

# The association between daily temperature with non-accidental mortality in Penang, Malaysia: A time series study

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NMRR ID-22-00996-SDE

## 1 Introduction

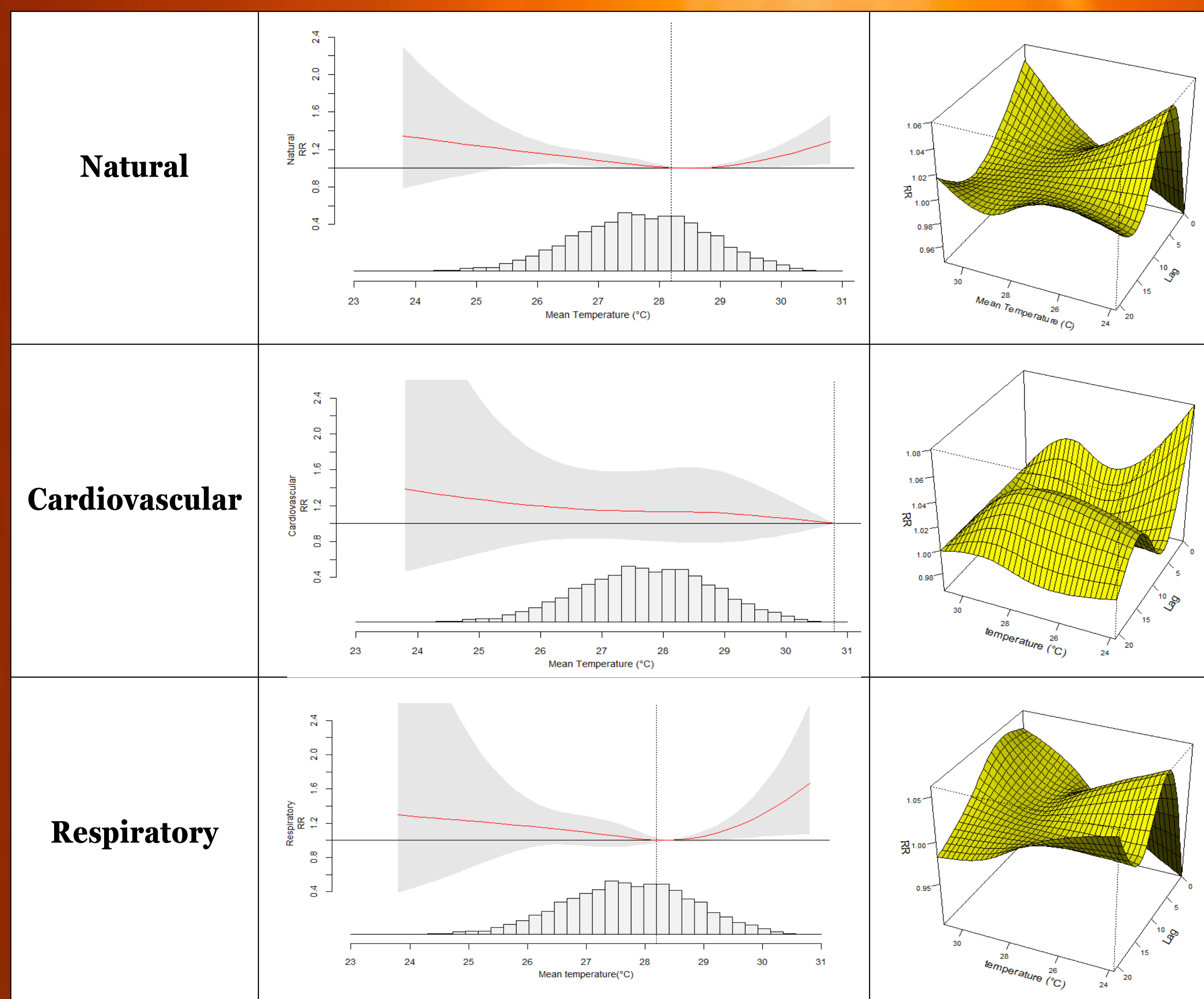
- Extreme temperatures bring negative consequences human health, including mortality.
- Studies on the association between daily ambient temperature and mortality concentrated in developed countries and still scanty in developing countries<sup>1</sup>, despite of the populated with more **vulnerable population, lack of infrastructure, limited access to healthcare services with lower socio-economic status**<sup>2,3</sup>
- Malaysia had an increase in annual mean temperature ranging from 2.7-4.0° C over past decade<sup>4</sup> while **Penang**, had **moderate to very-high heat exposure index** in Peninsular Malaysia<sup>4,5</sup>
- This study aimed to examine the relationship between daily temperature and non-accidental causes of mortality in Penang

## 2 Methodology

- This is a time series study utilised data from **1 Jan 2011 to 31 Dec 2020**
  - Mortality (DOSM): natural-cause (icd10: a00-r99), cardiovascular (i00-i99) and respiratory (j00-j99).
  - Air pollutants (DOE): PM10, SO<sub>2</sub>, Nox, CO and ozone
  - Meteorology (MetMalaysia): mean, max. and min. for temperatures and relative humidity (RH)
- Time series model examined the effects of average temperature on **mortality** while controlling for RH, day of the week, long-term trend and air pollutants using **distributed lag non-linear (DLNM)** model combined with **Generalized Linear Model (GLM) Poisson regression** for delayed effects of temperature on mortality up to 21 days, using R studio 4.3.0

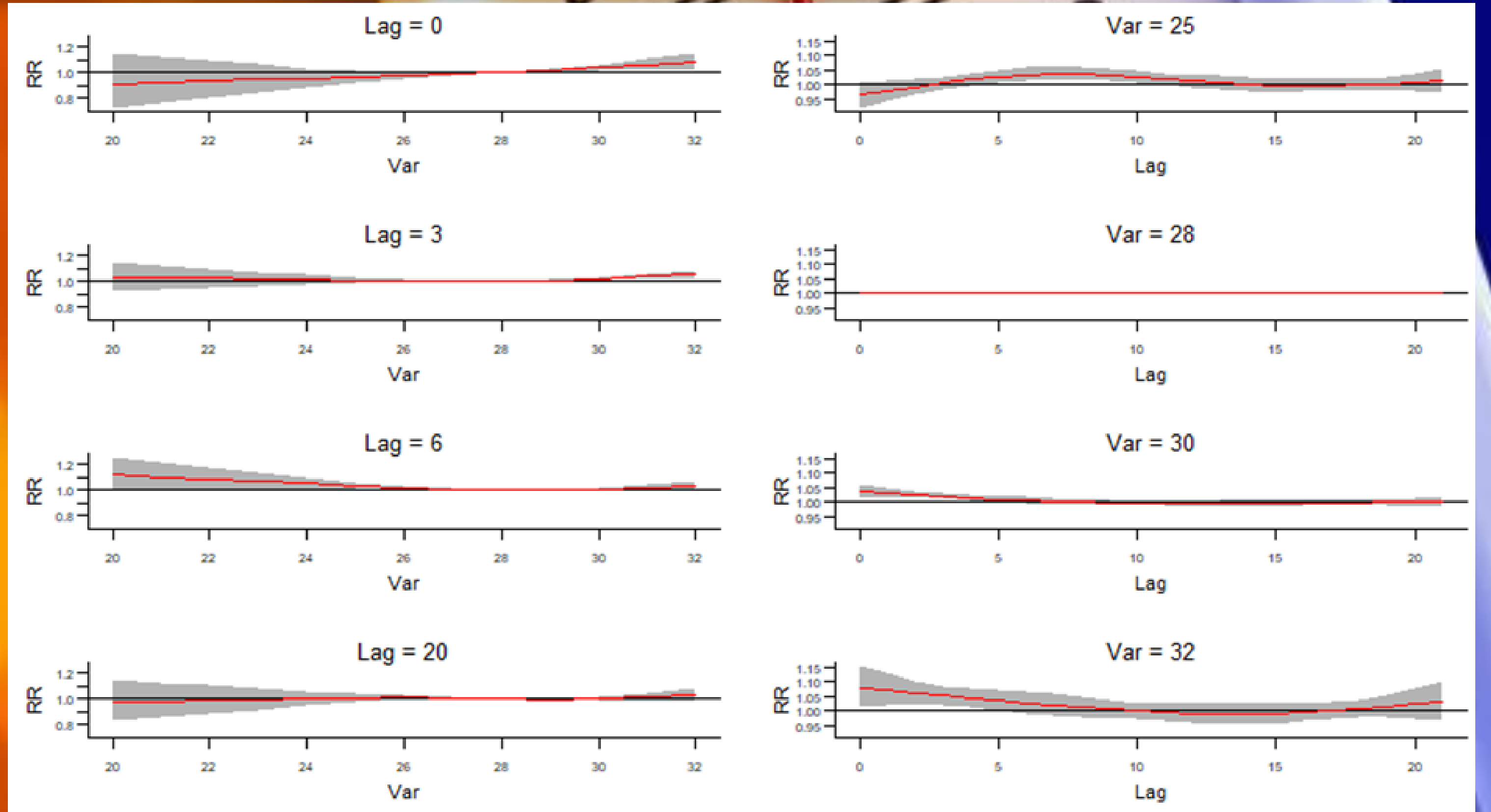
## 3 Results and discussion

- A total of **54,431** non-accidental mortality were recorded with a mean age of mortality at **65years old (SD±17)**.
- More than half of the mortality occurred among **males (59.26%)**, aged more than **65 years old (54.5%)**, and **Malaysian citizenship (95.5%)**



**Figure 1:** The estimated overall effect (left) and three-dimensional plot (right) of the relative risk of the mean temperature (°C) over lags 0–21 days on cause-specific mortality (natural, cardiovascular, and respiratory); Shaded areas=95% confidence intervals

- The minimum mortality temperature (MMT) for Penang is **28.4 °C**, comparable to Klang Valley (28.0°C)<sup>6</sup>, but slightly high when compared to other South-Asian countries in Thailand and Vietnam (26-27°C).
- The relationship between temperature and mortality is **non-linear with U-shaped**.
- The relative risk of mortality is higher at high and low temperatures for natural and cause-specific respiratory mortality
- No significant association of temperature with mortality for cause-specific cardiovascular mortality
- Right panel shows 3D in which both hot and cold temperatures were associated with increased risk of mortality at shorter lags for hot temperatures and longer lags for cold temperatures.



**Figure 2:** Relative risks of average temperature (°C) on natural-cause mortality by various lags and temperatures; Shaded areas=95% confidence intervals

- **Heat effects** on mortality were **immediate** and has **shorter lags** (lag 0-lag 5), whereas **cold effects** were **delayed** and **lasted longer** (lag 5-lag 10)
- Re-increase of mortality risk at very long lag 19-21 could be due to harvesting effect or frailty effect, varying seasonal susceptibility to temperature or change in the acclimatization behavior<sup>7</sup>.
- Both **extremely hot** (30.1°C, at 99th percentile) and **extremely cold** (25.6°C, at 1st percentile) temperature **increase risk of natural mortality** over lags 0-21 days with RR =1.13(95% CI=1.02, 1.25) and RR=1.19 (95% CI=1.01, 1.40) respectively.
- The magnitude of cold effect slightly higher than the hot effects which probably due to lack of adaptation to colder temperature<sup>8</sup>.
- **Elderly** (more than 65 years old) has **29% risk** (RR=1.29 (95% CI:1.09, 1.53) and **35%** (RR=1.35 (95% CI: 1.08, 1.69) risk of mortality following exposures to extremely hot and cold temperature.

## 4 Conclusion

- ❖ Our findings showed that **natural** and cause-specific **respiratory** mortality has significant association with temperature. While the elderly are vulnerable to the effects of extreme temperature.
- ❖ These findings would help relevant stakeholders and policymakers in developing effective public health policies and adaptation measures towards extreme temperatures as well as improve the healthcare system response in future extreme temperature events

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### Acknowledgement

This research is a part of collaboration of UiTM with NIH. We would like to thank the Director General of Health Malaysia for his permission to present these findings