Accelerating Heat Stress and Human Survivability Risk in Qatar

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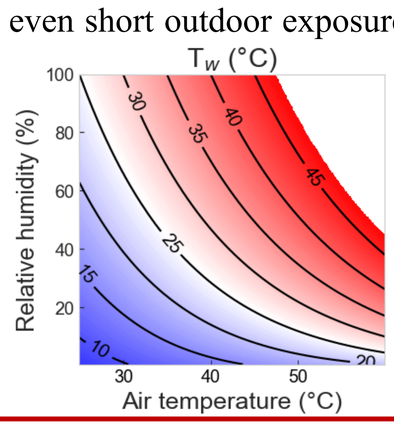
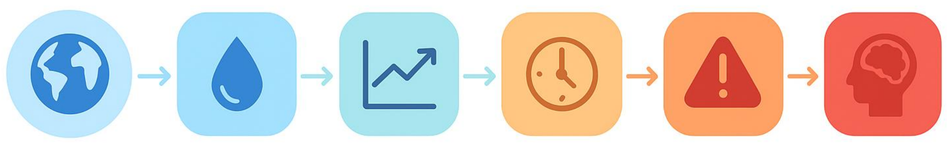
INTRODUCTION

- The Arabian Gulf is among the fastest-warming regions globally. In Qatar, rising temperature and humidity are driving up wet-bulb temperatures (T_w)—a key indicator of heat stress that reflects the body's ability to cool itself via sweating.
- When T_w exceeds physiological limits, even short outdoor exposure can be life-threatening, especially for older and other vulnerable population.
- This study evaluates the historical trends of T_w in Qatar and Doha over the past three decades and evaluates human survivability using physiological model that accounts for both age and duration of exposure.



METHODS



Data Acquisition and Wet-Bulb Calculation: Hourly 2-meter air temperature (T2m) and dew point temperature (D2m) data were obtained from the ERA5-Land reanalysis dataset (0.1° resolution) for Qatar region, from 1995–2024. Relative humidity (RH) was calculated using the Magnus formula, and T_w was estimated using Stull's empirical equation.

Trend Analysis: Twelve-month moving averages were applied to smooth seasonal variability and highlight long-term trends in temperature, humidity, and T_w across Qatar and Doha. Linear regression was used to quantify the long-term trends in these variables for the periods 1995–2024 and 2015–2024.

Hourly Patterns and Threshold Exceedance: Hourly T_w patterns were analyzed for each decade in Qatar and Doha from March to December. Daily maximum T_w values were used to count the number of days exceeding critical thresholds (30°C, 31°C) in each year, indicating exposure to severe heat stress.

Physiological Survivability Modeling: The human heat-stress survivability model was adopted from Vanos et al. (2023), where human core temperatures above 43°C cause death from hyperthermia. Daily T_w for Doha (JJAS) were averaged over 3-h and 6-h windows, and daily maxima is captured for peak exposure. Analyses were conducted for two decades (2005–2014 and 2015–2024), mapping corresponding T_2m and RH onto survivability zones for young (18–40 years) and older adults (65+ years) at 3- and 6-h outdoor exposure.

CONCLUSION

Qatar and Doha have experienced acceleration of warming and humidity in the past decade, leading to a sharp rise in T_w.

The T_w trend more than doubled in the recent decade (2015-2024), intensifying heat stress conditions.

Extreme T_w events are becoming more frequent and longer in duration, especially during summer months.

Physiological assessments reveal that older adults (65+) now face a dramatic increase in non-survivable exposure days—from 5–57 days (2005–2014) to 43–144 days (2015–2024) with 3–6 hours of outdoor exposure during JJAS in Doha.

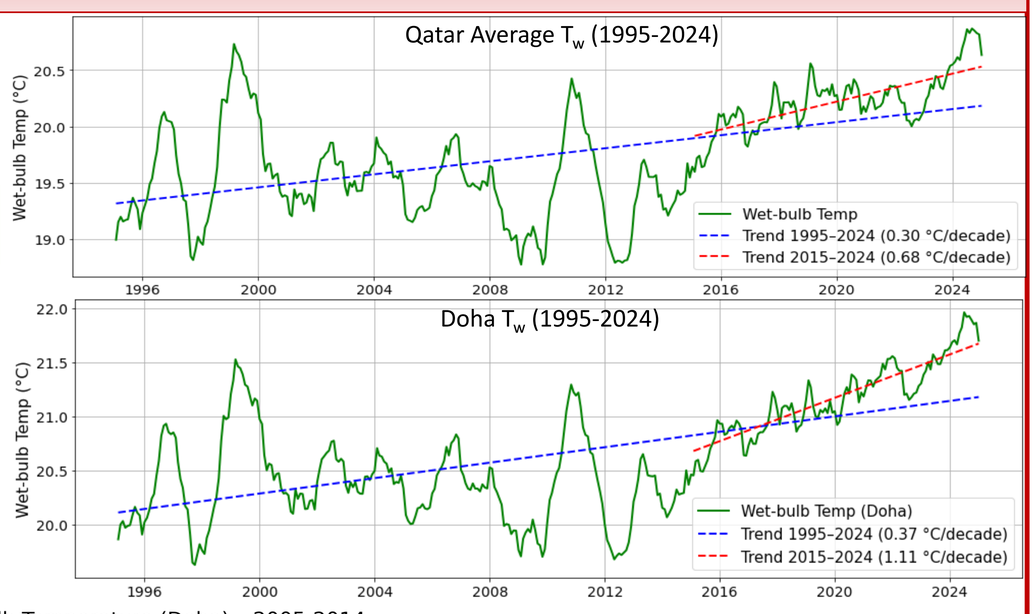
While young adults (18–40 years) remain within survivable zones, the rapid rise in T_w is steadily pushing the climate toward critical human survivability limits.

RESULTS

Figure 1. 12-month moving average of T_w for Qatar and Doha.

Trend (Doha)	1995-2024	2015-2024
T2m	0.27°C	0.51°C
RH	0.52%	2.94%
T_w	0.37°C	1.11°C

Table 1. Linear Regression trend per decade for Doha.



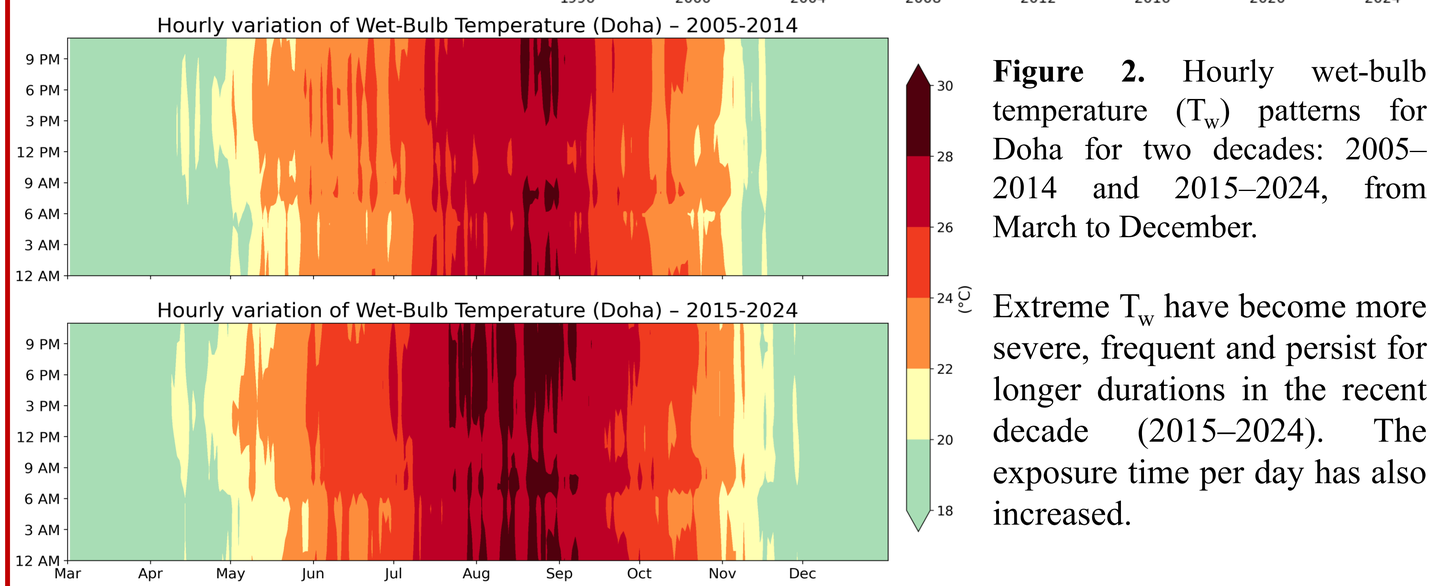


Figure 2. Hourly wet-bulb temperature (T_w) patterns for Doha for two decades: 2005–2014 and 2015–2024, from March to December.

Extreme T_w have become more severe, frequent and persist for longer durations in the recent decade (2015–2024). The exposure time per day has also increased.

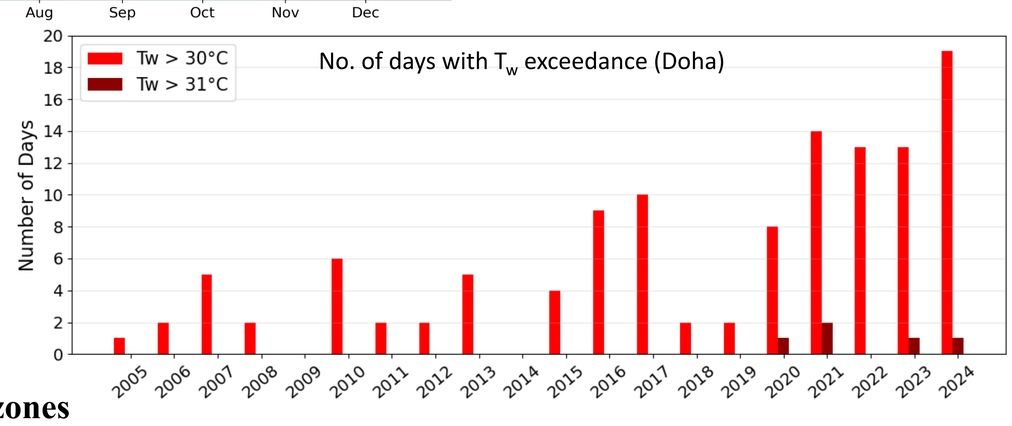
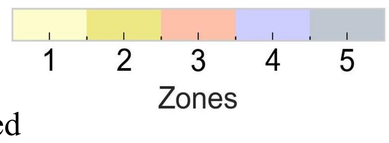


Figure 3. Yearly exceedance days of wet-bulb temperature (T_w > 30°C, 31°C) for Doha from 2005 to 2024.

Annual frequency of extreme heat events are increasing.

Physiological survivability zones

- Zone 1–2 (Yellow): Survivable — body maintains thermal balance.
- Zone 3 (Pink): Non-survivable — environment blocks heat dissipation.
- Zone 4 (Purple): Non-survivable — body reaches sweating limit.
- Zone 5 (Gray): Fatal — both environmental and sweating limits exceeded



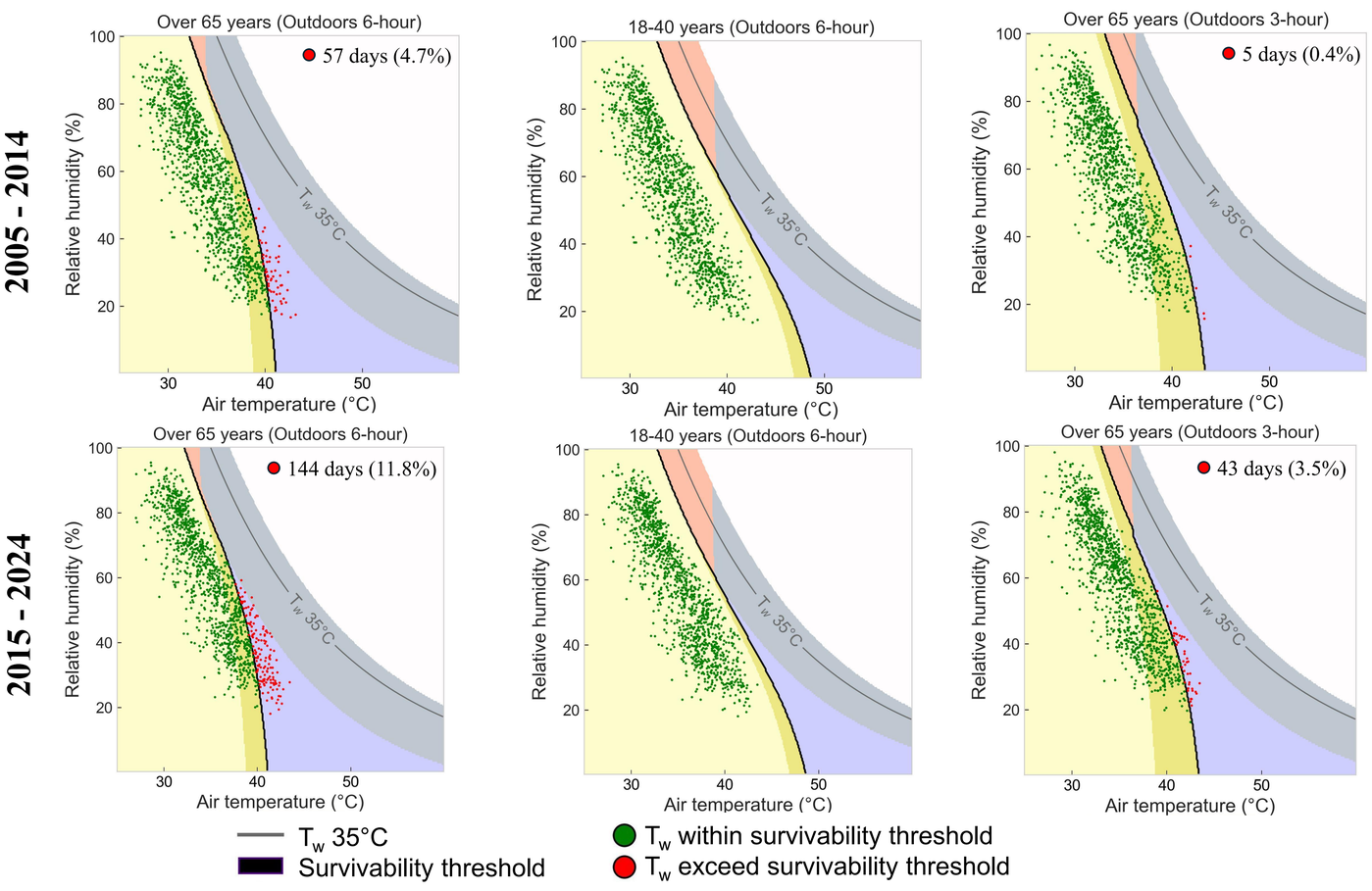


Figure 4. Physiological survivability maps for Doha for 65+ years(6 h), 18–40 years(6 h), and 65+ years(3 h) exposure. Scatter dots indicate daily peak T_w exposure in JJAS.

REFERENCES

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