Climate change, weather extremes and impacts in the MENA

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Temperature and precipitation anomalies from climate proxies and recent data
CMIP5 temperature vs. observations in reference period (1986 – 2005)
Coupled Model Inter-comparison Project Phase 5 – CMIP5: temperature projections

Model robustness high: dots $R \geq 0.85$, and cross-hatching $0.5 \leq R < 0.85$
Coupled Model Inter-comparison Project Phase 5 – CMIP5: precipitation projections
CMIP5: projected temperature indices, and observations in reference period
Observed (grey) and modeled (red) temperature changes relative to reference period 1961-1990
Heat waves are a major weather-related cause of premature mortality.
Probability distribution (PDF) of daytime maximum temperatures in summer (JJA)

Nicosia

Temperature (°C)

Probability

1961 - 1990
2010 - 2039
2040 - 2069
2070 - 2099
Probability distribution (PDF) of daytime maximum temperatures in summer (JJA)
Applying a DLNM to a case-crossover design permits a flexible assessment of the non-linear and delayed effects of temperature on mortality and corrects for the effects of seasonality by design [27]. In order to combine the DLNM with the case-crossover design, a Poisson regression model was used, which allows for overdispersion:

$$\log \mu_t(\cdot) = \alpha + \beta T_t, l + \lambda \text{Strata}_t + \eta \text{DOW}_t,$$

where $t$ is the day of the observation; $Y_t$ is the mortality count on day $t$; $\alpha$ is the intercept; $T_t$, $l$ is the matrix that is obtained when the DLNM is applied to temperature; $\beta$ is a vector of coefficients for that matrix; and $l$ is the lag in days. Strata$_t$ represents the case-control strata, a variable for the year and month that is used to control for long-term and seasonal trends; $\lambda$ is a vector of coefficients and DOW$_t$ is the day of the week on day $t$, with $\eta$ being a vector of coefficients [27].

As the cross-basis functions to describe the temperature-response relationship can be independently chosen for temperature and lag, a quadratic basis spline was used for temperature and a natural cubic spline was used for the lag. In the quadratic basis spline, 4 degrees of freedom were used, and the knots were by default located at evenly distributed percentiles. For the natural cubic spline 4 degrees of freedom were selected and the boundary knots were by default placed at the range of the predictor, here lag 0 and lag 10. The choices of the degrees of freedom were based on the literature [27,29] and to optimize with modified Akaike and Bayesian information criteria (QAIC and QBIC) [28]:

$$\text{QAIC} = -2 \log L_{\hat{\theta}} / C_{16}/C_{17} + 2 \hat{\varphi} k$$

and

$$\text{QBIC} = -2 \log L_{\hat{\theta}} / C_{16}/C_{17} + \log n(\cdot) \hat{\varphi} k$$

where $L$ is the log-likelihood of the fitted model; $\hat{\theta}$ represent the parameters of the fitted model; $\hat{\varphi}$ is the estimated overdispersion parameter; $k$ represents the total number of parameters; and $n$ is the total number of observations.

The model that minimizes these two criteria was selected as the final model. For the purpose of this study, Figure 2 Distribution of meteorological stations and the main urban areas.

Lubczyńska et al., 2015
Heat-related cardiovascular mortality risk in Cyprus
Figure 3 Relationship between temperature and relative mortality risks (RR) of aggregated cardiovascular diseases for lags ranging from 0 to 10 days for: (a) $T_{\text{mean}}$; (b) $T_{\text{max}}$; and (c) $T_{\text{min}}$. 

Figure 4 Relationships between temperature and relative mortality risk associated with the five categories of cardiovascular diseases. Legend: 

- (a) cerebrovascular diseases (ICD-10: I60-I69); 
- (b) ischaemic heart diseases (ICD-10: I20-I25); 
- (c) other heart diseases (ICD-10: I26-I51); 
- (d) hypertensive diseases (ICD-10: I10-I13); and 
- (e) remainder of diseases of circulatory system (ICD-10: I71-I99) for lags ranging between 0 and 10 days.
Future temperature in southwest Asia projected to exceed a threshold for human adaptability

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Pal and Eltahir, 2015
Mortality attributable to ambient air pollution

Units: Individuals per area of 1,000 km²/year

The Lancet Commission on pollution and health:
Pollution is the largest environmental cause of disease and death in the world today, responsible for an estimated 9 million premature deaths

Ambient air pollution causes respiratory and cardiovascular diseases, leading to 4.5 million premature deaths per year globally (8% of all deaths worldwide)
120 million years of life lost annually attributable to air pollution by ischaemic heart disease (IHD), chronic obstructive pulmonary disease (COPD), cerebrovascular disease (CEV), acute lower respiratory infections (ALRI) and lung cancer (LC): 18% due to child deaths in S/W-Asia and Africa
Aedes *albopictus* distributes pathogens that cause Chikungunya, Dengue fever, yellow fever and various encephalitides.

Habitat suitability depends on mean, winter minimum and summer maximum temperature; precipitation amount and annual distribution; and relative humidity.
Habitat suitability index change (scale 0-100) comparing middle with early 21st century
MENA is climate change hot spot

Strongly increasing temperature in summer (>2x winter): global temperature increase of 2°C means 4-5°C for MENA in summer

Projected temperature change is robust (high likelihood)

Warming amplification due to drying (Mediterranean) or arid soils

In several areas (e.g. Gulf), high humidity adds to discomfort

In urban locations heat stress combines with other environmental stresses (e.g., UHI effect, dust and air pollution)

Habitability for humans may be compromised

(climate change + poverty → migration)