The Relationship Between The Physical Environment and Quality of Life for Patients With Type 2 Diabetes Mellitus

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Abstract: *Background*: Diabetes Mellitus (DM) is a chronic disease with a high mortality rate and can affect a person's quality of life. One of the factors determining the quality of life is the physical environment, such as temperature, humidity, lighting, noise, and $PM_{2,5}$.

Objective: To determine the relationship between the physical environment and the quality of life of type 2 DM patients at the Barombong Community Health Center, Makassar City.

Materials and Methods: This research uses a study design case-control with purposive sampling. Interviews were conducted with the WHOQol questionnaire and measuring the physical environment in 138 patients with type 2 diabetes then analyzed with the odd ratio test and logistic regression on the Stata application.

Results: The results obtained showed a non-significant relationship for the variables humidity, lighting and $PM_{2,5}$ on the quality of life of type 2 DM patients due to value-p > 0.05 while the variables related to the quality of life of type 2 DM patients are house temperature (OR=4.833; 95% CI: 2.121-11.481) and noise (OR=4.723; 95% CI: 2.075-10.895) with a probability of type 2 DM with unqualified temperature and noise having a poor quality of life of 73.9%.

Conclusion: The most significant factor that affects the quality of life of people with type 2 diabetes mellitus is their home temperature.

Keywords: Physical Environment, Quality of Life, Diabetes mellitus.

INTRODUCTION

Diabetes mellitus (DM) is a heterogeneous metabolic disorder that occurs when blood glucose levels increase due to inadequate insulin production [1]. International Diabetes Federation (IDF) in 2021 noted that 537 million adults (aged 20-79 years), or 1 in 10 people, live with DM worldwide. DM also causes 6.7 million deaths [2]. DM is becoming more common in low- and middle-income countries [3]. Indonesia is in fifth position, with the number of DM patients at 19.5 million with a population of 179.72 million people. The number of people suffering from type 2 DM in Indonesia will increase from 19.5 million in 2021 to around 28.6 million in 2045 [2]. Data from the Makassar City Health Service shows that Makassar City is in first place for the highest number of DM patients from 21 regencies and 3 cities in 2022, with 24.739 DM patients [4].

DM disease has a significant mortality rate and can affect a person's productivity and quality of life [5]. Quality of life is an individual's perception of how good or bad their life is. Good quality of life is strongly correlated with response to treatment or therapy, disease progression, or death from DM. individuals perceive their quality of life differently not only in terms of physical health but also in terms of mental health, confidence, and social and environmental relationships [6]. World Health Organization (WHO) classifies the quality of life into 4 domains, including Domain I physical health, domain II psychological, domain III social relationships; and domain IV environment [7]. One domain that is important in influencing quality of life is the environment. Environmental factors have a relationship that can influence people's perceptions of well-being and quality of life because the environment has an important role in the physical, mental, and social conditions of individuals. The physical environment with quality of life is an aspect that examines individual perceptions of environmental conditions such as temperature, humidity, lighting, noise, and particulate matter 2,5 µg/m3($PM_{2,5}$). Inadequate home temperature and lighting can affect the quality of life of DM patients [6]. Humidity is also an environmental parameter vital in maintaining a healthy indoor environment and preventing the growth of dangerous microorganisms that can cause respiratory diseases [8]. Road traffic noise and air pollution ($PM_{2,5}$) surroundings can increase systemic inflammation,

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blood glucose levels, and the potential risk of lipid disorders such as noise and air pollution ($PM_{2,5}$) as a stress trigger that can cause direct adverse health effects such as sleep disturbances [9]. Air pollution $PM_{2.5}$ exposure is associated with a higher incidence of type 2 DM (per 10 µg/m3 increase in $PM_{2.5}$ concentration, hazard ratio (HR)=3.52 [10].

Puskesmas Barombong is one of the health centers in the work area of the Health Office which has a working area of 13 RW and 69 RT which is in the peripheral area and is located in the coastal area of Makassar City. Coastal areas are one of the aquatic environments that are easily affected by environmental pollution. The number of people suffering from type 2 DM in January-June 2023 is 171 people, and they will experience improvement; it is necessary to pay attention to the quality of life to reduce the occurrence of complications resulting from the physical environment because it is a factor that constantly interacts closely with humans which can affect the quality of life of DM patients. Therefore, this study was conducted to identify whether physical environmental factors are associated with the quality of life of patients with DM.

METHODS

Research Design

The type of research used in this study is an analytical observational approach to Case Control. This design is retrospective because it starts with determining the quality of life of DM patients. The quality of life of patients with DM based on the WHO QoL questionnaire is expressed by poor quality of life (score < 50) and good quality of life (score > 50). Then observed whether exposed to physical environmental factors. Direct measurement of physical environmental factors includes temperature (thermometer), humidity (hygrometer), and lighting (lux meter). Noise (sound level meter) and PM2.5 (dust sampler) at the respondent's house. The sampling technique used in this research is purposive sampling with the following criteria: patients with DM recorded in medical records at the Barombong Health Center, do not have a history of complications and are willing to become respondents.

Research Sites

This study was conducted at the Barombong Community Health Center, Makassar City, in 2023. The working area of Barombong Health Center is 7.34 km2, consisting of lowlands and beaches. This area map illustrates the research location which consists of 13 RW as shown in the figure below:

Figure 1: Map of barombong community health center working area boundaries.

Study Sample

The population in this study is all DM patients recorded in January-June 2023, as many as 171 people. The sample determination used the Lemeshow (1990) formula for case-control studies, which is as follows:

$$n1 = n2 = \frac{[\,Z_{1-\alpha/2}\sqrt{2P(1-P)} + Z_{1-\beta}\sqrt{P_1(1-P_1)+P_2(1-P_2)}\,]^2}{(P_1-P_2)^2}$$

Description:

n1 and n2 = number of samples for each group

Z1-α/2 = Z value for the degree of significance (α = 95%) = 1.96

Z1-β = Z value for test power (β = 80%) = 0.84

P = mean proportion = (P1+ P2)/2

P1 = proportion of quality of life in the case group

= (OR) P2)/(OR) P2+(1-P2)

P2 = Proportion of quality of life in the control group

P = Average proportion = (P1+ P2)/2

The description of the sample size calculation using the formula above is as follows.

It is known:

P2 = 0.33 OR = 3.332 (OR in Sepriani's research)

$Z_{1-\alpha/2}$ = 1,96, $Z_{1-\beta}$ = 0,84

$$P1 = \frac{(OR)\,P_2}{(OR)P_2+(1-P_2)} = \frac{(3{,}332)\,(0{,}33)}{(3{,}332)0{,}33+(1-0{,}33)} = \frac{1{,}09956}{1{,}76956} = 0{,}62$$

$$P = \frac{(P_1+P_2)}{2} = \frac{0{,}62+0{,}33}{2} = 0{,}48$$

then the number of samples needed :

$$n1 = n2 = \frac{[\,Z_{1-\alpha/2}\sqrt{2P(1-P)} + Z_{1-\beta}\sqrt{P_1(1-P_1)+P_2(1-P_2)}\,]^2}{(P_1-P_2)^2}$$

$$= \frac{[1{,}96\sqrt{2(0{,}48)(1-0{,}48)}+0{,}84\sqrt{0{,}62(1-0{,}62)+0{,}33(1-0{,}33)}\,]^2}{(0{,}62-0{,}33)^2}$$

$$= \frac{[1{,}96\sqrt{0{,}96(0{,}52)}+0{,}84\sqrt{0{,}2356+0{,}2211}\,]^2}{0{,}0841}$$

$$= \frac{[1{,}96(0{,}707)+0{,}84(0{,}676)\,]^2}{0{,}0841}$$

$$= \frac{[1{,}38572)+0{,}56784)\,]^2}{0{,}0841}$$

$$= \frac{3{,}816}{0{,}0841}$$

= 45,37 = 46

Based on the results of the sample calculation above, the number of samples obtained is 46. The ratio of case and control samples is 1: 2 so that a sample of 138 (46 cases and 92 controls) is obtained.

Data Analysis

Data processing and analysis were performed using the STATA version 14.0 program. This bivariate analysis is performed to determine the relationship between independent variables (temperature, humidity, illumination, noise, and $PM_{2.5}$) and dependent variables (Quality of life of DM patients). Data is presented in the form of cross-tabulation with the Chi-Square statistical test. The multivariate analysis to be used in this study is Logistic Regression analysis, on the grounds that the dependent variable (quality of life of DM patients) is categorical.

Ethical Approval

This study was approved by the Health Research Ethics Committee of Hasanuddin University with ethical approval recommendation number 5147/UN4.14.1/TP. 01.02/2023. Informed consent was obtained from all research respondents, data confidentiality was maintained and privacy was guaranteed.

RESULTS

Univariate Analysis Results

Table **1** shows that type 2 DM patients with poor quality of life are predominantly female at 65.22%, aged 56-65 years at 36.96%, elementary school education at 63.04%, housewife occupation (not working) at 73.91% and long-suffering from DM ≤ 5 years of 71.74%. Meanwhile, type 2 DM patients have a good quality of life; the female gender is dominant at 59.78%, 56-65 years old at 35.87%, elementary school education at 57.61%, not working at 75% and suffering from DM for a long time ≤ 5 years of 67.39%.

Table 1: Frequency Distribution based on Gender, Age, Education Level, Employment, and Length of Suffering from Type 2 DM

Respondent Characteristics	Quality of Life of Type 2 DM				Total	
	Bad		Good			
	n	%	n	%	n	%
Gender						
a. Man	16	34.78	37	40.22	5 53	38.41
b. Woman	30	65.22	55	59.78	8 85	61.59
Age Group						
a. 20-35 years	1	2.17	3	3.26	4	2.90
b. 36-45 years old	7	15.22	14	15.22	21	15.22
c. 46-55 years old	11	23.91	31	33.70	42	30.42
d. 56-65 years old	17	36.96	33	35.87	50	36.23
e. > 65 years	10	21.74	11	11.96	21	15.22
Education						
a. Elementary School	29	63.04	53	57.61	82	59.42
b. Junior High School	8	17.39	23	25.00	31	22.46
c. Senior High School	5	10.87	12	13.04	17	12.32
d. S1	3	6.52	4	4.35	7	5.07
e. S2	1	2.17	0	0	1	0.72
Work						
a. Doesn't work	34	73.91	69	75.00	103	74.64
b. Fishermen/Laborers	7	15.22	16	17.39	23	16.67
c. Private employees	2	4.35	5	5.43	7	5.07
d. Civil servants/TNI/Polri	3	6.52	2	2.17	5	3.62
Suffering from DM for a long time						
a. ≤ 5 years	33	71.74	62	67.39	95	68.84
b. > 5 years	13	28.26	30	32.61	43	31.16
Amount	46	100	92	100	138	100

Table 2: Distribution of Respondents' Quality of Life based on Physical Environment at Barombong Health Center Makassar City

Physical Environment	Quality of Life of Type 2 DM				Total	
	Bad		Good			
	n	%	n	%	n	%
a. Temperature						
TMS	29	63.04	24	26,09	53	38,41
MS	17	36.96	68	73,91	85	61,59
b. Humidity						
TMS	10	21,74	15	16,30	25	18,12
MS	36	78,26	77	83,70	113	81,88
c. Lighting						
TMS	12	26,09	17	18,48	27	19,57
MS	34	73,91	75	81,52	111	80,43
d. Noise						
TMS	31	67,39	28	30,43	59	42,75
MS	15	32,61	64	69,57	79	57,25
e. $PM_{2,5}$						
TMS	0	0	0	0	0	0
MS	46	100	92	100	138	100
Amount	46	100	92	100	138	100

Table **2** shows that the quality of life of patients with type 2 DM has an unqualified home temperature of 63.04%, unqualified home humidity of 27.74%, unqualified home lighting of 26.09%, and unqualified noise of 67.39%. Meanwhile, for the PM2.5 variable, both DM patients with good quality of life and poor quality of life, the results are found to be eligible based on the Minister of Health Regulation Number 2 of 2023 concerning Regulations for the Implementation of Government Regulation Number 66 of 2014 concerning Environmental Health. Because the $PM_{2.5}$ variable has home gen data, it does not proceed to bivariate analysis.

Bivariate Analysis Results

Table **3** shows a significant relationship between temperature and noise and the quality of life of type 2 DM patients. Humidity and lighting show an insignificant relationship with the quality of life of type 2 DM patients.

Table 3: Results of Bivariate Analysis of the Physical Environment with Quality of Life for Type 2 DM patients

Physical Environment	Quality of Life of Type 2 DM				OR (CI 95%, LL-UL)	*p-value*
	Bad		Good			
	n	%	n	%		
a. Temperature						
TMS	29	63.04	24	26.09	4,833	0,000
MS	17	36.96	68	73.91	(2,121-11,093)	
b. Humidity						
TMS	10	21.74	15	16.30	1,425	0.435
MS	36	78.26	77	83.70	(0.517-3.778)	
c. Lighting						
TMS	12	26.09	17	18.48	1,557	0.649
MS	34	73.91	75	81.52	(0.604-3.900)	
d. Noise					.	
TMS	31	67.39	28	30.43	4,723	0,000
MS	15	32.61	64	69.57	(2,075-10,895)	
Amount	46	100	92	100	138	100

Information:
TMS: Not Eligible.
MS: Eligible.

Table 4: Results of Logistic Regression Analysis of the Quality of Life of Type 2 DM Patients

Research variable	Coef.	S.E	*p-value*	OR	CI 95%	
					LL	UL
Temperature	1,628	0.419	0,000	5,098	2,242	11,591
Noise	1,606	0.419	0,000	4,982	2,189	11,342
Constanta	-2,193					

Multivariate Analysis Results

Table **4** shows the results of multivariate analysis using the logistic regression test. It can be concluded that the dominant factor most related to the quality of life of DM patients is temperature.

Table **4** shows how significant the probability of temperature and noise is to experience poor quality of life from the following regression equation (y value).

Y = constant + coef(temperature)*1 + coef(noise)*1

= -2.193592 + (1.628968*1) + (1.606027*1)

= 1.041403

Next, the following probability values are calculated:

$P = 1 / (1+ \exp^{(-y)})$

$P = 1 / (1 + \exp^{(-1.041403)})$

P = 0. 73912063

Based on these results, it can be concluded that the probability of type 2 DM with unqualified temperature and noise having a poor quality of life of 73.9%.

DISCUSSION

The Relationship between Temperature and Quality of Life in Type 2 DM Patients

Temperature has a risk of 14.50 times the quality of life of type 2 DM patients who do not meet the requirements for having a poor quality of life [6]. Temperature can worsen health conditions with a threshold ranging from 26°C to 32°C. Absorption of insulin doses in DM patients also increases significantly in hot indoor environments [11]. Temperature rise of 1^0C, the age-adjusted incidence of DM increased by 0.314% (95% CI 0.194% to 0.434%), and increased the worldwide prevalence of glucose intolerance by 0.170% (95% CI 0.107% to 0.234%) [12]. The dry season experienced by Indonesia that lasts for a long time can cause an increase in the earth's surface temperature. The highest temperature measurement results during the study were around 35^0C. this condition does not meet the temperature requirements in the house according to the Minister of Health Regulation Number 2 of 2023.

DM patients will experience dehydration more quickly. Not drinking enough fluids can increase blood sugar, and high blood sugar can make DM patients urinate more frequently [13]. The inability of DM people to regulate their body heat properly due to thermosensitivity problems ultimately results in disease or injury, including neuropathy [14]. The growth of microorganisms and air quality can be influenced by temperature. Due to decreased body immunity, DM patients are more susceptible to infection with microorganisms. One frequently encountered infectious disease is tuberculosis (TB) [15].

The Relationship between Humidity and Quality of Life in Type 2 DM Patients

Low humidity (approximately < 45%) was associated with an increased risk of DM mortality in Nanjing [16]. In rooms with common humidity conditions, the skin will feel dry quickly. Meanwhile, at high humidity, water vapor will come out of the mouth when breathing. Humidity is one of the factors that influences the growth of microbes in the air. The higher the humidity, the more microbes there are in the air, and the smell is also unpleasant. High levels of microbes in the air pose a risk of disease transmission (airborne disease) [17]. This condition can cause complications in DM patients, which will reduce their quality of life [18]. The condition of the houses owned by some respondents is semi-permanent and lacks ventilation which causes the humidity of the house to range <40-60% which does not meet the requirements according to the Minister of Health Regulation Number 2 of 2023.

DM patients who cannot control their blood sugar levels for a long time will experience a decrease in their immune system and will have a high risk of experiencing infection [19]. Having a history of DM carries a 1.38 times risk of suffering from TB. Home humidity that does not meet the requirements is 4.23 times more likely to suffer from TB than those who meet the requirements (95% CI 1.274-13.370) [20].

The Relationship between Lighting and the Quality of Life of Type 2 DM Patients

Visual impairment and blindness can result in a reduced quality of life, seen from a person's reduced ability to function doing work, filling free time, or carrying out daily activities [21]. Ambient light intensity greatly influences human glucose and triglyceride levels [22]. Lighting is one of the characteristics of a healthy home. If the house is included in the healthy house category, it will reduce disease transmission. Communities with poor lighting are at 77.6 times more risk of developing TB than those that meet health requirements [23]. Natural lighting that does not comply with regulations results in 1.5 times the risk of falling injuries [24]. Some respondents have lighting < 40 lux is said to be unqualified according to the Minister of Health Regulation Number 2 Year 2023. Nighttime light exposure in the bedroom in a home environment with low light intensity, significantly risk of depression.

The Relationship between Noise and Quality of Life in Type 2 DM Patients

Noise can cause various physiological, psychological, and social health consequences. Noise induces stress due to catecholamine dysregulation. The effects of stress can increase cortisol production so that the body's sensitivity to insulin is reduced, resulting in reduced glucose in cells. Over time, insulin resistance can occur, and glucose in the blood increases [25].

Each 10 dB increase in noise was associated with an 8% increase in the incidence of DM (95% CI, 1.07–1.09) [26]. Lack of quantity and quality of sleep provides a 2 times risk of DM among those living in busy traffic areas compared to quiet regions [27]. The Barombong area is one of the alternative roads connecting Makassar City and Takalar Regency so the volume of vehicles becomes a lot. This condition can cause noise and according to the measurement results, the highest noise is 100.4 dB in the house of one of the respondents whose house is located near the highway.

Lack of sleep is known to have quite disturbing effects on the health of the human body. This is because when a person sleeps, the body will undergo natural detoxification to expel toxins, especially for DM patients [28].

The Relationship between $PM_{2,5}$ and Quality of Life in Type 2 DM Patients

$PM_{2.5}$ is a pollutant that can harm human health and the environment. $PM_{2.5}$ diffuses into the blood vessels during the gas exchange process between the alveoli and blood vessels, disrupting the levels of glucose, insulin, and several other body cells [29]. $PM_{2.5}$ factors cause DM and any $PM_{2.5}$ upgrades of 10 µg/m3 were found OR = 3.09, suggesting a relationship between $PM_{2.5}$ exposure and DM in Mexican adults [30,31].

The load caused by $PM_{2.5}$ in the surrounding environment has changed from the 13th significant risk level in 1990 to the 7th level in 2019 for all ages. Long-term (5 years) $PM_{2.5}$ display was associated with the risk of DM in a cohort of 2.6 million participants living in Denmark [32]. According to WHO guidelines, $PM_{2.5}$ exposure at concentrations that are low in air quality can increase the risk of DM. $PM_{2.5}$ causes an increase in reactive oxygen species in the lungs, triggers systemic oxidative stress, causes inflammation of visceral adipose tissue, and subsequently causes insulin resistance. $PM_{2.5}$ was found to be positively associated with the prevalence of DM [33].

LIMITATIONS OF THE RESEARCH

The limitation of this research is that the data for one variable of the physical environment studied (temperature, humidity, noise lighting, and $PM_{2.5}$) has homogeneous data, namely $PM_{2.5}$ because the measurement results for type 2 DM patients with poor and good quality of life are all eligible (100%), so it cannot be continued for bivariate and multivariate analysis. In addition, the variables studied were still limited to physical environmental parameters, not fully examining other environmental factors such as chemical parameters and biological parameters.

CONCLUSION

There is a significant relationship between house temperature and noise on the quality of life of type 2 DM patients at the Barombong Community Health Center, Makassar City. At the same time, the factors of humidity, lighting, and $PM_{2.5}$ have an insignificant relationship with the quality of life of type 2 DM patients. The results of this study can be used in determining government policies to improve the quality of life of people with DM. Environmental health workers educate about the characteristics of healthy homes and optimize prolonged activities to reduce complications in type 2 DM patients.

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CONFLICT OF INTEREST

We have no competing interests.

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