Jurnal Pijar MIPA
https://jurnalfkip.unram.ac.id/index.php/JPM

ISSN 1907-1744 (Print)
ISSN 2460-1500 (Online)

Spatial Autoregressive Quantile Regression Modeling of the Distribution of Drug Users in the District Karo

Nanda*, Macrani Adi Putri Siregar

Mathematics Study Program, Universitas Islam Negeri Sumatera Utara, Sumatera Utara, Indonesia
*E-mail: nandantok29@gmail.com

Received: February 9, 2024. Accepted: February 26, 2024. Published: March 19, 2024

Abstract: BNN data shows that an average of 50 people die from drugs every day, and Karo Regency is in second place for the distribution of drug abuse in North Sumatra after Medan City. Variables that have this risk include drug factors, namely availability and ease of obtaining drugs, individual factors, environmental factors, family factors, and social factors. Based on this, a model is needed to determine the development of the case. The SARQR model combines SAR modeling with quantile regression (QR). Combining the SAR model with quantile regression produces a model that is good for overcoming the problems of dependency and heterogeneity in modeling spatial data and is resistant to outlier data. This research aims to determine the Spatial Autoregressive Quantile Regression Model for the distribution of drug users in the Karo Regency. The type of research used is quantitative research. The data type used is secondary data, namely, the kind of data already existing, and the data source used in this research is drug users in the Karo district. The research results show that the Spatial Autoregressive Quantile Regression model for the distribution of drug users in Karo Regency obtained estimation results for the distribution parameters of drug users using a significance test. This model explains that the factors that significantly influence drug abuse are age, gender, occupation, and other underlying factors.

Keywords: Drug Abuse Factors; Karo District; SARQR.

Introduction

Drug abuse is a very complex problem that requires comprehensive mitigation efforts involving cooperation and active community participation, which is carried out continuously, consistently, and consistently [1]. The development of drug abuse over time shows an increasing trend and has very detrimental consequences [2]. Narcotic abuse can have adverse effects on the user's body, both physically, psychologically and socially [3].

BNN data states that an average of 50 people die from drugs every day. Fifty people every day means around 18,000 people yearly [3]. Ironically, 18,000 human resources who should be able to provide innovation and energy to improve Indonesia's development in various sectors gave up their lives to become drug-enslaved people without making any contribution to the country [4].

Karo Regency is a strategic area for both drug distribution and use because it is the closest alternative transit point to both Medan City and Aceh Darussalam Province [5]. Karo Regency is ranked second in the distribution of drug abuse in North Sumatra after Medan City. Karo Regency also has many crime cases, which makes the residents anxious [6]. What's more, with the widespread promiscuity of young people who become dealers, dealers, and narcotics users, the number of drug cases in Karo Regency is still very high, with victims, both users and addicts, reaching thousands of people. In a year [7].

Based on research conducted [8] it shows that of the eight variables, only six variables have a relationship with the risk of drug abuse in adolescents. These variables include drug factors, namely the availability and ease of obtaining drugs, individual characteristics, environmental factors, family factors, and social factors [8].

Regression analysis is used to model the relationship between independent and dependent variables. According to [8], assumptions must be met in regression analysis. These assumptions include linear parameters, homoscedasticity, no autocorrelation, no multicollinearity, and regular distribution of errors [9]. The method used to analyze relationships between different variables is called spatial regression. This method considers the spatial influence at various locations, making it the research focus. This issue emphasizes the possibility that spatial dependence in data, spatial dependence, and spatial variability can impact spatial data [10]. Apart from these five assumptions, another assumption must be met in regression analysis: independence between observations. If an observation has a spatial effect, that is, an observation in a particular area is influenced by the area around it, then the analysis method used is spatial regression analysis [11].

Several regression models involve spatial dependence in their modeling, namely the spatial autoregressive model (SAR) with spatial dependence on the response variable, the spatial error model (SEM) with spatial dependence on the error, and the general spatial model (available spatial model/GSM) with spatial dependence on response and error [12]. Meanwhile, the spatial model for modeling spatial heterogeneity is a geographically weighted regression (GWR) model. Another alternative for modeling spatial heterogeneity and dependence is the spatial autoregressive quantile regression (SARQR) model [13].

The SARQR model is a model that combines SAR modeling with quantile regression (QR) [8]. Based on

How to Cite:
Nanda, & Macrani Adi Putri Siregar, M. A. P. (2024). Spatial Autoregressive Quantile Regression Modeling of the Distribution of Drug Users in the District Karo. *Jurnal Pijar Mipa*, *19*(2), 240–245. https://doi.org/10.29303/jpm.v19i2.6545

research conducted by Koenker and Basset (1978), quantile regression is a model that aims to minimize absolute errors with asymmetric weights to eliminate heterogeneity in the data. Another advantage of quantile regression modeling is that it produces a model resistant to outlier data. Combining the SAR model with quantile regression creates a model that is good for dealing with problems of dependency and heterogeneity in spatial data modeling and is also resistant to outlier data [11]. A resistant estimate is an estimate that is relatively unaffected by significant changes in small parts of the data or minor changes in large parts of the data.

According to [14], SARQR aims to determine the causal relationship of one or more independent variables to the dependent variable. Quantile Regression seeks to explain the relationship between the dependent variable and the dependent variable at various quantile levels. According to [12], quantile regression is a technique that describes the relationship between the dependent and independent variables at different quantile levels. This method will obtain more information regarding the relationship between the dependent and independent variables through quantile values [8].

Based on the background description along with the problem formulation that has been determined in carrying out the research, this research aims to find out what the Spatial Autoregressive Quantile Regression Model is for the distribution of drug users in Karo Regency and to find out what the results of parameter estimation are for the distribution of drug users.

Research Methods

The type of research used is quantitative research. Quantitative research involves collecting, processing, analyzing, and presenting data that requires using numbers, starting from collecting, interpreting, and displaying data [15]. The data type used is secondary data, namely, the kind of data already existing, and the data source used in this research is drug users in the Karo district. The data comes from the Karo Regency National Narcotics Agency (BNN).

Table 1. Research variable

Variable	Information	Variable Value	Measurement Scale
Y	Percentage of drug abuse	Percent of drug abusers from the total number of drug users	Nominal
X_1	Age factor	1. Children (0-10 Tahun) 2. Teenagers (11-17 Tahun) 3. Dewasa (>17 Tahun)	Nominal
X_2	Social and environmental factors	1. 1. Healthy 2. not healthy	Nominal
X_3	Background factors	1. Keluarga baik 2. Broken home	Nominal
X_4	Gender factor	1. Boy 2. Girl	Nominal
X_5	Educational factors	1. Elementary school graduate 2. Middle school graduate 3. High school graduate 4. College Graduate	Nominal
X_6	Job Factors	1. Work 2. Unemployment	Nominal
X_7	The factor of ease of obtaining drugs	1. Offered by a friend 2. Buying from drug dealers	Nominal

The percentage of drug abuse in Karo district was modeled using five quantile levels, which are commonly used levels, namely 0.1, 0.25, 0.5, 0.75, and 0.95. The percentage grouping of drug abuse is presented in Table 2.

Table 2. Grouping Percentage of Drug Abuse for Each Quantile Level (source: Risky et al., 2021)

Variable	Coefficient	Standard Error	Z	$p-values$
Spatial Lag	Nominal	Nominal	Nominal	Nominal
intercept	Nominal	Nominal	Nominal	Nominal
X_1	Nominal	Nominal	Nominal	Nominal
X_2	Nominal	Nominal	Nominal	Nominal
X_3	Nominal	Nominal	Nominal	Nominal
X_4	Nominal	Nominal	Nominal	Nominal
X_5	Nominal	Nominal	Nominal	Nominal
X_6	Nominal	Nominal	Nominal	Nominal
X_7	Nominal	Nominal	Nominal	Nominal
IV	Nominal	-	-	-

The implementation procedures used to achieve the research objectives are presented in Figure 1.

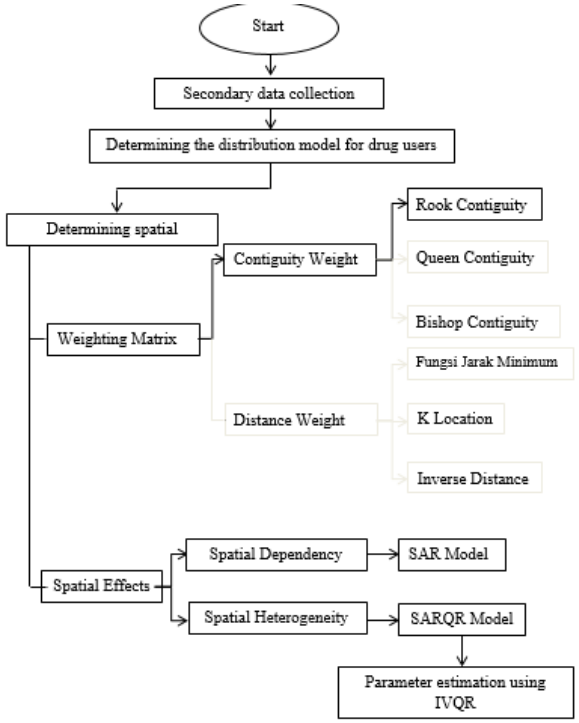

Figure 1. Research Flow Chart (Flowchart)

Results and Discussion

Data on drug abuse cases in 2023 at the Karo Regency National Narcotics Agency (BNN). Data processing in this research was done using Geoda software [16]. The following is data on drug abuse cases by sub-district in Karo Regency in Table 3.

Based on Table 3, it can be seen that the total number of drug users in Karo Regency is 116 people, where the highest number of cases were in the Berastagi subdistrict, and the lowest cases occurred in the Laubaleng subdistrict. Drug abuse cases that occur in Karo Regency are caused by several factors, such as age, gender, education, employment, social environment, background, and ease of obtaining drugs. Drug abuse data based on these factors is presented in Table 4.

Spatial Matrices and Weighting

In spatial analysis, the main component needed is a location map to determine the presence of spatial autocorrelation. The map is used to determine the close relationship between drug abuse cases between sub-districts in Karo Regency [17]. This way, it will be easier to weight each location or sub-district. From the sub-districts in Karo Province, it is known that there are 17 sub-districts, so the spatial weighting matrix will measure 17x17. Based on the spatial weighting matrix, it can be seen how many neighboring locations each district has. The graph of the number of neighborhoods for each district is as follows figure 2.

Table 3. Cases of Drug Abuse in Karo Regency

List of Districts in Karo Regency	Number of Drug Users
Barusjahe	5
Berastagi	13
Dolat Rayat	5
Juhar	5
Kabanjahe	17
Kutabuluh	7
Laubaleng	2
Mardingding	4
Merdeka	4
Merek	11
Munte	3
Naman Teran	7
Payung	4
Simpang Empat	8
Tigabinanga	9
Tigaderket	5
Tigapanah	7
Total	116

Table 4. Drug Abuse Cases Based on Variables

Variable	min	max	Average	Standard Deviation
Percentage of drug users	2	17	6.823529	3.876779
Age factor	0	14	3.411765	3.619121
Gender factor	0	17	3.411765	4.236334
Educational Factors	0	9	1.705882	2.007886
Occupation factors	0	17	3.515152	4.395461
Social Environmental Factors	0	16	3.411765	3.734505
Background Factors	0	14	3.411765	3.294786
Ease of Obtaining Drugs Factors	0	16	3.411765	3.50854

The number of neighbors graph (Figure 2) is a graph that explains the number of sub-districts that are directly adjacent to each other according to the provisions of rook contiguity with the sub-district being observed. Based on Figure 3, it can be seen that the sub-district that has the most location boundaries (neighbors) is the Barusjahe Sub-district, namely four neighbors.

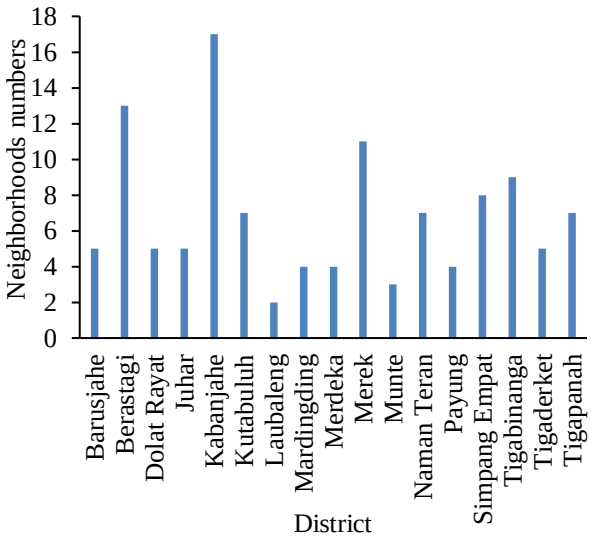

Figure 2. Neighborhoods of Each District

Spatial Regression

In spatial regression, the Moran Index test is carried out. The Moran Index (Moran's Index) is a spatial analysis technique that can be used to determine the existence of spatial autocorrelation between observation locations.

Table 4. Moran Index

y_i	y_j	$\bar{y}$	$(y_i - \bar{y})$	$(y_j - \bar{y})$	$(y_i - \bar{y})^2$
5	5	116	-111	-111	12321
13	13	116	-103	-103	10609
5	5	116	-111	-111	12321
5	5	116	-111	-111	12321
17	17	116	-99	-99	9801
7	7	116	-109	-109	11881
2	2	116	-114	-114	12996
4	4	116	-112	-112	12544
4	4	116	-112	-112	12544
11	11	116	-105	-105	11025
3	3	116	-113	-113	12769
7	7	116	-109	-109	11881
4	4	116	-112	-112	12544
8	8	116	-108	-108	11664
9	9	116	-107	-107	11449
5	5	116	-111	-111	12321
7	7	116	-109	-109	11881
116	116	1972	-1856	-1856	202872

Based on Table 4, a positive Moran index indicates positive autocorrelation, and a positive Moran index indicates positive autocorrelation [18]. From testing the Moran Index, it was concluded that at a significance level of 5%, it was stated that there was spatial autocorrelation of the number of drug cases in Karo Regency in 2023. The Moran Index value of 0.007 was in the range and indicated the existence of positive spatial autocorrelation. Still, the correlation could be weak because it was close to zero [9]. This means that it is concluded that one sub-district does not have similar values or indicates that the data is not grouped [11]. Setelah menggunakan Geoda, hasil perhitungan Indeks Moran adalah 0,77.

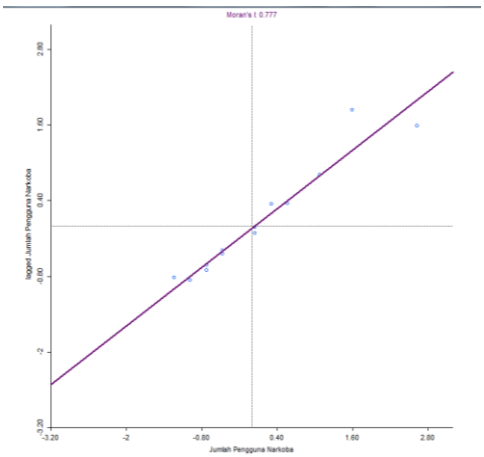

Figure 3. Moran Index

In the significance test, a normal approach is used to determine whether there is spatial autocorrelation. The hypothesis test is as follows:

H0: There is no spatial autocorrelation

H1: There is spatial autocorrelation

Table 5. Heterogeneity Test Results with Breusch Pagan Godfrey

F-Statistic	255.2222	Prob. F(6,109)	0.0000
R-Squared	108.2918	Prob.Chis-Squared (6)	0.0000
Scaled explained SS	163.8714	Prob. Chi-Squared. Chi-Squared (6)	0.0000

Spatial effect testing in the form of spatial dependency tests and spatial diversity tests was carried out again on the SAR model. This is done to check whether the SAR model can overcome spatial effects well. In the spatial heterogeneity test, m was obtained $p - value$ of 0.000, which is a value greater than the actual level of 0.05, meaning that the regions do not have the same variance.

Spatial Autoregressive (SAR) Modeling

The SAR model shows characteristics where $\rho \neq 0$ and $\lambda = 0$. In the context of this model, there is a spatial lag dependence. Estimates for SAR model parameters are in Table 6.

Based on Table 6, using a significance level of 5%, the probability value for X1 is 0.009; this result shows that this value significantly influences drug abuse cases [11]. Furthermore, X2 is 0.0004; these results indicate that this value significantly affects drug abuse cases. Then, at X3, it is 0.557; these results suggest that this value does not

substantially influence instances of drug abuse. At X4 of 0.013, these results indicate that this value significantly affects drug abuse cases. Then, the X5 is 0.1353; these results suggest that this value does not substantially influence drug abuse cases. At X6 of 0.002, these results suggest that this value significantly affects drug abuse cases. Furthermore, X7 is 0.804; these results indicate that this value dramatically influences drug abuse cases.

Table 6. SAR Model Parameter Estimation

Variable	Coefficient	Std.Error	t-Statistics	Probability
Constant	-0.13108	0.126554	-1.0423	0.32446
x1	0.180647	0.055462	3.25711	0.00988
x2	0.603646	0.113318	5.32701	0.00048
x3	-0.03974	0.065186	-0.60958	0.55722
x4	0.424371	0.138699	3.05965	0.01358
x5	0.104494	0.063709	1.64018	0.13539
x6	-0.12119	0.029798	-4.06697	0.00281
x7	0.008059	0.031623	0.254843	0.80457

Based on these results, the factors that significantly influence drug abuse are age, gender, occupation, and background factors.

Table 6 shows the model using SAR; the results of the model are as follows:

$$Y = -0,139 + 0,180X_1 + 0,603X_2 - 0,039X_3 + 0,424X_4 + 0,104X_5 - 0,121X_6 + 0,008X_7$$

Spatial Autoregressive Quantile Regression (SARQR) Modeling

Apart from focusing on regional analysis factors influencing drug use, we suggest using a quantile-based analysis method. This method can provide a more comprehensive picture and overview of the factors that influence inequality in various places at the quantity level. In contrast, the standard method describes it at an average level [18].

In quantile regression, various quantiles can obtain as many regression lines as the required quantiles. In this research, modeling was carried out using quantile levels, namely 0.01, 0.25, 0.5, 0.75 and 0.90 [19]. Parameter estimation was carried out using Instrumental Variable Quantile (SQR), and parameter significance testing was carried out using the Z test. Modeling results were carried out using SPSS 27 software. So, the drug abuse model uses Spatial Autoregressive Quantile Regression (SARQR) using quantiles 0.1, 0.25, 0.5, 0.75 and 0.9 are:

1) Quantile 0,1

$$Y = 2,0 + 2,0X_1 - 15,0X_2 + X_3 - 15,0X_4 - 4,0X_5 - 9,667X_6 + -15,0X_7$$

2) Quantile 0,25

$$Y = 6,274 - 2,724X_1 - 15,0X_2 - 0,501X_3 - 15,0X_4 - 4,0X_5 - 9,667X_6 - 10,0X_7$$

3) Quantile 0,5

$$Y = 8,273 - 3,273X_1 - 15,0X_2 - 2,0X_3 - 15,0X_4 - 4,0X_5 - 9,667X_6 - 8,0X_7$$

4) Quantile 0,75

$$Y = 11,308 - 4,308X_1 - 15,0X_2 - 0,967X_3 - 15,0X_4 - 4,0X_5 - 9,667X_6 - 8,0X_7$$

5) Quantile 0,9

$$Y = 13 - 4,0X_1 - 15,0X_2 - 6,0X_3 - 15,0X_4 - 4,0X_5 - 9,667X_6 - 6,0X_7$$

Conclusion

Based on thorough analysis, it was concluded that the Spatial Autoregressive Quantile Regression model for the distribution of drug users in Karo estimating parameters on the distribution of drug users using the model significance test explains that the factors that significantly influence drug abuse are age, gender, occupation, and background factors.

References

[1] Purbanto, H., & Hidayat, B. (2023). Systematic Literature Review: Penyalahgunaan Narkoba di Kalangan Remaja dalam Perspektif Psikologi dan Islam. *Al-Hikmah: Jurnal Agama dan Ilmu Pengetahuan*, *20*(1), 1-13.

[2] Banjar, H., *Narkoba dari Masa ke Masa*. Medan: Mitra Medan, 2019.

[3] Lukman, G. A., Alifah, A. P., Divarianti, A., & Humaedi, S. (2021). Kasus narkoba di Indonesia dan upaya pencegahannya di kalangan remaja. *Jurnal Penelitian Dan Pengabdian Kepada Masyarakat (JPPM)*, *2*(3), 405-417.

[4] Zulkarnain, A. (2020). *Fenomenologi terhadap Kalangan Pemuda Penyalahgunaan Narkoba di Perumnas Wekke'e Kota Parepare* (Doctoral dissertation, IAIN Parepare).

[5] Saputra, H., & Chalim, M. A. (2018). Penerapan sistem pemidanaan terhadap pelaku tindak pidana penyalahgunaan narkoba (Studi kasus di Polda Jateng). *Jurnal Daulat Hukum*, *1*(1).

[6] Santi, G. A. N., Yuliartini, N. P. R., & Mangku, D. G. S. (2019). Perlindungan Hukum Terhadap Korban Tindak Pidana Penyalahgunaan Narkotika di Kabupaten Buleleng. *Jurnal Komunitas Yustisia*, *2*(3), 216-226.

[7] Wirasila, A.A.N. dan Purwani, S.P.M.E., Tindak Pidana Narkotika Dan Penanggulangan (Bagian Hukum Pidana), Universitas Udayana, Bali, 2017.

[8] Wardani, R. A. (2018). Pemodelan Regresi Kuantil Spasial Autoregresif (Sarqr) untuk Mengatasi Efek Spasial Pada Data Yang Mengandung Outlier (Studi Kasus Pada Data Tingkat Kriminalitas Provinsi Jawa Tengah). *Universitas Negeri Semarang*.

[9] Yasin, H., Waryanto, B., & Hakim, A. R. (2020). Regresi Spasial (Aplikasi dengan R). *Ponorogo: WADE Group*.

[10] Arum, P. R., Gautama, R. P., Fitriani, I., & Naza, F. (2023). Identifying Factors that Influence Life Expectancy in Central Java Using Spatial Regression Models. Jurnal Ilmiah Toeri dan Aplikasi Statistik, 16(2) : 606-613.

[11] Rizki, M. I., Sadida, H. Q., & Fauziah, A. N. (2021, December). Pemodelan Spatial Autoregressive Quantile Regression pada Tingkat Kemiskinan di Provinsi Jawa Barat. In *E-Prosiding Seminar Nasional Statistika| Departemen Statistika FMIPA Universitas Padjadjaran* (Vol. 10, pp. 1-7).
[12] Rizki, M. I., & Ammar, T. (2022, May). Pemodelan Spatial Autoregressive Quantile Regression Pada Faktor Yang Memengaruhi Tingkat Incident Rate Demam Berdarah Dengue di Jawa Barat. In *Prosiding Seminar Nasional Matematika dan Statistika* (Vol. 2).
[13] Taqiyyuddin, T. A., & Irfan, M. Faktor Penyebab Kemiskinan di Provinsi Jawa Barat Menggunakan Spatial Autoregressive Quantile Regression. *Jurnal Sains Matematika dan Statistika*, *8*(1), 59-69.
[14] Siyoto, S., & Sodik, M. A. (2015). *Dasar metodologi penelitian*. literasi media publishing.
[15] Japany, A. M., & Firnanda, A. (2022, November). Analisis Spasial Upah Minimum Kabupaten/Kota di Provinsi Jawa Tengah Tahun 2017-2021 dengan Model SAR-RE. In *Seminar Nasional Official Statistics* (Vol. 2022, No. 1, pp. 731-740).
[16] Zebua, H. I. (2023). SPATIAL AUTOREGRESSIVE QUANTILE REGRESSION PADA KASUS TUBERKULOSIS DI KOTA BANDUNG. *Journal of Analytical Research, Statistics and Computation*, *2*(2).
[17] Bunsaman, S. M., & Krisnani, H. (2020). Peran orangtua dalam pencegahan dan penanganan penyalahgunaan narkoba pada remaja. *Prosiding Penelitian dan Pengabdian kepada Masyarakat*, *7*(1), 221-228.
[18] Lusiana, E. D., Pramoedyo, H. E. N. N. Y., & Sudarmawan, B. N. (2022). Spatial quantile autoregressive model: case study of income inequality in Indonesia. *Sains Malaysiana*, *51*(11), 3795-3806.
[19] Zebua, H. I., & Jaya, I. G. N. M. (2022). Spatial Autoregressive Model of Tuberculosis Cases in Central Java Province 2019. *CAUCHY: Jurnal Matematika Murni dan Aplikasi*, *7*(2), 240-248.