Climate and Adolescence Mortality: Exploring the Linkages

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ARTICLE INFO	ABSTRACT
	The rising frequency of heat-related illnesses among adolescences, particularly during the dry season, is quite concerning. High temperatures and heatwaves have been proven in studies to aggravate pre-existing health issues and raise the risk of mortality in this demographic group. Climate change is projected to worsen current health concerns while also creating new ones, especially among vulnerable groups such as adolescents and young people. Unfortunately, there has been little study on the influence of climate change on death rates among Malaysian adolescents. As a result, the goal of this study is to look at the relationship between annual temperature and mortality rates among Malaysian adolescents. The study's specific goal is to evaluate the extent to which one of the climate change variables, which is temperature is linked to mortality rates in this demographic group. In this study, a linear regression model is used to analyse data from 1980 to 2021 to investigate the relationship between annual temperature and mortality rates among Malaysian adolescents. To isolate the influence of climate change on mortality rates, the study controls for a variety of demographic and socioeconomic characteristics. The regression analysis results show that temperature is significantly associated with mortality rates among Malaysian adolescents. This study gives evidence of the major influence of climate change on mortality rates among adolescents and young people in Malaysia. The findings underline the critical need for targeted treatments and policies to address climate change-related health hazards and protect vulnerable groups.

1. Introduction

Mortality rate among adolescences in Malaysia has been a growing concern in recent years. According to data from the Department of Statistics Malaysia, the mortality rate among teenagers aged 15-19 years increased from 11.6 per 100,000 population in 2010 to 13.5 per 100,000 population in 2020 [1]. While the causes of this increase are complex and multifactorial, climate change may be a contributing factor that warrants further investigation.

Mortality rate among adolescence is a growing concern in Malaysia, and climate change may be a contributing factor to this issue. With a rise in temperatures, changes in weather patterns, and an

increase in extreme weather events, the impact of climate change on human health has become a pressing issue globally. In Malaysia, adolescence may be particularly vulnerable to the effects of climate change, given their age and developmental stage. This paper aims to explore the relationship between mortality rate among adolescence and climate change in Malaysia.

Climate change is a global phenomenon that has significant implications for human health. According to the World Health Organization (WHO), climate change is one of the greatest threats to human health in the 21st century, with an estimated 7 million deaths worldwide attributed to its effects each year [2]. In Malaysia, the effects of climate change are increasingly evident, with rising temperatures, more frequent extreme weather events, and changes in weather patterns [3]. These changes have the potential to impact the health of the population, particularly vulnerable groups such as adolescence.

Adolescences are a unique group in terms of their vulnerability to the effects of climate change. As a result of their age and developmental stage, they are more likely to engage in outdoor activities and are less aware of the risks associated with extreme weather events [4]. In Malaysia, where the climate is tropical, the effects of climate change may be particularly challenging for adolescences. Heatwaves, for example, may have significant implications for teenagers who spend extended periods outdoors, leading to dehydration, heat exhaustion, and in severe cases, death [5].

In Malaysia, several studies have highlighted the potential impact of climate change on human health, which may have significant consequences for the population. One of the major impacts of climate change on human health in Malaysia is heat-related illnesses. The study conducted by Heidari et al., [6] found that the incidence of heat-related illnesses increased significantly during periods of extreme heat in Malaysia. This is particularly concerning, given that Malaysia is a tropical country with high temperatures and humidity levels. Extreme heat can cause dehydration, heat cramps, heat exhaustion, and heatstroke, which can be life-threatening.

Another significant impact of climate change on human health in Malaysia is air pollution, which is caused by the release of harmful substances into the atmosphere, such as carbon monoxide, sulfur dioxide, nitrogen oxides, and particulate matter. These substances can have a significant impact on respiratory health, particularly in vulnerable populations such as the elderly, children, and those with pre-existing respiratory conditions. The study conducted by Onwusereaka et al., [7] found that air pollution, which is exacerbated by climate change, had a significant impact on respiratory health in Malaysia.

The impacts of climate change on human health in Malaysia may also have broader societal and economic consequences. For example, the increased incidence of heat-related illnesses and respiratory diseases may lead to increased healthcare costs, reduced productivity, and decreased quality of life. This can have significant consequences for the well-being of individuals, families, and communities. A study aimed to assess the knowledge, attitudes, and practices of young people in Malaysia regarding climate change and its impact on health. The study utilized a cross-sectional survey method and collected data from 451 respondents aged between 18 and 30 years. The study found that the majority of the respondents had limited knowledge about the impact of climate change on health, with only 37% of the respondents correctly identifying the link between climate change and health. The study also found that the majority of respondents had positive attitudes towards climate change and health, indicating a willingness to take action to mitigate the impact of climate change on health [8].

The study conducted by Aghamohammadi et al., [9] aimed to investigate the association between outdoor thermal comfort and heat-related symptoms among young adults in a hot-humid tropical urban environment in Malaysia. The study found that exposure to high temperatures was significantly associated with a higher risk of heat-related symptoms, including dizziness, fatigue, and

headaches. The study also found that young adults who reported experiencing heat-related symptoms were more likely to have a lower thermal comfort index.

The systematic review aimed to investigate the impact of air pollution on respiratory health among children and adolescents in Malaysia. The study included 21 articles that met the inclusion criteria and examined various aspects of air pollution, including particulate matter, nitrogen dioxide, and ozone. The review concluded that air pollution is a significant health risk to this population group, as it can lead to various respiratory illnesses and exacerbate existing conditions, such as asthma. The study found that exposure to air pollution was associated with increased respiratory symptoms, including coughing, wheezing, and shortness of breath, among children and adolescents in Malaysia. Exposure to air pollution was also associated with decreased lung function and increased incidence of asthma and other respiratory illnesses [8]. The review further highlighted that the adverse effects of air pollution on respiratory health were more pronounced in urban areas and among vulnerable populations, such as low-income families. Therefore, the aim of this study is to investigate the relationship between annual temperature and mortality rate among adolescences in Malaysia. The findings of this study may emphasize the urgent requirement for focused interventions and policies to tackle climate change-induced health risks and safeguard vulnerable populations.

2. Methodology
2.1 Linear Regression Analysis

Linear regression analysis is a statistical technique that is used to study the relationship between two continuous variables. It involves analyzing the association between a dependent variable (Y) and a single independent variable (X). In simple linear regression, the relationship between the two variables is modeled using a straight line, which is also known as the regression line or the line of best fit. The aim of the analysis is to find the equation of the line that best represents the relationship between the variables, based on the paired data that is available. Each of the paired observations can be expressed as follows:

$$y = \alpha + \beta x + \varepsilon$$

where α is the intercept, β represent the slope, and ε is the error.

2.2 Linearity Testing

Testing the linearity of the regression model is an important part in accessing the adequacy and significance of a linear regression model. The hypothesis for testing the linearity of the model is given by as follows:

H_0: There exist no linear relationship between mortality rate and temperature

H_1: There exist linear relationship between mortality rate and temperature

Null hypothesis is rejected if the *p*-value is less than 0.01 significance level, which indicates the existence of linear relationship between mortality rate and temperature.

2.3 Correlation Coefficient

The correlation coefficient is a statistical measure of the strength of a linear relationship between dependent variable (mortality rate) and independent variable (temperature). Its values can range from -1 to 1. A correlation coefficient of -1 describes a perfect negative, or inverse, correlation, with values in one series rising as those in the other decline, and vice versa. A coefficient of 1 shows a perfect positive correlation, or a direct relationship. A correlation coefficient of 0 means there is no linear relationship between those two variables.

$$\rho_{xy} = \frac{\text{cov}(x, y)}{\sigma_x \sigma_y}$$

where ρ_{xy} is the Pearson correlation coefficient Pearson correlation coefficient, $\text{cov}(x, y)$ is covariance of temperature (x) and mortality rate (y), and σ is the standard deviation of x and y.

3. Results and Discussion

In this study, the data are collected from two different sources. the annual temperature is collected from Malaysia Meteorological Department (MMD), while the mortality rate data is collected from Department of Statistics Malaysia (DOSM). The mortality data is collected from Figure 1 presents the annual temperature plot from year 1980 to 2021. Looking at the plot, there has been a discernible and concerning increasing trend in the annual temperature in Malaysia. Figure 2 displays the trend of the adolescences mortality rate in Malaysia over the period of 1980 to 2021. From the graph, we can observe that the mortality rate has been fluctuating throughout the years, with a slight decrease from the early 2000s until 2010. However, after 2010, there has been a steady decrease in mortality rate among adolescences in Malaysia. These trends may be attributed to a variety of factors such as changes in lifestyle, environmental factors, and socioeconomic status. By examining the relationship between temperature and mortality rate, we can gain a better understanding of how climate change may be affecting the health of vulnerable populations such as adolescences in Malaysia. This information can be useful in developing policies and interventions to mitigate the impact of climate change on human health and to ensure a healthier and more sustainable future for Malaysia.
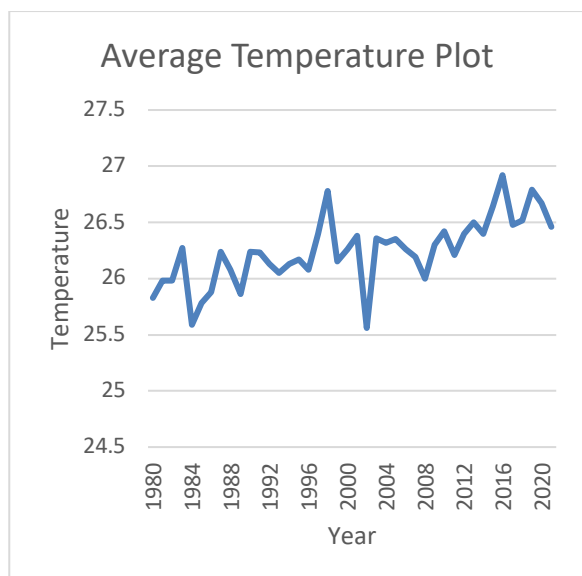
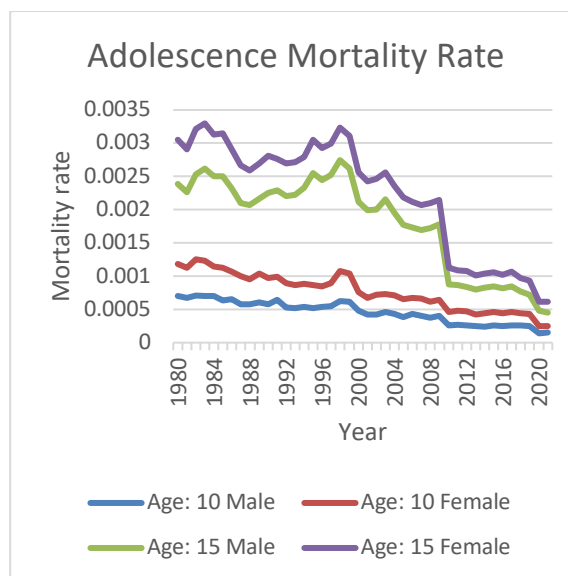**Fig. 1.** Annual time series average temperature

Fig. 2. Adolescence mortality rate in Malaysia

3.1 Linear Regression Model

In this study, a linear regression model was used to explore the relationship between temperature and mortality rate among adolescence in Malaysia. The model's parameter estimates were presented in Table 1, with y representing mortality rate and x representing the average temperature in Malaysia. The results of the model indicated that if the temperature increases by one degree Celsius, the mortality rate of male adolescences aged 10 will decrease by 0.0003, while that of male adolescences aged 15 will decrease by 0.001. Similarly, for female adolescences aged 10 and 15, the model predicted a decrease in mortality rate of 0.0002 and 0.0004, respectively, for every one-degree Celsius (°) increase in temperature.

Table 1
Estimation of Regression Coefficients

Gender	Age	Variable	Coefficients	Standard Error	t Statistics	p-value
Male	10	Intercept	0.0096	0.0019	5.1465	0.0000
		Temperature	-0.0003	0.0000	-4.9040	0.0000
	15	Intercept	0.0234	0.0057	4.0974	0.0002
		Temperature	-0.001	0.0002	-3.9177	0.0004
Female	10	Intercept	0.0062	0.0013	4.7187	0.0000
		Temperature	-0.0002	0.0000	-4.4830	0.0000
	15	Intercept	0.0100	0.0016	6.1788	0.0000
		Temperature	-0.0004	0.0000	-5.9234	0.0000

The parameter estimates of the model, which is displayed in Table 1, is presented as follows, where $\hat{y}$ = mortality rate, and x = average temperature in Malaysia.

a) Male, aged 10: $\hat{y} = 0.0096 - 0.0003x$
b) Male, aged 15: $\hat{y} = 0.0234 - 0.0010x$
c) Female, aged 10: $\hat{y} = 0.0062 - 0.0002x$
d) Female, aged 15: $\hat{y} = 0.0100 - 0.0004x$

Figure 3 shows the regression plot for temperature vs. mortality rate. The findings from the linear regression model used in this study provide important insights into the relationship between temperature and mortality rate among adolescence in Malaysia. The model's parameter estimates, presented in Table 1, show that there is a negative association between temperature and mortality rate. Specifically, the results indicate that increasing temperatures are associated with lower mortality rates among male and female adolescences in Malaysia. The magnitude of this effect varies slightly based on gender and age, with older male adolescences exhibiting a greater decrease in mortality rate with each one-degree Celsius increase in temperature.
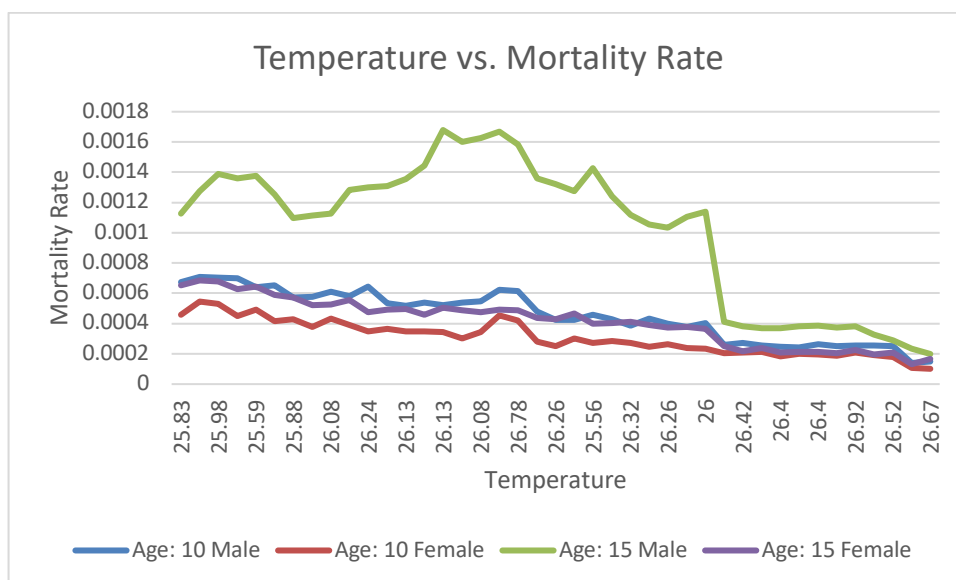

Fig. 3. Regression plot for temperature vs. mortality rate

These findings show that temperature can have a significant impact on human health, particularly among vulnerable populations such as children and adolescents. However, it is important to note that the relationship between temperature and mortality rate is likely to be complex and multifaceted, with a range of individual, social, and environmental factors contributing to the observed associations. As such, further research is needed to explore the underlying mechanisms that may be driving the relationship between temperature and mortality rate among adolescences in Malaysia.

In addition to the parameter estimates presented in Table 1, the p-values indicate the existence of a linear relationship between temperature and mortality rate among all categories of adolescences, including both male and female adolescences aged 10 and 15. This suggests that the linear regression model used in this study provides a useful framework for exploring the relationship between these variables and can help to inform public health policies and interventions aimed at reducing mortality rates among adolescence in Malaysia. However, it is important to note that the linear regression model used in this study has several limitations, including the potential for omitted variable bias and the assumption of linearity in the relationship between temperature and mortality rate. As such, future research may need to explore alternative modeling approaches or consider additional variables to fully capture the complex relationship between temperature and mortality rate among adolescences in Malaysia.

3.2 Correlation Analysis

In addition to the linear regression model used to predict the relationship between temperature and mortality rate among adolescences in Malaysia, a correlation analysis was also performed to examine the strength and direction of the relationship between these two variables. The results of this analysis were presented in Table 2. Based on Table 2, the correlation value is between -0.5 to -0.7, which indicated a moderate negative correlation between mortality rate and temperature. However, it is important to note that correlation does not imply causation, and there may be other factors that are contributing to the observed relationship between these two variables.

Table 2
Correlation analysis between mortality rate and temperature

Gender	Age	Correlation coefficient
Male	10	-0.6176
	15	-0.5314
Female	10	-0.5832
	15	-0.6882

Figure 4 displays the scatter plot for each age, 10 and 15, male and female respectively. The scatter plot displays show there exists a negative association between the variables. The mortality rate is lower as the temperature increases. One potential explanation for the observed moderate negative correlation is that the relationship between temperature and mortality rates may not be linear. Instead, there may be threshold effects or interactions with other variables that could impact the strength of the relationship. For example, extreme temperatures may have a greater impact on mortality rates than moderate temperatures, or there may be other environmental or social factors that interact with temperature to affect mortality rates among adolescents. Additionally, there may be other factors that are not accounted for in the current analysis, such as individual-level characteristics or socioeconomic status, that could be driving the observed relationship between temperature and mortality rate.

Despite these limitations, the findings from this study provide valuable insights into the potential impact of temperature on mortality rates among adolescences in Malaysia. The results suggest that increasing temperatures may have a protective effect on mortality rates among male and female adolescences, particularly those in the 10-15 age range. However, further research is needed to confirm these findings and explore the underlying mechanisms that may be driving the observed relationship between temperature and mortality rate. Understanding these mechanisms could help inform public health interventions and policies aimed at reducing mortality rates among adolescences in Malaysia and other similar contexts.
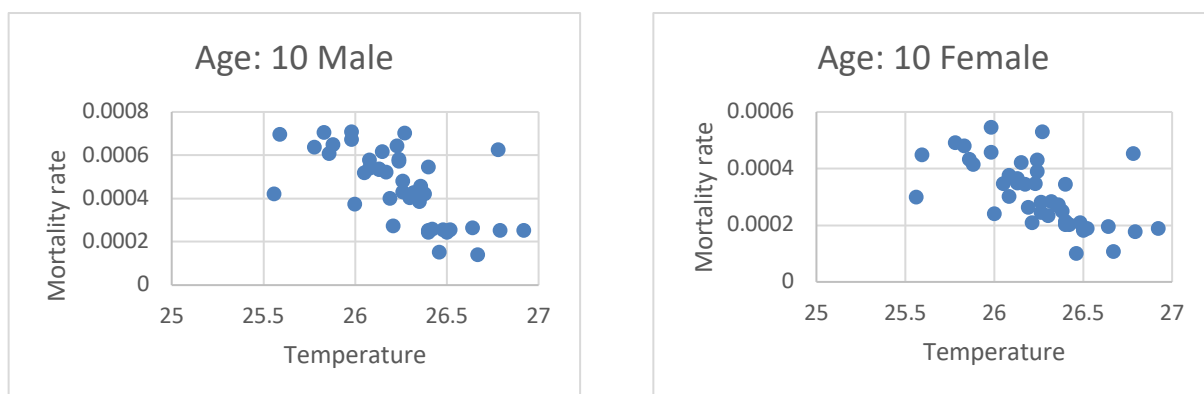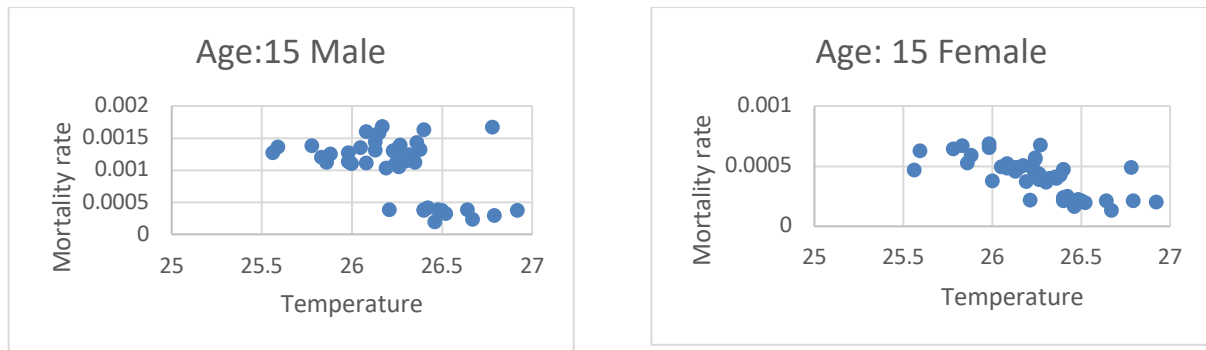
Fig. 4. Scatter plot for each age and gender

4. Conclusions

The study conducted aimed to investigate the relationship between temperature and mortality rate among adolescences in Malaysia, spanning from 1980 to 2021. The findings of the study indicated a significant negative relationship between the adolescence mortality rate and temperature, which suggests that higher temperatures have a significant negative impact on the mortality rate of adolescence in Malaysia. The results of this study are consistent with previous research, which highlights the potentially significant effects of climate change on human health, particularly among vulnerable populations such as adolescence [10].

The observed negative relationship between temperature and mortality rate underscores the urgent need for effective strategies to mitigate the impact of climate change on human health in Malaysia. Climate change is likely to have significant effects on human health in Malaysia, which may include increased mortality rates, greater incidence of infectious diseases, and a range of other adverse health outcomes [6,7,11]. To address these challenges, a range of interventions will be needed, including public health education, urban planning and green infrastructure initiatives, and efforts to reduce greenhouse gas emissions and promote sustainability [12].

In conclusion, the findings of this study highlight the urgent need for action to address the impact of climate change on human health, particularly among vulnerable populations such as adolescence in Malaysia. By adopting a proactive and evidence-based approach to climate change mitigation and adaptation, policymakers and stakeholders can help to ensure a healthier and more sustainable future for Malaysia. Further research is needed to explore the underlying mechanisms driving the observed relationship between temperature and mortality rate among adolescence, and to identify effective strategies for mitigating the impact of climate change on human health in Malaysia and beyond.

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