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**ASSESSING HEALTH RISK FOR COMMUNITY ADAPTATION IN URBAN
HEAT ISLAND AREA OF PADANG CITY**

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ABSTRACT

Areas classified as Urban Heat Islands (UHI) have a higher health risk due to climate change. High population activity, increasing population density, and low vegetation cover cause this area to become warmer than its surroundings. From the detection of the spatial pattern, Padang City has nine sub-districts belonging to UHI. In this area, environmental problems often occur due to climate calamities and have an impact on health. Therefore, this study was to determine the classification of public health risks and community adaptation to climate change in urban heat island areas. This research was conducted on 141 households in Koto Tangah sub-district as the large UHI area and highly prone to climate problems. Data collected by questionnaires, observation, and literature study. The risk assessment matrix was used to identify health risk status. The results showed that water pollution, respiratory problems, and diarrheal diseases are classified as high risks. The community needs to adapt to climate change, mainly doing routine physical activities, to increase immunity from many diseases.

Keywords : Health Risk, Urban Heat Island, Adaptation Strategy to Climate Change

INTRODUCTION

Climate change contributes to rising health problems, such as heatwaves, forest fires, floods, hurricanes, and increased morbidity and mortality. Climate change is often associated with the growth of infectious diseases because of the rising temperature. Simultaneously, extreme weather modifies the incidence of contagious diseases and raises the frequency of outbreaks⁽¹⁾.

To minimize the problems that will occur, risk assessment activities are needed. Risk assessment is a part of the risk management process that measures the magnitude of the risk consequences and the likelihood. Therefore, adaptation strategies can be carried out according to the high or low risk of events⁽²⁾. Research using the risk assessment matrix of climate change impacts on health problems found that the extreme risk for health was the inability to meet daily energy needs, heat waves, and increased air pollution. Then the risk status of health impacts due to climate change in the high category was the presence of aeroallergens and food-borne diseases⁽³⁾.

Haines et al. (2006), in their study, showed that the health effects of climate change were diseases related to temperature change, vector-borne diseases, and malnutrition⁽⁴⁾. Canyon, Speare, and Burkle (2016) also discovered several health problems caused by climate change. Those were changes

in the distribution of endemic pathogens, increasing temperatures, and flood events that affect the high rates of infectious diseases and water contamination⁽⁵⁾. This also caused high death and injury rates, infectious diseases transmitted by food, water, and vectors, malnutrition, and increased heart and respiratory disease⁽⁶⁾.

Increasing temperatures in a region cause the Urban Heat Island (UHI) phenomenon because of high activity and population density (urbanization flow) followed by low vegetation cover. Therefore, this area becomes hotter than its surrounding⁽⁷⁾. The maximum temperature of Padang City increased from 2007 by 30.250 C to 33.230 C in 2016. From the results of the detection of the spatial pattern of UHI, Padang City had nine sub-districts belonging to UHI. Areas that have large UHI were Koto Tengah District (305.56 Ha) followed by Padang Utara District (219.19 Ha) and Nanggalo District (200.46 Ha)⁽⁸⁾.

In addition, the city of Padang has a high potential for flooding equal to 91.8% of all existing areas. Koto Tengah is the highest sub-district that has the potential to flood hazards and also the most potential area for extreme weather hazards such as drought and tornadoes. Koto Tengah has a vast potential danger of epidemics than other regions and becomes the highest sub-district in dengue

cases because of the increasing DHF vector during the rainy season ^(9,10).

From the background above, Koto Tangah sub-district is an Urban Heat Island area in Padang City that is vulnerable to climate change's health impacts. Previous research has examined the health effects of climate change ⁽¹¹⁾. However, the analysis of the risk of specific health impacts for UHI, which is highly potential for climate change, has never been studied. Therefore, this study aims to assess the risk status of the effects of climate change on public health and determine household adaptation strategies to climate change in the Urban Heat Island area in the City of Padang.

METHODS

This study used a descriptive qualitative approach using the Risk Assessment Matrix to assess health risk. The health risks of climate change were heat stress and heat symptoms caused by heat waves, extreme weather, air pollution, growth of aeroallergens, decreasing food sources, rising vector, and water transmitted diseases, socio-economic disturbances, and the effects of ozone depletion. This research was conducted in June-July 2018 in Koto Tangah sub-district, Padang City. In this study, all family heads were determined as the sample as many as 141 heads of households. Sampling for this study had the purposes of ensuring the data's validity

and reducing subjectivity. The sampling technique used Proportional Stratified Random Sampling, and the method of collecting data in this study was: the determination of the likelihood of possible health problems by questionnaire; finding the level of consequences by literature studies; determination of risk status; and finding adaptation strategies by questionnaires and observations technique.

The purpose of risk assessment in the context of climate change is to identify risks and events that can be induced or exacerbated by climate change and to evaluate the magnitude of the consequences and the likelihood that will occur. Risk assessment can be a useful tool for planning adaptation strategies because they can be used to address various climate-related impacts based on the likelihood or risk of events ⁽²⁾. Some of the steps taken in climate change risk assessment are as follows ⁽¹²⁾

Determination of the likelihood of possible risks

The likelihood of risk occurrence was done to reduce subjectivity to ensure the validity of the data obtained. The category of the likelihood was obtained by multiplying the frequency score with the weight. The maximum score was 5 for each respondent divided by the results of the multiplication of frequency and weights, followed by multiplying by 100%. The result classified to

rare (≤ 20), unlikely (21-40), possible (41-60), likely (61-80), and almost certain (81-100).

Finding the level of consequences

This assessment was conducted to identify system failures that impact the system and vulnerable groups using previous studies' literature studies. The consequences were classified as catastrophic, major, moderate, minor, and insignificant.

Determination of risk status

Finding the risk scores multiplied the likelihood of possible health problems with the level of consequences. Afterward, each health problem was classified into an extreme, high, medium, and low risk grouped in the risk status matrix.

RESULT

Risk likelihood of the impact of climate change on health

Table 1 shows the risk likelihood of the effects of climate change on health. The table provides information that the symptoms of heart disease and respiratory disorders due to hot weather are on the unlikely category. The symptoms of heat stress, classified as possible, are lethargy, muscle cramps, and headache. Furthermore, the health impact due to extreme weather caused by climate change in the probable category is water pollution, while air pollution impacts such as eye irritation and respiratory disorders are also in the same category. Then, the risk of infectious diseases in the form of diarrhea is also categorized into a possible classification.

Table 1. Risk likelihood of the impact of climate change on health

Health impact	Likelihood					Likelihood mean
	Rare (1)	Unlikely (2)	Possible (3)	Likely (4)	Almost certain (5)	
<i>Symptoms of disease due to heat wave</i>						
Heart disorders	127	9	1	4	0	2
Respiratory disorders	33	89	9	10	0	2
<i>Symptoms of Heat Stress</i>						
Lethargy	16	81	19	22	3	3
Muscle cramp	23	58	13	40	7	3
Headache	12	69	25	30	5	3
<i>Impact of extreme weather</i>						
Died	141	0	0	0	0	1
Injuries	117	24	0	0	0	2
Polluted water	80	21	8	22	10	3
Lack of food	82	47	6	4	2	2
Difficulty accessing health facilities	79	39	9	13	1	2

Impact of air pollution

Eye irritation	9	69	16	33	14	3
Respiratory disorders	13	84	19	20	5	3

Infectious Diseases

DHF	104	22	12	1	2	2
Malaria	126	8	4	2	1	2
Diarrhea	60	10	20	41	10	3
Typhoid	119	11	9	2	0	2
Skin disease	132	4	5	0	0	2

Level of consequences of the impact of climate change on health

Table 2 shows the consequences of the effects of climate change on health. Determination of the level of consequences is based on previous research, where studies of climate change impacts are adjusted to the

study's location. As the effects of extreme weather, the most common is flooding, some consequences are adjusted for the flood's effects. The consequences of catastrophic categories are increased heart symptoms due to heat, death, and injuries due to extreme weather, dengue fever, malaria, and diarrhea.

Tabel 2. Level of Consequences of the Impact of Climate Change on Health

Health Impact	Literature Study	Consequences
<i>Symptoms of disease due to heat wave</i>		
Heart disorders	Death from heart complications are the biggest impact of heatwave in Shanghai. ⁽¹³⁾ In hot temperatures cities, heatwave is a factor that causes death from heart complications ⁽¹⁴⁾ .	Catastrophic
Respiratory disorders	Warm weather is a high risk factor for the increased incidence of Chronic Obstructive Pulmonary Disease (COPD) ⁽¹⁵⁾ . It is estimated that COPD will be the fifth cause of disability in developed countries by 2020 ⁽¹⁶⁾ .	Major
<i>Symptoms of Heat Stress</i>		
Lethargy	An increase in temperature can cause lethargic and affect work productivity ⁽¹⁷⁾ . Heat stress which causes weakness makes difficulties in maintaining work levels and work output during very hot weather ⁽¹⁸⁾ .	Moderate
Muscle cramp	Hot air reduces muscle strength because muscles become cramped and reduce work ability ⁽¹⁹⁾ .	Minor

Headache	Headaches are a persistent effect caused by heatstress due to the temperature of hot air ⁽²⁰⁾ .	Moderate
<i>Impact of extreme weather</i>		
Died	2/3 of deaths due to extreme weather (floods) caused by water flow and sinking ⁽²¹⁾ .	Catastrophic
Injuries	The probability of injury due to flooding can be followed by death ⁽²²⁾ .	Catastrophic
Polluted water	Enteric virus contamination is found in water contaminated by flooding ⁽²³⁾ and in ground water, so the water that is distributed to houses contains pathogens ⁽²⁴⁾ . This increases the epidemic of gastrointestinal diseases ^(25,26) .	Major
Lack of food	Weather changes such as changes in rainfall patterns result in changes in cropping patterns that reduce agricultural yields ⁽²⁷⁾ . Extreme weather due to climate change will worsen food insecurity, so people become vulnerable to hunger and malnutrition ⁽²⁸⁾ .	Major
Difficulty accessing health facilities	Floods can damage and soak roads that connect residents' houses with important facilities ⁽²⁹⁾ . This facility includes health facilities such as hospitals and health centers. In addition, health facilities can also be damaged and submerged due to flooding, thereby reducing services to the community, especially those that require emergency services ⁽³⁰⁾ .	Catastrophic
<i>Impact of air pollution</i>		
Eye irritation	Effects of air pollution due to climate conditions for visual impairments such as conjunctivitis and eye surface problems including minor subjective symptoms ⁽³¹⁾ .	Minor
Respiratory disorders	Climate factors (temperature, wind speed, humidity, thunderstorms, etc.) can affect the biological and chemical components of allergen interactions with diseases associated with respiratory allergies such as rhinitis and bronchial asthma ⁽³²⁾ .	Major
<i>Infectious Diseases</i>		
DHF	The DHF epidemic rises due to the growth of the aedes mosquito vector capacity which has increased significantly due to climate change and increases mortality ⁽³³⁾ .	Catastrophic
Malaria	The mortality burden due to malaria is very large, especially in adults. Although the incidence of malaria	Catastrophic

Diarrhea	<p>in the world has declined considerably ⁽³⁴⁾, but all anopheles species easily transmit the four Plasmodium species which routinely infect humans in Indonesia due to geographical factors and climate change ^(35,36).</p> <p>Diarrhea is estimated to reach 17% of all deaths among children aged <5 years and ranks 5th as the biggest cause of death in the world ⁽³⁷⁾. Climate factors such as rainfall, relative humidity, and air pressure can contribute to changes in the incidence of diarrhea because it impacts on the level of replication of certain pathogenic bacteria and protozoa that cause diarrhea ⁽³⁸⁾.</p>	Catastrophic
Typhoid	Floods significantly increase the number of typhoid fever cases with a 1-week lag effect and potentially complications ^(39,40) .	Major
Skin disease	Skin problems encountered during floods are eczema caused by gram negative bacteria that can be cured with atopic treatment ⁽⁴¹⁾ .	Minor

Determining of health risk status

Table 3 shows the risk status for the impact of climate change on health. The table gives information that most of the risks of climate change health impacts are moderate.

Simultaneously, high risks are diarrhea, diseases, water pollution, and respiratory disorders due to air pollution.

Table 3. Risk status for the impact of climate change on health.

Health Impact	Likelihood	Consequences	L x C	Risk Category
<i>Symptoms of disease due to heat wave</i>				
Heart disorders	2	5	10	Medium
Respiratory disorders	2	4	8	Medium
<i>Symptoms of Heat Stress</i>				
Lethargy	3	3	9	Medium
Muscle cramp	3	2	6	Low
Headache	3	3	9	Medium
<i>Impact of extreme weather</i>				
Died	1	5	5	Medium
Injuries	2	5	10	Medium
Polluted water	3	4	12	High
Lack of food	2	4	10	Medium

Difficulty accessing health facilities	2	5	10	Medium
<i>Impact of air pollution</i>				
Eye irritation	3	2	6	Low
Respiratory disorders	3	4	12	High
<i>Infectious Diseases</i>				
DHF	2	5	10	Medium
Malaria	2	5	10	Medium
Diarrhea	3	5	15	High
Typhoid	2	4	8	Medium
Skin disease	2	2	4	Low

DISCUSSION

The high category of health risks requires major attention to minimize the impact of climate change that worsens the surrounding community's health conditions. The significant effect of climate change in this area is flood disaster because 91.8% of this area is prone to inundate by flood during extreme rain periods ⁽⁹⁾. Research shows that diarrhea is classified as a high category. This is evidenced by most diarrhea cases in Padang City located in Koto Tengah sub-district ⁽¹⁰⁾. This is supported by research conducted in other flood-prone areas that show the rising of diarrhea cases when floods occur ⁽⁴²⁾. The incidence of diarrhea is higher in flood-prone areas than areas that are not prone to flooding in the same season ⁽⁴³⁾.

Besides, the rising temperature is followed by the increasing of pathogenicity of microorganisms that cause diarrhea. Studies conducted in Japan find that the weekly number of infectious gastroenteritis cases increase by 7.7% for 1° C ⁽⁴⁴⁾. Extreme rainy

days are also significantly associated with diarrhea morbidity. The maximum temperature impact on diarrhea-related morbidity occurs mainly among children (0-14 years) and ages 40-64. However, it has less effect on adults (15-39 years). This shows that children and older adults are the most vulnerable to diarrhea-related morbidity caused by climate variations ⁽⁴⁵⁾. Therefore, diarrhea disease is identified as a priority for more routine monitoring because changes in climate conditions will increase infection with salmonellosis, campylobacteriosis, vibriosis, listeriosis and other parasites ⁽⁴⁶⁾.

Climate change in the form of floods and droughts can have implications for water security. Floods can carry stools and disease pathogens. Then the polluted water sources increase health risks that can damage the community. Also, drought causes a reduction in the amount of groundwater, which impacts water wells draining and increases pollution in water sources ⁽⁴⁷⁾. This is very risky because this area is classified as an area that has a high

risk of drought, and almost all parts of Koto Tengah are potentially submerged in floods when heavy rains occur. The trend of decreasing water quality raises the risk of health problems, especially in extreme weather. Nearly 80% of the world's human population is threatened by inadequate availability of clean water ⁽⁴⁸⁾. Therefore, integrated water resources management is needed, which involves the community and the government to improve water shortages due to climate change.

Respiratory disorders are also included in the risk with a high category. Several studies have shown that respiratory disorders characterized by fever and bronchial asthma have become common in populations throughout the past two decades. The lifestyle of urban communities that adopt the life patterns of 'western' countries such as vehicle use increases greenhouse gas emissions that increase allergens in the air ⁽⁴⁹⁾. When air allergens and air pollution increases in the atmosphere, the body produces IgE-mediated responses to aeroallergens. It improves respiratory tract inflammation increasing the frequency of respiratory allergies and asthma. Climate factors (temperature, wind speed, humidity, thunderstorms, etc.) can affect the biological and chemical components of allergen interactions with diseases associated with respiratory allergies such as rhinitis and bronchial asthma⁽³²⁾.

The sensitivity of the respiratory tract and the hyperresponsive of exposed subjects increase respiratory problems due to pollution. Mucosa damage, respiratory tract, and impaired mucociliary clearance caused by air pollution can facilitate access to inhaled allergens to enter the immune system's cells. Also, plants react with air pollution and environmental conditions and affect their allergens. Several factors influence this interaction, including types of air pollutants, plant species that cause allergens, and nutrient balance ⁽⁴⁹⁾.

Household adaptation strategies on climate change to reduce health impacts

Lack of physical activity is a risk factor for many health problems. The vulnerability of the human body due to climate changes, the number of pathogens found in floods, and allergens cause a person susceptible to disease. To overcome this problem it requires good immunity. One of them is doing enough physical activity ⁽⁵⁰⁾. Not only with exercise, but physical activity can also be done by changing lifestyles, such as choosing to use a bicycle rather than a vehicle or getting used to walking ⁽⁵¹⁾. In addition to increasing immunity and avoiding diseases, especially cardiovascular disorders, carrying out these activities can also reduce greenhouse gas emissions that increase global climate change ⁽⁵²⁾. However, the timing of physical activity in

hot weather also needs to be considered. It is better to do in the morning to reduce the risk of health problems due to heatwaves.

Fast food increases health risks because it does not meet the needs of the body's micronutrients. Fast food is associated with a high consumption of fats and sugars, which increases the risk of obesity and increases other diseases' risk. The high consumption of fast food increases from year to year and the lifestyle and business, especially in children and working-age ⁽⁵³⁾. Health problems due to climate change, such as increasing the symptoms of cardiovascular disorders, can be reduced by reducing the habit of eating fast food.

Temperature also increases the risk of mental health problems due to climate change. Exposure to high temperatures is associated with increased mental disorders for vulnerable groups ⁽⁵⁴⁾. One thing to reduce heat exposure is to install an air conditioner because the temperature can be adjusted according to body needs. However, not all people use air conditioning because economic factors influence it. This is caused by high prices, high operational costs, and requires periodic maintenance.

Reducing vulnerability to health problems is a strategy for adaptation to climate change. Adaptation activities that focus on reducing vulnerability are carried out by making the body and environment more

resistant to climate-related hazards ⁽¹¹⁾. By promoting safety and health, the burden of pre-existing diseases will be reduced by building social capital and strengthen community resilience to various health hazards, including extreme weather events. Public health organizations (health centers, hospitals, and other health organizations) and medical staff can play an active role in reducing human vulnerability to climate-related health problems through the health promotion slogan "healthy individuals, healthy family members, healthy communities" ⁽⁵⁵⁾. Healthy people tend not to suffer from morbidity or mortality related to climate change, and they become resistant to health problems

CONCLUSIONS

Due to climate change, high-risk health problems in the urban heat island of Padang city are diarrhea, water pollution, and respiratory problems due to air pollution. It needs to improve health promotion and appropriate prevention of the impact of high-risk climate change. This can be done in the form of increasing physical activity and reducing the use of motorized vehicles, increasing fiber intake, and reducing fast-food consumption. The improvement of the drinking water supply system needs to reduce water sources' vulnerability from the potential pollutant due to flooding.

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