

Spatial Analysis of Health Human Resources (SDMK) Readiness in Addressing the Double Burden of Diseases in Hospitals Across Indonesia

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ABSTRACT

The double burden of disease characterized by the increase of non-communicable diseases along with the high level of infectious diseases requires adequate and equitable preparedness of Human Health Resources (SDMK) in hospitals. Inequality in the distribution of health workers between regions causes service capacity is not optimal, so spatial analysis becomes an important approach in planning SDM. Purpose: This study aims to analyze the relationship between sdmk readiness and the ability of hospitals to cope with the double burden of disease in Indonesia, as well as mapping priority areas for strengthening SDM through Geographic Information Systems (GIS), with field validation at Dr. M. Djamil Padang. Methods: quantitative research with GIS-based cross-sectional design involving 514 public hospitals selected using stratified random sampling by region. Data were obtained from the Ministry of Health, SDM Information System, hospital profile, observation, and structured interviews. Analysis was conducted using univariate statistics, chi-square test, multiple logistic regression, Moran's I, and Hotspot Analysis (Getis-Ord Gi). Results: a total of 61.3% of hospitals have high sdmk readiness, while 38.7% are still low. Hospitals with adequate SDM were better able to manage the double burden of disease optimally than hospitals with inadequate SDM (68.5% vs 42.1%; $p=0.001$; OR=2.94; 95% CI=1.98–4.36). Spatial analysis showed positive autocorrelation (Moran's $I=0.41$; $p<0.001$) with priority cluster in eastern Indonesia. Implication: Dr. M. Djamil Padang has the potential to become a reference Center for SDM capacity development and strengthening spatial mapping-based service networks. Conclusion: Sdmk readiness is significantly related to the ability of hospitals to manage the double burden of disease, while spatial analysis effectively identifies priority areas for intervention and equitable distribution of national SDM.*

Keywords: Readiness, Hospitals, Geospatial



INTRODUCTION

Changes in disease patterns globally have led health systems in various countries to face increasingly complex challenges. On the one hand, infectious diseases are still the leading cause of illness and death in many developing countries, while on the other hand there is a sharp increase in non-communicable diseases due to changes in demographics, urbanization, and people's lifestyles. This condition is known as the double burden of disease which requires the readiness of the health system as a whole, including the availability and distribution of human health resources (SDMK). The World Health Organization affirms that the success of health services in facing the epidemiological transition is largely determined by the adequacy of competent, adaptive, and evenly distributed health workers. (World Health Organization [WHO], 2023).

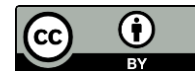
The double burden of disease is a major challenge of health development because it has an impact on the increasing need for promotive, preventive, curative, and rehabilitative services simultaneously. Global Data shows that non-communicable diseases account for about 74% of all deaths worldwide, but infectious diseases such as tuberculosis, HIV/AIDS, malaria, and emerging infectious diseases still make a large contribution, especially in low-and middle-income countries. This situation causes the hospital to be able to provide comprehensive services with the support of health workers who have multidisciplinary competence. Therefore, strengthening SDMK capacity is one of the priorities in achieving Universal Health Coverage (UHC). (WHO, 2023; United Nations, 2023).

Indonesia is one of the countries that is experiencing an epidemiological transition with the characteristics of an increasingly real double burden of disease. Non-communicable diseases such as hypertension, diabetes mellitus, heart disease, and cancer continue to increase every year, while infectious diseases such as tuberculosis, dengue hemorrhagic fever, and Infectious Diseases of the respiratory tract are still a public health problem. These conditions result in increased need for hospital services in both acute and chronic cases of the disease. The complexity of these services requires sdmk readiness that is not only sufficient in number, but also has competence according to the development of health care needs. (Ministry of Health, 2024; WHO, 2024).

SDMK readiness is one of the main components in strengthening the National Health System. SDMKS not only includes doctors, specialists, nurses, midwives, pharmaceutical workers, public health workers, laboratory analysts, and other health professions, but also includes aspects of distribution, competence, productivity, and equitable distribution of services. National reports indicate that the distribution of health workers in Indonesia is still concentrated in urban areas and large hospitals, while remote areas and eastern Indonesia are still experiencing a shortage of health workers. This inequality has the potential to create gaps in access to services and worsen the ability of hospitals to deal with the double burden of disease. (Ministry of Health, 2024).

Hospitals as referral health care facilities have a strategic role in reducing the double burden of disease. The increase in the number of visits by patients with chronic diseases accompanied by still high cases of infectious diseases causes the burden of hospital services to be greater. This condition requires hospital management to plan SDMKS needs appropriately based on regional characteristics, disease patterns, and service capacity. However, SDMKS planning in various hospitals is still based more on the ratio of health workers than needs analysis that considers spatial variation and disease distribution. (Ministry of Health, 2023; WHO, 2023).

Spatial analysis approach is becoming one of the methods that are increasingly used in the field of Public Health to identify patterns of disease distribution, health resources, and service inequality between regions. Through the use of Geographic Information System (GIS), information about the distribution of health workers can be mapped more comprehensively so as to facilitate region-based decision-making. Spatial analysis is also able to identify priority areas that require sdmk strengthening interventions based on



geographical and epidemiological characteristics. Thus, the integration of spatial data in SDMK planning is expected to increase the effectiveness of national health policies. (WHO, 2023; ESRI, 2024).

A number of studies have shown that the distribution of health workers has a close relationship with the quality of hospital services and public health outcomes. Research conducted by Asamani et al. (2021) found that the inequality in the distribution of health workers affects the low access to health services in various regions. Another study by Zhang et al. (2022) shows that the spatial approach is able to identify the unevenness in the distribution of health workers so that it becomes the basis for preparing the sdmk equitable distribution policy. In Indonesia, research on the distribution of health workers is still dominated by descriptive analysis and not much integrate spatial analysis with the condition of the double burden of disease in hospitals. (Asamani et al., 2021; Zhang et al., 2022).

Based on the description, there are still gaps in research on the relationship of sdmk readiness with the double burden of disease analyzed using a spatial approach on a national scale. Most of the previous studies only discussed the distribution of health workers, SDMK needs, or disease patterns separately without connecting these three aspects in one analysis model. In addition, there are not many studies that use the National Referral Hospital as a validation location for spatial mapping results, including Dr. M. Djamil Padang which has a strategic role as a Regional Referral Hospital in Sumatra. Therefore, this study is important to produce evidence-based information on the preparedness of SDMK in dealing with the double burden of disease through spatial analysis as the basis for the preparation of policies on the equitable distribution of health workers in Indonesia. (WHO, 2023; Ministry of Health, 2024).

Research on sdmk preparedness in dealing with the double burden of disease is growing as the need for complex health services increases. However, most studies still focus on the adequacy of the number of health workers or the evaluation of services at the health facility level without considering spatial factors. In fact, the geographical characteristics of Indonesia as an archipelagic country cause uneven distribution of health workers, thus affecting access and quality of hospital services. This condition shows that spatial analysis is an important approach to complement conventional analysis in SDMK planning. (WHO, 2023; Ministry of Health, 2024).

Research Zhang et al. (2022) shows that the use of Geographic Information System (GIS) is able to identify health workforce distribution inequality more accurately than conventional statistical analysis. The results showed that there are clusters of areas with low density of health workers and correlated with low access to health services. Similarly, the study of Alegana et al. (2021) found that the spatial approach can be the basis in the preparation of health personnel redistribution policies so that they are more in line with the needs of the region. However, the two studies have not linked the distribution of SDMK with the condition of the double burden of disease in hospitals, so it has not been able to explain the readiness of the service system in a comprehensive manner. (Alegana et al., 2021; Zhang et al., 2022).

In Indonesia, several studies have also discussed the distribution of SDMK and the equitable distribution of health workers. Research Kurniawati et al. (2023) reported that the concentration of specialist doctors is still dominated by hospitals on the island of Java and large cities, while hospitals in the eastern region of Indonesia are still experiencing a shortage of certain health workers. Research Prameswari et al. (2023) shows that these inequalities have an impact on variations in service quality and patient waiting times at referral hospitals. However, the two studies have not used spatial analysis to map the relationship between the distribution of SDMK with the characteristics of the burden of disease so that it still leaves room for research development. (Kurniawati et al., 2023; Prameswari et al., 2023).

The double burden of disease also has consequences for the increasing need for health workers who have cross-sector competence. Hospitals not only need medical personnel to deal with infectious diseases, but also professionals who are able to manage chronic diseases through multidisciplinary services. Increased cases



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of diabetes mellitus, hypertension, cardiovascular disease, and cancer that occur along with still high cases of tuberculosis and other infectious diseases cause the workload of health workers higher. Therefore, sdmk readiness needs to be assessed not only from the aspect of quantity, but also competence, equity, and adaptability to changes in disease patterns. (WHO, 2023; Institute for Health Metrics and Evaluation, 2024).

METHODS

This study uses a quantitative approach with observational analytical design through cross-sectional design combined with spatial analysis based on Geographic Information System (GIS). The research was conducted at a public hospital in Indonesia with validation location at Dr. M. Djamil Padang. The study population was all public hospitals registered with the Ministry of health of the Republic of Indonesia in 2024. The sample of 514 hospitals was determined using stratified random sampling technique based on region (Sumatra, Java, Kalimantan, Sulawesi, Bali–Nusa Tenggara, Maluku, and Papua) to obtain national representation. Inclusion criteria include hospitals that have complete data on human resources (SDMK), indicators of hospital services, as well as data on infectious and non-infectious diseases during the study period. Exclusion criteria include hospitals that have incomplete data, do not report service indicators consistently, or experience changes in operational status during the study period. Field validation was conducted at Dr. M. Djamil Padang by involving the director of services, head of human resources, head of related installations, and health workers who meet the criteria as respondents through purposive sampling technique. Sdmk readiness is formed from indicators of the adequacy of the number of health workers, competence, distribution, and Human Resources Development. The total score is then categorized into high when it is above or equal to the median value and low when it is below the median. The ability of hospitals to cope with the double burden of disease was measured through indicators of readiness for infectious and non-infectious disease services, availability of SDM, and service support, and then categorized into optimal ($\geq$ median) and suboptimal ($<$ median).

Data collection was conducted through the analysis of secondary documents derived from the human resources Health Information System (SISDMK), Indonesian Health Profile, Hospital profile, and disease burden data from the Ministry of health of the Republic of Indonesia. Primary Data were obtained through observation using structured observation sheets and interviews using questionnaires that have been tested for the validity of the contents by three experts in hospital management and public health and have a reliability value of Cronbach's alpha of 0.89, which indicates very good internal consistency. Univariate analysis was used to describe the distribution of sdmk readiness characteristics and the ability of hospitals to cope with the double burden of disease. Relationships between variables were analyzed using Chi-square test, followed by multiple logistic regression to obtain the magnitude of the relationship expressed in the Odds Ratio (OR) and 95% Confidence Interval (CI). Spatial analysis was conducted using Global Moran's I to identify spatial autocorrelation and Hotspot Analysis (Getis-Ord G_i^*) to determine cluster priority areas. This study has obtained ethical approval from the Health Research Ethics Committee of RSUP Dr. M. Djamil Padang and research permits from relevant agencies. All respondents involved in primary data collection were given an explanation of the purpose, benefits, procedures, data confidentiality, and the right to resign at any time, then signed a consent sheet to participate in the research (informed consent) before the data collection process was carried out.

RESULTS

1. Univariate Analysis

Table 1. Distribution of SDMK Readiness and Ability of Hospitals to Cope with the Double Burden of Disease (n=514)

Variable	Category	n	%
SDMK readiness	Height	315	61,3
	Low	199	38,7
Ability to cope with the double burden of disease	Optimal	301	58,6
	Less than optimal	213	41,4
Availability of strategic health personnel	Adequate	337	65,6
	Inadequate Evenly	177	34,4
SDMK distribution by region	Evenly	286	55,6
	Uneven	228	44,4

The results of univariate analysis showed that most hospitals have sdmk readiness in the high category of 315 hospitals (61.3%), while as many as 199 hospitals (38.7%) are still in the low readiness category. Based on the ability to cope with the double burden of disease, as many as 301 hospitals (58.6%) have optimal capabilities, while 213 hospitals (41.4%) still experience limitations in dealing with a combination of infectious and non-infectious diseases. The distribution of SDMK shows that more than half of the hospitals have adequate strategic health personnel, but distribution inequality is still found, especially in areas with difficult geographical characteristics.

2. SDMK readiness relationship with hospital's ability to cope with double burden of disease

Table 2. Relationship of SDMK Preparedness with Hospital's Ability to Cope with Double Burden of Disease (n=514)

SDMK readiness	Ability to Cope with the Double Burden of Disease				
	Optimal n (%)	Less than optimal n (%)	Total	p-value	OR (95% CI)
Height	216 (68,5)	99 (31,5)	315		
Low	85 (42,7)	114 (57,3)	199	0,001	2,94 (1,98–4,36)
Total	301 (58,6)	213 (41,4)	514		

The results of bivariate analysis showed a significant relationship between sdmk readiness with the ability of hospitals to cope with the double burden of disease ($p=0.001$). Hospitals with high SDMK readiness have an optimal proportion of the ability to cope with the double burden of disease by 68.5%, higher than hospitals with low sdmk readiness. The relationship was further analyzed by considering the type of hospital as a confounding variable, considering that differences in hospital types can affect the availability of resources, service capacity, and ability to handle the double burden of disease. With low sdmk readiness of 42.7%. $Or=2.94$ (95% CI: 1.98–4.36) indicates that hospitals with high sdmk readiness have about 2.94 times greater chance of being able to optimally handle the double burden of disease than hospitals with low sdmk readiness.

3. Spatial analysis of SDMK readiness

Spatial analysis using Global Moran's I method showed a pattern of distribution of sdmk readiness between hospital regions in Indonesia. The results showed the value of Moran's I is 0.41 with $p<0.001$, which indicates there is a positive spatial autocorrelation. This shows that hospitals with high sdmk readiness tend to cluster in certain areas, as well as hospitals with low readiness to form their own clusters.000 Hotspot Analysis



results (Getis-Ord G_i^*) identified that areas with low sdmk readiness and higher need for strengthening health workers were found mainly in eastern Indonesia. In contrast, urban areas with a large concentration of referral hospitals showed a better pattern of sdmk readiness hotspots.

DISCUSSION

The results showed that most hospitals in Indonesia have sdmk readiness in the high category of 61.3%, while 38.7% of hospitals are still in the low readiness category. These findings illustrate that although efforts to strengthen SDMK have been ongoing, there are still gaps in the capacity of health workers that have the potential to affect the ability of hospitals to deal with changes in disease patterns. This study also found that sdmk readiness has a significant relationship with the ability of hospitals to cope with the double burden of disease ($p=0.001$), with hospitals that have high sdmk readiness have a 2.94 times greater chance of providing optimal service response than hospitals with low sdmk readiness. The results of spatial analysis showed a pattern of grouping areas with the value of Moran's $I=0.41$ ($p<0.001$) which shows that the distribution of sdmk readiness does not occur randomly, but forms a certain spatial pattern, especially in areas with limited access and distribution of health workers.

The finding that there are still 38.7% of hospitals with low SDMK readiness shows that the main challenge of the Indonesian health system is not only in the number of health workers, but also in equitable distribution, competence suitability, and adaptability to changing service needs. The concept of health workforce readiness explains that the readiness of health workers is influenced by the availability of the number of workers, professional competence, work environment, and health system support that allows health workers to provide services effectively. The results of this study reinforce this theory because hospitals with better SDMK components show higher capabilities in dealing with a combination of infectious and non-infectious diseases. The researchers assume that hospitals that have a more planned SDMK management system tend to have better adaptability when faced with an increased burden of service due to epidemiological transitions.

The double burden of disease causes hospitals to face increasingly complex service needs because they have to maintain control of infectious diseases while increasing the capacity of chronic disease services. This condition requires health workers who are not only available in quantity but also have multidisciplinary competence in the management of patients with various clinical conditions. The World Health Organization explains that a resilient health system is highly dependent on the ability of health workers to adapt to changing patterns of disease and the needs of society. The results of this study are in accordance with the concept because hospitals with high sdmk readiness show better disease burden management capabilities than hospitals with sdmk limitations. (World Health Organization [WHO], 2023).

The significant relationship between sdmk readiness and hospital capability in this study shows that investment in health workers is a strategic factor in strengthening the health care system. The OR value of 2.94 indicates that the improvement of SDMK readiness provides a nearly three-fold advantage to the ability of hospitals to deal with the double burden of disease. These findings are in line with the research of Asamani et al. which states that the shortage and uneven distribution of health workers is related to the low capacity of the health system to provide quality services. The researcher considered that strengthening SDMK cannot be done only through increasing the number of personnel, but needs to be directed to planning based on disease needs and regional characteristics. (Asamani et al., 2021).

The distribution of sdmk readiness that forms a spatial pattern shows that geographical factors have an important role in determining the capacity of hospital services. The results of Moran's I analysis of 0.41 showed a positive spatial autocorrelation, which means that hospitals with certain sdmk readiness characteristics tend to be adjacent to other hospitals with similar conditions. These findings support research

on the use of GIS in health workforce planning which shows that spatial analysis is able to describe the inequality of health workforce distribution more clearly than the national aggregate approach. Researchers argue that the spatial pattern occurs because the distribution of health workers is still influenced by regional economic factors, the availability of health education facilities, as well as the attractiveness of urban areas. (Zhang et al., 2022; International Labour Organization, 2022). The results of the study that showed the existence of priority clusters in eastern Indonesia illustrate that SDMK inequality is still a problem in National Health Development. Regions with archipelagic geographical characteristics, limited transportation access, and a smaller number of health facilities are likely to experience barriers to sustainably maintaining health workers. Previous studies have shown that regions with high geographic challenges are more likely to experience a shortage of health workers due to retention and distribution of professionals. The researcher assumes that the sdmk equalization strategy in Indonesia needs to consider a region-based approach, not just using national health worker ratio standards. (Dussault et al., 2021).

RSUP Dr. M. Djamil Padang as a research validation location has relevant characteristics in describing the needs of SDMK in regional referral hospitals. As a tertiary referral hospital, this hospital receives complex case referrals from various regions in Sumatra, so it requires a higher readiness of health workers compared to basic service level hospitals. This condition is in line with the concept of hub and spoke system in health services, where referral hospitals become Centers for strengthening clinical capacity and knowledge distribution for health facilities in the surrounding area. Researchers argue that the strategic position of Dr. M. Djamil Padang can be used as a Competence Development Center for SDMK to support the equitable distribution of health services in Sumatra.

The results of this study also show that the spatial approach provides added value in understanding the problems of SDMK compared to ordinary statistical analysis. Spatial analysis not only shows the number or proportion of health workers, but is also able to describe the location of territories that require priority intervention. This approach is consistent with the development of modern health planning that emphasizes the use of location-based data to improve the accuracy of decision-making. Previous research has shown that the integration of GIS in health planning can help governments determine resource distribution strategies more effectively and efficiently. (Alegana et al., 2021; International Journal of Health geography, 2022).

SDMK readiness in this study not only describes the availability of health workers, but also reflects the capacity of the hospital system in responding to changing public health needs. Epidemiological transformation causes hospitals to have health workers who are able to provide services simultaneously against infectious and non-infectious diseases. Health system resilience theory explains that a strong health system is a system that is able to absorb pressure, adapt, and maintain service functions when faced with changing health burdens. The results of this study support this theory because hospitals with higher sdmk readiness show better service capabilities in dealing with the double burden of disease. (Kruk et al., 2022).

The increase in non-communicable diseases in Indonesia puts new pressure on the need for health workers in hospitals. Chronic diseases such as hypertension, diabetes mellitus, heart disease, and cancer require ongoing services involving a variety of health professions, while infectious diseases still require robust systems of surveillance, diagnosis, and infection control. Global research shows that countries with good SDMK capacity have a higher ability to integrate chronic disease and infectious disease services in one health care system. The findings reinforce evidence that SDMK preparedness is an important component in hospitals' success in coping with changing epidemiological patterns. (GBD 2021 Diseases and Injuries Collaborators, 2024).

The results of the study, which showed a significant relationship between sdmk readiness and the ability of hospitals to handle the double burden of disease, are in line with the concept of Health Workforce Planning, which emphasizes that health workforce planning should be based on service needs, not solely on

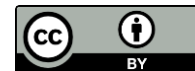


population. SDMK planning that does not consider the pattern and distribution of the burden of disease has the potential to cause discrepancies between service needs and the capacity of available health workers. Research on health workforce planning in various countries also shows that a needs-based approach is more effective in ensuring the availability of health workers than a simple ratio-based approach (Liu et al., 2022). The findings are reinforced by the results of interviews and observations at Dr. M. Djamil Padang. Informants said that although the number of health workers in general has met the standards, the distribution of personnel between service units has not been fully balanced, especially in services with a high caseload of non-communicable diseases and infectious diseases. Observations also show that an increase in the number of referrals from districts/cities in West Sumatra and surrounding provinces causes the need for health workers in certain units to be greater than the available formations. This condition requires more adaptive SDMK redistribution arrangements, strengthening competencies through continuous training, and health personnel planning that considers variations in disease burden and regional characteristics. Thus, Indonesia needs to develop SDMK planning based on service needs, disease burden, and regional context to reduce health service inequality between regions.

CONCLUSIONS

This study concludes that the readiness of Health Human Resources (SDMK) has an important role in the ability of hospitals in Indonesia to cope with the double burden of disease. Most hospitals already have sdmk readiness in the high category, but the proportion of hospitals with low readiness is still found which indicates a gap in service capacity between regions. The results of the analysis showed that sdmk readiness is significantly related to the ability of hospitals to deal with a combination of infectious and non-infectious diseases, where hospitals with better sdmk readiness have a greater chance of providing optimal service response. In addition, spatial analysis shows that the distribution of sdmk readiness is not evenly distributed, but forms a pattern of grouping certain areas with priority interventions, especially in areas with limited health workers.⁰⁰⁰ The implications of this study indicate that SDMK planning and strengthening needs to be done through a regional needs-based approach and disease burden characteristics. The use of spatial analysis can be an important instrument in determining the priority distribution of health workers, competence development, and strengthening hospital service networks. Dr. M. Djamil Padang as a Regional Referral Hospital has strategic potential to be developed as a center for strengthening SDMK capacity through training programs, assistance, and collaboration with hospitals in regions with limited resources. This approach is expected to support the equitable distribution of Health Care Quality and strengthen the resilience of the National Health System in the face of epidemiological changes.

This study has some limitations that need to be considered in the interpretation of the results. First, the cross-sectional study design only describes sdmk readiness conditions and hospital capabilities in one observation period so that it cannot explain the longitudinal causal relationship. Second, some of the research data came from secondary data of the National Health Information System so that the quality of the analysis results depends on the completeness and consistency of each hospital's reporting. Third, although spatial analysis is able to identify distribution patterns and priority areas, this study has not examined in depth the social, economic, regional policies, and retention of health workers that can affect the distribution of SDMK. Therefore, further research is recommended to use a longitudinal design with a mixed methods approach to identify determinants of SDMK inequality more comprehensively and evaluate the effectiveness of region-based interventions. In addition, the results of this study can serve as a basis for the Ministry of Health in developing an evidence-based sdmk equalization policy through the use of spatial analysis as part of National Planning. One strategy that can be considered is the implementation of incentive schemes and retention of health workers based on spatial risk zones, by providing proportionate financial and nonfinancial incentives



for health workers serving in areas with SDMK shortages or high double burden of disease. The policy can be combined with the redistribution of health personnel, career path development, ongoing education and training support, and regular monitoring using Geographic Information Systems to ensure interventions are more targeted and sustainable.

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