Impact of anomalous temperature on injury mortality by age and sex in the USA

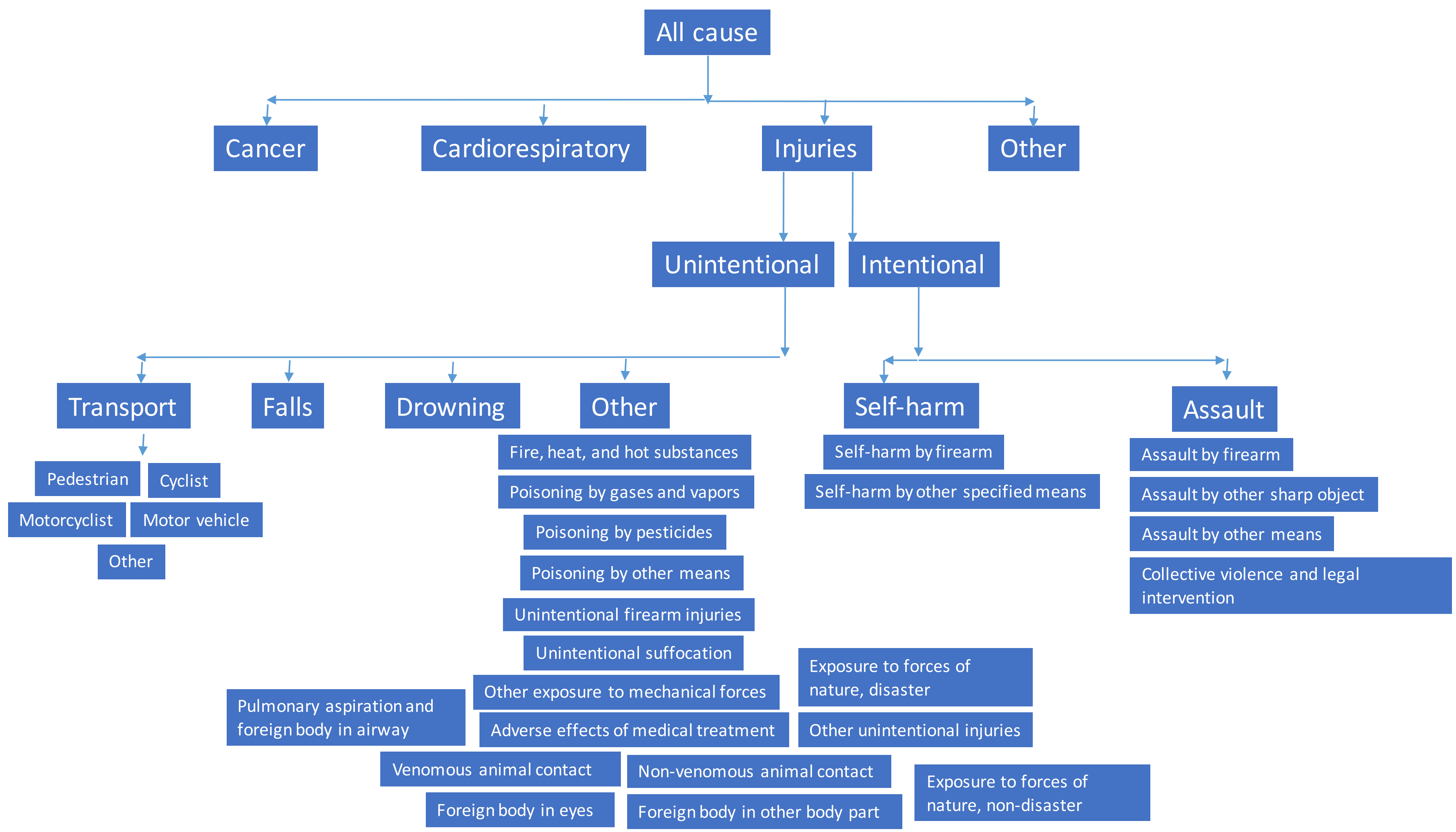
Robbie Parks

Global Environmental Health

Background

Mortality data: Overview

- 5.8 million injury deaths in contiguous USA 1980-2016
- Injury cause of death categories:



Global Environmental Health

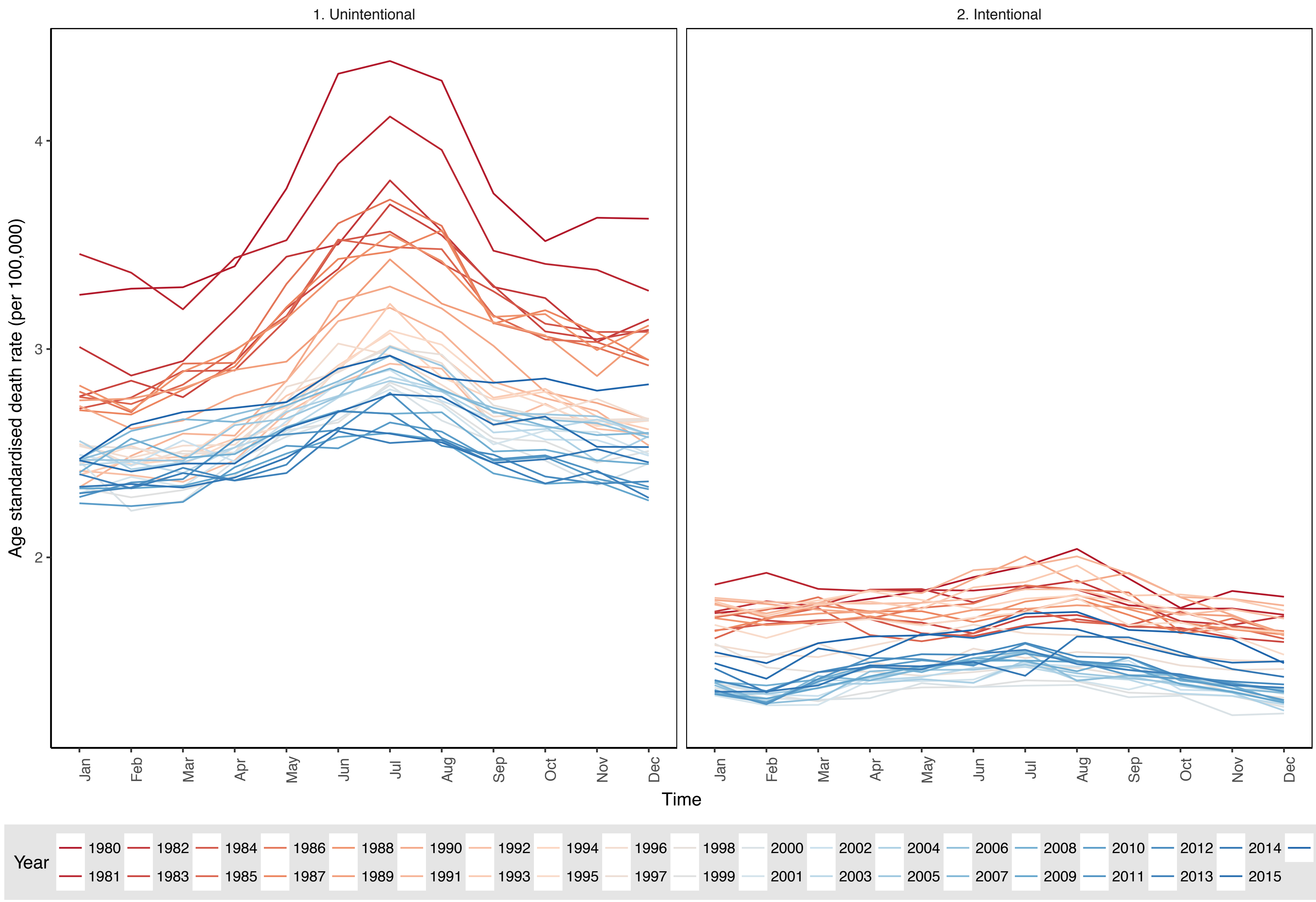
Mortality data: Overview

- 5.8 million injury deaths in contiguous USA 1980-2016
- Injury cause of death categories:

Cause		Male	Female	Total
Unintentional		2,470,093	1,340,723	**3,810,816**
	Transport	1,186,839	498,661	1,685,500
	Falls	337,946	322,662	660,608
	Drowning	112,023	29,246	141,269
	Other	833,285	490,154	1,323,439
Intentional		1,536,361	417,138	**1,953,499**
	Assault	582,220	162,517	744,737
	Intentional self-harm	954,141	254,621	1,208,762
				5,764,315

Global Environmental Health

Mortality data: Age-standardised death rates



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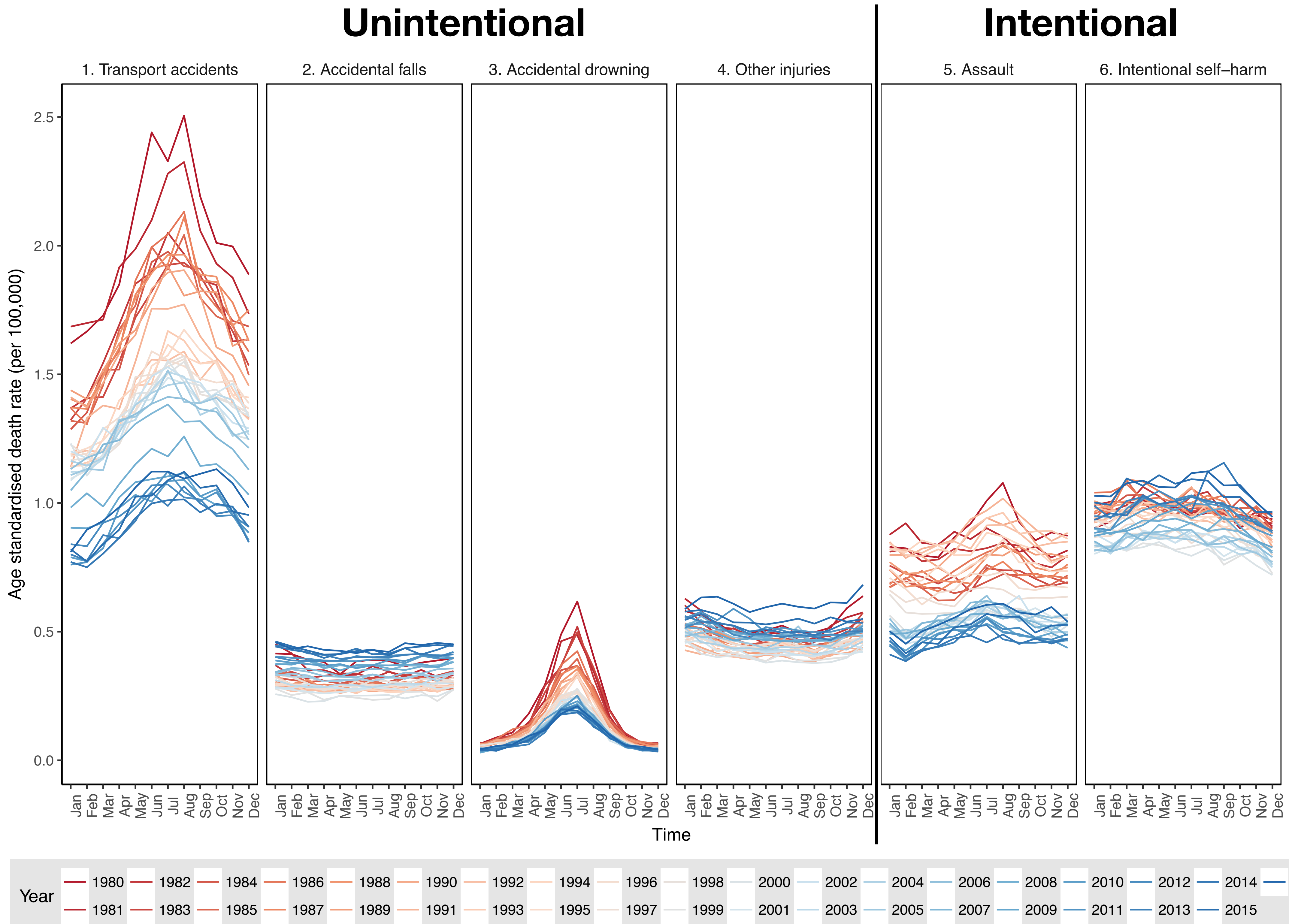
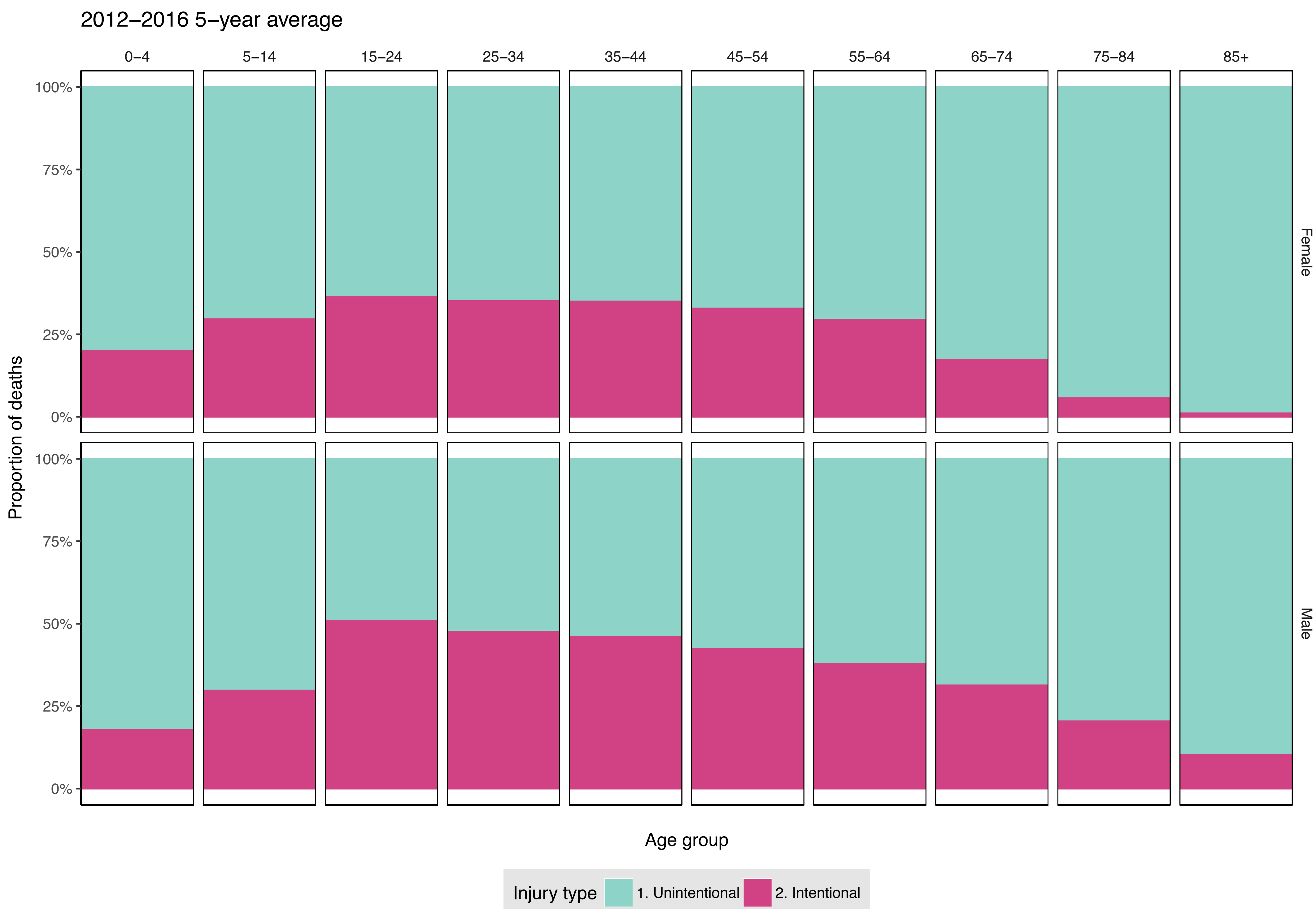
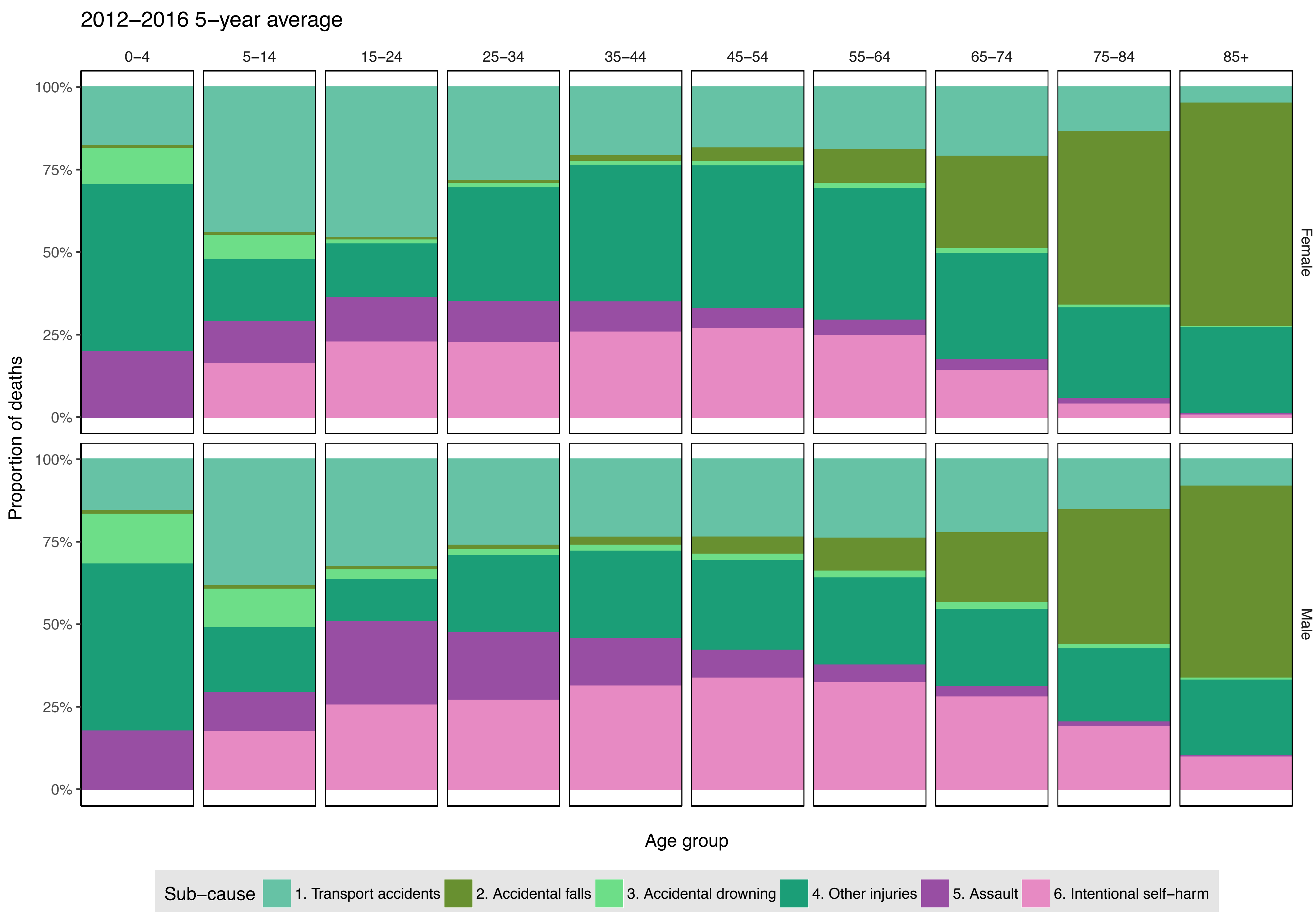


Mortality data: Proportion of broad causes of death by age-sex group

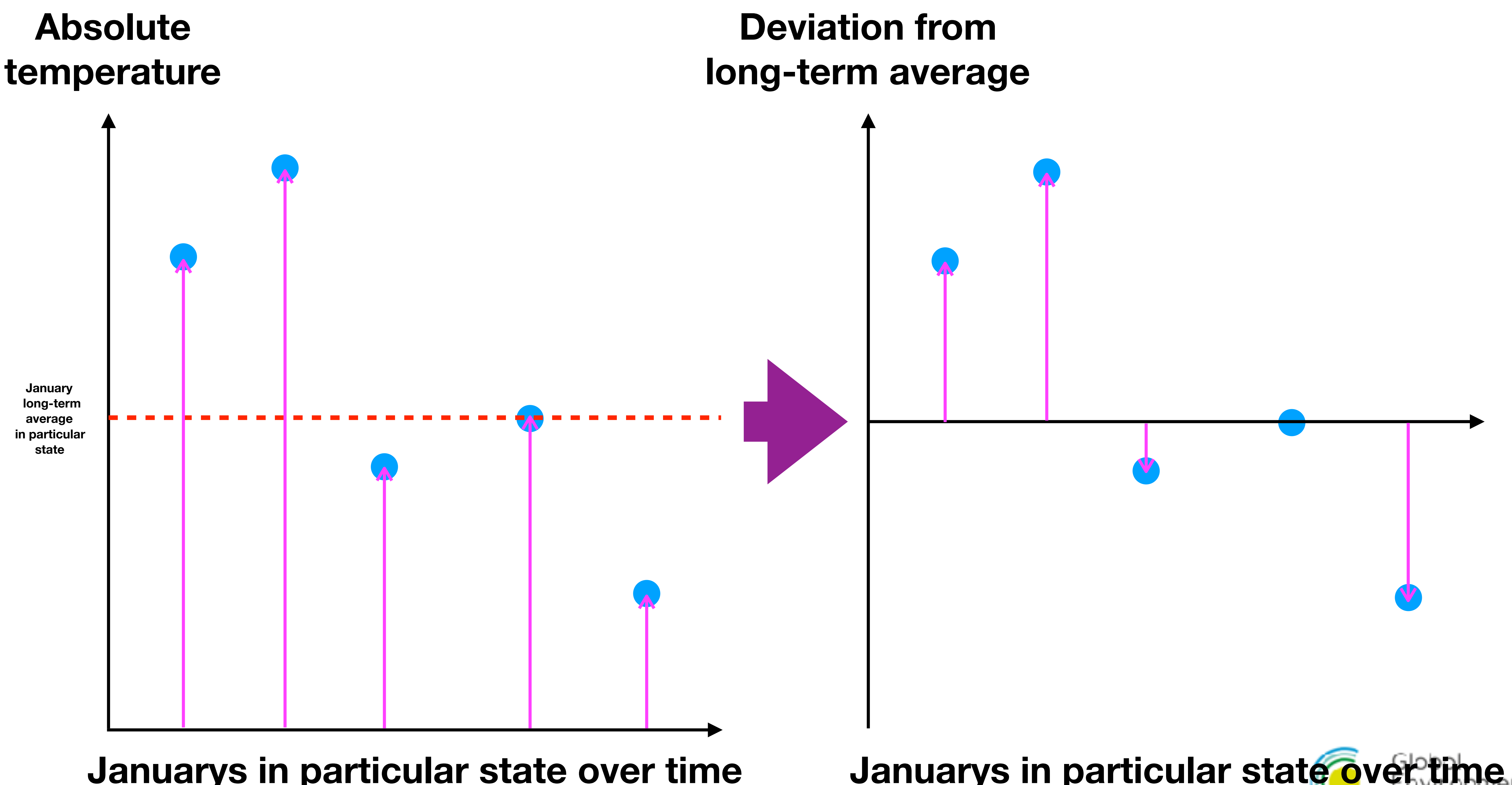


Mortality data: Proportion of broad causes of death by age-sex group



Temperature data: Schematic of change from long-term average

- Monthly population-weighted temperature by state throughout analysis period
- Only interested in deviation from long-term average of each state-month



Model: Overview

- Bayesian spatiotemporal model
- 20 separate age-sex groups:
  - Age groups of 0,5-14,15-24,….85+
  - Female and male
- All of contiguous USA for 1980-2016
- Implemented in R-INLA (Integrated Nested Laplace Approximation)

Model: Terms

$$\text{deaths}_{[m,s,t]} \sim \text{Poisson}(\mu_{[m,s,t]} E_{[m,s,t]})$$

Link function

$$\begin{aligned}\log(\mu_{m,s,t}) =&\alpha_0 + \alpha_{M[m]} + \alpha_{S[s]} + \alpha_{X[m,s]} + \\ &(\beta_0 + \beta_{M[m]} + \beta_{S[s]} + \beta_{X[m,s]})t + \\ &\gamma_{M[m]}(\text{Anomaly})_{m,s} + \\ &\pi_t + \epsilon_{m,s,t},\end{aligned}$$

Model: Terms

$$\text{deaths}_{[m,s,t]} \sim \text{Poisson}(\mu_{[m,s,t]} E_{[m,s,t]})$$

$$\log(\mu_{m,s,t}) = \boxed{\alpha_0 + \alpha_{M[m]} + \alpha_{S[s]} + \alpha_{X[m,s]} +}$$

Intercepts

$$\boxed{(\beta_0 + \beta_{M[m]} + \beta_{S[s]} + \beta_{X[m,s]})t} +$$

Linear trends

$$\boxed{\gamma_{M[m]}(\text{Anomaly})_{m,s} +}$$

Temperature anomaly term

$$\boxed{\pi_t + \epsilon_{m,s,t},}$$

Non-linear trends
and overdispersion

Global
Environmental
Health

Model: Terms

$$\text{deaths}_{[m,s,t]} \sim \text{Poisson}(\mu_{[m,s,t]} E_{[m,s,t]})$$

Month terms

Common terms

State terms

$$\log(\mu_{m,s,t}) = \alpha_0 + \alpha_{M[m]} + \alpha_{S[s]} + \alpha_{X[m,s]} +$$
$$(\beta_0 + \beta_{M[m]} + \beta_{S[s]} + \beta_{X[m,s]})t +$$

State month interaction

$$\gamma_{M[m]}(\text{Anomaly})_{m,s} +$$

Temperature anomaly term

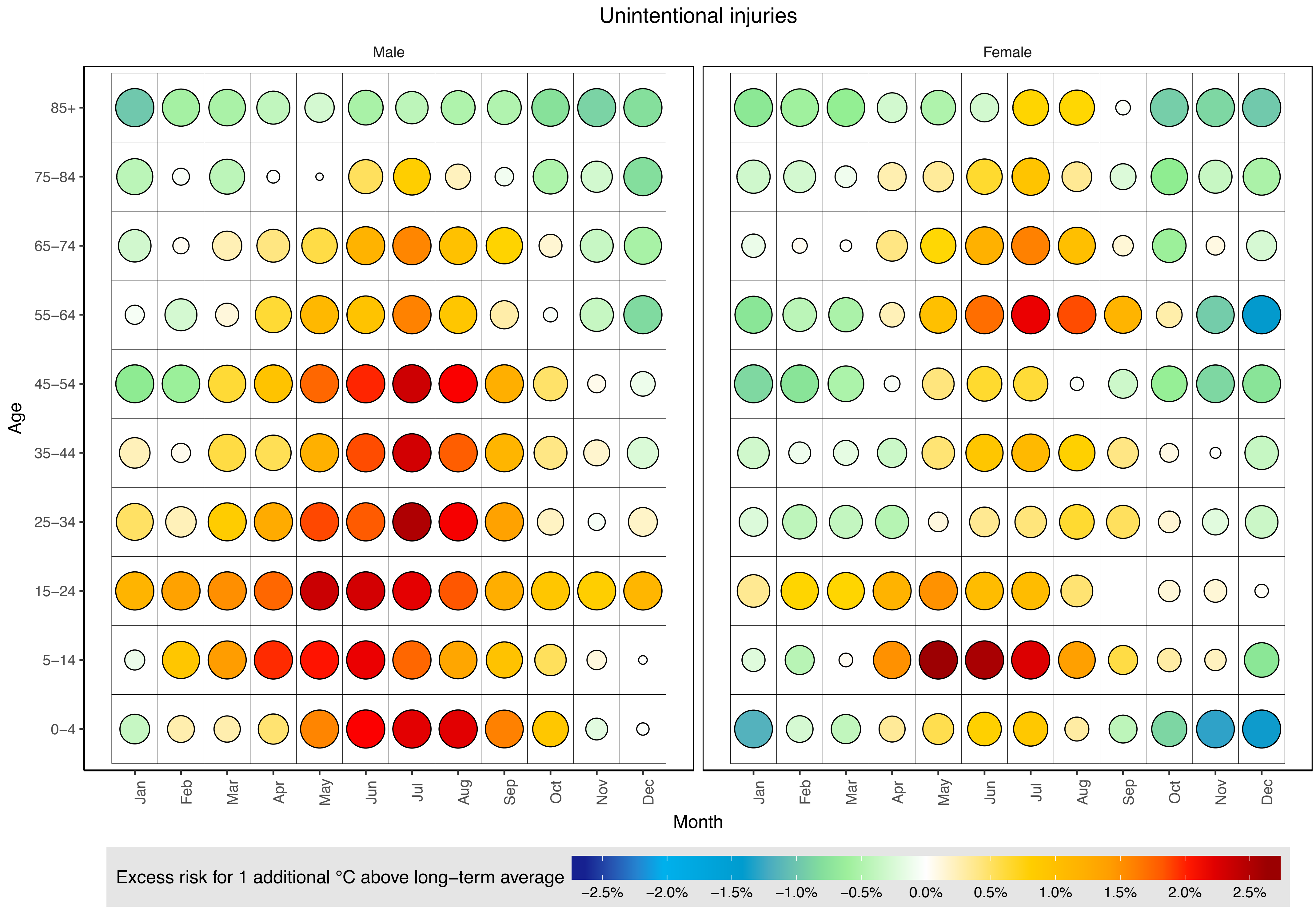
$$\pi_t + \epsilon_{m,s,t},$$

Random walk and overdispersion

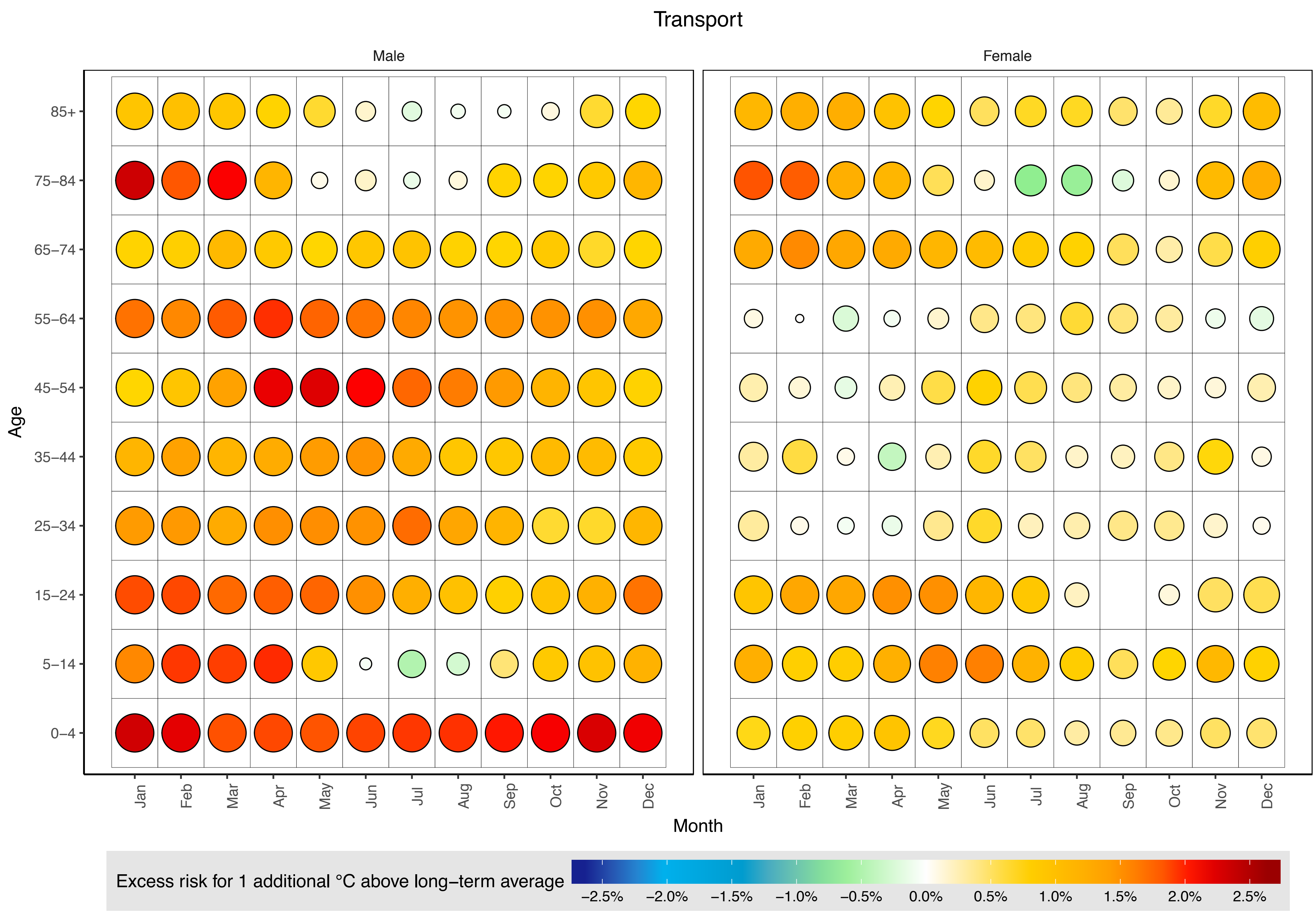
Reporting

Risk figures

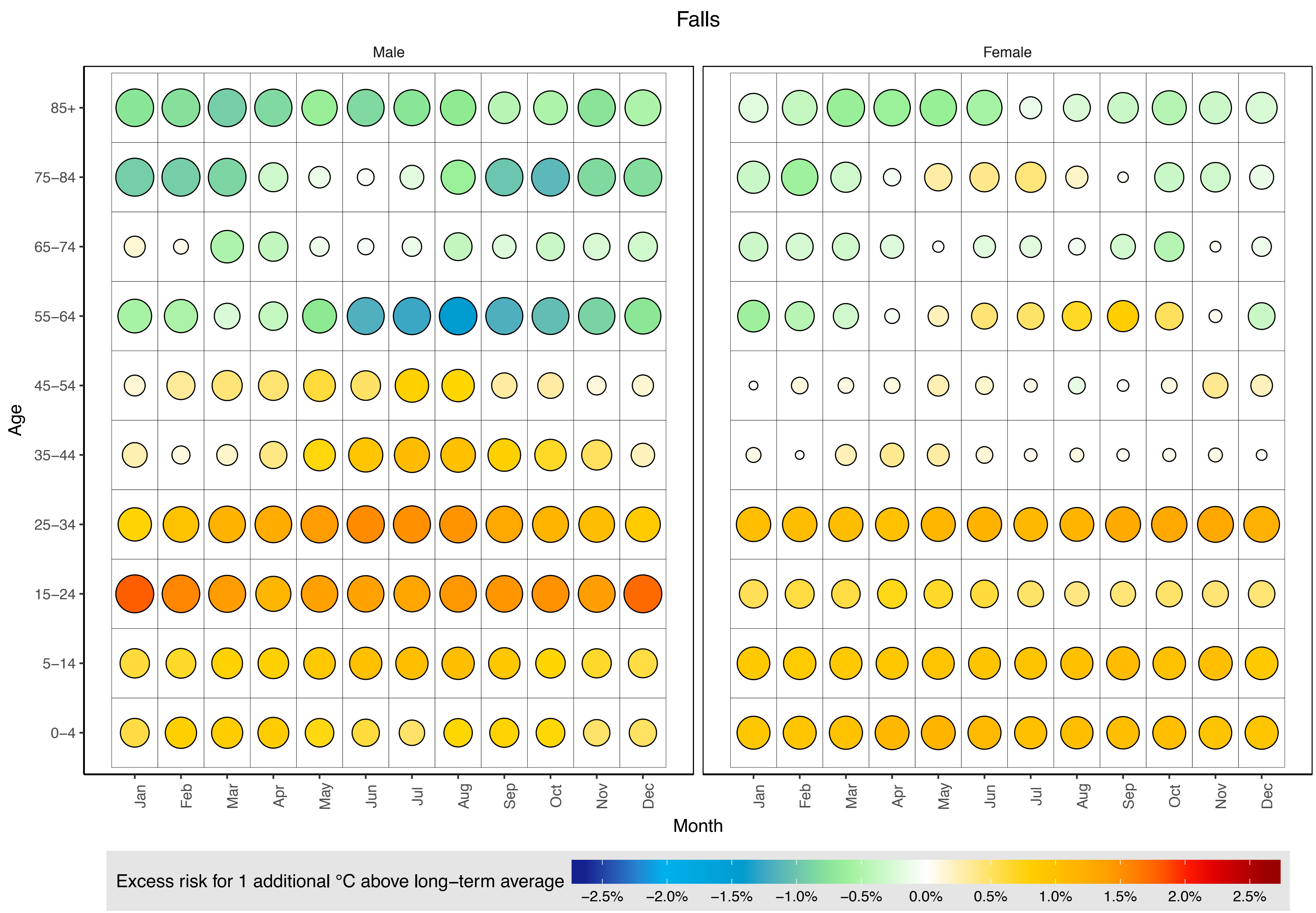
Unintentional injury excess risk (2-metre temperature)



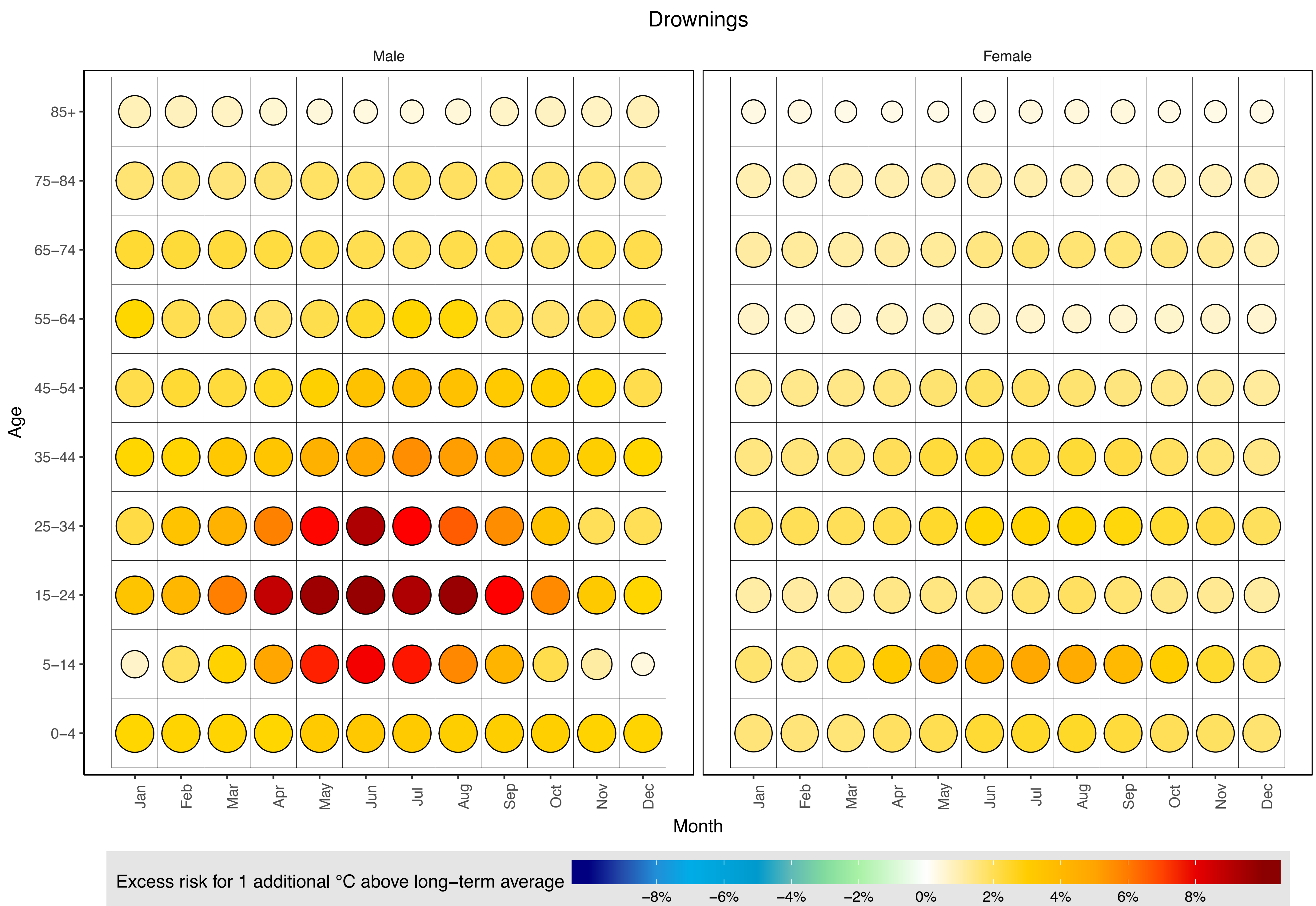
Transport accidents (2-metre temperature)



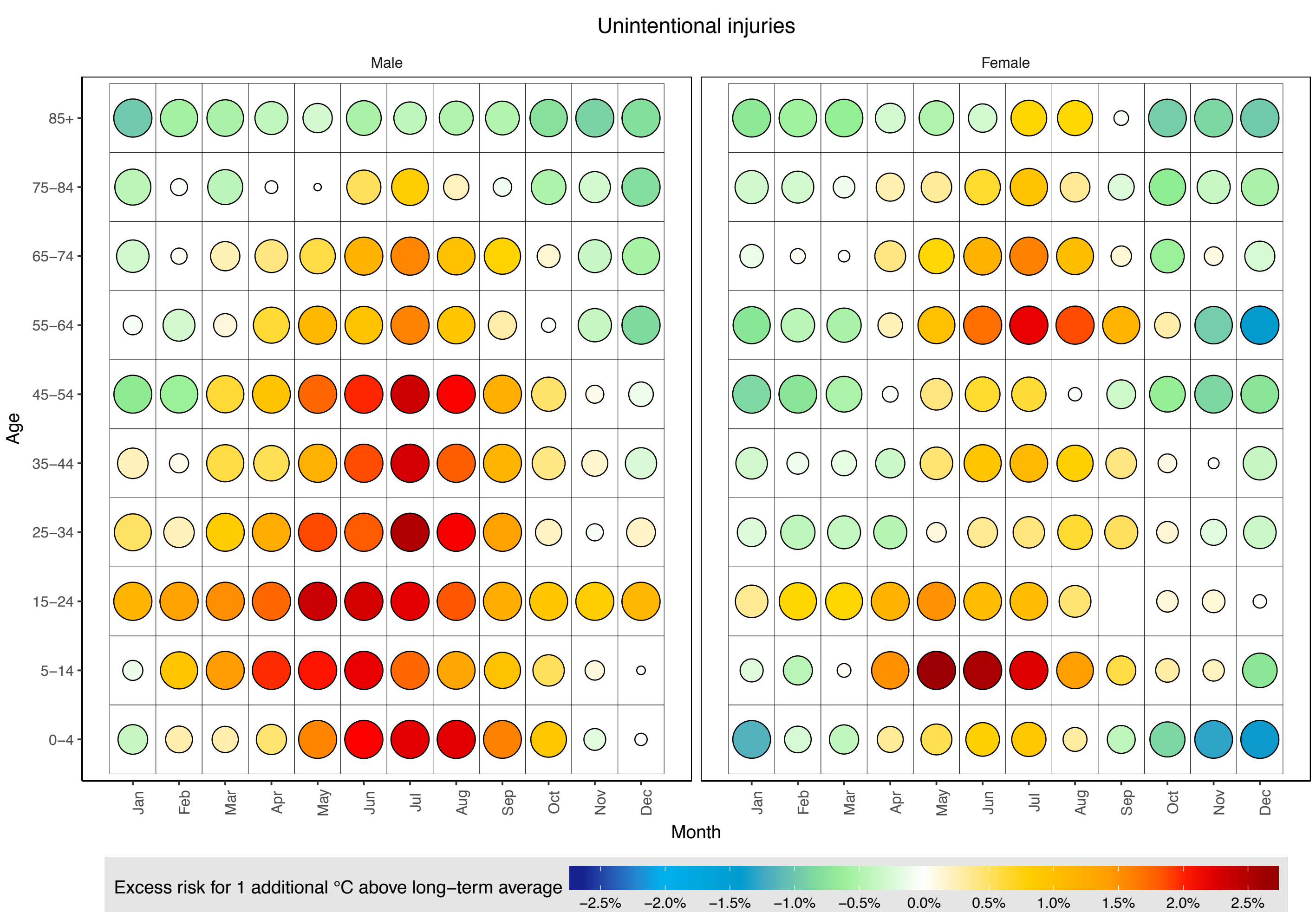
Accidental Falls (2-metre temperature)

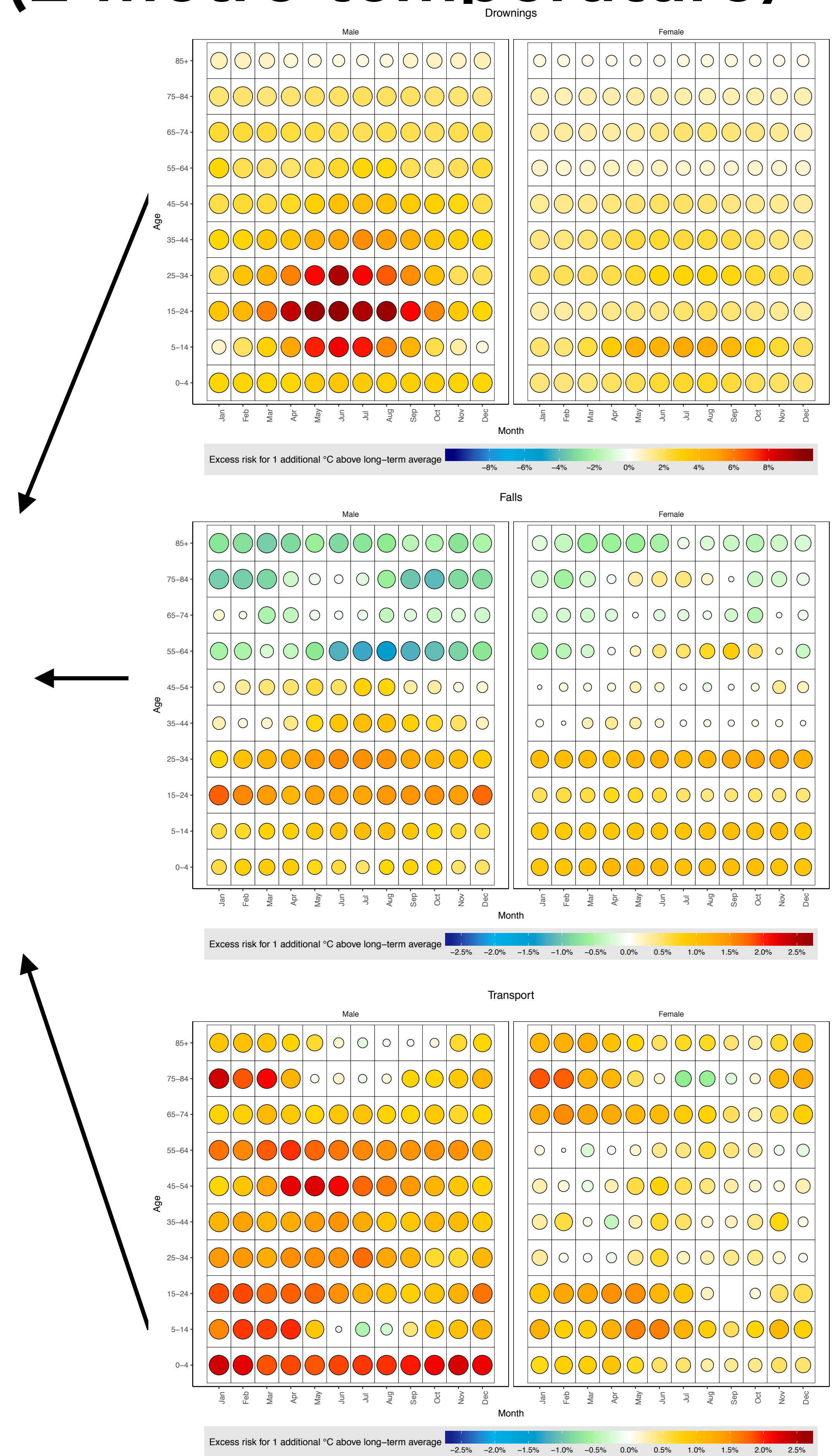


Drowning (2-metre temperature)

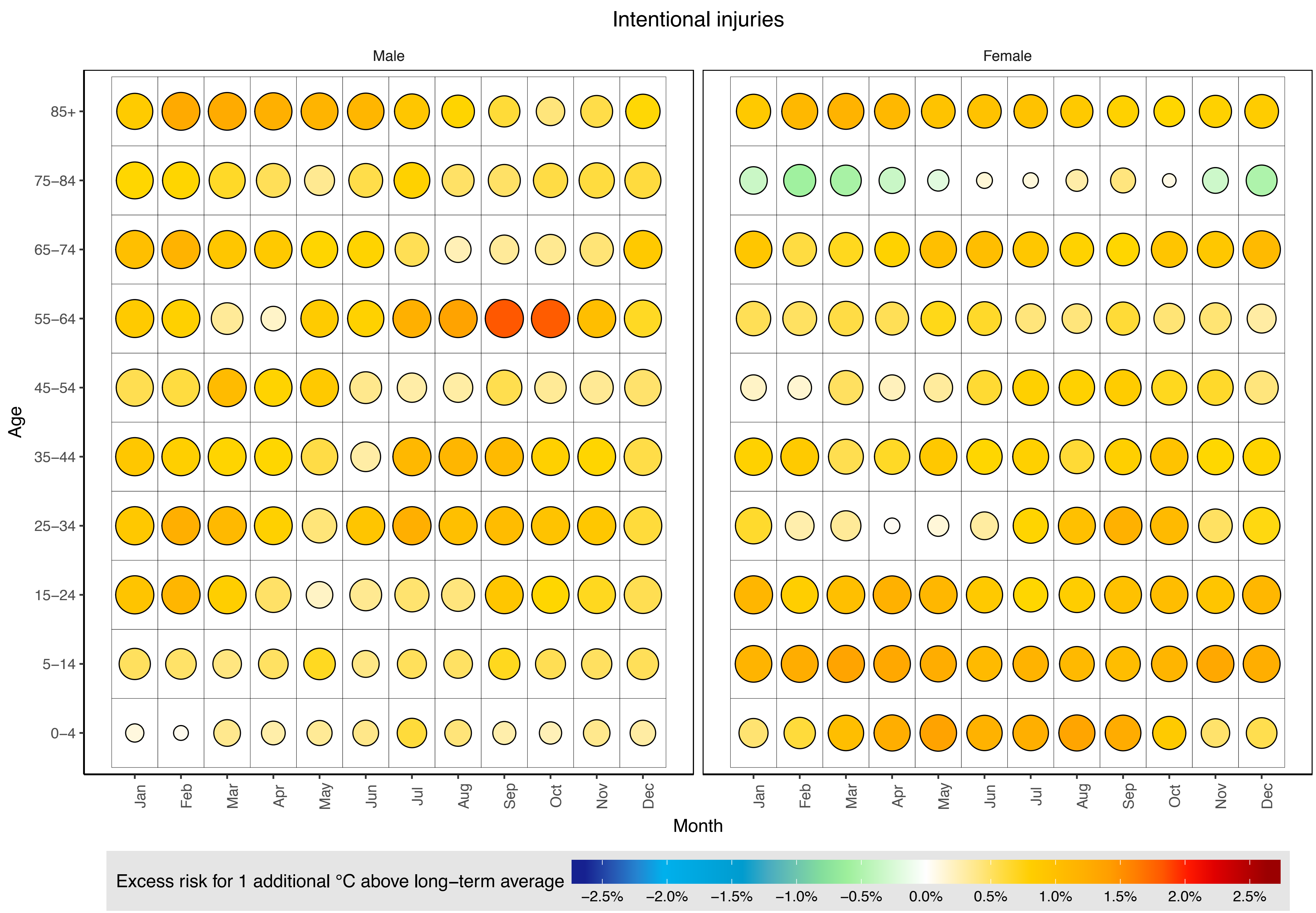


Unintentional injury excess risk (2-metre temperature)

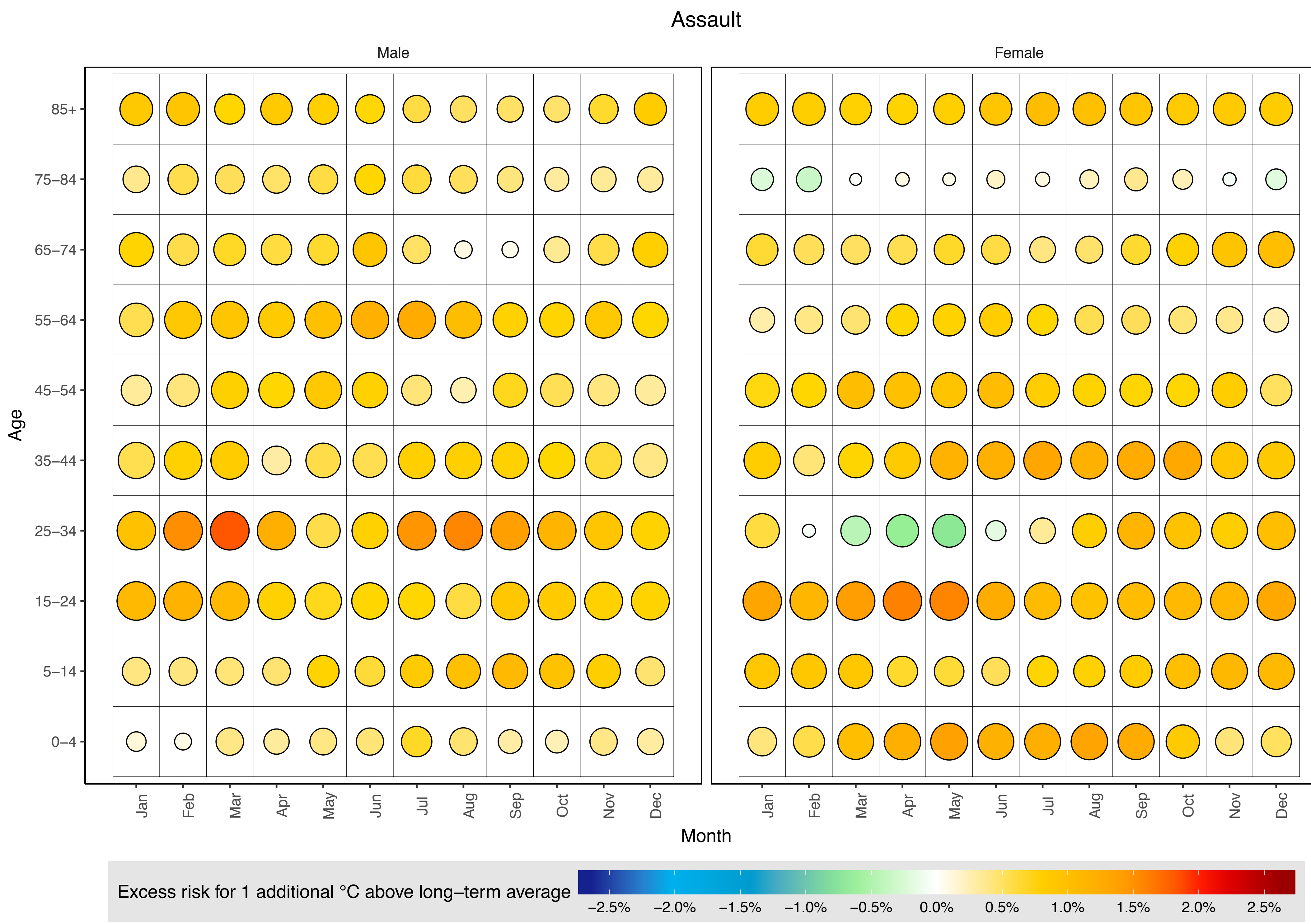




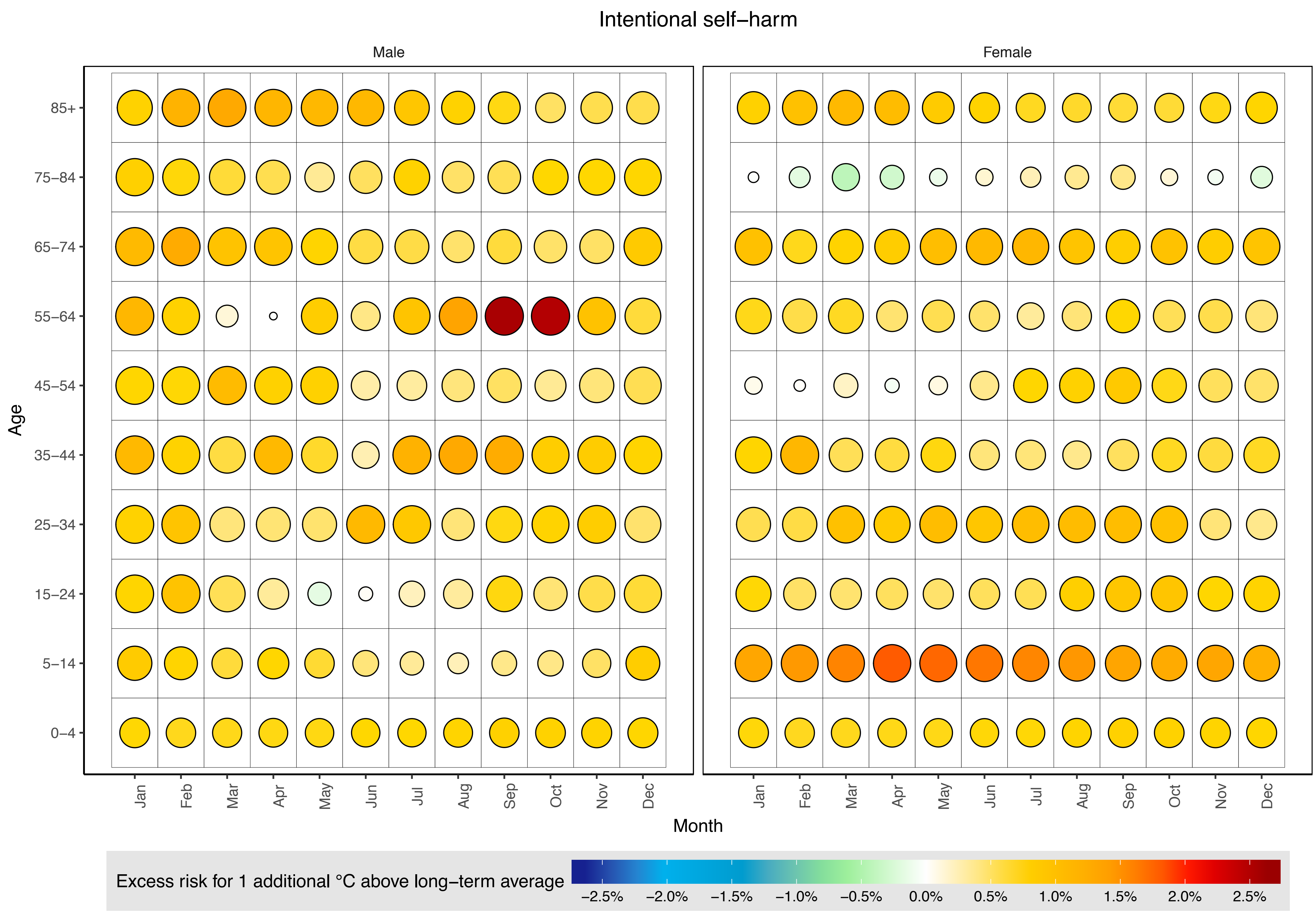
Intentional injury excess risk (2-metre temperature)



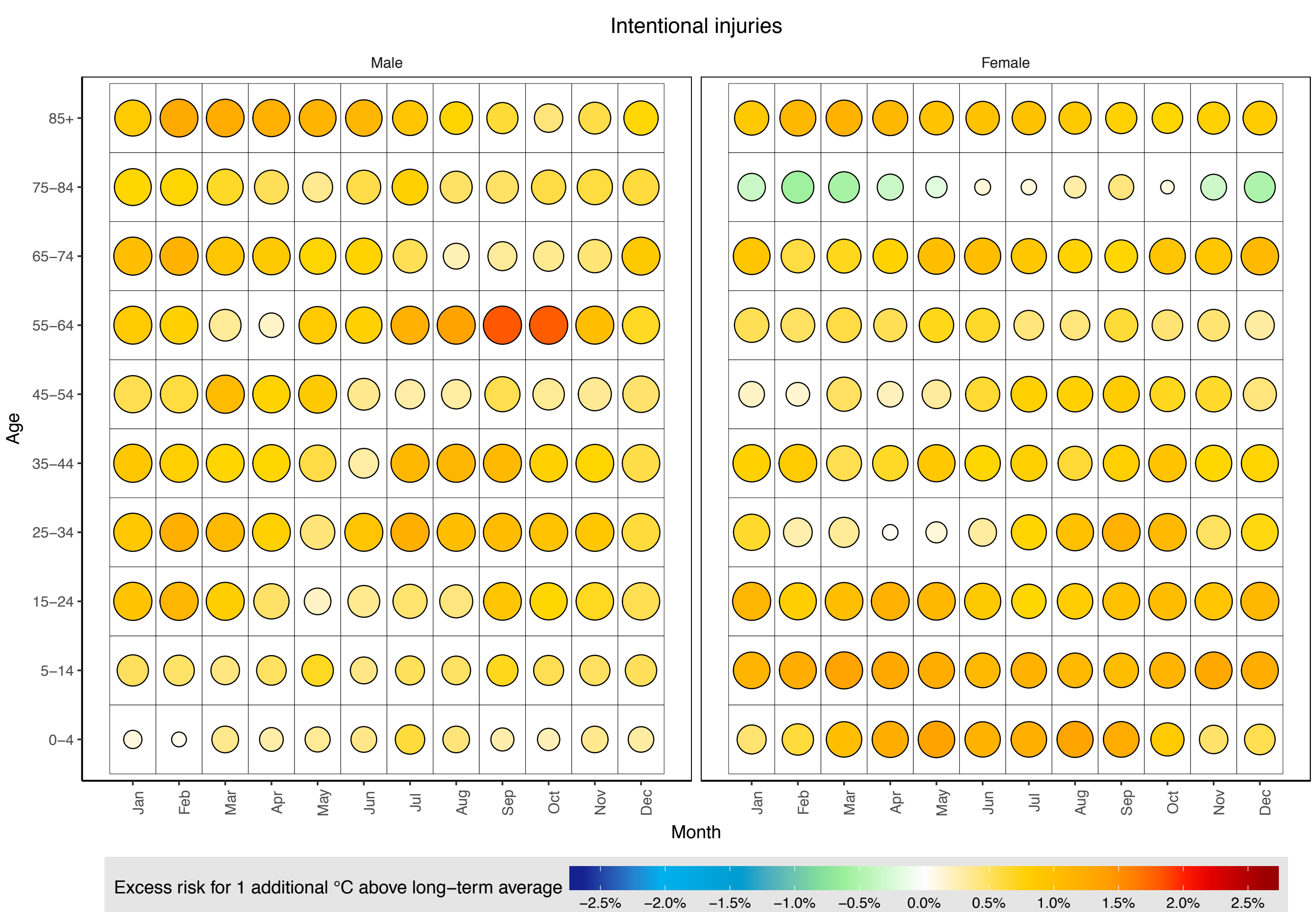
Assault injury excess risk (2-metre temperature)

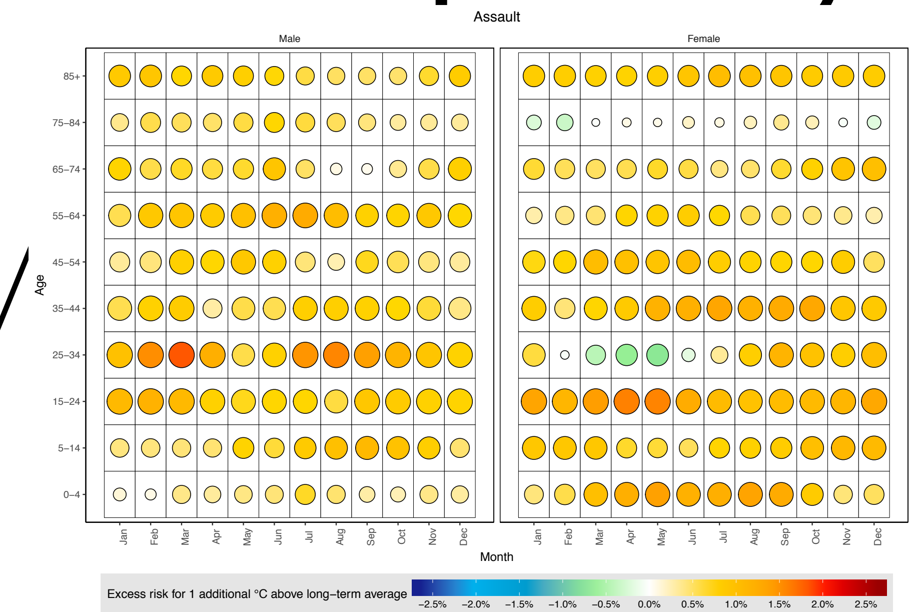


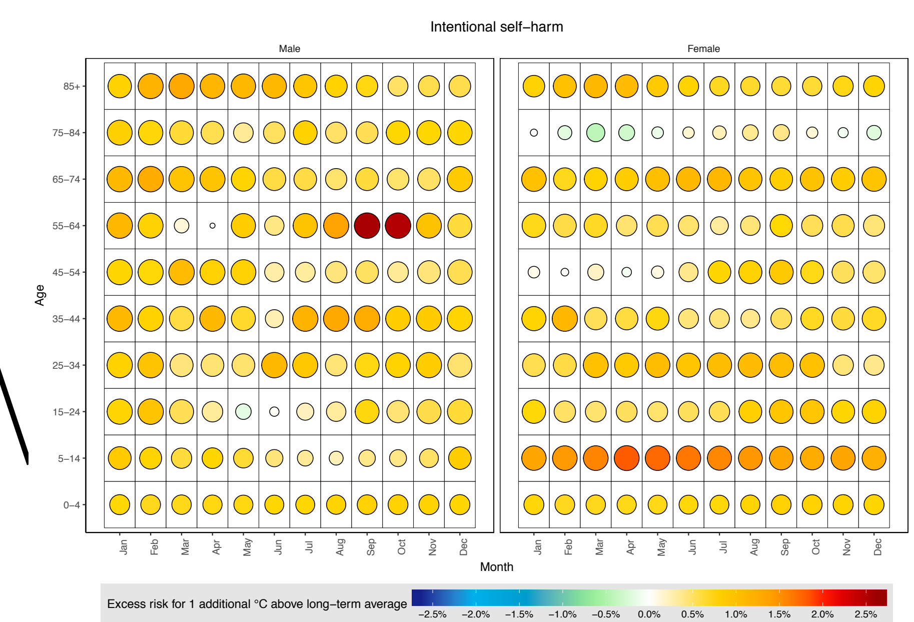
Assault injury excess risk (2-metre temperature)



Unintentional injury excess risk (2-metre temperature)







Poster

Impact of anomalous temperature on monthly injury mortality by age and sex in the USA

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[β]Space and Atmospheric Physics, Department of Physics, Imperial College London
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Background

- Temperatures which deviate from long-term averages will be more frequent as the global climate changes, and could have adverse health consequences.
- Much previous work has focussed on how mortality from natural causes is affected by daily or multi-day hot/cold episodes, and not on weather patterns that reflect inter-annual variations, as expected under global climate change, nor on injuries.

Objective

- To develop a mathematical model to establish the association between monthly injury mortality with deviations from long-term monthly mean temperature.

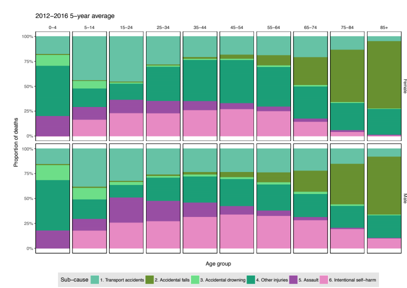

Figure 1: Average breakdown of type of injury deaths in the USA by age and sex, for 2012-2016. Unintentional deaths are in green shades, with intentional deaths in purple.

Data and methods

- Monthly death rates calculated for each age group, sex, state, cause of death, from 5,952,877 injury deaths in contiguous USA for 1980-2016 (type of which summarised in Fig. 1).
- Monthly population-weighted temperature statistics from the ERA- Interim project. Data then transformed to monthly anomaly data by subtracting 30-year state-month means (during 1980-2009).
- Bayesian spatiotemporal model implemented in R-INLA.
- Death counts modelled in a single age-sex group during a particular month m, per state s, at time t by:

$$\text{Deaths}_{[m,s,t]} \sim \text{Poisson}(\mu_{[m,s,t]} E_{[m,s,t]}), \tag{1}$$

with μ the predicted death rate and E the population.

- Log-transformed μ modelled via link function as in Equation 2, with:
  - α intercepts varying by state and month,
  - β temporal slopes varying by state and month,
  - (Anomaly) the temperature term, with e^{γ} reported in Results,
  - π random walk,
  - ϵ overdispersion term.

$$\begin{aligned}\log(\mu_{m,s,t}) = &\alpha_0 + \alpha_{M[m]} + \alpha_{S[s]} + \alpha_{X[m,s]} + \\ &(\beta_0 + \beta_{M[m]} + \beta_{S[s]} + \beta_{X[m,s]})t + \\ &\gamma_{M[m]}(\text{Anomaly})_{m,s} + \\ &\pi_t + \epsilon_{m,s,t},\end{aligned} \tag{2}$$

Results

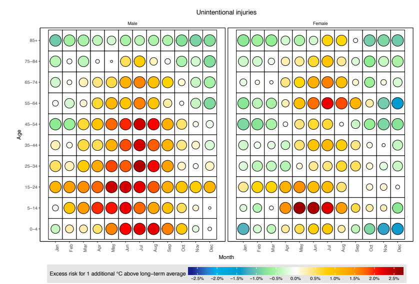

Figure 2: Heat map of excess risk per additional °C above long-term monthly state mean, for unintentional injury deaths, by age and sex. Size of circle is proportional to the probability of marginal for that parameter being the sign of the median estimate.

- Excess risk of dying from unintentional injuries (per additional °C) (Fig. 2):
  - RESULTS TO FINISH
  - RESULTS TO FINISH

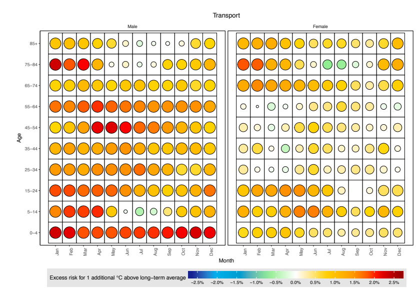

Figure 3: Heat map of excess risk per additional °C above long-term monthly state mean, for transport deaths, by age and sex. Size of circle is proportional to the probability of marginal for that parameter being the sign of the median estimate.

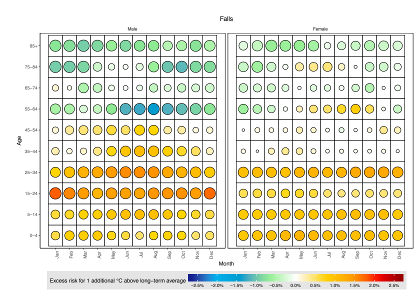

Figure 4: Heat map of excess risk per additional °C above long-term monthly state mean, for deaths from falls, by age and sex. Size of circle is proportional to the probability of marginal for that parameter being the sign of the median estimate.

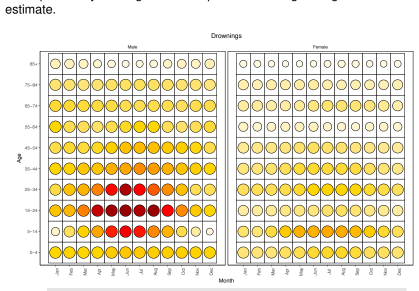

Figure 5: Heat map of excess risk per additional °C above long-term monthly state mean, for deaths from drownings, by age and sex. Size of circle is proportional to the probability of marginal for that parameter being the sign of the median estimate.

- Excess risk of dying from intentional injuries (per additional °C) (Fig. 3):
  - RESULTS TO FINISH
  - RESULTS TO FINISH

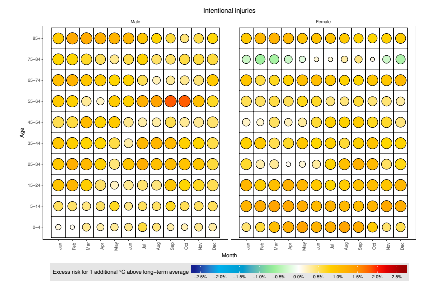

Figure 6: Heat map of excess risk per additional °C above long-term monthly state mean, for intentional injury deaths, by age and sex. Size of circle is proportional to the probability of marginal for that parameter being the sign of the median estimate.

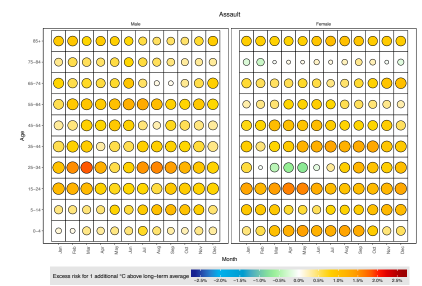

Figure 7: Heat map of excess risk per additional °C above long-term monthly state mean, for deaths from assault, by age and sex. Size of circle is proportional to the probability of marginal for that parameter being the sign of the median estimate.

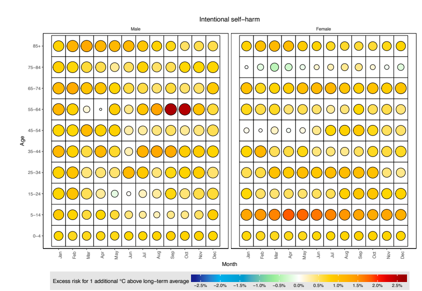

Figure 8: Heat map of excess risk per additional °C above long-term monthly state mean, for deaths from intentional self-harm, by age and sex. Size of circle is proportional to the probability of marginal for that parameter being the sign of the median estimate.

Conclusions

- CONCLUSIONS TO FINISH
- More frequent or extreme anomalously-warm months are likely to increase mortality for unintentional injuries in spring and summer months for males.
- There are likely to be no consistent change in mortality from intentional injuries.
- Age, sex, and month are important factors for change in excess risk with deviation of temperature from long-term mean.

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