World Health Organization

Web Annex G

Estimation of minimal risk and maximum acceptable temperatures for selected cities

Lidia Morawska and Phong Thai

In:

WHO Housing and health guidelines

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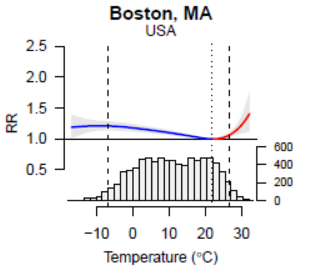
High indoor temperatures – Estimation of minimal risk and maximum acceptable temperatures for selected cities

<table>
<tr><th>City & Lancet´s curve</th><th>Papers used as evidence</th><th>Information extracted</th></tr>
<tr><td rowspan="2">

Boston



The minimal risk indoor temperature would be 21-22oC.

The maximum acceptable temperature would be 25oC

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1. Nguyen et al. 2013. Relationship between indoor and outdoor temp (in Harvard staff/student homes)

→ linear regression for warmer temperature

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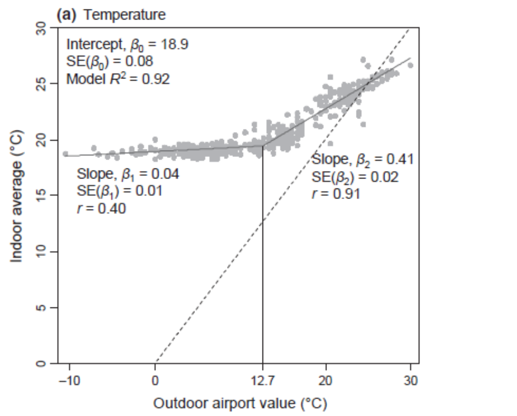

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<tr><td>

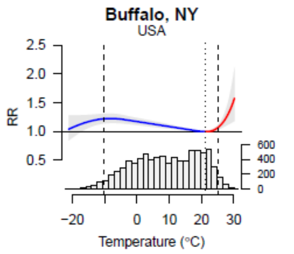
2. Nguyen & Dockery, 2016. Daily indoor/outdoor relationship in different cities

</td><td>

- Only one home in each city
- Indoor temp in Boston is stable year round (without extreme heat)
- Linear indoor/outdoor relationship from >21oC

</td></tr>
<tr><td rowspan="2">

New York



The minimal risk indoor temperature would be 22-24oC

</td><td>

1. Quinn et al. 2014. Predicting indoor heat exposure

$$\text{Indoor}(T/DP/HI) \sim \text{outdoor}(T/DP/HI) + \text{lag\_1day\_outdoor}(T/DP/HI) + \text{lag\_2days\_outdoor}(T/DP/HI),$$

Parameters of the equation shown in next column

</td><td>

- 265 homes of low & middle incomes

	Model 1: Temperature (°C)
Fixed effects estimates:	
Intercept ± SE	26.69 ± 0.10*
Outdoor (same day) ± SE	0.20 ± 0.01*
Outdoor (1 day lag) ± SE	0.085 ± 0.002*
Outdoor (2 days lag) ± SE	−0.001 ± 0.002*
Random effects standard deviation:	
Intercept	1.65
Outdoor (same day)	0.16
Residual	1.08

</td></tr>
<tr><td>

2. Uejio et al. 2015. Summer indoor heat exposure & emergency calls in NY

- Temp measured by emergency staffs during home visits

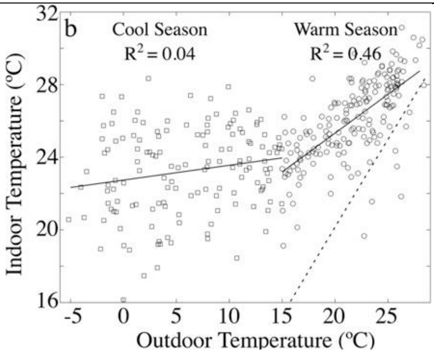
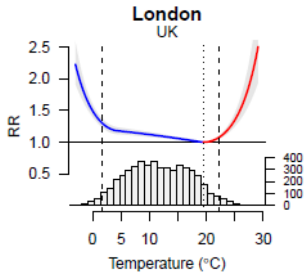
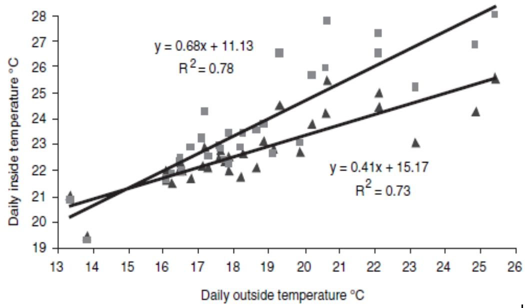
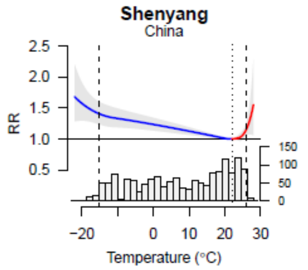
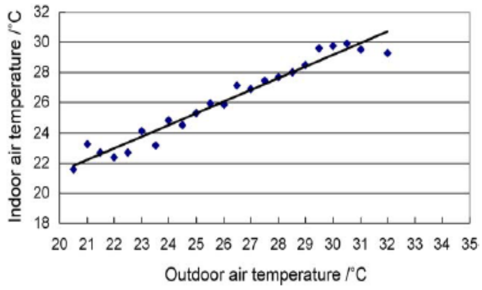
</td><td>

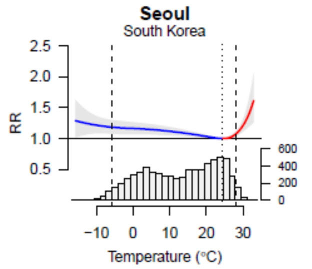
- Multivariate model for best fit

Table 3 Generalized linear model results relating outdoor conditions and sociodemographics to indoor temperature or specific humidity

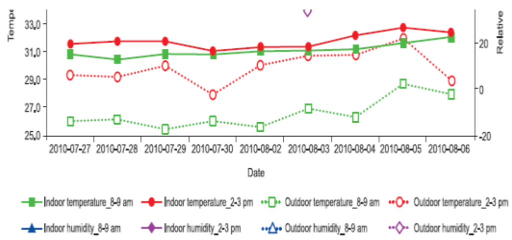
Indoor condition	Independent variable	Estimate (95% CI)	s.e.	P-value
Temperature °C *N* = 764	Intercept	19.44 (17.64, 21.24)	0.90	<0.001
	Outdoor temperature °C (Lag 1)	0.16 (0.08, 0.25)	0.04	<0.001
	Outdoor solar radiation W/m² (Lag 4)	0.19 (0.08, 0.30)	0.05	<0.001
	Outdoor wind speed m/s (Lag 3)	−0.14 (−0.24, −0.04)	0.05	0.007

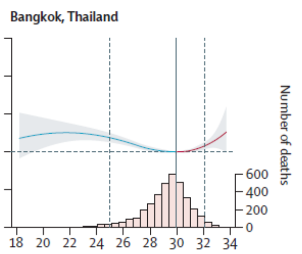
</td></tr>
</table>

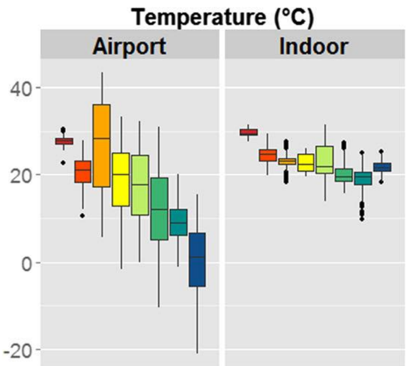
The maximum acceptable temperature would be 27-28oC	3. Tamerius et al., 2013 Socioeconomic and Outdoor Meteorological Determinants of Indoor Temperature and Humidity in New York City Dwellings	
London/Manchester  The minimal risk indoor temperature would be 22-23oC The maximum acceptable temperature would be ~25oC	1. Wright et al. 2005. Dwelling temperature and comfort during the August 2003 heatwave	
Harbin  The minimal risk indoor temperature is ~24oC The maximum acceptable temperature would be 26oC	1. Wang et al. 2010 Thermal responses for naturally ventilated residential buildings in Harbin since people have the custom of opening their windows	- During summer, range and average temperature is similar between indoor and outdoor  **Fig. 13.** Indoor air temperature against outdoor air temperature.

<table>
<tr>
<td rowspan="2"><u>South Korea</u>

The minimal risk temperature is ~25-26oC

The maximum acceptable temperature would be ~29-30oC</td>
<td>1. Kim et al, 2012. Effect of heatwave on body temperature and blood pressure in the poor and elderly

Indoor ~outdoor + 2oC</td>
<td></td>
</tr>
<tr>
<td>2. Moon et al. 2014. Seasonal evaluation of bioaerosols

In spring & summer, indoor temperature ~ outdoor temperature</td>
<td>Table 3 Seasonal temperature and relative humidity for 25 apartments according to seasons
<table>
<tr><th>Seasons</th><th colspan="2">Temperature (°C)</th><th colspan="2">Relative humidity (%)</th></tr>
<tr><th></th><th>Indoor</th><th>Outdoor</th><th>Indoor</th><th>Outdoor</th></tr>
<tr><td>Spring</td><td>26.2±2.3[a]</td><td>25.9±3.0</td><td>46.9±8.6</td><td>42.1±14.1</td></tr>
<tr><td>Summer</td><td>29.1±1.8</td><td>29.0±3.3</td><td>68.5±7.6</td><td>69.2±12.0</td></tr>
<tr><td>Autumn</td><td>22.7±3.6</td><td>15.1±1.2</td><td>39.8±9.2</td><td>44.2±8.5</td></tr>
<tr><td>Winter</td><td>20.6±2.8</td><td>7.7±3.08</td><td>24.7±9.5</td><td>28.7±8.9</td></tr>
</table></td>
</tr>
<tr>
<td><u>Thailand</u>

The minimal risk temperature is ~30oC

The maximum acceptable temperature would be ~32oC</td>
<td>1. Studies in neighbouring countries like Malaysia, Singapore, Vietnam indicated that Indoor temperature ≥ Outdoor temperature (Kamar et al., 2012; Wong & Li, 2007; Nguyen & Dockery, 2016)</td>
<td>
Ho Chi Minh City, Vietnam (far left) by (Nguyen & Dockery, 2016)</td>
</tr>
</table>

Contributors

The analysis was conducted by Lidia Morawska and Phong Thai (International Laboratory for Air Quality and Health, Queensland University of Technology, Australia).

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