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# Spatial mapping and determinants of health performance in North Sumatra province

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**Abstract:** The province of North Sumatra has the lowest health performance in Sumatra, with disparities amongst districts /cities. This study aims to analyze the health performance factor of North Sumatra districts/cities using a Geographically Weighted Panel Regression (GWPR) model analysis in 33 districts/cities with a time series of 2012-2019. The analysis results showed that the determinants of health performance differed between districts/cities grouped into 15 groups based on influencing factors and four clusters based on the area of the development areas. The income variable has a significant positive effect on all 33 districts, the education variable has a positive effect on 19 districts, the human health resources variable has a positive effect on 12 districts, the immunization variable has a positive effect on 11 districts, the proper sanitation variable has positive on nine districts, the government spending in health sector variable has positive on five districts, and the medical facility variable has positive on one district namely Karo. Determinants in the Nias Island Area: income, government spending in the health sector, and human resources. West Coast area: income, education, and proper sanitation. East Coast Area: income, education, health, human resources, and immunization. The determinant Highland area differs between regencies/cities. To improve the performance of health development in the province, it is necessary to carry out a spatial approach based on cluster equations and influencing factors. Increased income, education, and human health resources must be prioritized in almost all district areas.

**Keywords:** GWPR; Health Performance; North Sumatra; Spatial Mapping
**JEL Classification**: I150; I180

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## Introduction

Human development puts health indicators into the main measurement component in addition to economic and educational indicators. The fundamental need and human right that must be met is health because every human being needs to be healthy to move and survive (de Campos 2012). Health is a major component of well-being and a prerequisite for increasing productivity (North Sumatra Health Office (Dinkes), 2020). Bloom et al. (2004) and Anwar (2018) empirically prove that health positively affects economic growth through increased worker productivity.

To realize the Sustainable Development Goals (SDGs), the government created a health development program reflected in the third goal: ensuring a healthy life system and increasing the population's prosperity

at all ages. The goal is to prevent child mortality, maternal mortality, and the death of people aged less than 70 years due to disease (BPS - Statistics Indonesia, 2019).

Demand in the health economy is a derivative demand, namely goods or services consumed/used by consumers to produce output in the form of health. The demand is the level of immunization services, the level of bed occupancy, the number of dental poly services, the number of diagnostic tests, and so on. The determinants of demand for health services are price, patient income, patient preferences, and alternative goods (Folland et al., 2012).

Health supply is procuring health services intended for consumers/patients by a combination of human resources for health services and physical health facilities (hospitals, clinics, and clinical laboratories). The determinants of health services include human resources, finance, materials, methods, markets, equipment, technology, time, and information. The production function describes the relationship between input and output currents at a certain time. Health status is a production function of improving health services influenced by biological, environmental, and lifestyle characteristics. An improvement in one of these factors will shift the production function upwards. Health services consist of many inputs. The marginal contribution of health care is its marginal product, meaning the amount of improvement in health performance caused by an additional unit of health services assuming ceteris paribus (Janis, 2014).

Health services are one of the production factors in producing the output of healthy days. As a production function, health services can be combined with other inputs, such as environmental factors, socioeconomic culture, and individual internal factors in the production process, to produce health outputs (Trisnantoro, 2006).

The estimate of the average length of a person's life is defined as Life Expectancy (UHH). The indirect estimation approach is used to calculate Life Expectancy (UHH). Life Expectancy was obtained from Live Born Children (ALH) and Living Children (AMH) data. Based on the standards set by UNDP, the highest life expectancy value is 85 years, while the lowest life expectancy value is 20 years (BPS - Statistics Indonesia, 2019). Ideally, UHH is accumulated based on the age-specific death rate. The data is sourced from the death registration, which is recorded periodically, making it easier to create a death table. However, this method cannot be implemented in Indonesia because the population registration system in Indonesia has not been implemented properly. Therefore, the Mortpak Lite program is used in Indonesia, which is an indirect method to calculate UHH. Mortpak Lite is a software released by UNDP for demographic measurement in developing countries that emphasizes mortality estimation. To obtain the indicator's constituent variables, other methods can obtain data, including a Population Census and an Inter-Census Population Survey (SUPAS). Population Census and SUPAS activities are carried out by the Central Statistics Agency (BPS - Statistics Indonesia, 2019).

UHH is a benchmark for countries and regions in determining whether or not the government's steps successfully improve people's welfare. The government's efforts through maximum support for public health can be seen in the development of UHH

(Wardhana et al., 2018; Sambodo, 2018). In addition to determining the level of public health, the quality of life of people and health services organized through health development efforts are also illustrated by UHH (North Sumatra Health Office (Dinkes), 2019). UHH is a media that is used to analyze the government's performance, which generally seeks to improve public welfare and, in particular, the quality of health (BPS - Statistics Indonesia, 2019).

Health performance measurement is carried out by measuring mortality and morbidity rates, and life expectancy is information about mortality rates (Notoadmodjo 2011). Mahumud et al. (2013); Ministry of Health (2020), life expectancy is often used to plan and evaluate public health performance. Research results from Foreman et al. (2018) revealed that Indonesia's life expectancy in 2040 is predicted to be 76.77 years to be ranked sixth in the Southeast Asian region and the highest position reached by Singapore at 85.4 years.

Indonesia's life expectancy in 2015-2019 had a positive trend of 70.78 (2015), then rose to 71.34 (2019). The same trend occurs at the provincial level, but there are still many provinces whose performance is below the national level, 25 provinces (76%) out of 33 provinces, including all of Sumatra Island except Riau Province (Figure 1).

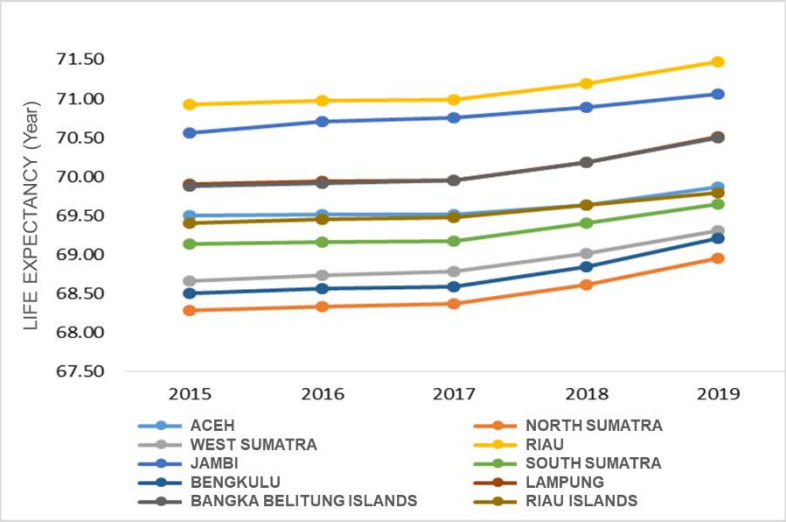


**Figure 1** Life expectancy by province on Sumatra Island in 2015 – 2019
Source: BPS - Statistics Indonesia (2021)

North Sumatra Province has GRDP at the highest position in Sumatra and fifth place in Indonesia, but the lowest health performance in Sumatra during 2015-2019 (Figure 2). This is not in line with the results of previous research, namely Zaini (2013); Ali et al. (2014) that per capita income is significantly positive with health performance as measured by life expectancy.

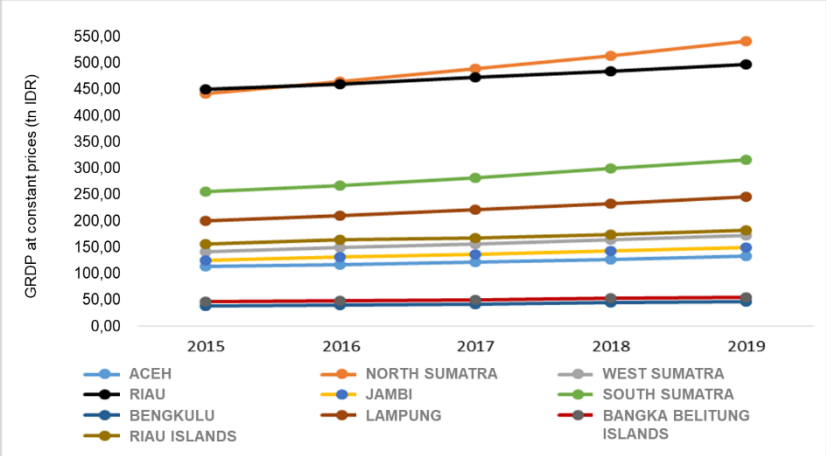


**Figure 2** GRDP at constant prices by the province in Sumatra Island in 2015 – 2019
Source: BPS - Statistics Indonesia (2020)

The HDI concept is measured by a three-dimensional approach, namely the health, education, and economic dimensions. Regarding health dimensions, North Sumatra Province is below the national figure. Based on national rankings, the life expectancy indicator has the lowest rank compared to education and economic dimension indicators (Table 1).

**Table 1** HDI Indicators of North Sumatra Province and Indonesia in 2019

| HDI Indicators | North Sumatra | Indonesia | North Sumatra Ranking |
|---|---|---|---|
| Life expectancy (years) | 68.95 | 71.34 | 24 |
| Expected Length of School (years) | 13.15 | 12.95 | 13 |
| Average Length of School (years) | 9.45 | 8.34 | 5 |
| Expenditure Per Capita (million rupiah) | 10.65 | 11.30 | 18 |
| HDI | 71.74 | 71.92 | 12 |

Source: BPS – North Sumatra (2019)

In addition to being in the lower position, the life expectancy of North Sumatra Province based on the regency/city level shows inequality. In 2019, the highest number was 73.33 years in Pematang Siantar, and the lowest was 62.51 years in Mandailing Natal, with a difference of 10.82 years (Figure 3 & Figure 4).

Figure 3 demonstrates that from 2015 to 2019, the provincial life expectancy in Sumatra was consistently lower than the national life expectancy, despite both seeing modest increases. In 2015, the life expectancy in North Sumatra was 68.29, while the national life expectancy was 70.78. In 2019, the life expectancy in North Sumatra was 68.95, while the national life expectancy was 71.34.

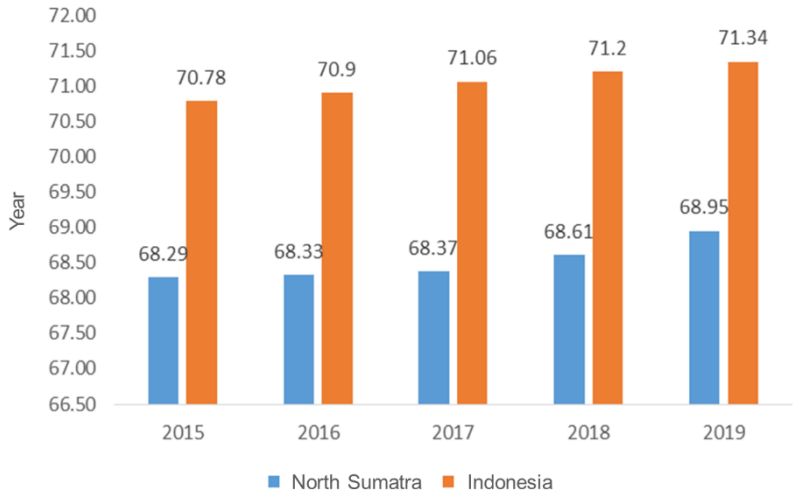


**Figure 3** Comparison of life expectancy trends in Indonesia and North Sumatra in 2015 – 2019
Source: BPS - Statistics Indonesia (2021)

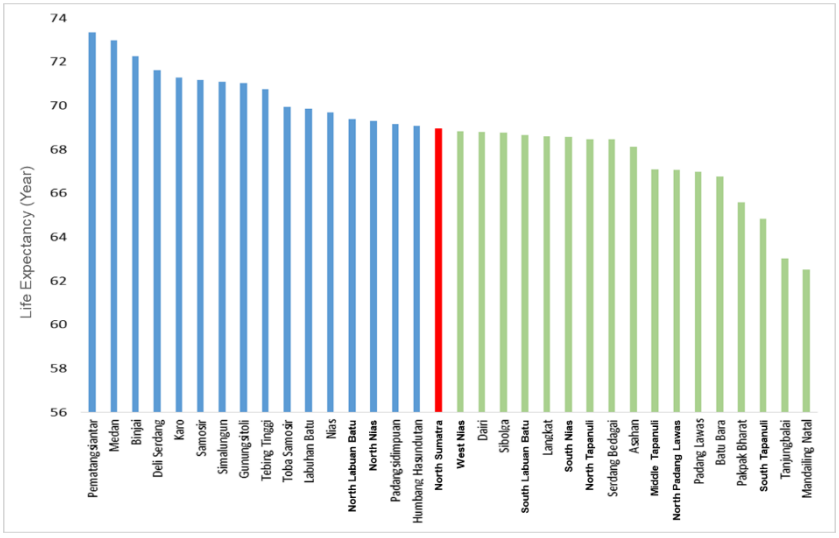


**Figure 4** Life expectancy by regency/city in North Sumatra Province in 2019
Source: BPS - Statistics Indonesia (2021)

Figure 4 shows the unequal condition of life expectancy between districts and cities in North Sumatra province, the highest figure is shown by Pematang Siantar, with a life expectancy of 74, while Mandailing Natal shows the smallest figure with a life expectancy of 64.

Life expectancy is influenced by local potential and local government policy efforts through its programs to improve health performance. In the era of regional autonomy, efforts to increase life expectancy are the direct responsibility of local governments at the regency/city level. The condition of the adjacent area influenced the business.

Differences in regional potential between regencies /cities in North Sumatra Province, both in terms of natural resources, human resources, and socioeconomic and cultural conditions, will affect health performance, according to the results of the studies by Joumardi et al. (2008); Paripurna et al. (2017); Bilas et al. (2014); Ali et al. (2016); Kristanto et al. (2019). Differences in conditions between development areas with four regional groups with different characters and structures can also be differences in health performance. Differences in fiscal capability between districts /cities will also cause differences in existing development performance, according to the results of the studies are Sari et al. (2019) and Zaini (2013).

The study analyzed the determinants of health development performance in North Sumatra. Some of the research that has been done is analyzed by panel regression analysis which assumes that the condition of the area is homogeneous without spatial heterogeneity. Responding to the condition of the area, it is necessary to test spatial heterogeneity (spatial dependence), one of which is the Breusch-Pagan statistical test. Spatial dependence testing is an effort to check whether test data at one location is correlated with tests in other places at a close distance. The following tests are important to carry out, considering that if ignored, the estimated results can be inefficient, so biased conclusions will be obtained (Rahayu, 2017; Perdana, 2015; Pongoh et al. 2015; Bruna & Yu, 2013). The use of spatial analysis if the test results are met (Rahayu, 2017; Bruna & Yu, 2013; Mahumud et al. 2013; Yu 2010; Rahman et al., 2023; Lymperopoulou & Baniiister, 2022). Based on background and problems, this study intends to map and analyze the determinants of health performance in each district/city of North Sumatra Province spatially.

## Research Method

### Type and Data Resource

This study used secondary data from panel data, namely cross-sectional data from 33 districts/cities in North Sumatra Province, and time series data for nine years from 2010 to 2018. The data sources are from the Central Statistics Agency (BPS) and the North Sumatra Health Office (Dinkes).

### Research Variables

The variables used in the study were life expectancy (UHH) as a dependent variable and seven independent variables, namely GRDP per capita, government spending in the health sector, expected length of the school, proper sanitation, health facilities, human health resources, and immunization coverage. The data are presented in Table 2.

**Table 2** Variables, Units, and Sources Used in Research

| Variable | Explanation | Unit | Source |
|---|---|---|---|
| Y | Life Expectancy | Year | BPS |
| X1 | GRDP Per Capita | Rupiah | BPS |
| X2 | Government Spending in Health | Rupiah | Health Office |
| X3 | Expected Length of School | Year | BPS |
| X4 | Proper Sanitation | Percent | BPS |
| X5 | Health Facilities | Unit | Health Office |
| X6 | Human health Resources | Person | Health Office |
| X7 | Immunization Coverage | Percent | Health Office |

**Method Analysis**

To analyze the determinants of health performance in each regency/city of North Sumatra Province, the analysis applied is the Geographically Weigthed Panel Regression (GWPR) which is a development of the Geographically Weigthed Regression (GWR). GWR model parameter estimation was carried out using the Weighted Least square (WLS) method by giving different weights to each observation location. The role of weights in the GWR model is significant because the values of these weights represent the location of the observation data with each other. Estimation of GWR model parameters using the Weighted Least Square (WLS) method by providing different weights at each observation location. The role of weighting is to represent the observation data's location with each other. Several weights can be used, including the distance inverse and kernel weighting functions. The weighting value of data will be close to one if the distance is close together or coincides and will get smaller if the distance is further away.

The stages in the GWPR analysis are the first, estimate of the global panel regression model. The Chow and Hausman tests are carried out to get the best model. The best model will be obtained from these tests with FEM or REM analysis. Furthermore, dependency and heterogeneity tests were carried out using the Breusch-Pagan and Pasaran's CD tests. If heterogeneity of the problem is found, it is followed by GWPR analysis by finding the optimal bandwidth and carrying out weighting with of adaptive bisquare, gaussian or exponential, followed by local analysis. The results of the local analysis are mapped spatially based on the equation of the determinant factors and based on regional development planning.

The GWR model is in mathematically as follows:

$$UHH_{it} = \alpha\ (\ \mu_i\ ,\ v_i\ )\ +\ \beta_1(\mu_{it}, v_{it}) Ln\ PdrbK_{it}\ +\ \beta_2(\mu_{it}, v_{it})\ PersenKes_{it}\ +\ \beta_3(\mu_{it}, v_{it})\ HLS_{it}\ +\ \beta_4(\mu_{it}, v_{it}) San_{it}\ +\ \beta_5(\mu_{it}, v_{it})\ Faskes_{it}\ +\ \beta_6(\mu_{it}, v_{it})\ SdmKes_{it} + \beta_7(\mu_{it}, v_{it})\ \mathrm{Imun}_{it} + \varepsilon_{it}$$

Where the notation means:

$\beta_j$ : Slope Variabel (j = 1,2,…,9); $i$ : Districts/cities (*i*=1, 2,…,33); $t$ : Year (2012, 2013,…,2019); $\varepsilon$ : Error ; $UHH$ : Life Expectancy ; $PdrbK$ : Income per Capita; $PPKes$ : Government Spending in the Health Sector ; $HLS$ : Expected Length of School ; $San$ :

Proper Sanitation ; $Faskes$ : Health Facilities ; $SdmKes$ : Human Health Resources ; $Imun$ : Immunization Coverage ; $(\mu_i,v_i)$ : Latitude dan longitude coordinates of the midpoint of a region

All independent variables (life expectancy, income per capita, government spending in the health sector, expected length of school, proper sanitation, health facilities, human health resources, and immunization coverage) are hypothesized to positively affect the dependent variable, namely life expectancy.

## Result and Discussion

**Determinants of Health Performance in Each District/ City of North Sumatra Province**

First, a panel regression was performed with the global model. The selection of the best model was carried out using the Hausman test. Based on the Hausman Test that has been carried out, a decision was made to reject H0 with a probability value of 0.0004 < α (0.05), therefore it can be concluded that the model that should be chosen is the FEM model rather than the REM model at a significant level of 5%. Because the panel regression applied in GWPR modeling is the FEM model with a within estimation, it is necessary to make data transformations according to the concept of within estimation.

Testing whether there is an inequality of variance in the regression model from the error of one test to another is carried out with the heteroscedasticity test. The Breusch-Pagan test is one of the statistical tests that can be applied in panel regression. Based on these tests, the BP value is 36,488, and the p-value is 0.0000. The p-value of 0.0000 indicates a value less than the 1% significance level. This means that the assumption of homoscedasticity is unmet, so the resulting panel regression model detects heteroscedasticity problems. This shows the diversity of variance between observations, thus proving that the characteristics of health performance in North Sumatra Province in 2012 - 2019 have a spatial effect.

Handling this problem can be done through local modeling locally by examining existing spatial aspects, namely diversity between observation locations. With the fulfillment of spatial heterogeneity requirements, the analysis is continued to the GWPR model. The comparison between the global regression model and the GWPR model in terms of adjusted R-square, Root Mean Square Error (RMSE), and Akaike's Information Criteria (AIC) values show that the GWPR model is superior to the global regression model. The GWPR model can explain 92.0% of UHH diversity, while the FEM model can only explain UHH diversity with a percentage of 88.9%. In the GWPR model, the RMSE value is lower than in the FEM model, which is 0.116. Furthermore, the AIC value in the GWPR model is also lower than in the FEM model, which shows the number -408.7.

**Table 3** Comparison of global regression models and GWPR models

| Model | *Adjusted R2* | *RMSE* | *AIC* |
|---|---|---|---|
| Global | 0.8733600 | 0.1463164 | -288.8813 |
| GWPR | 0.9200166 | 0.1164525 | -408.7264 |

The estimation of the GWPR model starts by calculating the optimum bandwidth and spatial weighting matrix based on the Kernel Adaptive Bisquare function. The optimum bandwidth value is the bandwidth value that results in a minimum Cross Validation value. Table 4 shows that the optimum bandwidth obtained differs for each regency/city.

**Table 4** Optimum Bandwith Value by District /City of North Sumatra Province

| No | District /City | *Bandwith* | No | District /City | *Bandwith* |
|---|---|---|---|---|---|
| 1 | Nias | 6.968483 | 18 | Serdang Bedagai | 7.93052 |
| 2 | Mandailing Natal | 7.835419 | 19 | Batu Bara | 8.000971 |
| 3 | South Tapanuli | 6.084939 | 20 | North Padang Lawas | 6.502002 |
| 4 | Central Tapanuli | 4.787885 | 21 | Padang Lawas | 7.554855 |
| 5 | North Tapanuli | 4.793856 | 22 | South Labuhanbatu | 7.018423 |
| 6 | Toba Samosir | 5.873099 | 23 | North Labuanbatu | 6.606328 |
| 7 | Labuhan Batu | 7.127665 | 24 | North Nias | 7.320451 |
| 8 | Asahan | 7.153187 | 25 | West Nias | 7.469164 |
| 9 | Simalungun | 6.992386 | 26 | Sibolga | 5.098739 |
| 10 | Dairi | 6.282515 | 27 | Tanjungbalai | 7.798566 |
| 11 | Karo | 6.973728 | 28 | Pematangsiantar | 6.979519 |
| 12 | Deli Serdang | 7.986373 | 29 | Tebing Tinggi | 7.917501 |
| 13 | Langkat | 8.428603 | 30 | Medan | 8.335918 |
| 14 | South Nias | 8.428603 | 31 | Binjai | 8.203104 |
| 15 | Humbang Hasundutan | 4.984097 | 32 | Padangsidimpuan | 6.326152 |
| 16 | Pakpak Bharat | 5.559963 | 33 | Gunungsitoli | 6.930986 |
| 17 | Samosir | 5.769207 | | | |

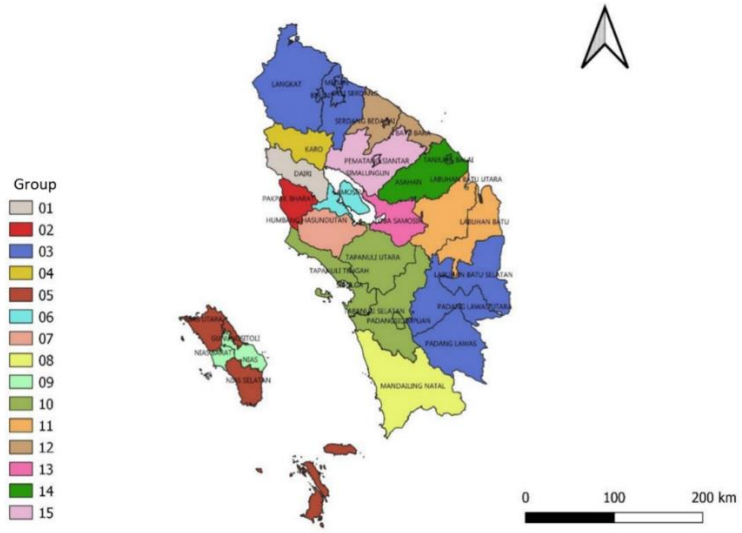


**Figure 5** Regional grouping based on significant variables that affect health performance in North Sumatra Province
Source: BPS and North Sumatra Health Office (Dinkes) (2021)

GWPR estimation was carried out at each location. The estimation results were local, meaning the 33 districts /cities analyzed in this study had different models. The grouping of districts /cities is based on significant variables. Areas that are geographically close together tend to have similar characteristics. Based on the results of the GWPR analysis, it can be seen that there is a tendency for variables to collect in a certain location. The districts/cities in North Sumatra Province are classified into 15 groups based on variables that significantly influence health performance. The grouping results are presented in Figure 5.

The first group where the significant variable positively affects health performance in the North Sumatra region is only the income variable. Only one area is included in this group, namely the Dairi district. This finding is consistent with that of Bilas et al. (2014); Zaini (2013); Delavari et al. (2016); Paripurna et al. (2017). The second group where the variables significantly affect income and government spending in the health sector. Only one area is included in this group, namely the Pakpak Barat district. The income variable has a positive effect; the government spending variable in the health sector often has a negative effect.

The third group where the influential variables are income and education variable. This group comprises seven districts: Deli Serdang, Langkat, Padang Lawas Utara, Labuhan Batu Selatan, Medan City, and Binjai City. The income variable has a positive effect, while the education variable has a negative effect. The fourth group was positively affected by income and negatively by health facilities. The area is included in the Karo district.

The fifth group where the variables that significantly influence are income and human health resources. Income and human health resources have a positive effect on health performance. The areas included in these groups were the Nias Island, namely South Nias, North Nias, and Gunung Sitoli. This finding is consistent with that of Zaini (2013); Mukti (2013); Nawawi (2012); Khariza (2015), and Kristanto et al. (2019).

The sixth group where the variables that had a significant positive effect were income and immunization coverage. The area included in this group was Samosir District. This finding is consistent with Pongoh et al. (2015) and Paripurna et al. (2017). There was just one Humbang Hasundutan District in the seventh group, where the variables with a substantial beneficial influence are income, government spending on health, and education. The income variable had a favorable effect on health performance, but government spending on health and education had a negative effect.

In the eighth group, where the variable that has a significant positive effect are income, government spending on health, and proper sanitation, there was only one Mandailing Natal. The ninth group where the variable that had a significant positive effect was income, government spending on health, and human health resources were Nias and West Nias Districts. The tenth group of variables that had a significant positive effect were income, education, and proper sanitation. These groups consist of the Districts of Tapanuli Selatan, Tapanuli Tengah, Tapanuli Utara, Sibolga, and Padang Sidempuan. Income and

proper sanitation variables have a positive effect, while education has a negative effect on health performance.

The eleventh group where the variable with a significant positive effect is income, education, and immunization coverage. The area was Labuhan Batu and Labuhan Batu Utara. The influence of income and immunization coverage were positive, while the education variable negatively affected health performance. The variables significantly affected the twelfth group were income, human health resources, and vaccine coverage. On health performance, income and vaccine coverage have a favorable effect, but human health resources have a negative effect. These consist of Serdang Bedagai, Batu Bara, and Tebing Tinggi Districts.

The variables affecting the thirteenth group include income, education, appropriate sanitation, and immunization. Only one area was included in this group, namely Toba Samosir District. Income, immunization, and proper sanitation variable have a positive effect, while education has a negative effect on health performance. The fourteen groups were the variable that significantly affected income, education, human health resources, and immunization coverage. These areas were Asahan and Tanjung Balai Districts. Income and immunization coverage variables have a positive effect, while education and human health resources have a negative effect.

The fifteenth category, where income, appropriate sanitation, human health resources, and vaccine coverage have substantial effects. The area are Simalungun District and Pematang Siantar City. The income and immunization coverage variable has a positive effect, while the education and human health resources variable negatively affects health performance. The income variable has a significant positive effect on all 33 districts, the education variable has a positive and negative effect on 19 districts, the human health resources variable has a positive and negative effect on 12 districts, the immunization variable has a positive effect on 11 districts, the proper sanitation variable has positive on 9 districts, the government spending in the health sector variable has positive and negative on 5 districts, and the medical facility variable has positive on one district namely Karo.

**Determinants of Health Performance of North Sumatra Province according to Development Area**

In addition to being based on significant variables, the grouping of districts /cities in North Sumatra Province is classified based on regional development planning. Based on the regional development planning, North Sumatra Province consists of 4 areas, namely:

Nias Island Area

Health performance in Nias Island is influenced by income, government spending in the health sector, and human health resources. Based on the determinants, it can be said that health performance in this region is very similar between districts/cities. Nias and West Nias Districts are affected by income, government spending in the health sector, and

human health resources. Health income and human resources affect South Nias, North Nias, and Gunung Sitoli Districts. All districts on Nias Island are designated as underdeveloped areas in Presidential Regulation (Perpres) Number 63 of 2020 concerning the Designation of Underdeveloped Regions for 2020-2040. Improving the economy, namely people's income, increasing the government's participation in allocating the health sector budget, and equitable distribution of health workers to remote areas must be a priority to improve health performance on Nias Island.

**Table 5** Grouping of district /cities based on significant variables for the Nias Island Area

| Group | Significant Variable | District/City |
|---|---|---|
| I | X1, X2, X6 | Nias, West Nias |
| II | X1, X6 | South Nias, North Nias, Gunung Sitoli |

West Coast Area

Income, education, and sanitation levels generally affect health performance in the West Coast Area. The scope of this area is divided into three groups based on the influencing variables. The first group is influenced by income, education, and sanitation: South Tapanuli District, Central Tapanuli District, Sibolga City, and Padang Sidempuan City. The second group consists of only one district, Mandailing Natal, where the variables that affect it are income, government spending in the health sector, and proper sanitation. The third group is influenced by income and education, namely Padang Lawas and North Padang Lawas District.

**Table 6** Grouping of district /cities based on significant variables for the West Coast Area

| Group | Significant Variables | District/City |
|---|---|---|
| I | X1, X3, X4 | South Tapanuli, Central Tapanuli, Sibolga, Padang Sidempuan |
| II | X1, X2, X4 | Mandailing Natal |
| III | X1, X3 | Padang Lawas and North Padang Lawas |

East Coast Area

In the East Coast area, the determinants of health performance are income, education, human health resources, and immunization. This area is divided into four groups based on the determinants of health performance. The first group is influenced by income, education, human health resources, and immunization variables: Asahan District and Tanjung Balai City. The second group is influenced by income, education, and immunization variables, namely Labuhanbatu and North Labuhanbatu. The third group is influenced by income, human health resources, and immunization: Serdang Bedagai District, Batu Bara District, and Tebing Tinggi City. The fourth group is influenced by income and education variables, namely Deli Serdang District, Langkat District, South Labuhan Batu District, Medan City, and Binjai City.

**Table 7** Grouping of districts/cities based on significant variables for the East Coast Area

| Group | Significant Variables | District /City |
|---|---|---|
| I | X1, X3, X6, X7 | Asahan, Tanjung Balai |
| II | X1, X3, X7 | Labuhanbatu, North Labuhanbatu |
| III | X1, X6, X7 | Serdang Bedagai, Batu Bara, Tebing Tinggi |
| IV | X1, X3 | Deli Serdang, Langkat, South Labuhanbatu, Medan, Binjai |

Highland Area

The determinants of health performance in the Highland Area are different for each district/city, except for Simalungun District and Pematang Siantar City, have similar health performance models due to income, proper sanitation, number of health facilities, and immunization coverage. For example, Toba Samosir District is influenced by four variables: income, education, number of health facilities, and immunization coverage. Samosir District is only influenced by two variables, namely income and immunization coverage, while Dairi District is only influenced by one variable, namely income. Determinants of health performance in each district/city in the highland area can be seen in Table 8.

**Table 8** Grouping of district /cities based on significant variables for the Highland Area

| Group | Significant Variables | District/City |
|---|---|---|
| I | X1, X4, X6, X7 | Simalungun, Pematang Siantar |
| II | X1, X3, X4, X7 | Toba Samosir |
| III | X1, X3, X4 | North Tapanuli |
| IV | X1, X2, X3 | Humbang Hasundutan |
| V | X1, X5 | Karo |
| VI | X1, X2 | Pakpak Bharat |
| VII | X1, X7 | Samosir |
| VIII | X1 | Dairi |

## Conclusion

The health performance of North Sumatra Province, as measured by life expectancy (UHH) indicators, shows an upward trend from 2015 to 2019, but is consistently behind the national average. In addition to underperformance, there was inequality amongst districts/cities, with Pematang Siantar District having the greatest performance (73.33) and Mandailing Natal having the lowest (62.51), a discrepancy of 10.82.

This study attempts to analyze the determinants of North Sumatra's health performance with the Geographically Weighted Panel Regression (GWPR) model, analysis in 33 districts/cities with a time series of 2012-2019. The results of the analysis showed that the determinants of health performance differed between districts/cities grouped into 15 groups based on influencing factors and four clusters based on the area of the development areas.

The income variable has a significant positive effect on all 33 districts, the education variable has a positive and negative effect on 19 districts, the human health resources variable has a positive and negative effect on 12 districts, the immunization variable has a positive effect on 11 districts, the proper sanitation variable has positive on nine districts, the government spending in the health sector variable has positive and negative on five districts, and the medical facility variable has positive on one district namely Karo. Health performance determinants differ in each district/city of North Sumatra Province. In the Nias Island area, health performance is caused by income, government spending in the health sector, and the number of human health resources. In the West Coast area, health performance is caused by income, government spending in the health sector, education, and proper sanitation. The East Coast area is caused by income, education, the number of human health resources, and immunization coverage. The determinants of the Highland area has differences between district/cities except for Simalungun district and Pematang Siantar city, which have similar determinants of health performance.

**Recommendation**

To improve the performance of health development in the province, it is necessary to carry out a spatial approach based on cluster equations and influencing factors. Increased income, education, and human health resources must be prioritized in almost all district areas.

The Government of North Sumatra needs to increase the development of health-oriented education. This can be done by promoting school health business activities (UKS) so that people understand the importance of health from an early age. It is also necessary to collaborate with the communication and information sector through the dissemination of health information.

The North Sumatra Provincial Government is trying to increase the health sector budget, especially for activities that directly impact public health, to influence health performance in North Sumatra Province positively.

The policies implemented to improve health performance in North Sumatra Province are not the same for each district/city. The community's economy needs to be improved by all district/city governments, which can be done through increasing the UMKM sector and increasing regional investment, which is expected to create new jobs for the people. As an underdeveloped and remote area, there should be an increase in the equitable distribution of health workers on Nias Island. Promotive health efforts in the form of counseling related to environmental health to increase the coverage of proper sanitation are mainly carried out in the West Coast area. Immunization coverage should also be increased, especially in the East Coast area, by establishing effective communication between health workers, cadres, and the public.

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