The Seybold REPORT

ISSN 1533-9211

DOI 10.5281/zenodo.6618669

OPTIMAL LOCATION DETERMINATION OF PUBLIC SAFETY CENTER BASED ON DISASTER RISK IN BARRU REGENCY

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ABSTRACT

To improve the quality of services in handling emergency victims/patients, an integrated handling system was created in the form of a Public Safety Center (PSC) with access number 119. Many factors can cause emergency events, including accidents, fires, diseases, and natural disasters. The high potential of emergency in Barru Regency makes the innovation of PSC 119 Brigade Barru Siaga (BARUGA) is expecting to overcome emergency cases appropriately and quickly. This research aims to analyze the coverage of PSC networking facility services and potential emergencies in the Barru Regency. Network analysis is using to create a coverage model of existing PSC networking facilities. The potential for an emergency is obtaining from disaster risk analysis, traffic accidents, and disease prevalence. With the Simple Additive Weighting (SAW) method, the priority location of the PSC facility is determined. The result required the addition of ambulances stations in Bulo-Bulo, Pujananting, Gattareng, and Harapan Village.

Keywords: PSC 119, network analysis, simple Additive weighting (SAW)

INTRODUCTION

Emergency events that a person may face are unpredictable, whenever a person can experience an emergency. Many factors can cause emergency events, including accidents, fires, diseases, and natural disasters. This condition requires proper and immediate emergency treatment for optimal first aid in victims/patients (Pradita Nurmalia, 2018).

To improving the quality of service in the handling of emergency patients, an integrated system is needed by involving various parties. Integrated Emergency Management System (SPGDT) is an integrated emergency service mechanism based on Call Centers using telecommunications access code 119. The implementation of SPDGT is a Public Safety Center (PSC). PSC must establish by the Regency/City Government. PSC can be a work unit that is carried out together with other technical units outside the field of health, such as police and fire departments, in the specificity and needs of the region. In the event of a disaster, the implementation is in coordination with the agency that handles the disaster by the laws and regulations (Regulation of Minister of Health Number 19 of 2016).

Natural disasters, the risk of traffic accidents with fatalities are still emergency problems in Indonesia (Rinata, 2017). Barru Regency has a high category of the multi-hazard disaster risk

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ISSN 1533-9211
DOI 10.5281/zenodo.6618669

index (IRBI, 2018). From Regional Disaster Management Agency (BPBD) data, the number of natural and non-natural disasters continues to increase. Disasters are dominated by hydrometeorological disasters, namely floods, landslides and, strong winds. Disasters not only cause losses, refugees, and fatalities but can also cut off access to transportation and damage emergency facilities. The flood incident in Barru Regency on January 12, 2020, caused the Mangkoso Health Center and Bojo Baru Health Center patients had to be evacuated.

As a developing area, Barru Regency faces the risk of fire and health problems due to development and increasing population. Health problems are dominated by cases of Hypertension, ISPA, and Gastritis (BPS, 2020), and Covid-19 cases since May 2020 (Task Force Covid-19 Kab. Barru). Barru Regency is traversed by a national road along 71.4 km (BPS, 2020) high risk of traffic accidents. According to data Barru District Police, the number of fatal accidents that cause fatalities is increasing. Several factors that cause accidents include human factors, facilities factors, infrastructure factors, environmental factors and, other factors (Dwi, 2017).

All of these potential emergencies must be addressed to prevent death and disability. The absence of a disaster management plan, the lack of a disaster management service fleet and, a wide range can increase the risk to the community. Population growth in Barru Regency is not accompanied by additional health facilities. First-level health facilities are more concentrated around cities and not evenly distributed in remote and mountainous areas. For this reason, the innovation of PSC 119 Baruga is expected to overcome emergency cases appropriately and quickly so that patients can get help at the scene as soon as possible before receiving professional services at health facilities. The speed element in PSC is fulfilled by the transportation and communication system, while the accuracy element is met by the ability to help (Hartono, 2020).

PSC is a combination of elements of emergency ambulance service, security, and rescue. Call Center PSC 119 BARUGA Barru Regency is currently networked with 12 health centers but has not been integrated with other units outside the health sector. One of the pre-hospital services is an emergency ambulance service. The place where an ambulance is sent to a request location is called an ambulance station, usually located in an emergency center, hospital or, operating independently (Sina et al., 2020). Ambulance service response times were adjusted from the patient's triage results, where patients were labeled red 10 minutes, yellow < 30 minutes and, green >30 minutes. Triage results are using to decide whether patients need medical care that may be available at certain facilities (Chen, Chen and Yu, 2016). To ensure that emergency calls are responded to on time, the government is obliged to implement an effective ambulance location plan. In practice, emergency medical services systems work in uncertain environments with stochastic demand, response times, and travel times. The uncertainty of these factors significantly affects ambulance location planning (W. Yang *et al.*, 2020).

Compared to other health services, emergency medical services rely on the accessibility of space and time (Zhou, Wang and Xu, 2020). Strategies to increase the accessibility of health

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services are carried out by increasing supply, reducing barriers, and increasing demand (laksono, 2018). Previous research considers specific factors to an area like factors that affect demand, the range of existing facility services and, factors that hinder services including disaster events. The location of emergency facilities plays an important role both in pre-disaster services and in post-disaster relief (Yu, 2020).

In determining the location of PSC in Barru Regency, analysis is needed to find out the range of existing PSC networking facility services. Assessment of service areas based on areas that can reach by ambulances within a certain time limit or distance (Chen, 2015). According to WHO standards, the ideal response time is ± 8 minutes (Maya, 2021), while health facilities should be located at a distance of 5 km, but the recommendations fail to take into account the terrain, means of transportation and, the state of rural roads (Ngowi and William, 2020). Michael (2019) using buffer analysis to determine the radius of service coverage of social facilities based on SNI 03-1733-2004. Requests are generally allocated to nearby facilities. With road network data, the service area of the facility can be determined. Compared to circular areas with the same radius, service areas need to take into account transportation networks and travel costs from facilities. Iriana, et al (2015) showed the coverage area that can be reached by the existing post with network analysis. In patients who need prompt care and response, the best distance-based service area is assumed to be 5 and 10 Km and based on driving times of 5, 10 and, 15 minutes (Silalahi *et al.*, 2020).

In addition to geographical factors and the availability of transportation infrastructure, it is necessary to pay attention to the spatial distribution of the population (Grady, 2012). Recent studies fail to consider the effects of spatial uncertainty from demand because it is difficult to describe quantitatively (W. Yang *et al.*, 2020). Sina, et al., (2020) maximize efficiency by building new facilities. Demand depends on the population, frequency and, severity of traffic accidents in a region. The average speed of ambulances during peak hours is also considered. Zhou, et al., (2020) research combines time, traffic, population, and other factors. With population distribution network data to simulate the potential distribution of demand for emergency medical services. Then traffic data is used to simulate road traffic conditions at different times. Emergency services needs can also be classified based on areas at risk and loss of life. The research of Yang et al., (2020) proposed a model for the optimal location of multi-coverage emergency facilities based on the level of demand from the simulation results of the impact of the fluvial flood inundation model. Placing emergency service facilities in places near disaster-prone areas is very important in increasing response times, but the risk of being affected is also greater. Damage to buildings and roads will cause traffic jams and complicate rescues (Y. Yang et al., 2020). Andersson et al., (2020) combine strategic (search for ambulance stations) and tactical (allocating ambulances to the station). The proposed mitigation measure would be to add ambulances to areas affected by the disaster closures.

The decision-making process is not an easy thing. Many alternative decisions are based on various considerations to produce the best decision. The use of a decision support system will help in the decision-making process (Firgiawan, Zulkarnaim and Cokrowibowo, 2019). The Simple Additive Weighting (SAW) method is one of the methods to solve multi-attribute

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decision-making problems. The SAW method is often also known as the weighted summation method. The assumption underlying the SAW method is that each attribute is independent, so they will not affect each other (Aso Sudiarjo, 2020). Andretha et al., (2017) use SAW for weighting combined with Geographic Information System in determines flood disaster evacuation locations. To optimation, PSC facilities need to be placed in high-demand locations but not served by existing facilities. This research aims to analyze the coverage of PSC networking facility services and the potential emergency to determine the priority of PSC locations in Barru Regency.

MATERIALS AND METHODS

The location of this study is in Barru Regency which is geographically between 4°05'49"S - 4°47'35"S and 119°35'00"E - 119°49'16"E with an area of 1,174.72 km^2. Barru Regency is administratively divided into seven subdistricts consisting of 15 urban villages, and 40 villages. With a population of 184,452 people (BPS, 2021). Barru Regency has formed PSC 119 BARUGA since March 1, 2017, which networked with 12 Health Centers.

The data is conducting by observation and documentation techniques. Service coverage of PSC networking facilities is analyzed by spatial analysis with network analysis tools in QGIS 3.16.9 software. Potential emergency requests are processed from data on the risk of floods, landslides, fires, disease prevalence, and the number of accidents. The technique used is overlay where the risk attribute is given weight to create a multi-hazard disaster risk map. The SAW method is used to determine the priorities of areas with high potential emergency requests that are not served by existing facilities.

1. Analysis of the service coverage of Existing PSC Network facilities

The coverage model is made with service area by building a network analysis layer from a road network map with the location point of existing PSC network facilities. Based on the Decree of the Minister of Health and Social Welfare of the Republic of Indonesia Number 143 / MENKES-KESOS / SK / II / 2001, the speed limit of emergency ambulance vehicles is a maximum of 40 km/h on ordinary roads and 80 km/h on freeways. A model is made based on the range of the speed limit and ambulance response time.

Tabel 1. Emergency vehicle mileage matrix

distance (Km) = speed * time						
Time		Speed (km/h)				
Minute	Hour	40	50	60	70	80
5	0,08	3,33	4,17	5,00	5,83	6,67
10	0,17	6,67	8,33	10,00	11,67	13,33
15	0,25	10,00	12,50	15,00	17,50	20,00
30	0,50	20,00	25,00	30,00	35,00	40,00

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2. *Emergency potential analysis*

Multi-hazard disaster risk maps are created by combining flood risk maps, fire risk and, landslide risk. The overlay union type is used then scored by multiplying the risk value of the map by the predetermined weight. The results obtained are then divided into high, medium and, low-risk classes with an interval formula. The area of each risk class is calculated using calculate geometry and processed to obtain the risk area for each village that will be used in the SAW analysis.

Tabel 2. Weight of disaster type

Type of disaster	Weight
Banjir	3
Kebakaran	2
longsor	1

Interval class formula

$$\text{Interval classes} = \frac{\text{highest value} - \text{lowest value}}{\text{number of classes}} \qquad (1)$$

3. *Location prioritization*

The basic concept of the Simple Additive Weighting (SAW) method is to find the weights obtained from the performance ratings of each alternative against all existing criteria. It is also necessary to normalize the decision matrix which becomes a balanced scale between all criteria (Firgiawan, Zulkarnaim and Cokrowibowo, 2019). The alternative method is chosen if it meets the predetermined criteria. The SAW method is more efficient because the time required for calculations is shorter (Putra *et al.*, 2016). There are three approaches to determining the weight of criteria: objective, subjective, and integration of both (Mulyati, 2016). In this study, the weights were determined from the analysis of the demand for PSC 119 BARUGA in 2017-2020. The steps for the completion of the SAW method are as follows:

a. Determine the alternative, namely Ai;
b. Determining the criteria that will be used as a reference in decision making, namely Cj;
c. Normalize the decision matrix by calculating the value of the normalized performance rating (rij) from the alternative Ai on the Cj criteria. Matrix normalization is adjusted to the type of attribute first to determine the nature of each existing criteria, whether it is benefit or cost. In this study, the weights were determined from the analysis of the demand for PSC 119 BARUGA in 2017-2020. Criteria of the profit if the value provides an advantage for the decision-maker, instead of the cost criteria if it incurs costs (Mulyati, 2016);

$$rij = \frac{Xij}{MaxXij} \quad \text{if j is a benefit attribute} \qquad (2)$$

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$$rij = \frac{MInXij}{Xij}$$ if j is a cost attribute (3)

Description;

rij = matrix is normalized [i] [j]

X_{ij} = decision matrix [i] [j]

Max_i = the highest value of each column of the matrix

Min_i = the lowest value of each column of the matrix

d. Determine the preference weight or level of importance (W) of each criterion
W = [W1 W2 W3:j];

e. Determine the final value of the alternative (Vi). A greater Vi value indicates that alternative Ai is preferred (andretha, 2017).

$$Vi = \sum_{j=1}^{n} Wi\, rij \quad (4)$$

Description;

Vi = the final value of the alternative

Wi = weight value

rij = normalized value

n = number of criteria

RESULTS

1. Service coverage of existing PSC network facilities

The results of the analysis of the existing services coverage showed that at the speed limit of 80 km/h there are villages that cannot be reached within 10 minutes, namely Kamiri, Anabanua, Pujananting, Gattareng, and Bulo-Bulo Village. In Harapan Village, the travel time takes more than 15 minutes from the nearest health center.

2. Potential emergency

From the results of disaster risk overlay, the area of multi-hazard disaster risk in the village is obtained by making a percentage of the disaster area for high, medium, and low-risk classes. The impact of a disaster becomes the basis of weighting any risk where a flood disaster is given the highest weight. The result is that the high-class risk area exceeds 40% of the total area, namely Bulo-bulo (79%), Mangempang (67%), Sepee (55%), Pujanating (47%), Nepo (45%), and Harapan Village (40%).

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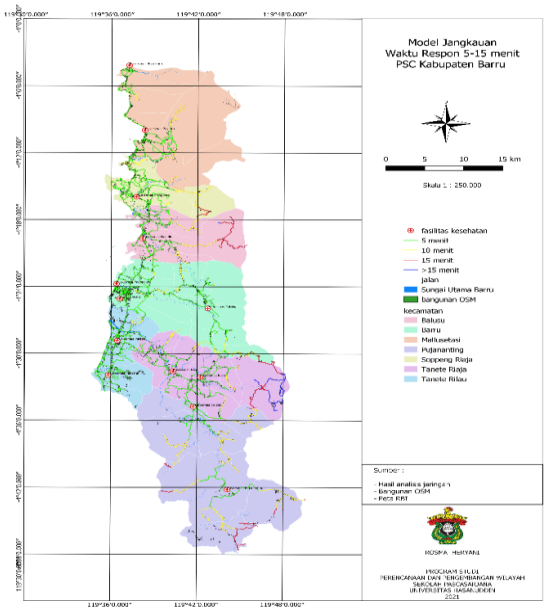
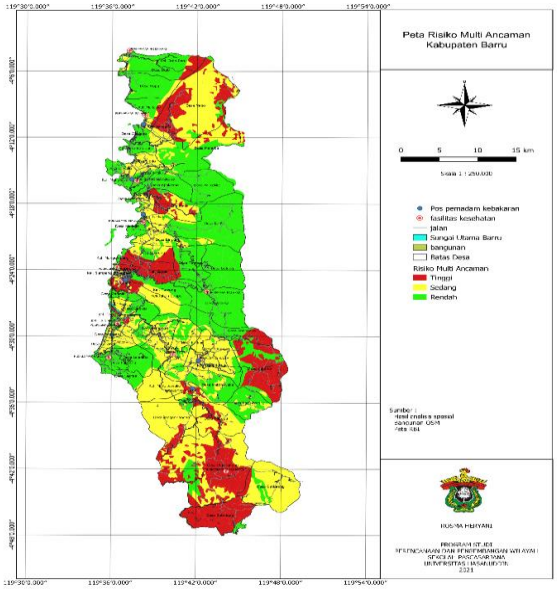


(a)



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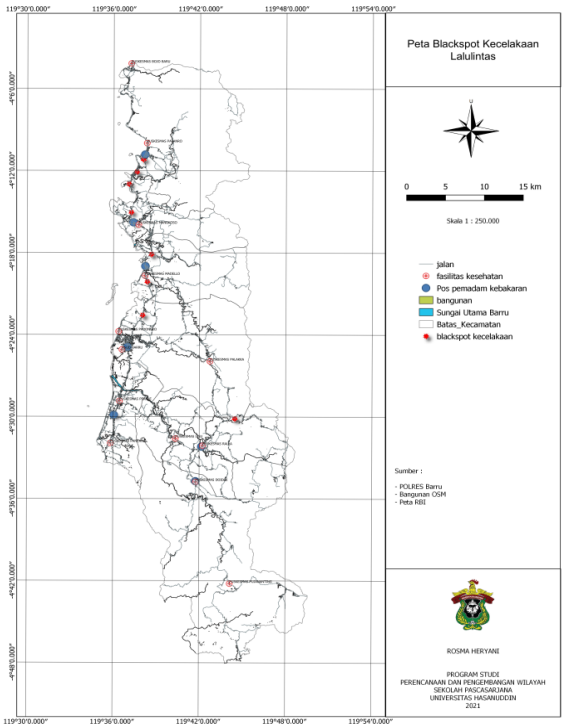

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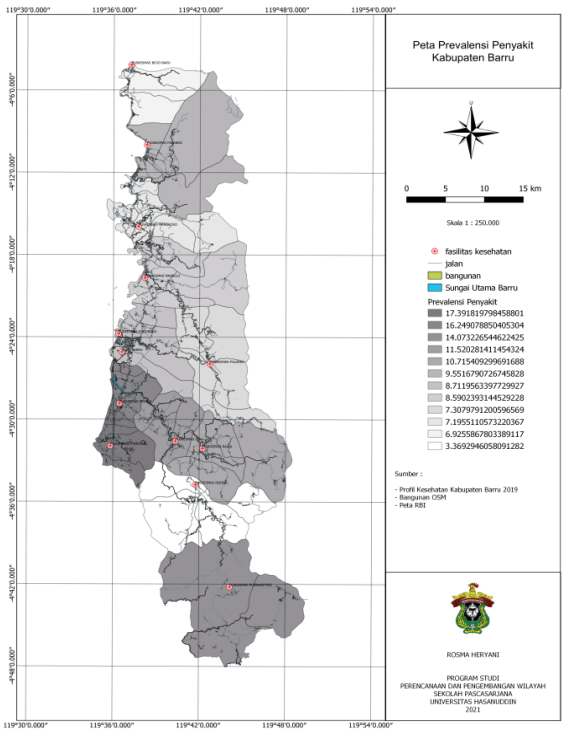

(d)

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Figure 1. (a) PSC network service coverage map, (b) Multi-hazard disaster risk map (c) Traffic accident Blackspot map, (d) Disease prevalence map.

Blackspot traffic accidents are generally located along the Trans Sulawesi line that crosses Barru Regency. Soppeng Riaja and Mallusetasi districts have the most blackspots. The highest prevalence of diseases (Diabetes Mellitus, Hypertension, DHF, Malaria, Measles, Leprosy, Diarrhea, Tuberculosis, and Pneumonia) was in Tanete Rilau Sub-district in the working area of Pekkae Public Health Center and Pancana Health Center, while the lowest prevalence of disease was in Pujananting District in the Doi-doi Public Health Center working area.

3. Priority PSC location

The number of female patients is higher with maternal cases, then cases of chronic diseases, and a small number of accident cases. The enforcement of patients is more done in the health center so the weight is higher. The criteria determined are the high potential demand but not supported by facilities. Vi values of the alternative 55 villages are sorted. Then the interval formula is divided into three classes, namely high, medium and low priority classes. The results obtained four villages with high location priority classes, 22 villages with medium priority locations, and 29 villages with low priority.

Criteria (C)		Weight (W) %		Information
C1	area of high disaster risk	W1	7	Benefit
C2	Disease Prevalence	W2	9	Benefit
C3	Number of traffic accidents	W3	7	Benefit
C4	Number of Female Population	W4	10	Benefit
C5	Total population	W5	7	Benefit
C6	Area	W6	7	Benefit
C7	Hospital Coverage	W7	10	Benefit
C8	Health Center range	W8	12	Benefit
C9	Number of Health Workers	W9	9	Cost
C10	Number of Health Facilities	W10	8	Cost
C11	Signal Strength	W11	7	Cost
C12	Public transport route	W12	7	Cost

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DOI 10.5281/zenodo.6618669

Table 4. Priority PSC location as a result of SAW

Location priority classes	Village
Tinggi	Bulo-bulo, Pujananting, Gattareng, Harapan
Sedang	Nepo, Takkalasi, Corawali, Jangan-jangan, Lempang, Sumpang binangae, Binuang, Pattappa, Manuba, Mattirowalie, Bacu-bacu, Pao-pao, Kamiri, Tanete, Palanro, Libureng, Kupa, Tellumpanua, Bojo, Lipukasi, Cilellang, Lalabata
Rendah	Lompo Riaja, lasitae, Coppo, Lampoko, Balusu, Lompo Tengah, Ajakkang, Anabanua, Lalolang, Lawallu, Bojo Baru, Paccekke, Mangkoso, Siawung, Pancana, Kading, Mangempang, Madello, Garessi, Mallawa, Siddo, Galung, Sepee, Batupute, Tompo, Palakka, Tuwung, Kiru-kiru, Mattappawalie

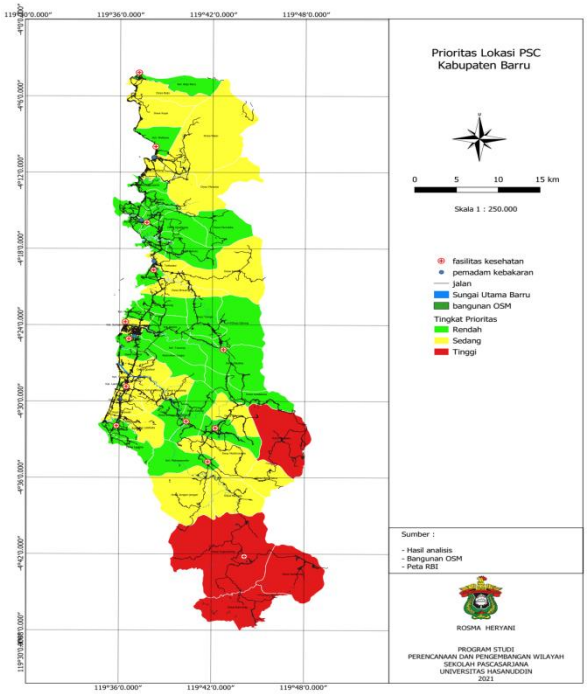

Figure 2. Map of location priority determination using SAW

DISCUSSION

From the analysis of the coverage of the existing PSC network facilities, there are still villages that can be reached in 10 minutes. This indicates that if an emergency occurs with a red triage patient, the ambulance cannot meet the 10 minute response time. The faster the

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DOI 10.5281/zenodo.6618669

response time is better, but it can cause new problems such as an ambulance having an accident (Khaerah and Harakan, 2019). The wider the area that is to be covered, if an emergency simultaneously occurs in different locations within one region, the time needed to reach that location will be longer. Ambulance requests must be supported by other facilities, especially if the facilities in the area are limited.

The number of blackspot in a region indicates the vulnerability of traffic accidents in that region is very high. Potential accidents can befall local and cross-district transportation users. The cause of the accident according to the Barru Regency Police, were high speed, straight roads, median openings, lack of lighting at night, and lack of traffic signs. Accident patients are very prone to death due to late treatment (Khaerah and Harakan, 2019). Traffic accident patients are usually transported by public transportation around the scene where there are no services such as BLS (Basic Life Support) or ALS (Advanced Life Support) (Wiwid Novitaria, Putri Asmita Wigati, 2017). According to Regulation of the Minister of Health 47 of 2018, if there is no transportation ambulance or Emergency Ambulance, medical evacuation can be done using other means of transportation while maintaining efforts to maintain resuscitation and stabilization.

The population, in general, will increase the need for health facilities. Most of the PSC requests in Barru county are women with maternal cases. Based on Government Regulation of the Republic of Indonesia Number 47 of 2016 concerning Health Care Facilities article 11 mentioned that the District / City Government must provide at least one community health center (Puskesmas) in each sub-district with consideration of population, service needs, and accessibility. The number of health facilities can also describe the resilience conditions of existing communities (Sadali and Intizhar, 2017). The number of health facilities in Barru Regency has been adequate, very important to improve its accessibility, considering that the population is exposed or underserved within the WHO standard distance of 5 km (Ngowi and William, 2020). Areas with unequal distribution of health facilities and do not have these supporting health facilities need to be prioritized (Sadali and Intizhar, 2017).

Access to a hospital that is close and easy will speed up the time to get services. Likewise with access to health centers. The longer the distance of the health facility, the longer the travel time needed. The availability of public transportation will make it easier for people to reach health facilities. The number of health workers affects the quality of health services. While a strong signal will accelerate the communication flow of PSC service requests. Number 119 can be accessed by the public via mobile phone or landline (Hartono, 2020).

The number of people affected by the disease is indicated by the prevalence or incidence of the disease. Jumlah penduduk yang terkena penyakit ditunjukan oleh angka prevalensi atau insiden penyakit (Symond, 2013). The number of people with chronic diseases and infectious diseases has the potential to cause emergency conditions. Most cases of death in Covid-19 patients are identified as accompanied by comorbidities, such as hypertension, diabetes mellitus, respiratory diseases such as asthma, and chronic obstructive pulmonary disease (Silalahi *et al.*, 2020).The number of patients with the disease is obtaining from data from health center data. There is a possibility that patients with diseases are not recording because

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ISSN 1533-9211
DOI 10.5281/zenodo.6618669

they do not go to the health center. Someone who does treatment many times can also lead to a high number of sufferers.

Disasters can cause an impact on health, such as an increased risk of infectious diseases, injuries, trauma, or psychiatric disorders, resulting in fatalities. This condition is aggravated by changes in environmental conditions, limited health workers, damage to health facilities, inadequate medicine, and health equipment, and poor sanitation due to disasters (Putri, 2019). The condition of people vulnerable to poverty, lack of vigilance, and helplessness and its location away from the center of government, and the difficulty of accessibility, especially in disaster-prone areas are factors that need serious attention and treatment from local governments (Ahdi, 2015).

Bulo-Bulo, Pujananting, Gattareng, and Harapan villages are high-priority location. These villages have a high risk of disaster, a large area, low signal quality, inconvenient access to public transportation, long distances from health centers and hospital. To support the PSC 119 BARUGA network to address daily emergency conditions and during disasters. Then definitely the addition of an ambulance in the village. Ambulance location suitability research can conducting to complete this study. For areas with moderate priority, health services need to improve. In this study, the results were influenced by the variables and weights used.

CONCLUSIONS AND SUGGESTIONS

1. The range of existing facilities at the highest speed limit of 80 km/h cannot reach several villages at a response time of 10 minutes, namely in Gattareng, Bulo-Bulo, Pujananting, and Harapan Village.
2. Based on disaster risk, traffic accidents, and prevalence of the disease. Potential emergency departments at high risk of disaster in The Village Of Doi-Doi, Bulo-Bulo, Pujananting, Harapan, and Mangempang. The highest prevalence of diseases is in Tanete Rilau District. The most blackspot accidents are in Soppeng Raja and Mallusetasi sub-districts.
3. From the results of the SAW method, a new ambulance station is needed in Harapan, Pujananting, Gattareng, Bulo-Bulo Village to support PSC in emergency response. Ambulance stations can be placed at available sub-health centers or continued with research into the suitability of ambulance locations.

ACKNOWLEDGMENT

Thanks to Regional Disaster Management Agency (BPBD) Barru District and Barru District healt service who supported the availability of data and information on this study.

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DOI 10.5281/zenodo.6618669

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