Surabaya)
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No	City/Regency	Number of Ophthalmologists	Ratio of Ophthalmologists per 20,000 Population	Number of population per Ophthalmologist	Total Population 2023
23	Ngawi Regency	5	0.11	176,279	881,393
24	Pacitan Regency	2	0.07	298,325	596,649
25	Pamekasan Regency	4	0.09	215,502	862,009
26	Pasuruan City	2	0.19	106,725	213,450
27	Pasuruan Regency	10	0.12	162,603	1,626,029
28	Ponorogo Regency	7	0.14	138,940	972,582
29	Probolinggo City	3	0.24	81,725	245,174
30	Probolinggo Regency	4	0.07	290,965	1,163,859
31	Sampang Regency	1	0.02	992,210	992,210
32	Sidoarjo Regency	36	0.34	58,739	2,114,588
33	Situbondo Regency	7	0.20	99,154	694,081
34	Sumenep Regency	4	0.07	285,824	1,143,295
35	Surabaya City	142	0.98	20,378	2,893,698
36	Trenggalek Regency	4	0.11	186,090	744,358
37	Tuban Regency	6	0.10	202,633	1,215,795
38	Tulungagung Regency	9	0.16	123,775	1,113,973

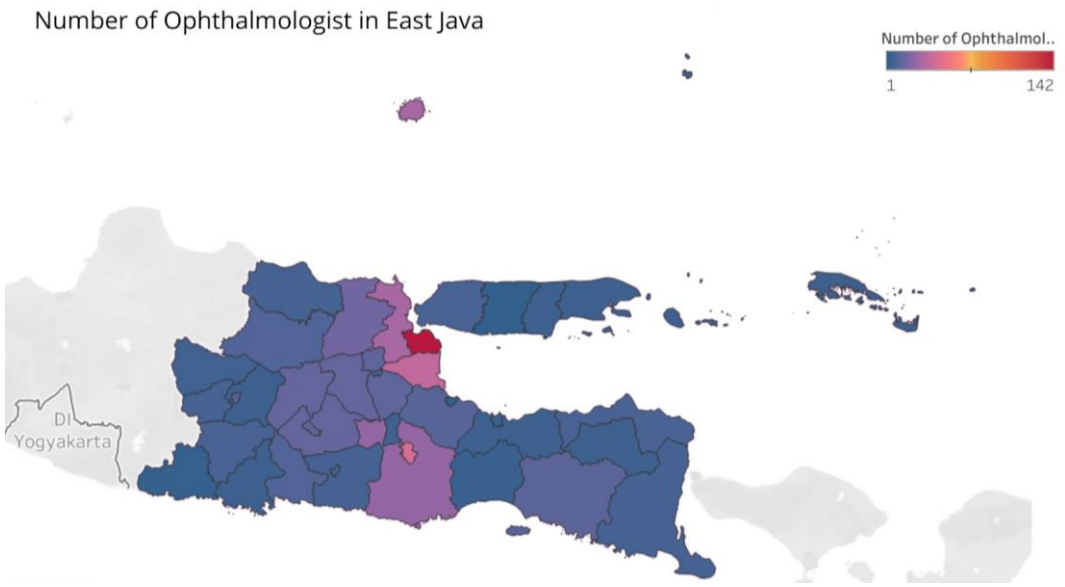

Figure 1. The estimated number of ophthalmologists in each regency/city in East Java in 2023

The land area of East Java is 47,995 square kilometers. The administrative jurisdiction of East Java is divided into 29 regencies and 9 cities. Based on the 2020 data from the Indonesian Central Bureau of Statistics, the population of East Java was approximately 40.66 million [5]. In 2023, the Indonesian Ophthalmological Association had a network of over 3,000 ophthalmologists stationed across Indonesia. According to the data presented in Table 1, the estimated number of ophthalmologists in East Java in 2023 was 505. The number of ophthalmologists varied from one in Sampang Regency to 142 in Surabaya City. The regions with the highest concentration of ophthalmologists were Surabaya, Malang, Sidoarjo, and Gresik. In other words, every regency or city in East Java had at least one ophthalmologist.

The primary finding of this study is a choropleth map that illustrates the distribution of ophthalmologists in East Java as a ratio per 20,000 population. The distribution was segmented into the following categories: 0-0.29, 0.3-0.5, 0.51-0.7, 0.71-0.9, 0.91-1.10, and greater than 1.10. Most areas in East Java had a ratio of 0-0.29 per 20,000 population.

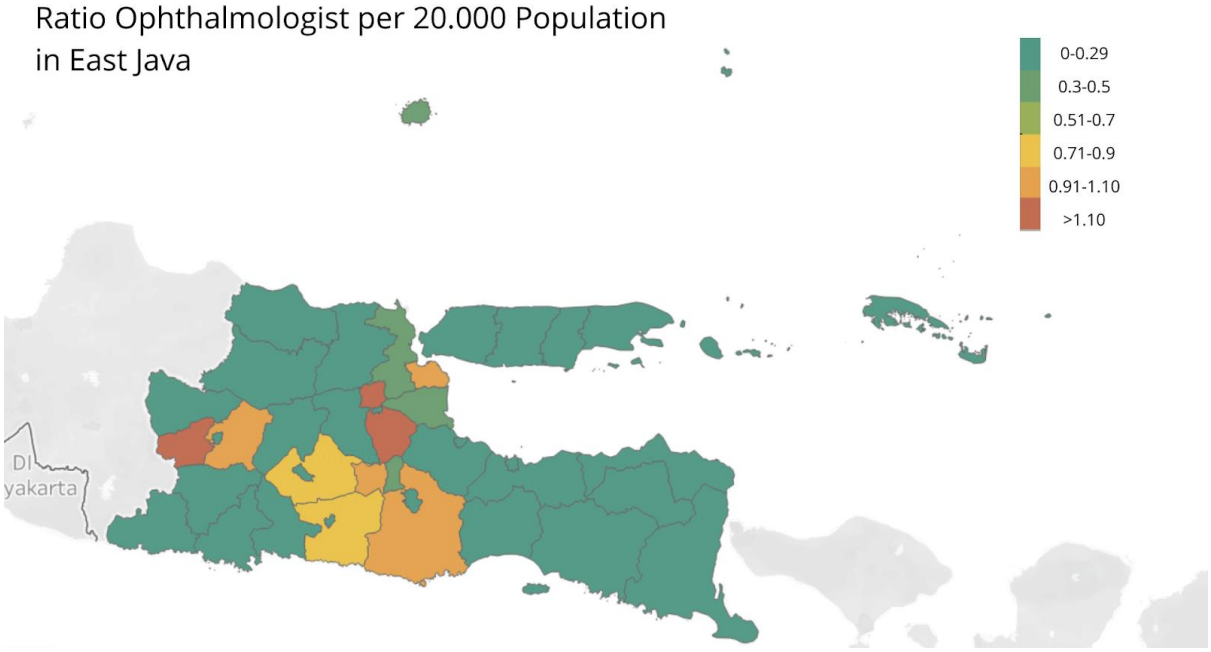

Figure 2. The ratio of ophthalmologists per 20,000 population in each regency/city in East Java

The optimal proportion of ophthalmologists was determined based on data from the Indonesian Ministry of Health, namely one ophthalmologist per 20,000 individuals. According to the data in Table 1, the average ratio of every regency or city in East Java was 0.29 ophthalmologists per 20,000 people (O/P ratio), which deviates from the ideal ratio of 1:20,000 set by the WHO. The only region that fulfilled the ratio of 1:20,000 was Mojokerto City. Malang and Surabaya Cities achieved the ratio of 0.99 and 0.98, respectively. The region with the lowest ratio of ophthalmologists was Sampang City, with a ratio of 0.02. The estimated average of ophthalmologist concentration in East Java varied from one ophthalmologist per 16,000 people to one ophthalmologist per 992,000 people.

Table 2. Correlation of the ratio of ophthalmologists with human development index, education, purchasing power index, and health index

Variable	**Descriptive Statistics**			**Ratio of Ophthalmologists**	
	Mean	**Standard Deviation**		***r***	***p-value***
Human Development Index	72.97	5.07		0.820	< 0.001
Education Index	0.65	0.07		0.833	< 0.001
Purchasing Power Index	67.00	2.11		0.639	< 0.001
Variable	**Descriptive Statistics**			**Ratio of Ophthalmologists**	
	Median	**Minimum**	**Maximum**	***r***	***p-value***
Health Index	0.81	0.73	0.84	0.526	0.001
Regional Minimum Wage	Rp2,355,842.00	Rp2,172,287.00	Rp4,725,479.00	0.266	0.106

Surabaya Medical Journal (SMJ IDI Surabaya)
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Furthermore, the Pearson correlation test was performed to determine the relationship between the ratio of ophthalmologists and other indicators, including the human development index, health index, education index, purchasing power index, and regional minimum wage. A notable correlation was observed between the number of ophthalmologists and all previously determined variables. The correlation coefficients between the ratio of ophthalmologists and other factors suggested different degrees of correlation. A significant correlation was observed between the ratio of ophthalmologists and the human development index, education index, health index, and purchasing power index. Meanwhile, a moderate correlation was observed between the number of ophthalmologists and the regional minimum wage.

DISCUSSION

This study aims to present a comprehensive analysis of the geographic distribution of ophthalmologists in East Java. According to the WHO, the optimal proportion of ophthalmologists is one ophthalmologist per 20,000 population (Carvalho et al., 2012; Wang et al., 2022). This study indicated that only Mojokerto City had a ratio of ophthalmologists per population that is greater than one. Surabaya City and Malang City, which are major cities, had ratios that are nearly equal to one (0.98 and 0.99, respectively). The regions that had an ophthalmology residency program, such as Surabaya City and Malang City, tended to have higher proportions of ophthalmologists per population. The regions with the lowest ratio, which was less than 0.08 per 20,000 populations, were located far from metropolitan areas, for instance, Sampang Regency, Lumajang Regency, Banyuwangi Regency, Probolinggo Regency, and Pacitan Regency. The number of ophthalmologists varied from one in Sampang Regency to 142 in Surabaya city.

This finding is similar to the phenomenon observed in West Java, Indonesia, which showed that each region had between one and 101 ophthalmologists. Bandung, a major city, had the highest number of ophthalmologists, with a total of 101. Bogor and Cirebon had 15 and 19 ophthalmologists, respectively. However, several regions, such as Tasikmalaya Regency and Pangandaran Regency, had only one ophthalmologist. Furthermore, it was observed that there a similar phenomenon occurred in which ophthalmologists were mostly located in major urban centers, while being scare in places that were located far away from these urban centers (Lita et al., 2019).

In this study, Surabaya and Malang Cities were identified as locations for residency programs, which were also identified as primary factors influencing the location choices of physicians, as well as regions with greater gross domestic product (GDP) per capita. Continuous medical education and employment prospects are provided to the partner. A study conducted in Brazil in 2012 found a correlation between the ratio of ophthalmologists to the population (1:20,000) and the level of gross domestic product (GDP). A positive correlation was observed between the number of ophthalmologists per capita and the level of economic growth, as indicated by the GDP per capita, in certain regions (Carvalho et al., 2012).

In 2023, Indonesia was estimated to have approximately 3,000 ophthalmologists. With a total population of 270 million people, this implies that each ophthalmologist will provide care for approximately 100,000 people. There are approximately 505 ophthalmologists in East Java, which has a population of 40.66 million people. This implies that there might be approximately one ophthalmologist per 100,000 population. A similar phenomenon was observed in Thailand, a country in Southeast Asia with a ratio of 1.52 ophthalmologists per 100,000 population. This finding is consistent with the fact that in Thailand, there was a higher density of ophthalmologists in large urban regions compared to rural areas (Estopinal et al., 2013).

A study conducted in the United States revealed that the national density of ophthalmologists declined from 6.30 to 5.68 per 100,000 individuals between 1995 and 2017. In 2017, the density of ophthalmologists in rural areas experienced an average annual rise of 2.26%. However, it remained much lower (0.58 per 100,000) compared to nonmetropolitan areas (2.19 per 100,000 inhabitants) and

metropolitan districts (6.29 per 100,000 individuals). From 1990 to 2017, the ophthalmologist-to-population ratio increased from 11.06 to 16.16 per 100,000 individuals. The presence of ophthalmologists is closely associated with a greater percentage of individuals possessing higher education degrees and health insurance, as well as a more advanced healthcare system (Feng et al., 2020).

The results of this study demonstrated a significant correlation between the number of ophthalmologists and the human development index. A positive correlation was observed between the ratio of ophthalmologists in a region and its human development index. This finding is consistent with a study conducted in South America. Guatemala, a country in South America, had the highest level of socio-geographic inequality in the distribution of ophthalmologists. Merely 2% of the total number of ophthalmologists in the country were accessible to the least developed 20% of the population, whereas the highest quintile had access to nearly 75% of all available ophthalmologists (Hong et al., 2016).

This discovery has a similarity to the situation seen in the United States of America. Washington, DC, Maryland, Massachusetts, and New York, which are major cities, had the highest ophthalmologist concentration per 10,000 inhabitants, with values of 1.42, 0.94, 0.87 and 0.86 respectively. On the other hand, Wyoming, Idaho, New Mexico, and Nevada had the lowest concentrations, with values of 0.19, 0.36, 0.38, and 0.39 respectively. States exhibiting the highest relative demand index might indicate areas with a greater likelihood of unmet medical requirements (Akosman et al., 2023).

The education index is calculated as the average of two indicators, namely the average years of schooling and the predicted years of schooling. This study found a significant correlation between the ratio of ophthalmologists and the education index. New approaches are required to enhance the overall quantity and allocation of ophthalmologists to address the needs of the aging population and reduce the prevalence of visual impairment in East Java. The education index exerted a significant influence on the prevalence of moderate to severe visual impairment and blindness (Sengo et al., 2023).

According to a study on the socioeconomic differences of adults in the United States in using eye care services, people with educational attainment below a high school diploma were less likely to mention consulting an eye care provider compared to those with at least a college degree. Therefore, there is a possibility that ophthalmologists might prefer places with a higher educational attainment (Zhang et al., 2013).

A study of 21 Global Burden of Disease (GBD) regions including 90 countries or territories in 2017 revealed a significant correlation between national socioeconomic factors and differences in vision loss globally, as well as between blindness and levels of moderate-to-severe visual impairment. A positive correlation was observed between a higher human development index and a reduced prevalence of blindness and moderate-to-severe visual impairment. A correlation was also observed between vision loss and national health cost indicators, highlighting the importance of population-wide prevention and management efforts for vision-threatening conditions (Akosman et al., 2023).

A study conducted in California between 2018 and 2020 found a significant association between the number of eye care professionals and the incidence of visual impairment per 100,000 population. The adjusted analyses showed that an increased number of eye care professionals in the region and health care study areas was associated with a decreased prevalence of visual impairment (Wang et al., 2022).

The majority of ophthalmologists in Australia were concentrated in urban areas and typically stayed in the same location. Government intervention is necessary to provide training, recruitment, and retention of ophthalmologists in remote, rural, and regional locations in order to enhance the distribution of healthcare professionals outside of urban areas. Resolving the problem of uneven distribution of work can improve the accessibility of eye care services for those living in rural and regional areas (Allen et al., 2021).

Surabaya Medical Journal (SMJ IDI Surabaya)
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The primary objective of the WHO's 2030 In Sight initiative is to eradicate avoidable blindness and empower individuals to reach their maximum capabilities. Eye care and rehabilitation therapies are readily available, adaptable, and affordable. People require services that are free from stigma because they understand the significance of maintaining their visual well-being. Early detection and prompt medical treatment can prevent 90% of vision loss, making eye care treatments very cost-effective worldwide. Nevertheless, notable disparities exist in the accessibility and quality of eye healthcare, a scarcity of professionals in the field, and inadequate system integration (Stern et al., 2023).

A study conducted in Nampula showed that the number and distribution of ophthalmologists, along with the accessibility of essential resources, serve as crucial health benchmarks in a specific area as they profoundly influence the extent and quality of healthcare services provided. Nampula faces a shortage of personnel in the eye health sector, exacerbated by an unequal distribution of these resources. While Nampula City boasts a significant number of specialists, some provinces experience a total absence of professionals. This affects the community's capacity to receive comprehensive coverage and access to these services. Health managers must reexamine their strategies for allocating human and material resources in eye health to provide equitable access to eye care at all levels (Sengo et al., 2023).

A study conducted at regional hospitals in rural China revealed the distribution of surgical procedures and the effectiveness of outpatient services in rural Chinese hospitals across different regions. Factors such as phacoemulsification devices, socioeconomic status, and GDP per capita likely played a role in the growth of rural cataract surgery capabilities. The study could serve as a useful reference for government investment aimed at expanding surgical procedures and outpatient services (Zhong et al., 2021).

Despite an increase in the number of ophthalmologists across most Southeast Asian countries, with the exception of Timor-Leste, only four out of 10 nations (Maldives, India, Thailand, and Bhutan) had a sufficient ratio of one ophthalmologist per 100,000 people. However, this did not have a significant impact due to the unequal distribution between urban and rural areas. Enhancing capabilities and ensuring equitable allocation of personnel to effectively serve rural populations, in addition to poverty reduction, are crucial factors for achieving universal eye health (Das et al., 2018).

According to a study conducted in the United States in 2017, geographical considerations can influence the delivery of cataract patients to eye care. Patients in rural areas typically traveled a greater distance to see an ophthalmologist, resulting in lower rates of cataract surgery than expected. As a result, this might be considered when determining the distribution of ophthalmologist practices and eye care facilities (Lee et al., 2017).

The relationship between each variable in the government is of paramount importance to provide equitable access to healthcare across regions and cities. Consequently, each individual is afforded an equal opportunity to access healthcare services through the equitable allocation of health resources, including healthcare professionals, medical facilities, and funding for health advancements.

Strengths and Limitations

This study has several limitations. First, the researchers addressed ophthalmologists who were registered in hospitals, eye clinics, and private clinics. We simply analyzed the data obtained from social media platforms or websites and only reached out to customer assistance if there were any discrepancies in the information. We did not directly observe the location of the practice. Second, we excluded resident physicians from this study. Although resident physicians are involved in eye services, the division of duties and involvement in eye services remains unclear. Third, we made the assumption that all ophthalmologists listed in the directory were employed on a full-time or part-time basis in their respective hospitals, eye care facilities, and private practices.

Moreover, ophthalmologists practicing in various locations within the same regency or city were considered as one individual for calculation. Meanwhile, an individual ophthalmologist practicing in a different city was considered as a different calculation. Varying assumptions could have impacted the provider-to-population ratios documented in this study. Fouth, this study did not include collecting information on the quantity of eye surgical equipment in hospitals, eye clinics, or private clinics in East Java.

CONCLUSION

The distribution of ophthalmologists in East Java remains imbalanced. Big cities, such as Surabaya City and Malang City, had a significant concentration of ophthalmologists, with a corresponding presence in the surrounding regencies or cities. The areas with the lowest ratio of ophthalmologists were situated in remote areas, such as Sampang, Probolinggo, Lumajang, Pacitan, and Banyuwangi Regencies, which are distant from urban areas. The ratio of ophthalmologists showed a significant correlation with various factors, including the human development index, education index, health index, buying power index, and regional minimum wages. The findings suggested that a large percentage of ophthalmologists had a preference for practicing in developed areas, as determined by the indices of human resources, education, health, and economics.

Acknowledgment

None.

Conflict of Interest

All authors have no conflict of interest to declare.

Authors' Contribution

KDS: conceptualization, study design, data curation, formal analysis, data interpretation, methodology, manuscript writing, and content revision; TAF: conceptualization, study design, data interpretation, methodology, investigation, manuscript writing, and content revision; UU: conceptualization, study design, data interpretation, methodology, investigation, manuscript writing, content revision, and supervision.

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