

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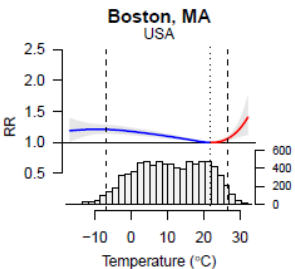
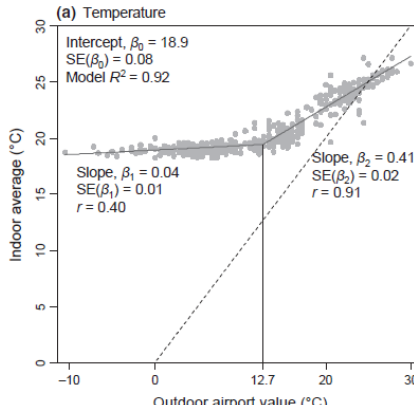
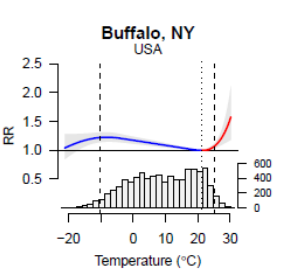
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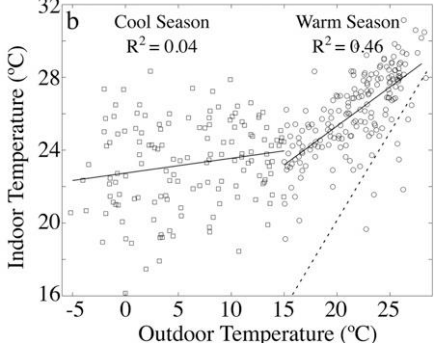
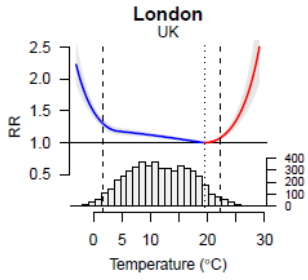
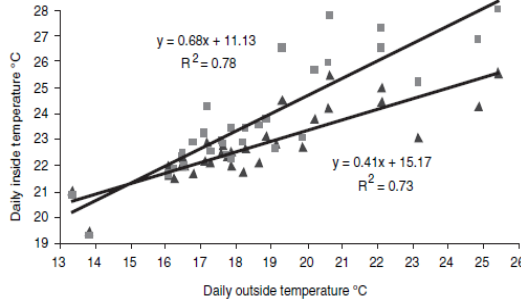
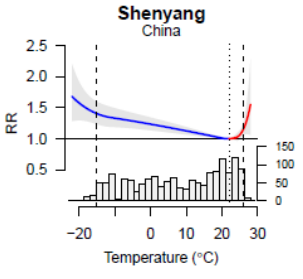
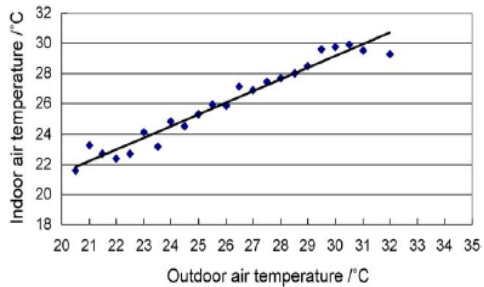
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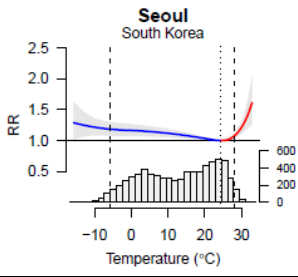
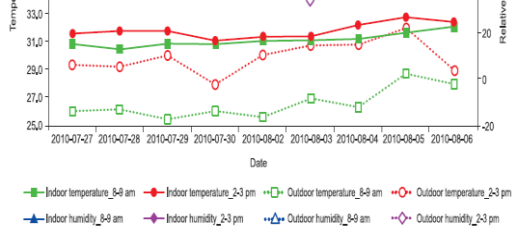
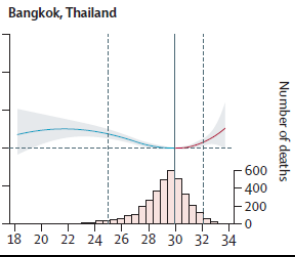
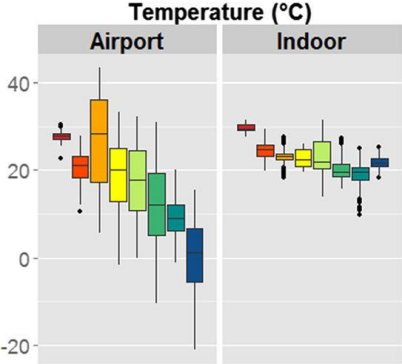
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High indoor temperatures – Estimation of minimal risk and maximum acceptable temperatures for selected cities

City & Lancet's curve	Papers used as evidence	Information extracted																																										
<p><u>Boston</u></p>  <p>The minimal risk indoor temperature would be 21-22oC.</p> <p>The maximum acceptable temperature would be 25oC</p>	<p>1. Nguyen et al. 2013. Relationship between indoor and outdoor temp (in Harvard staff/student homes)</p> <p>→ linear regression for warmer temperature</p> <p>2. Nguyen & Dockery, 2016. Daily indoor/outdoor relationship in different cities</p>	 <ul style="list-style-type: none"> - Only one home in each city - Indoor temp in Boston is stable year round (without extreme heat) - Linear indoor/outdoor relationship from >21oC 																																										
<p><u>New York</u></p>  <p>The minimal risk indoor temperature would be 22-24oC</p>	<p>1. Quinn et al. 2014. Predicting indoor heat exposure</p> $\text{Indoor}(T/DP/HI) \sim \text{outdoor}(T/DP/HI) + \text{lag_1day_outdoor}(T/DP/HI) + \text{lag_2days_outdoor}(T/DP/HI),$ <p>Parameters of the equation shown in next column</p> <p>2. Uejio et al. 2015. Summer indoor heat exposure & emergency calls in NY</p> <p>- Temp measured by emergency staffs during home visits</p>	<p>- 265 homes of low & middle incomes</p> <table border="1" data-bbox="957 1164 1468 1388"> <thead> <tr> <th colspan="2">Model 1: Temperature (°C)</th> </tr> </thead> <tbody> <tr> <td colspan="2"><i>Fixed effects estimates:</i></td> </tr> <tr> <td>Intercept ± SE</td> <td>26.69 ± 0.10*</td> </tr> <tr> <td>Outdoor (same day) ± SE</td> <td>0.20 ± 0.01*</td> </tr> <tr> <td>Outdoor (1 day lag) ± SE</td> <td>0.085 ± 0.002*</td> </tr> <tr> <td>Outdoor (2 days lag) ± SE</td> <td>-0.001 ± 0.002*</td> </tr> <tr> <td colspan="2"><i>Random effects standard deviation:</i></td> </tr> <tr> <td>Intercept</td> <td>1.65</td> </tr> <tr> <td>Outdoor (same day)</td> <td>0.16</td> </tr> <tr> <td>Residual</td> <td>1.08</td> </tr> </tbody> </table> <p>- Multivariate model for best fit</p> <p>Table 3 Generalized linear model results relating outdoor conditions and socio-demographics to indoor temperature or specific humidity</p> <table border="1" data-bbox="957 1545 1468 1747"> <thead> <tr> <th>Indoor condition</th> <th>Independent variable</th> <th>Estimate (95% CI)</th> <th>s.e.</th> <th>P-value</th> </tr> </thead> <tbody> <tr> <td rowspan="5">Temperature °C N = 764</td> <td>Intercept</td> <td>19.44 (17.64, 21.24)</td> <td>0.90</td> <td><0.001</td> </tr> <tr> <td>Outdoor temperature °C (Lag 1)</td> <td>0.16 (0.08, 0.25)</td> <td>0.04</td> <td><0.001</td> </tr> <tr> <td>Outdoor solar radiation W/m² (Lag 4)</td> <td>0.19 (0.08, 0.30)</td> <td>0.05</td> <td><0.001</td> </tr> <tr> <td>Outdoor wind speed m/s (Lag 3)</td> <td>-0.14 (-0.24, -0.04)</td> <td>0.05</td> <td>0.007</td> </tr> </tbody> </table>	Model 1: Temperature (°C)		<i>Fixed effects estimates:</i>		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*	<i>Random effects standard deviation:</i>		Intercept	1.65	Outdoor (same day)	0.16	Residual	1.08	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/m ² (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
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<p>The maximum acceptable temperature would be 27-28oC</p>	<p>3. Tamerius et al., 2013 Socioeconomic and Outdoor Meteorological Determinants of Indoor Temperature and Humidity in New York City Dwellings</p>	
<p>London/Manchester</p>  <p>The minimal risk indoor temperature would be 22-23oC</p> <p>The maximum acceptable temperature would be ~25oC</p>	<p>1. Wright et al. 2005. Dwelling temperature and comfort during the August 2003 heatwave</p>	
<p>Harbin</p>  <p>The minimal risk indoor temperature is ~24oC</p> <p>The maximum acceptable temperature would be 26oC</p>	<p>1. Wang et al. 2010</p> <p>Thermal responses for naturally ventilated residential buildings in Harbin since people have the custom of opening their windows</p>	<p>- During summer, range and average temperature is similar between indoor and outdoor</p>  <p>Fig. 13. Indoor air temperature against outdoor air temperature.</p>

<p>South Korea</p>  <p>The minimal risk temperature is ~25-26oC</p> <p>The maximum acceptable temperature would be ~29-30oC</p>	<p>1. Kim et al, 2012. Effect of heatwave on body temperature and blood pressure in the poor and elderly</p> <p>Indoor ~ outdoor + 2oC</p>																														
<p>The minimal risk temperature is ~25-26oC</p> <p>The maximum acceptable temperature would be ~29-30oC</p>	<p>2. Moon et al. 2014. Seasonal evaluation of bioaerosols</p> <p>In spring & summer, indoor temperature ~ outdoor temperature</p>	<p>Table 3 Seasonal temperature and relative humidity for 25 apartments according to seasons</p> <table border="1" data-bbox="959 546 1449 775"> <thead> <tr> <th rowspan="2">Seasons</th> <th colspan="2">Temperature (°C)</th> <th colspan="2">Relative humidity (%)</th> </tr> <tr> <th>Indoor</th> <th>Outdoor</th> <th>Indoor</th> <th>Outdoor</th> </tr> </thead> <tbody> <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> </tbody> </table>	Seasons	Temperature (°C)		Relative humidity (%)		Indoor	Outdoor	Indoor	Outdoor	Spring	26.2±2.3 ^a	25.9±3.0	46.9±8.6	42.1±14.1	Summer	29.1±1.8	29.0±3.3	68.5±7.6	69.2±12.0	Autumn	22.7±3.6	15.1±1.2	39.8±9.2	44.2±8.5	Winter	20.6±2.8	7.7±3.08	24.7±9.5	28.7±8.9
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<p>Thailand</p>  <p>The minimal risk temperature is ~30oC</p> <p>The maximum acceptable temperature would be ~32oC</p>	<p>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)</p>	 <p>Ho Chi Minh City, Vietnam (far left) by (Nguyen & Dockery, 2016)</p>																													

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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