Impact of anomalous temperature on injury mortality in the USA

Robbie Parks

Global Environmental Health

Figures

Figure 1

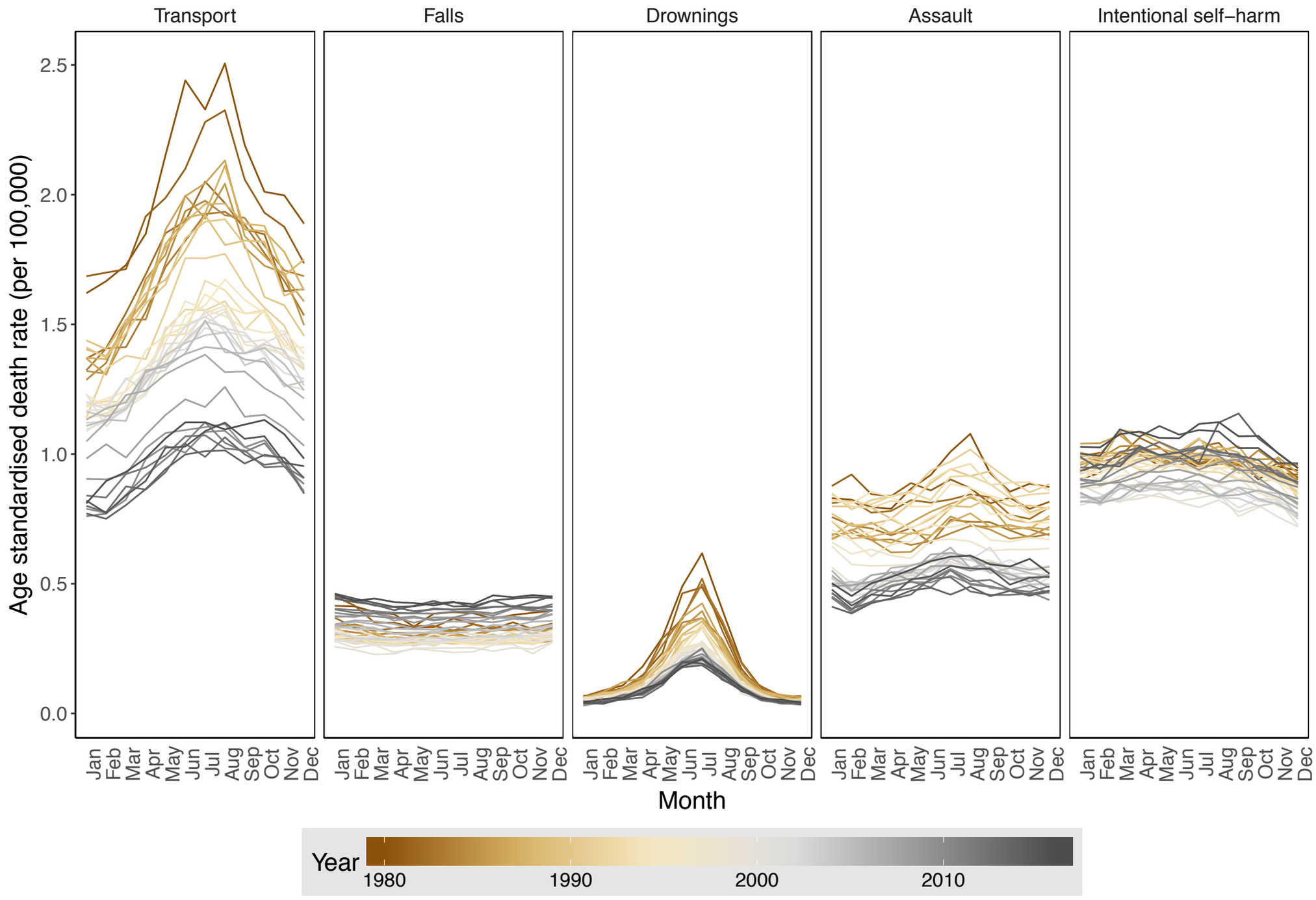

Transport
Falls
Drownings
Assault
Intentional self−harm
Age standardised death rate (per 100,000)
2.5
2.0
1.5
1.0
0.5
0.0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Year
1980
1990
2000
2010

Figure 1 (alt)

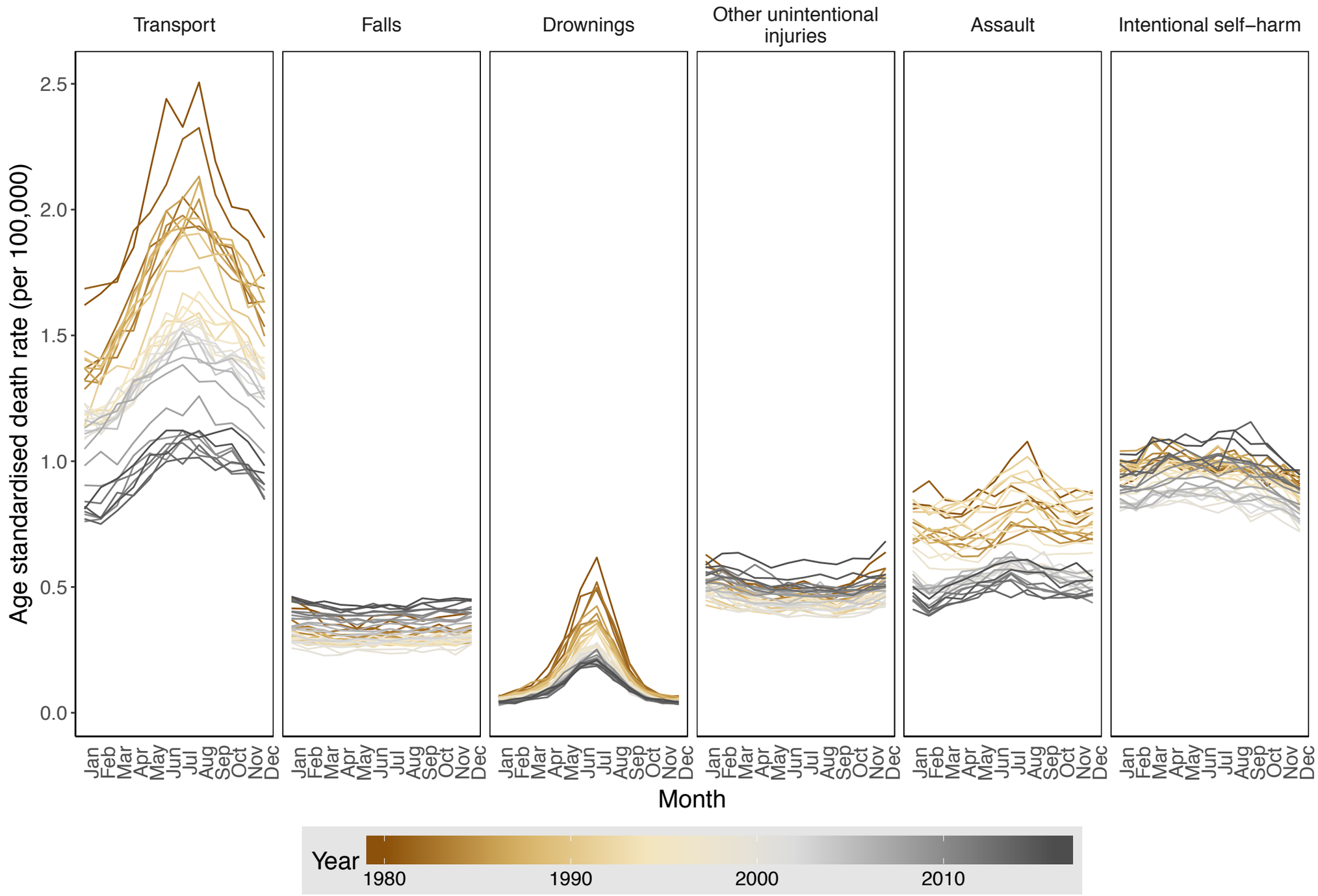

Transport
Falls
Drownings
Other unintentional injuries
Assault
Intentional self−harm
Age standardised death rate (per 100,000)
2.5
2.0
1.5
1.0
0.5
0.0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month
Year
1980
1990
2000
2010

Figure 2

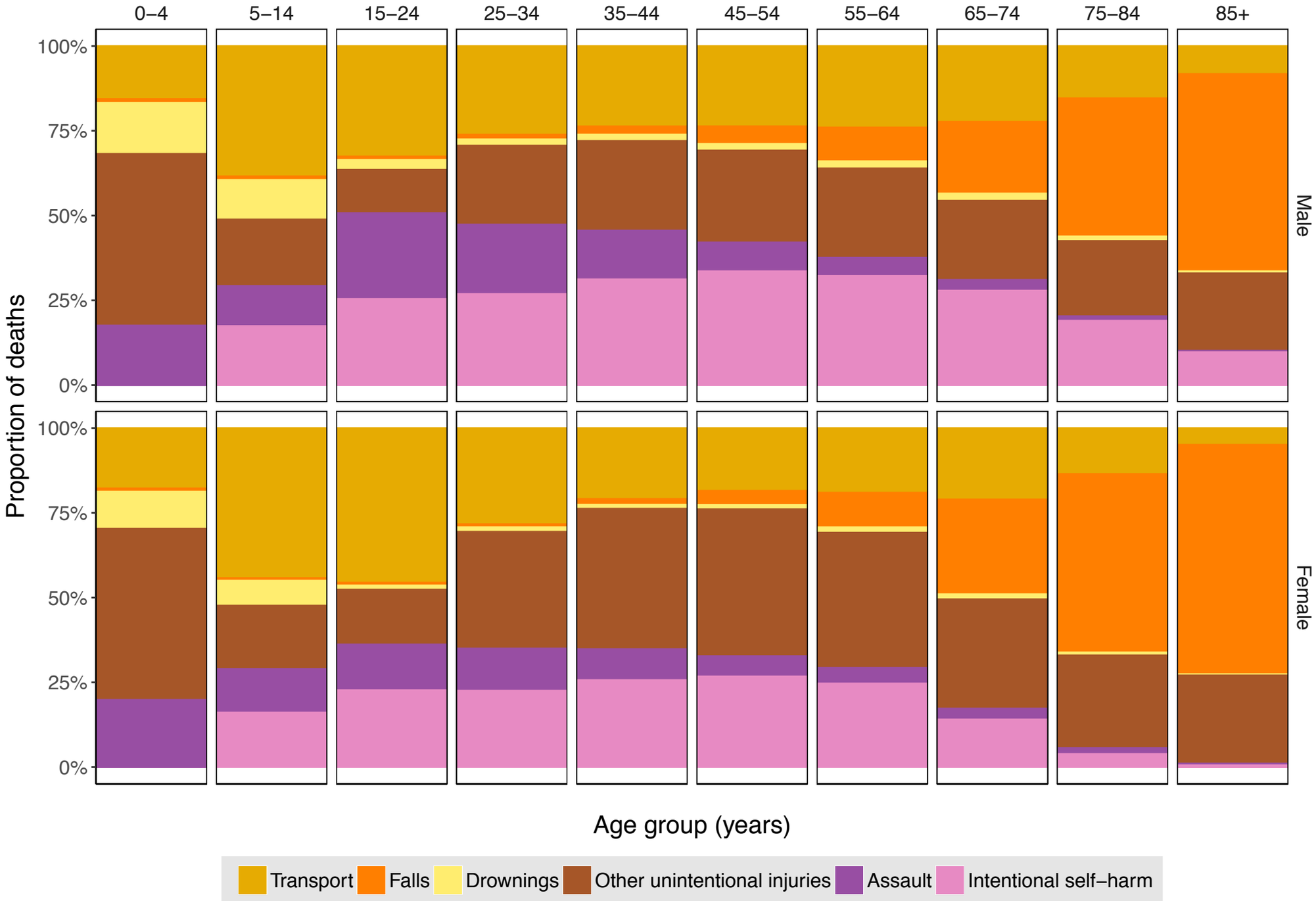
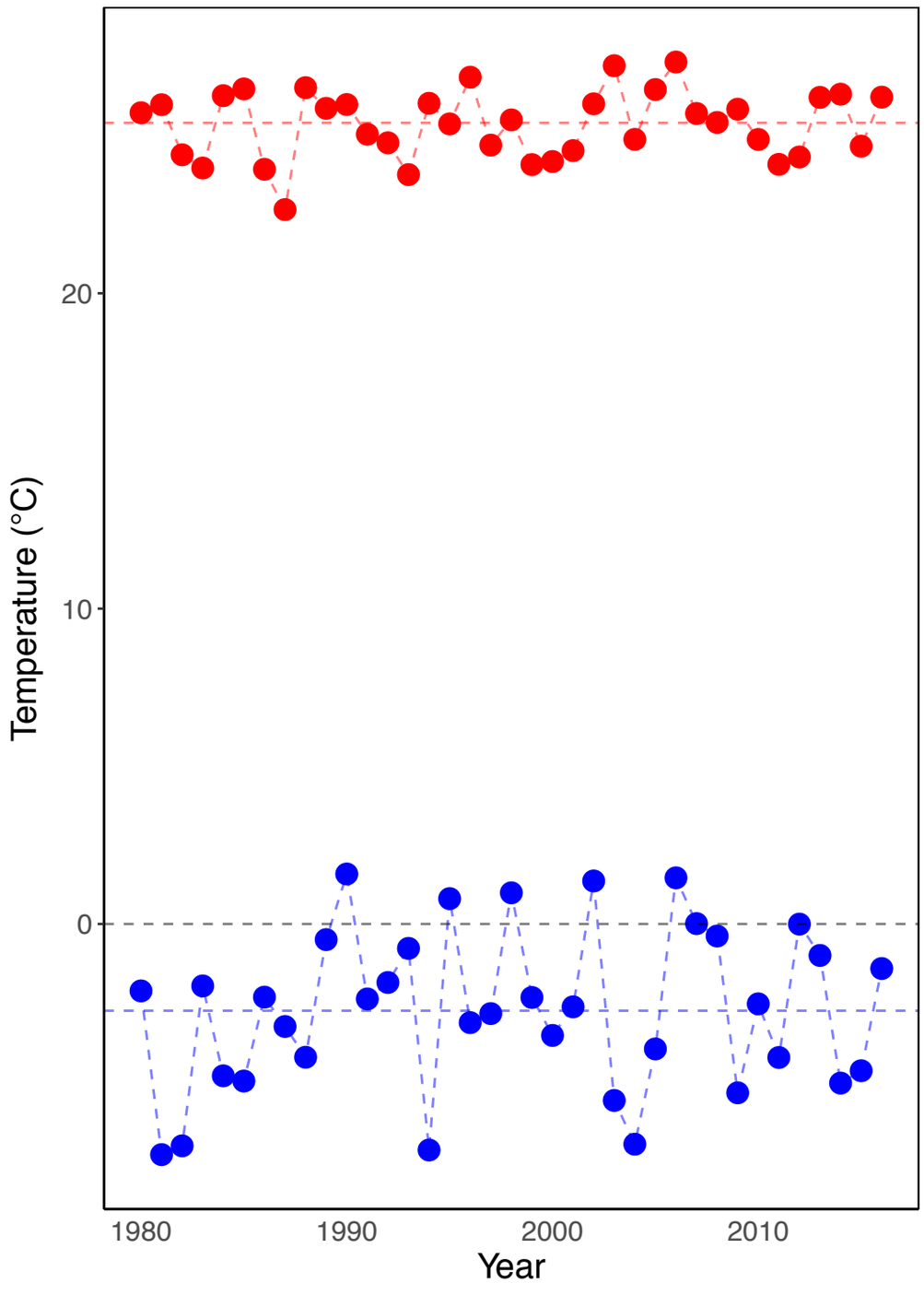

0–4
5–14
15–24
25–34
35–44
45–54
55–64
65–74
75–84
85+
100%
75%
50%
25%
0%
Proportion of deaths
Male
Female
Age group (years)
Transport
Falls
Drownings
Other unintentional injuries
Assault
Intentional self–harm

Figure 3


20
10
0
Temperature (°C)
1980
1990
2000
2010
Year

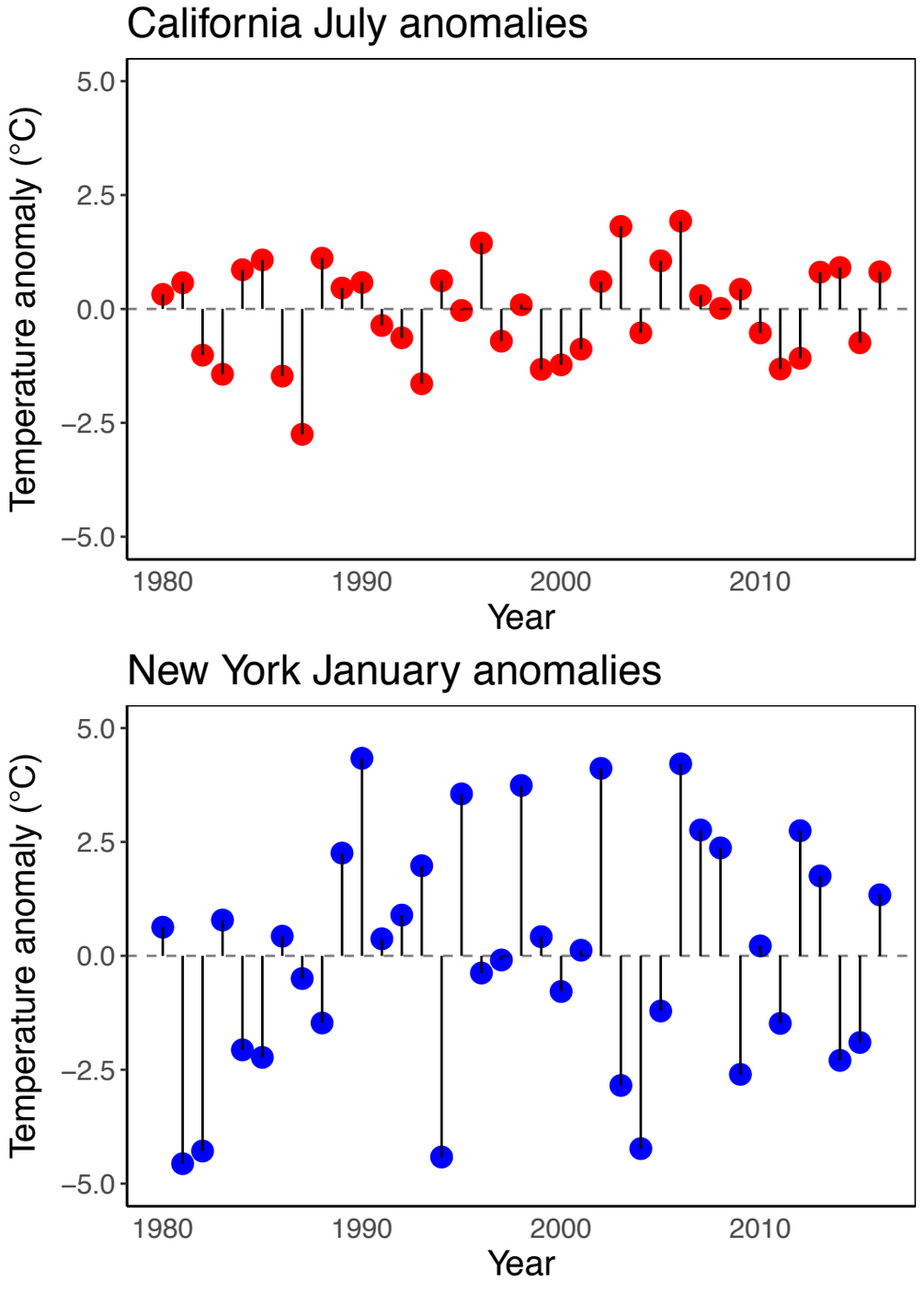

California July anomalies
5.0
2.5
0.0
−2.5
−5.0
Temperature anomaly (°C)
1980
1990
2000
2010
Year
New York January anomalies
5.0
2.5
0.0
−2.5
−5.0
Temperature anomaly (°C)
1980
1990
2000
2010
Year

Figure 4

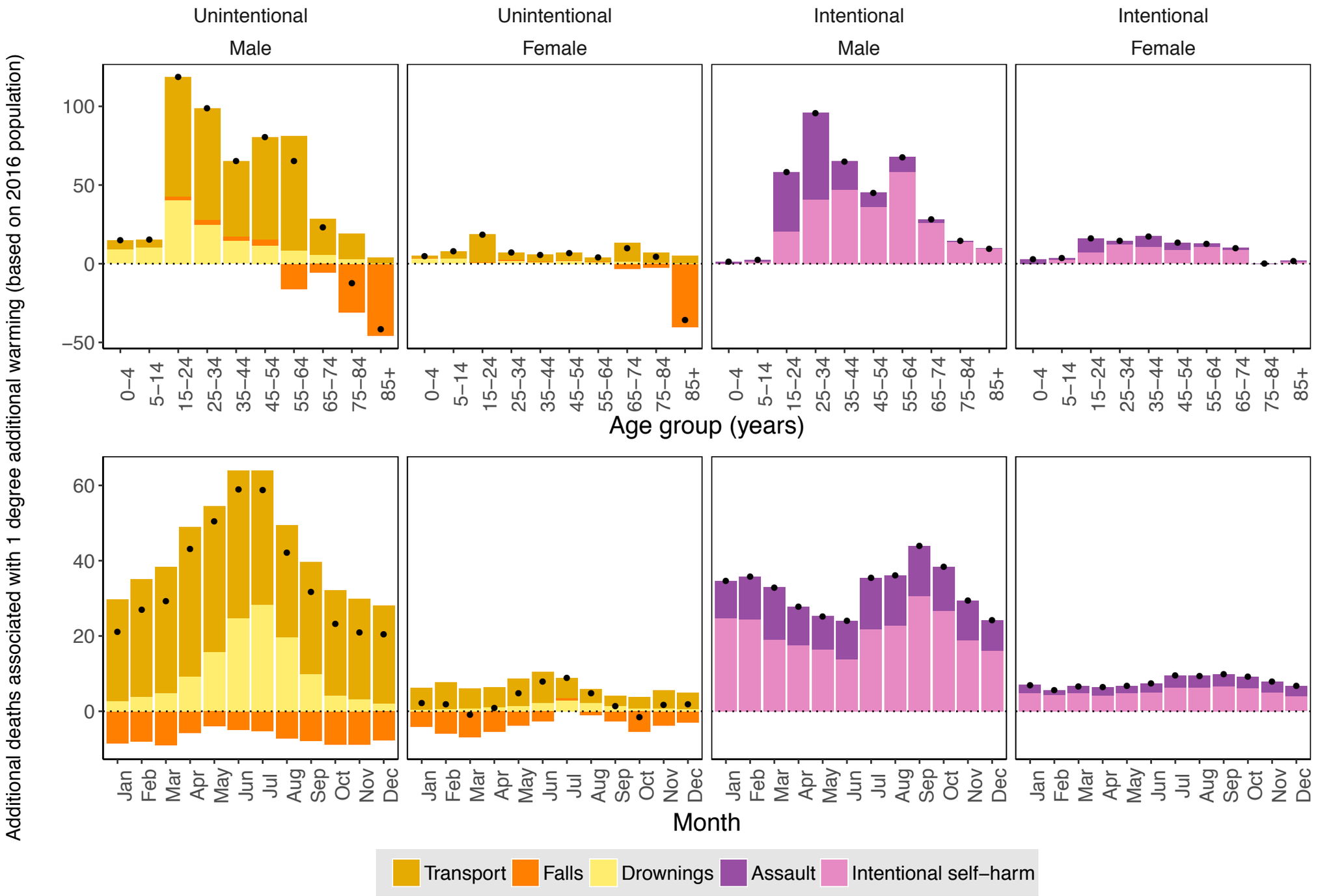

Unintentional
Male
Unintentional
Female
Intentional
Male
Intentional
Female
Additional deaths associated with 1 degree above MMT (based on 2016 population)
100
50
0
−50
60
40
20
0
0–4
5–14
15–24
25–34
35–44
45–54
55–64
65–74
75–84
85+
Age group (years)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Transport
Falls
Drownings
Assault
Intentional self–harm

Figure 4 (alt)

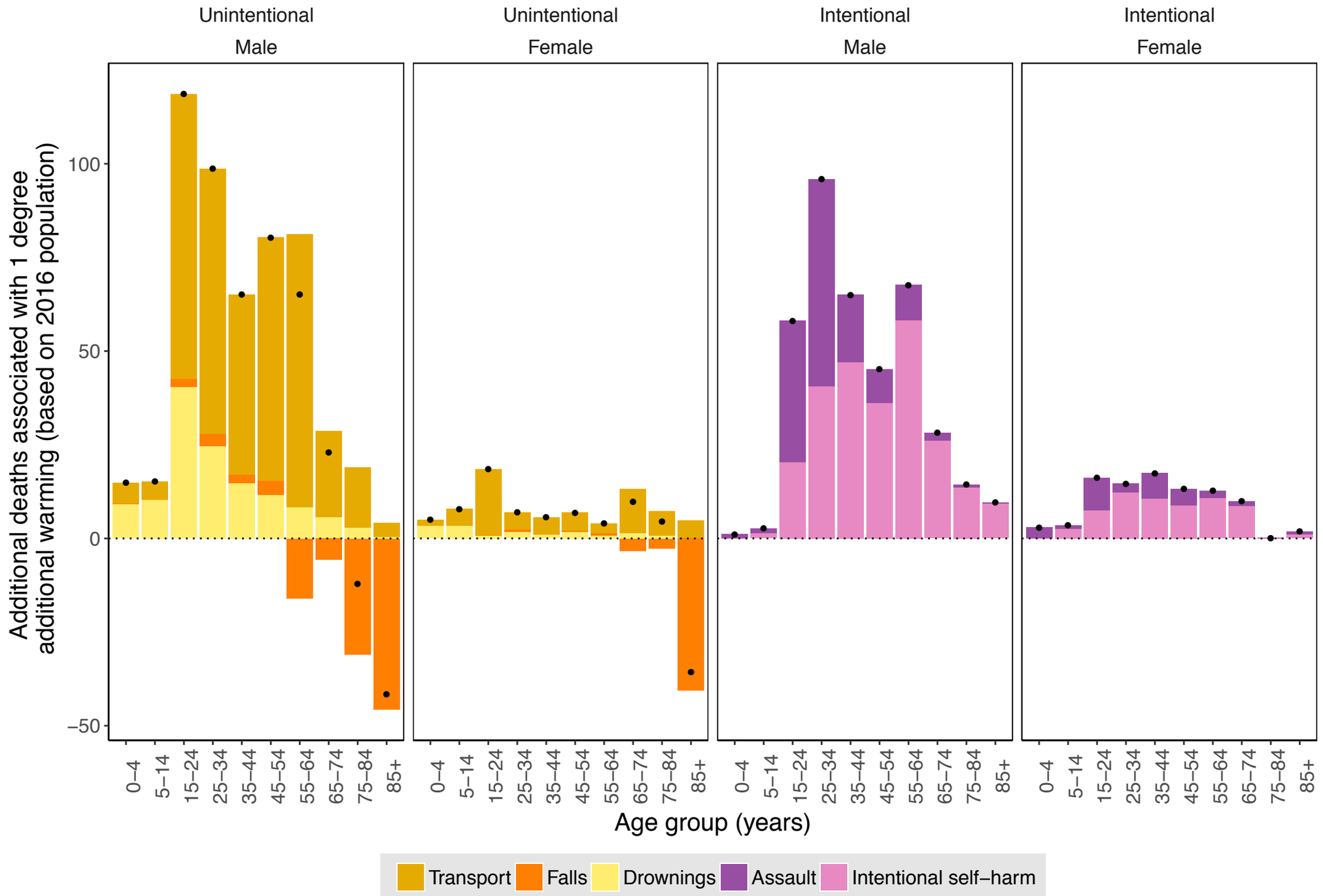

Unintentional
Male
Unintentional
Female
Intentional
Male
Intentional
Female
Additional deaths associated with 1 degree additional warming (based on 2016 population)
100
50
0
−50
0–4
5–14
15–24
25–34
35–44
45–54
55–64
65–74
75–84
85+
Age group (years)
Transport
Falls
Drownings
Assault
Intentional self−harm

Figure 4 (alt)

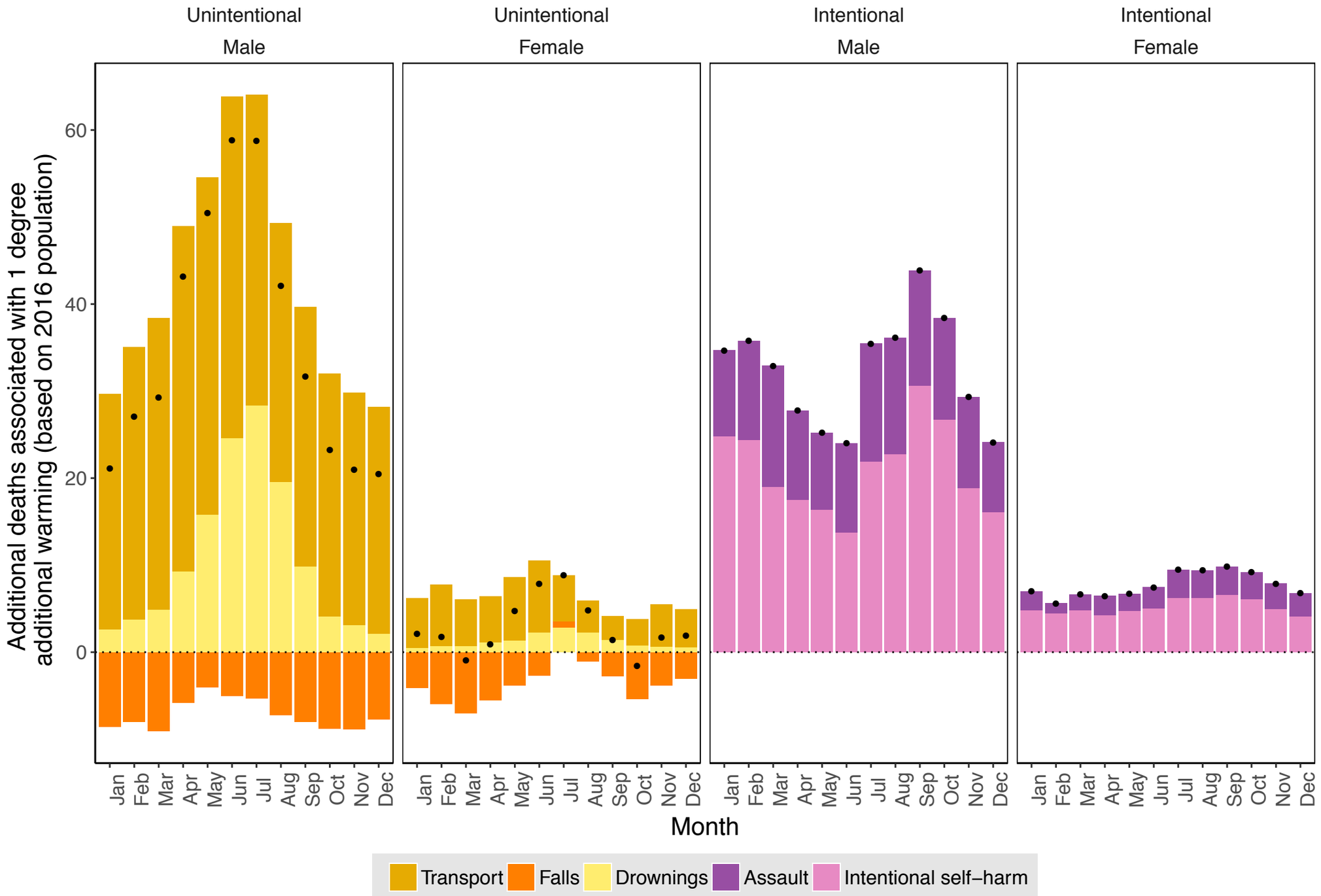

Unintentional
Male
Unintentional
Female
Intentional
Male
Intentional
Female
Additional deaths associated with 1 degree additional warming (based on 2016 population)
60
40
20
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Transport
Falls
Drownings
Assault
Intentional self−harm

Figure 4 (alt)

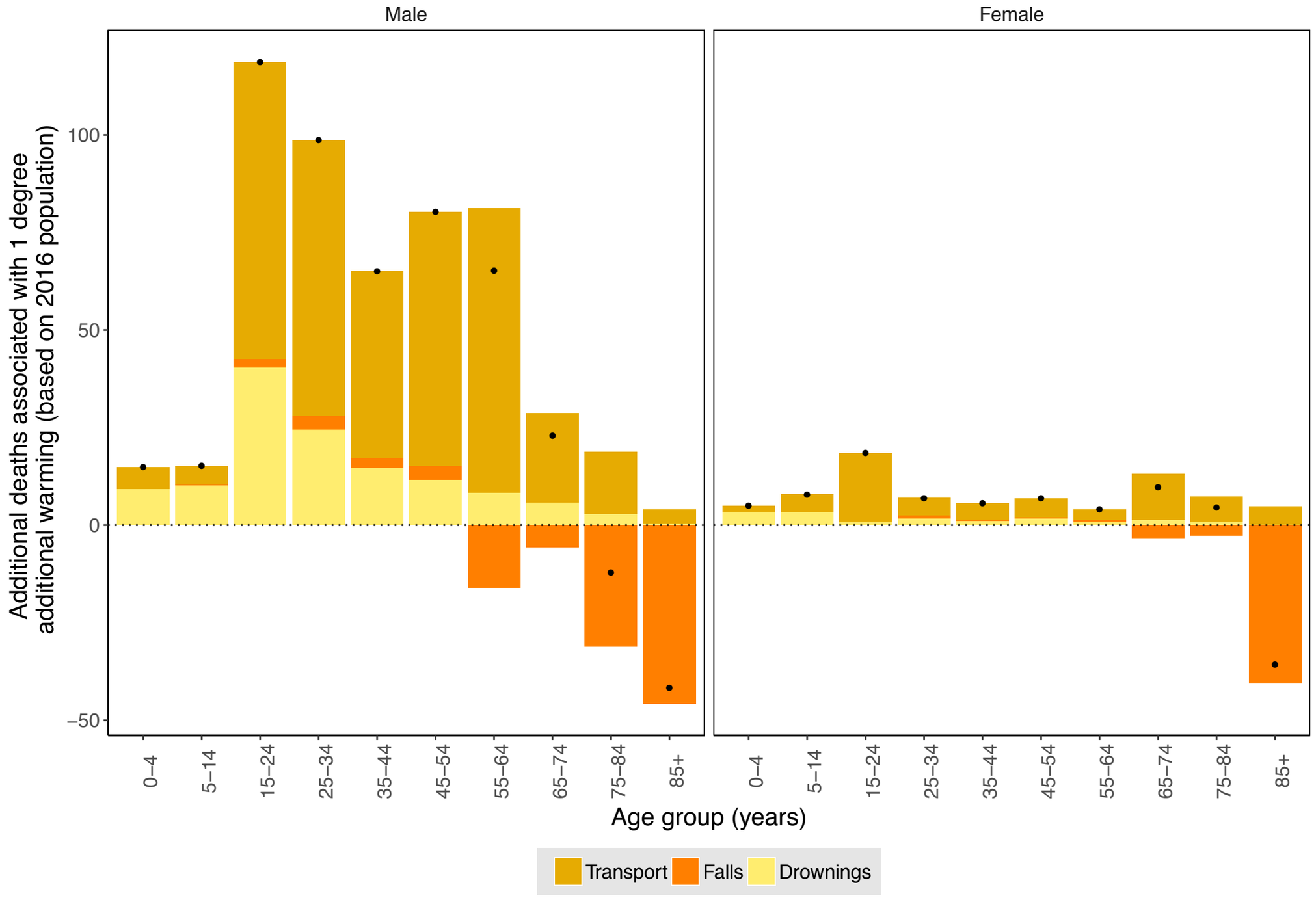

Male
Female
Additional deaths associated with 1 degree additional warming (based on 2016 population)
100
50
0
−50
0–4
5–14
15–24
25–34
35–44
45–54
55–64
65–74
75–84
85+
Age group (years)
Transport
Falls
Drownings

Figure 4 (alt)

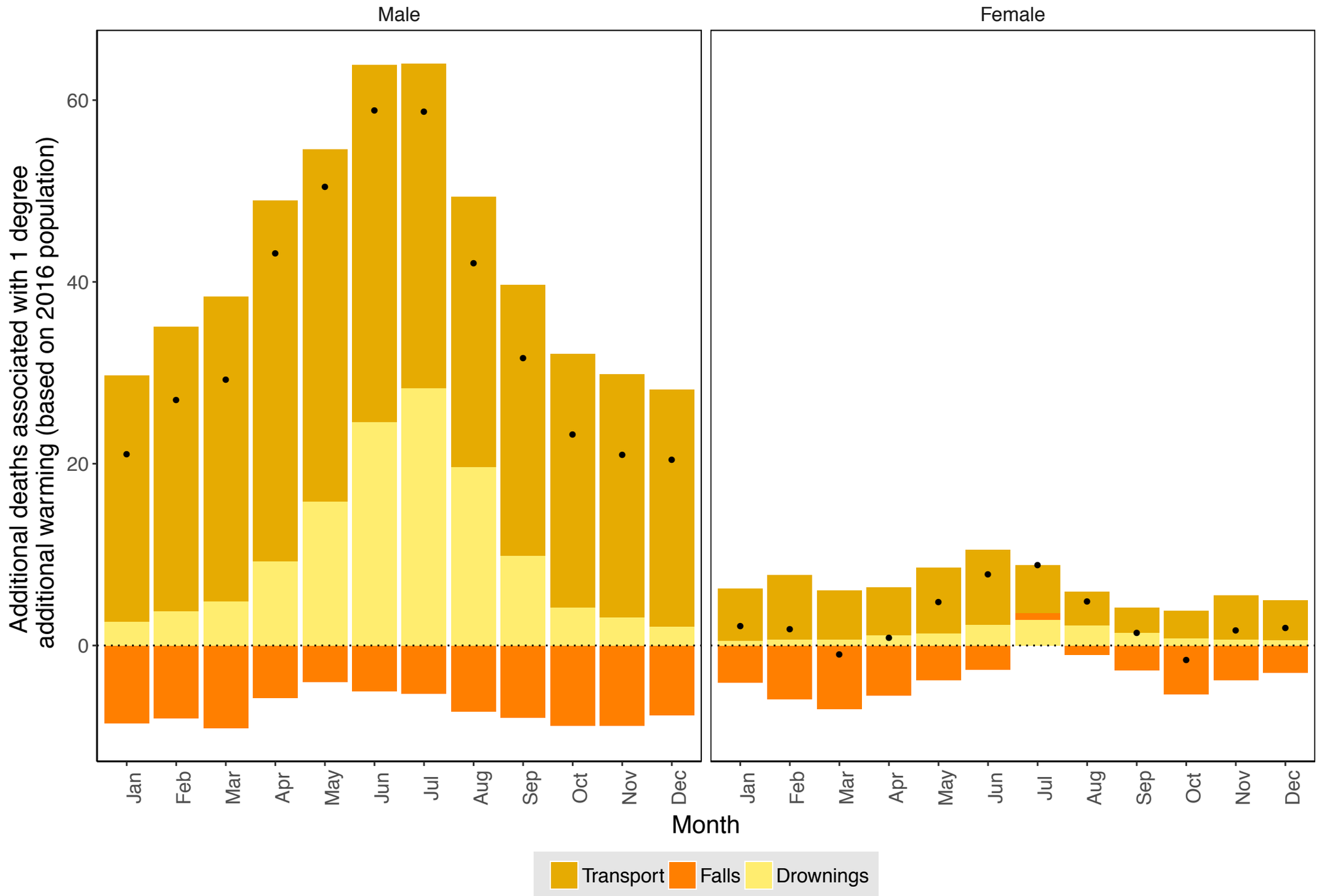

Male
Female
Additional deaths associated with 1 degree additional warming (based on 2016 population)
60
40
20
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Transport
Falls
Drownings

Figure 4 (alt)

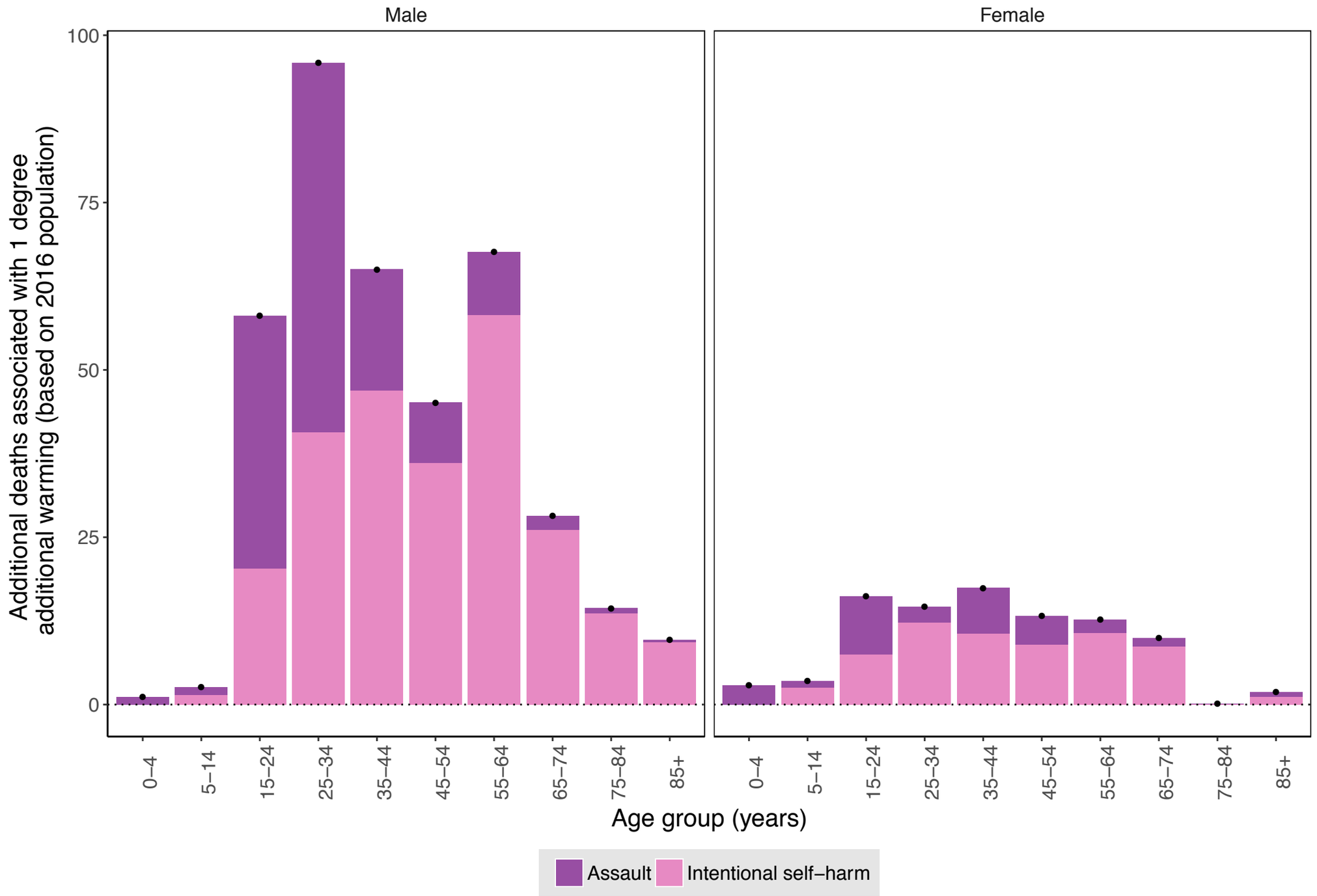
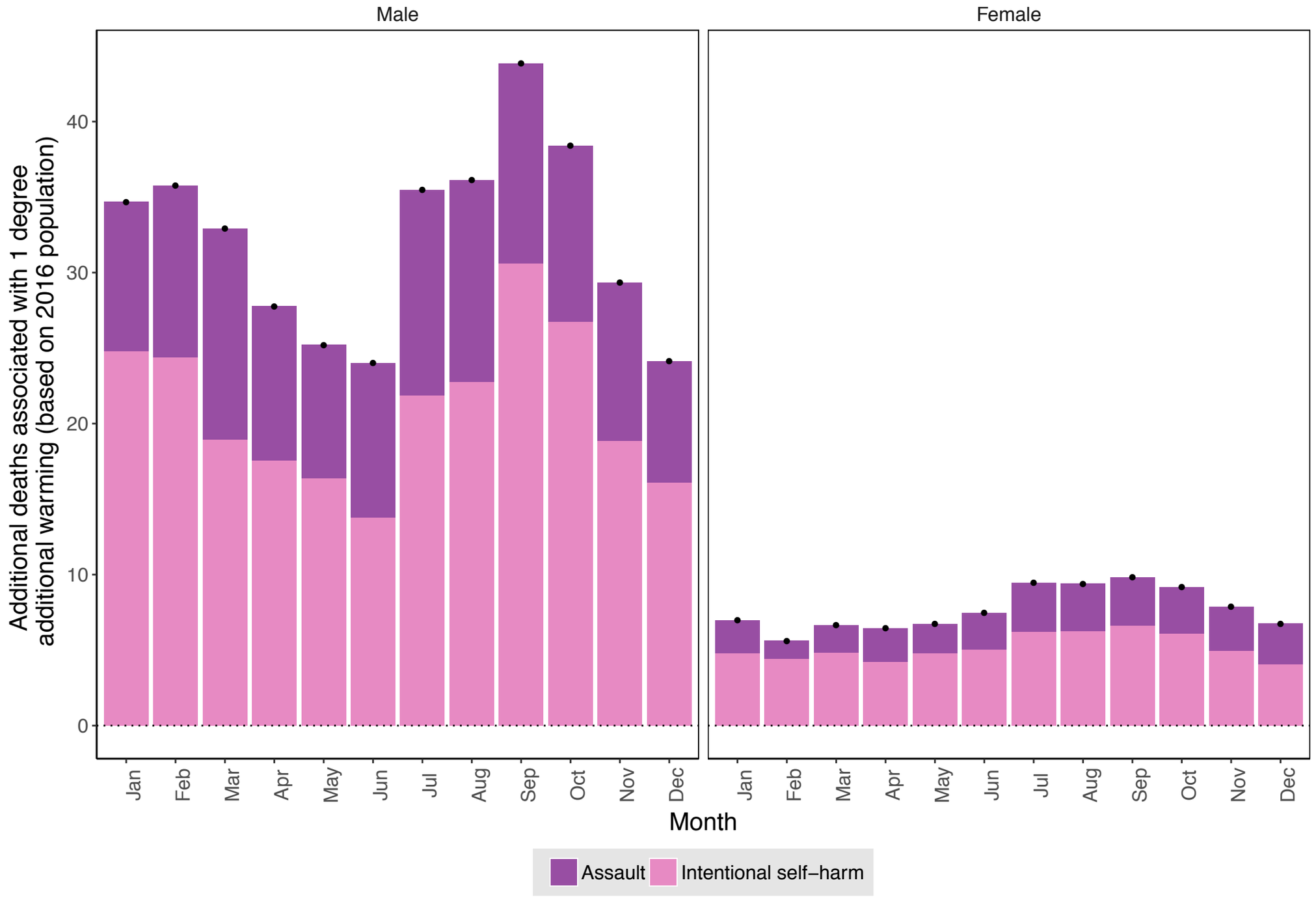
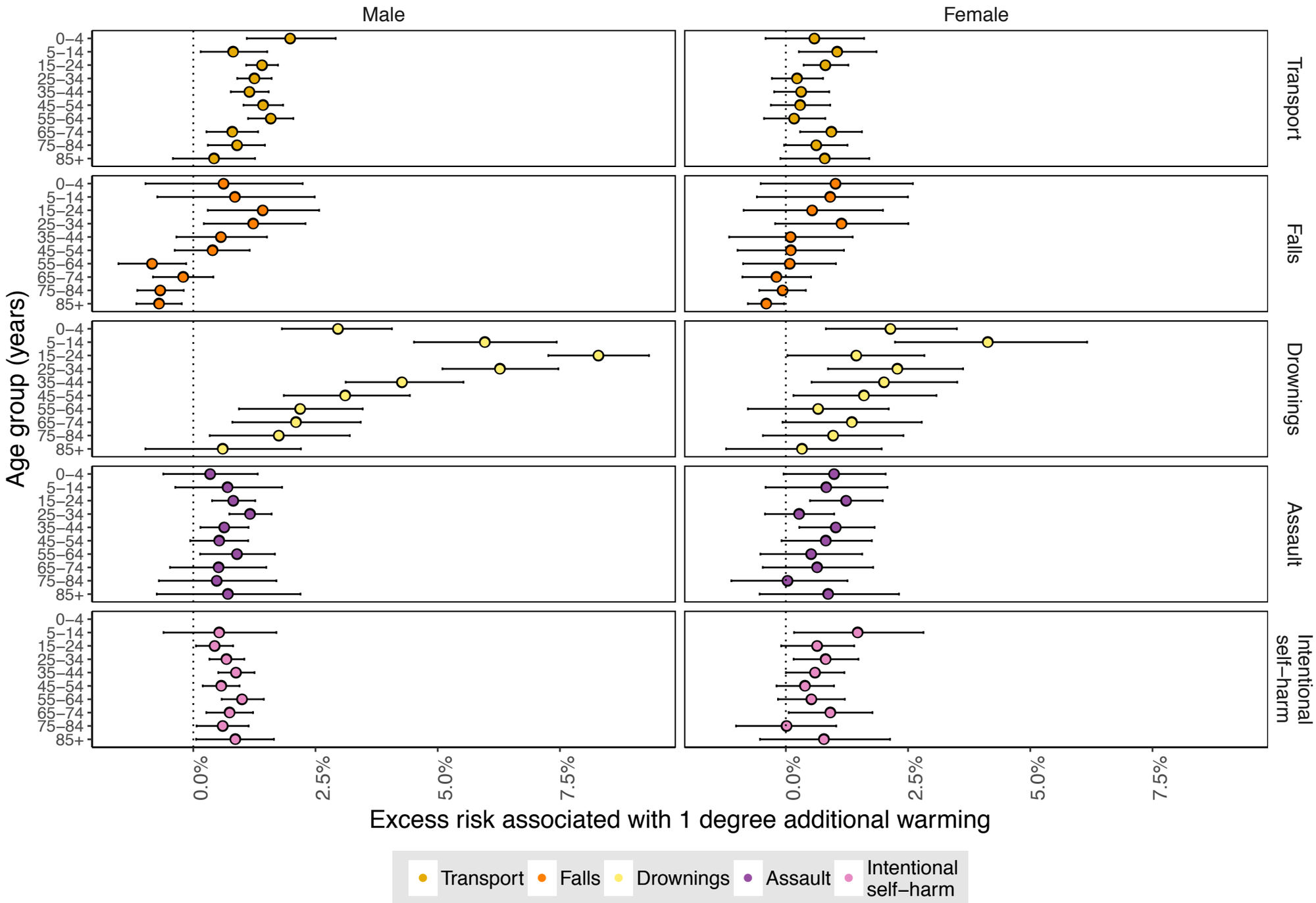

Male
Female
Additional deaths associated with 1 degree additional warming (based on 2016 population)
100
75
50
25
0
0–4
5–14
15–24
25–34
35–44
45–54
55–64
65–74
75–84
85+
Age group (years)
Assault
Intentional self–harm

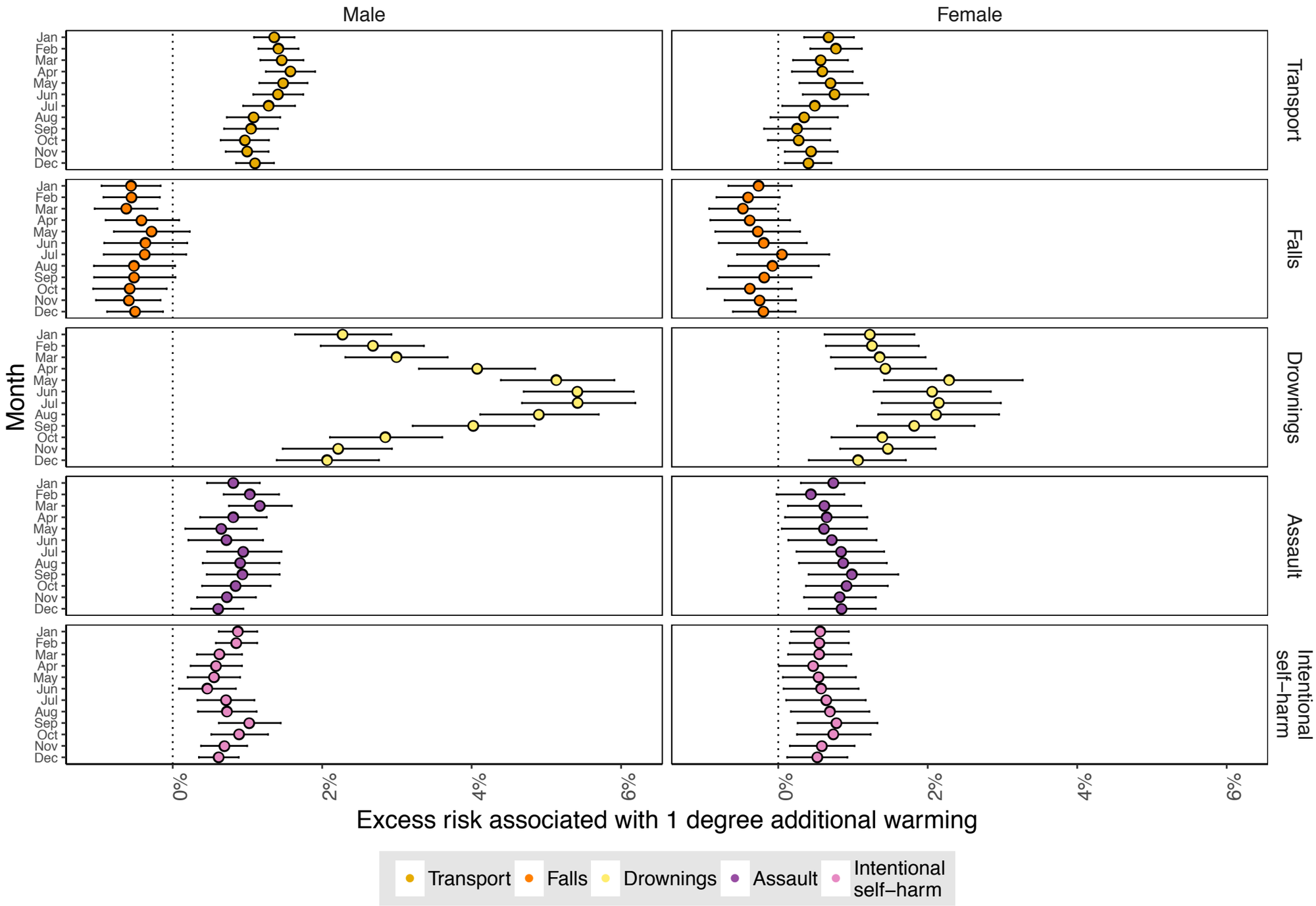
Figure 4 (alt)


Male
Female
Additional deaths associated with 1 degree additional warming (based on 2016 population)
40
30
20
10
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Assault
Intentional self−harm

Supplementary Figure 1



Supplementary Figure 2 (?)



Tables

Table 1

Sex	Cause	0-4	5-14	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85+	All ages
Both	All injuries	24.0 (17.0, 31.0)	29.0 (22.0, 37.0)	211.0 (176.0, 248.0)	216.0 (178.0, 254.0)	153.0 (121.0, 186.0)	146.0 (109.0, 183.0)	150.0 (108.0, 190.0)	71.0 (38.0, 104.0)	7.0 (-28.0, 41.0)	-66.0 (-115.0, -17.0)	941.0 (831.0,1053.0)
Male	All injuries	16.0 (11.0, 21.0)	18.0 (12.0, 24.0)	177.0 (144.0, 209.0)	195.0 (159.0, 230.0)	130.0 (101.0, 160.0)	125.0 (92.0, 158.0)	133.0 (96.0, 170.0)	51.0 (22.0, 80.0)	2.0 (-24.0, 29.0)	-32.0 (-64.0, 0.0)	815.0 (721.0, 909.0)
Female	All injuries	8.0 (4.0, 12.0)	11.0 (7.0, 16.0)	35.0 (21.0, 49.0)	22.0 (6.0, 37.0)	23.0 (9.0, 38.0)	20.0 (3.0, 38.0)	17.0 (-2.0, 36.0)	20.0 (2.0, 37.0)	5.0 (-17.0, 27.0)	-34.0 (-73.0, 4.0)	126.0 (66.0, 185.0)
Both	Unintentional	20.0 (14.0, 25.0)	23.0 (17.0, 29.0)	137.0 (116.0, 157.0)	106.0 (82.0, 128.0)	71.0 (52.0, 90.0)	87.0 (64.0, 109.0)	69.0 (41.0, 98.0)	33.0 (5.0, 60.0)	-8.0 (-40.0, 24.0)	-77.0 (-126.0, -29.0)	461.0 (377.0, 543.0)
Male	Unintentional	15.0 (11.0, 19.0)	15.0 (10.0, 20.0)	119.0 (100.0, 137.0)	99.0 (78.0, 119.0)	65.0 (48.0, 82.0)	80.0 (59.0, 101.0)	65.0 (40.0, 90.0)	23.0 (0.0, 46.0)	-12.0 (-36.0, 12.0)	-42.0 (-73.0, -11.0)	427.0 (361.0, 492.0)
Female	Unintentional	5.0 (2.0, 8.0)	8.0 (4.0, 12.0)	19.0 (9.0, 29.0)	7.0 (-3.0, 17.0)	6.0 (-2.0, 14.0)	7.0 (-4.0, 18.0)	4.0 (-8.0, 16.0)	10.0 (-5.0, 25.0)	5.0 (-17.0, 26.0)	-36.0 (-75.0, 2.0)	34.0 (-19.0, 86.0)
Both	Transport	7.0 (3.0, 11.0)	9.0 (4.0, 15.0)	94.0 (73.0, 113.0)	75.0 (53.0, 97.0)	52.0 (35.0, 71.0)	70.0 (48.0, 90.0)	75.0 (53.0, 99.0)	35.0 (18.0, 52.0)	23.0 (10.0, 35.0)	8.0 (-1.0, 17.0)	448.0 (394.0, 501.0)
Male	Transport	6.0 (3.0, 8.0)	5.0 (1.0, 9.0)	76.0 (59.0, 94.0)	71.0 (51.0, 90.0)	48.0 (32.0, 64.0)	65.0 (47.0, 83.0)	73.0 (51.0, 94.0)	23.0 (8.0, 38.0)	16.0 (5.0, 26.0)	4.0 (-4.0, 11.0)	385.0 (339.0, 431.0)
Female	Transport	1.0 (-1.0, 4.0)	4.0 (1.0, 8.0)	18.0 (8.0, 28.0)	4.0 (-6.0, 15.0)	4.0 (-3.0, 12.0)	5.0 (-5.0, 15.0)	3.0 (-7.0, 12.0)	12.0 (4.0, 20.0)	7.0 (0.0, 13.0)	5.0 (-1.0, 10.0)	63.0 (39.0, 88.0)
Both	Falls	0.0 (0.0, 1.0)	0.0 (0.0, 0.0)	3.0 (1.0, 4.0)	4.0 (1.0, 7.0)	2.0 (-2.0, 7.0)	4.0 (-4.0, 12.0)	-15.0 (-31.0, 0.0)	-9.0 (-30.0, 13.0)	-34.0 (-64.0, -4.0)	-86.0 (-134.0, -38.0)	-131.0 (-193.0, -68.0)
Male	Falls	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	2.0 (0.0, 4.0)	3.0 (1.0, 6.0)	2.0 (-1.0, 6.0)	4.0 (-3.0, 11.0)	-16.0 (-29.0, -3.0)	-6.0 (-23.0, 11.0)	-31.0 (-53.0, -9.0)	-46.0 (-76.0, -15.0)	-87.0 (-130.0, -44.0)
Female	Falls	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 1.0)	1.0 (0.0, 2.0)	0.0 (-1.0, 1.0)	0.0 (-3.0, 4.0)	1.0 (-7.0, 8.0)	-3.0 (-16.0, 9.0)	-3.0 (-23.0, 17.0)	-41.0 (-79.0, -4.0)	-44.0 (-89.0, 2.0)
Both	Drownings	13.0 (8.0, 17.0)	14.0 (11.0, 17.0)	41.0 (36.0, 46.0)	26.0 (22.0, 31.0)	16.0 (12.0, 20.0)	13.0 (8.0, 19.0)	9.0 (4.0, 14.0)	7.0 (3.0, 11.0)	4.0 (1.0, 6.0)	1.0 (-1.0, 2.0)	143.0 (130.0, 157.0)
Male	Drownings	9.0 (6.0, 13.0)	10.0 (8.0, 13.0)	40.0 (35.0, 45.0)	25.0 (20.0, 29.0)	15.0 (11.0, 19.0)	12.0 (7.0, 17.0)	8.0 (4.0, 13.0)	6.0 (2.0, 9.0)	3.0 (1.0, 5.0)	0.0 (-1.0, 1.0)	128.0 (116.0, 141.0)
Female	Drownings	3.0 (1.0, 6.0)	3.0 (2.0, 5.0)	1.0 (0.0, 1.0)	2.0 (1.0, 3.0)	1.0 (0.0, 2.0)	2.0 (0.0, 3.0)	1.0 (-1.0, 3.0)	1.0 (0.0, 3.0)	1.0 (0.0, 2.0)	0.0 (0.0, 1.0)	15.0 (11.0, 19.0)
Both	Intentional	4.0 (0.0, 8.0)	6.0 (2.0, 11.0)	74.0 (46.0, 103.0)	110.0 (79.0, 142.0)	82.0 (56.0, 109.0)	58.0 (29.0, 86.0)	80.0 (50.0, 110.0)	38.0 (18.0, 57.0)	14.0 (2.0, 27.0)	11.0 (2.0, 20.0)	480.0 (410.0, 550.0)
Male	Intentional	1.0 (-2.0, 4.0)	3.0 (-1.0, 6.0)	58.0 (31.0, 85.0)	96.0 (67.0, 126.0)	65.0 (41.0, 89.0)	45.0 (19.0, 70.0)	68.0 (41.0, 95.0)	28.0 (11.0, 46.0)	14.0 (2.0, 26.0)	10.0 (1.0, 18.0)	388.0 (323.0, 451.0)
Female	Intentional	3.0 (0.0, 6.0)	4.0 (1.0, 6.0)	16.0 (6.0, 26.0)	15.0 (3.0, 26.0)	17.0 (6.0, 29.0)	13.0 (-1.0, 27.0)	13.0 (-2.0, 27.0)	10.0 (1.0, 18.0)	0.0 (-4.0, 4.0)	2.0 (0.0, 4.0)	92.0 (63.0, 122.0)
Both	Assault	4.0 (0.0, 8.0)	2.0 (0.0, 4.0)	46.0 (26.0, 67.0)	58.0 (37.0, 80.0)	25.0 (10.0, 40.0)	13.0 (2.0, 25.0)	11.0 (3.0, 20.0)	3.0 (-1.0, 8.0)	1.0 (-2.0, 3.0)	1.0 (0.0, 2.0)	165.0 (129.0, 201.0)
Male	Assault	1.0 (-2.0, 4.0)	1.0 (-1.0, 3.0)	38.0 (18.0, 58.0)	55.0 (35.0, 76.0)	18.0 (4.0, 32.0)	9.0 (-1.0, 19.0)	9.0 (1.0, 18.0)	2.0 (-2.0, 6.0)	1.0 (-1.0, 3.0)	0.0 (0.0, 1.0)	135.0 (100.0, 170.0)
Female	Assault	3.0 (0.0, 6.0)	1.0 (0.0, 2.0)	9.0 (3.0, 14.0)	2.0 (-4.0, 8.0)	7.0 (2.0, 12.0)	4.0 (0.0, 9.0)	2.0 (-2.0, 6.0)	1.0 (-1.0, 3.0)	0.0 (-1.0, 1.0)	1.0 (0.0, 2.0)	30.0 (18.0, 42.0)
Both	Intentional self-harm	0.0 (0.0, 0.0)	4.0 (0.0, 8.0)	28.0 (8.0, 47.0)	53.0 (30.0, 76.0)	57.0 (35.0, 80.0)	45.0 (18.0, 72.0)	69.0 (40.0, 97.0)	35.0 (16.0, 53.0)	14.0 (1.0, 26.0)	10.0 (2.0, 19.0)	315.0 (256.0, 375.0)
Male	Intentional self-harm	0.0 (0.0, 0.0)	1.0 (-2.0, 5.0)	20.0 (3.0, 38.0)	41.0 (20.0, 62.0)	47.0 (28.0, 67.0)	36.0 (12.0, 60.0)	58.0 (34.0, 84.0)	26.0 (9.0, 43.0)	14.0 (2.0, 26.0)	9.0 (1.0, 18.0)	253.0 (200.0, 306.0)
Female	Intentional self-harm	0.0 (0.0, 0.0)	3.0 (0.0, 5.0)	7.0 (-1.0, 16.0)	12.0 (2.0, 22.0)	11.0 (0.0, 21.0)	9.0 (-4.0, 22.0)	11.0 (-3.0, 25.0)	9.0 (1.0, 17.0)	0.0 (-4.0, 4.0)	1.0 (-1.0, 3.0)	62.0 (35.0, 89.0)

Table 1 (alt)

Sex	Cause	0-4	5-14	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85+	All ages
Both	Transport	7.0 (3.0, 11.0)	9.0 (4.0, 15.0)	94.0 (73.0, 113.0)	75.0 (53.0, 97.0)	52.0 (35.0, 71.0)	70.0 (48.0, 90.0)	75.0 (53.0, 99.0)	35.0 (18.0, 52.0)	23.0 (10.0, 35.0)	8.0 (-1.0, 17.0)	448.0 (394.0, 501.0)
Male	Transport	6.0 (3.0, 8.0)	5.0 (1.0, 9.0)	76.0 (59.0, 94.0)	71.0 (51.0, 90.0)	48.0 (32.0, 64.0)	65.0 (47.0, 83.0)	73.0 (51.0, 94.0)	23.0 (8.0, 38.0)	16.0 (5.0, 26.0)	4.0 (-4.0, 11.0)	385.0 (339.0, 431.0)
Female	Transport	1.0 (-1.0, 4.0)	4.0 (1.0, 8.0)	18.0 (8.0, 28.0)	4.0 (-6.0, 15.0)	4.0 (-3.0, 12.0)	5.0 (-5.0, 15.0)	3.0 (-7.0, 12.0)	12.0 (4.0, 20.0)	7.0 (0.0, 13.0)	5.0 (-1.0, 10.0)	63.0 (39.0, 88.0)
Both	Falls	0.0 (0.0, 1.0)	0.0 (0.0, 0.0)	3.0 (1.0, 4.0)	4.0 (1.0, 7.0)	2.0 (-2.0, 7.0)	4.0 (-4.0, 12.0)	-15.0 (-31.0, 0.0)	-9.0 (-30.0, 13.0)	-34.0 (-64.0, -4.0)	-86.0 (-134.0, -38.0)	-131.0 (-193.0, -68.0)
Male	Falls	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	2.0 (0.0, 4.0)	3.0 (1.0, 6.0)	2.0 (-1.0, 6.0)	4.0 (-3.0, 11.0)	-16.0 (-29.0, -3.0)	-6.0 (-23.0, 11.0)	-31.0 (-53.0, -9.0)	-46.0 (-76.0, -15.0)	-87.0 (-130.0, -44.0)
Female	Falls	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 1.0)	1.0 (0.0, 2.0)	0.0 (-1.0, 1.0)	0.0 (-3.0, 4.0)	1.0 (-7.0, 8.0)	-3.0 (-16.0, 9.0)	-3.0 (-23.0, 17.0)	-41.0 (-79.0, -4.0)	-44.0 (-89.0, 2.0)
Both	Drownings	13.0 (8.0, 17.0)	14.0 (11.0, 17.0)	41.0 (36.0, 46.0)	26.0 (22.0, 31.0)	16.0 (12.0, 20.0)	13.0 (8.0, 19.0)	9.0 (4.0, 14.0)	7.0 (3.0, 11.0)	4.0 (1.0, 6.0)	1.0 (-1.0, 2.0)	143.0 (130.0, 157.0)
Male	Drownings	9.0 (6.0, 13.0)	10.0 (8.0, 13.0)	40.0 (35.0, 45.0)	25.0 (20.0, 29.0)	15.0 (11.0, 19.0)	12.0 (7.0, 17.0)	8.0 (4.0, 13.0)	6.0 (2.0, 9.0)	3.0 (1.0, 5.0)	0.0 (-1.0, 1.0)	128.0 (116.0, 141.0)
Female	Drownings	3.0 (1.0, 6.0)	3.0 (2.0, 5.0)	1.0 (0.0, 1.0)	2.0 (1.0, 3.0)	1.0 (0.0, 2.0)	2.0 (0.0, 3.0)	1.0 (-1.0, 3.0)	1.0 (0.0, 3.0)	1.0 (0.0, 2.0)	0.0 (0.0, 1.0)	15.0 (11.0, 19.0)
Both	Assault	4.0 (0.0, 8.0)	2.0 (0.0, 4.0)	46.0 (26.0, 67.0)	58.0 (37.0, 80.0)	25.0 (10.0, 40.0)	13.0 (2.0, 25.0)	11.0 (3.0, 20.0)	3.0 (-1.0, 8.0)	1.0 (-2.0, 3.0)	1.0 (0.0, 2.0)	165.0 (129.0, 201.0)
Male	Assault	1.0 (-2.0, 4.0)	1.0 (-1.0, 3.0)	38.0 (18.0, 58.0)	55.0 (35.0, 76.0)	18.0 (4.0, 32.0)	9.0 (-1.0, 19.0)	9.0 (1.0, 18.0)	2.0 (-2.0, 6.0)	1.0 (-1.0, 3.0)	0.0 (0.0, 1.0)	135.0 (100.0, 170.0)
Female	Assault	3.0 (0.0, 6.0)	1.0 (0.0, 2.0)	9.0 (3.0, 14.0)	2.0 (-4.0, 8.0)	7.0 (2.0, 12.0)	4.0 (0.0, 9.0)	2.0 (-2.0, 6.0)	1.0 (-1.0, 3.0)	0.0 (-1.0, 1.0)	1.0 (0.0, 2.0)	30.0 (18.0, 42.0)
Both	Intentional self-harm	0.0 (0.0, 0.0)	4.0 (0.0, 8.0)	28.0 (8.0, 47.0)	53.0 (30.0, 76.0)	57.0 (35.0, 80.0)	45.0 (18.0, 72.0)	69.0 (40.0, 97.0)	35.0 (16.0, 53.0)	14.0 (1.0, 26.0)	10.0 (2.0, 19.0)	315.0 (256.0, 375.0)
Male	Intentional self-harm	0.0 (0.0, 0.0)	1.0 (-2.0, 5.0)	20.0 (3.0, 38.0)	41.0 (20.0, 62.0)	47.0 (28.0, 67.0)	36.0 (12.0, 60.0)	58.0 (34.0, 84.0)	26.0 (9.0, 43.0)	14.0 (2.0, 26.0)	9.0 (1.0, 18.0)	253.0 (200.0, 306.0)
Female	Intentional self-harm	0.0 (0.0, 0.0)	3.0 (0.0, 5.0)	7.0 (-1.0, 16.0)	12.0 (2.0, 22.0)	11.0 (0.0, 21.0)	9.0 (-4.0, 22.0)	11.0 (-3.0, 25.0)	9.0 (1.0, 17.0)	0.0 (-4.0, 4.0)	1.0 (-1.0, 3.0)	62.0 (35.0, 89.0)

Model comparison

Model: Overview

- 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:

$$\text{Deaths}_{[m,s,t]} \sim \text{Poisson}(\text{Population}_{[m,s,t]}.\text{Death rates}_{[m,s,t]})$$

- $\text{Death rates}_{[m,s,t]}$ modelled via log-link function:

$$\begin{aligned}\log(\text{Death rates}_{[m,s,t]}) =& (\alpha_0 + \beta_0.t) \\ &+(\alpha_m + \beta_m.t) \\ &+(\alpha_s + \beta_s.t) \\ &+\gamma_m.\text{Anomaly}_{m,s,t} \\ &+\xi_{m,s} \\ &+\pi_t+ \\ &+\epsilon_{m,s,t}\end{aligned}$$

where:
α = intercepts, β = time-slopes, γ = temperature effects,
ξ = state-month interaction, π = random walk over time,
ϵ = overdispersion.
Anomaly = Temperature anomaly term (see Fig. 3)

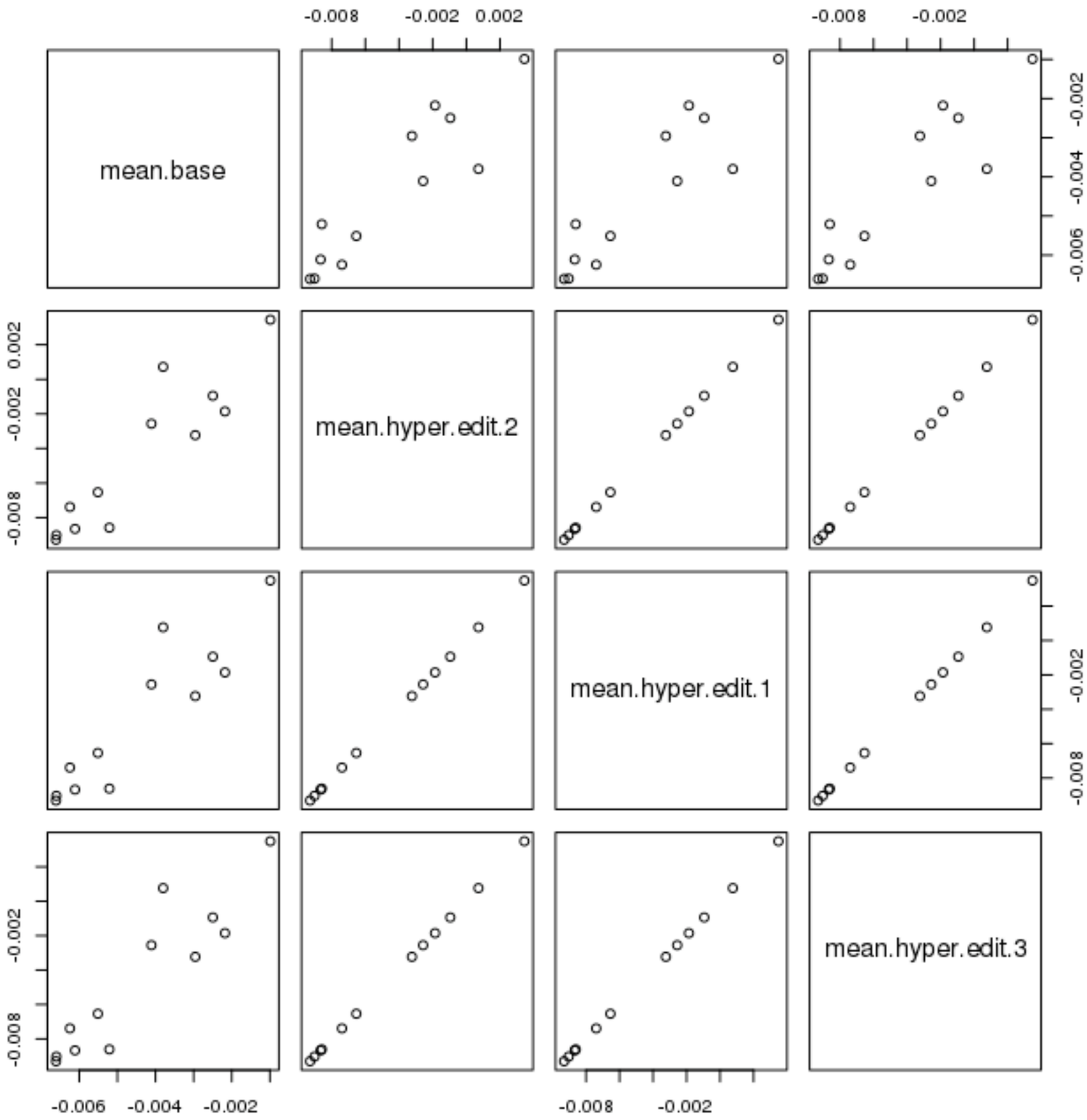
Global Environmental Health

Models

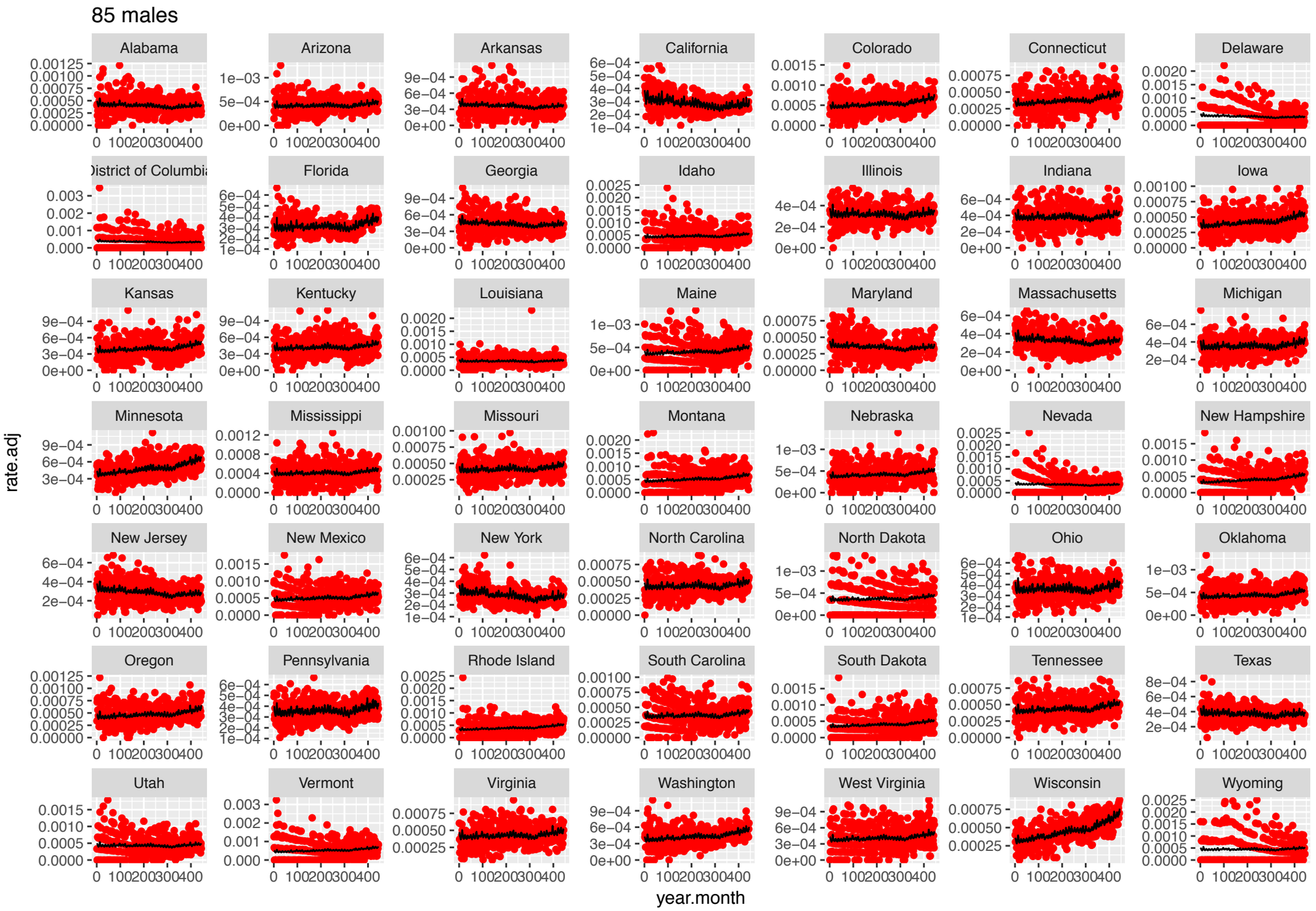
Fix this

Model	Global Intercept	Global Slope	Month-specific intercept	Month-specific slope	State-specific intercept	State-specific slope	State-month specific intercept	State-month specific slope	Mon specific ANOMALY	RW1 over time	Overdispersion
Base	Y	Y	Cyclic RW1	Cyclic RW1	Besag	Besag	Cyclic RW1 (Besag)	Cyclic RW1 (Besag)	Cyclic RW1	National	Y
Hyper edit 1	Y	Y	Cyclic RW1 (hyper edit)	Cyclic RW1 (hyper edit)	Besag (hyper edit)	Besag (hyper edit)	Cyclic RW1 (hyper edit only RW1)	Cyclic RW1 (hyper edit only RW1)	Cyclic RW1	National	Y
Hyper edit 2	Y	Y	Cyclic RW1 (hyper edit)	Cyclic RW1 (hyper edit)	Besag (hyper edit)	Besag (hyper edit)	Cyclic RW1 (hyper edits fixed=FALSE)	Cyclic RW1 (hyper edits fixed=FALSE)	Cyclic RW1	National	Y
Hyper edit 3	Y	Y	Cyclic RW1 (hyper edit)	Cyclic RW1 (hyper edit)	Besag (hyper edit)	Besag (hyper edit)	Cyclic RW1 (hyper edits fixed=TRUE)	Cyclic RW1 (hyper edits fixed=TRUE)	Cyclic RW1	National	Y
Simple 1	Y	Y			IID	IID				National	Y
Simple 2	Y	Y			IID	IID				State-specific	Y

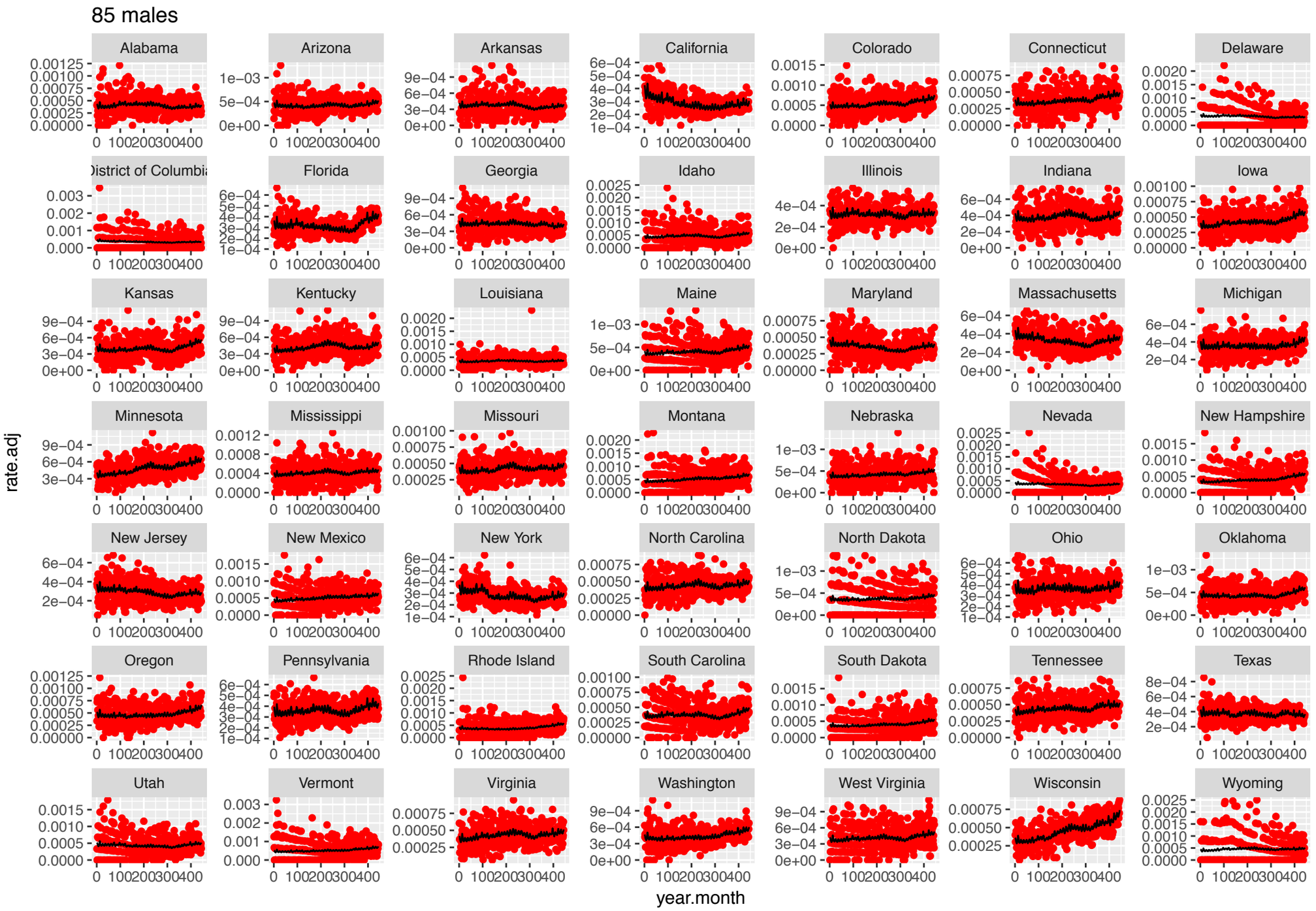
How does changing priors affect anomaly term?



How does having a state-specific RW1 over time affect fit? National RW1 over time



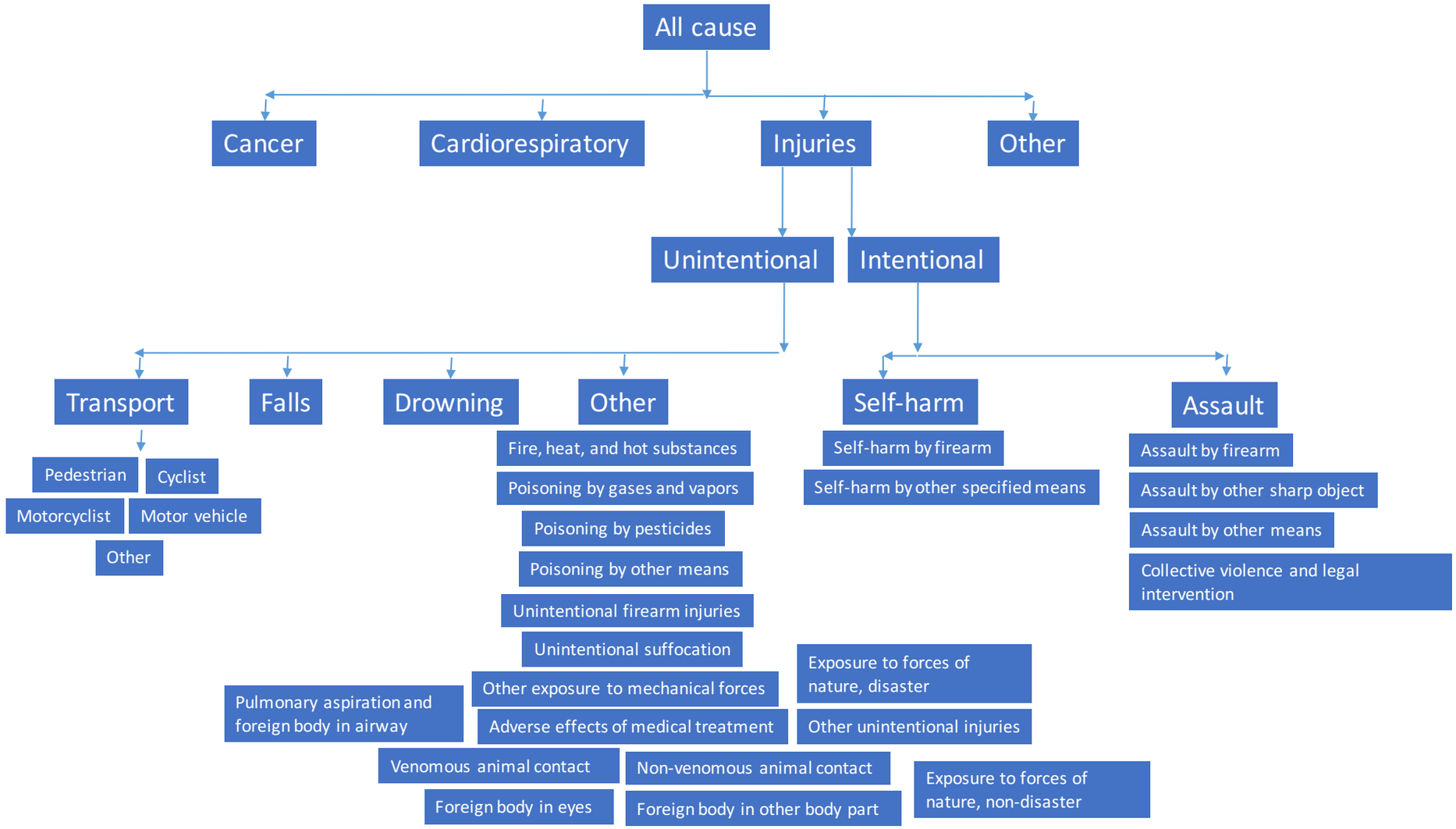
How does having a state-specific RW1 over time affect fit? State RW1 over time



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:

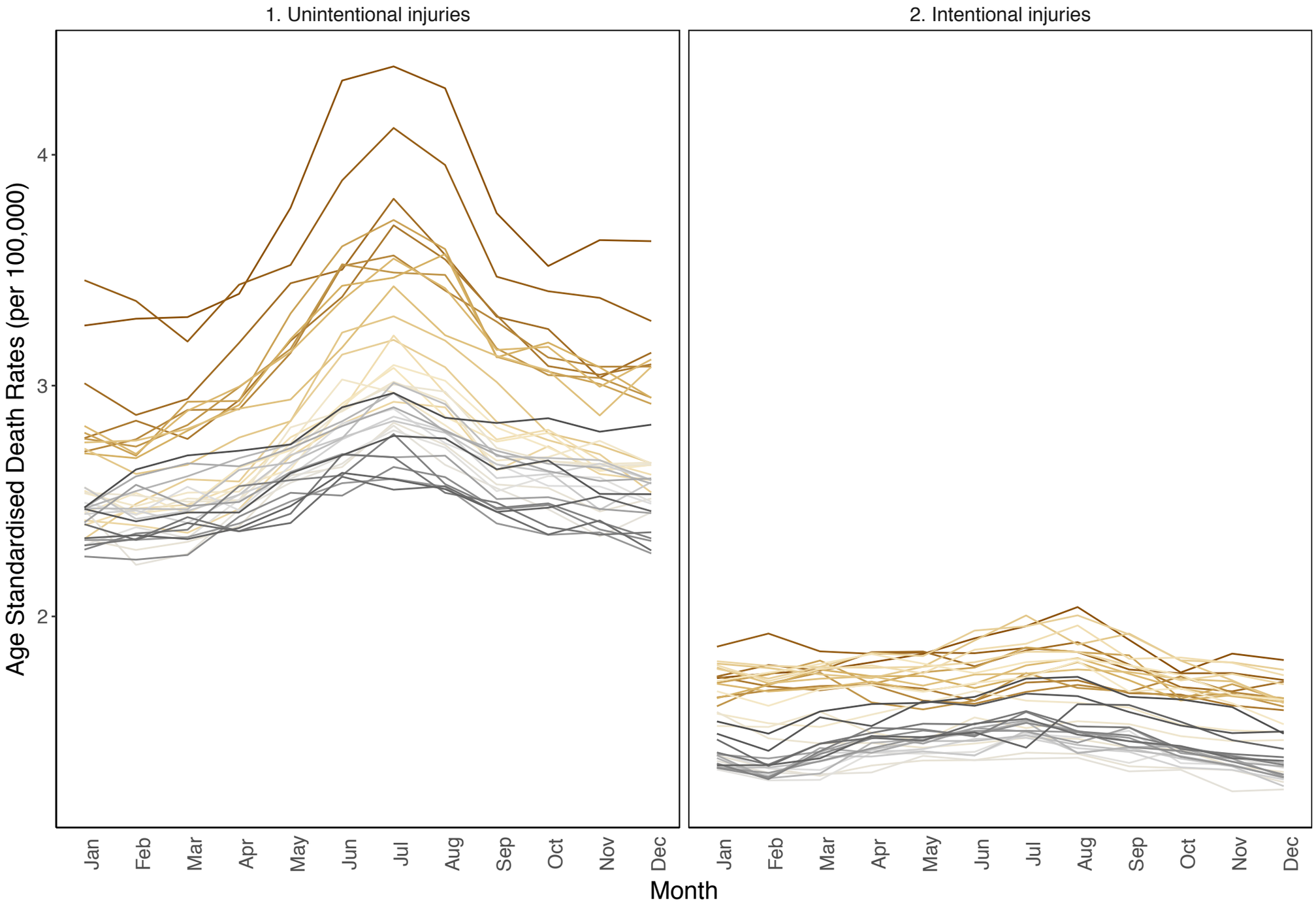
Cause			Male	Female	Total
Unintentional			2,470,093	1,340,723	**3,810,816**
	Transport		1,186,839	498,661	1,685,500
	Falls		337,946	322,662	660,608
	Drowning		112,023	29,246	141,269
	Other		833,285	490,154	1,323,439
Intentional			1,536,361	417,138	**1,953,499**
	Assault		582,220	162,517	744,737
	Intentional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

Mortality data: Overview

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

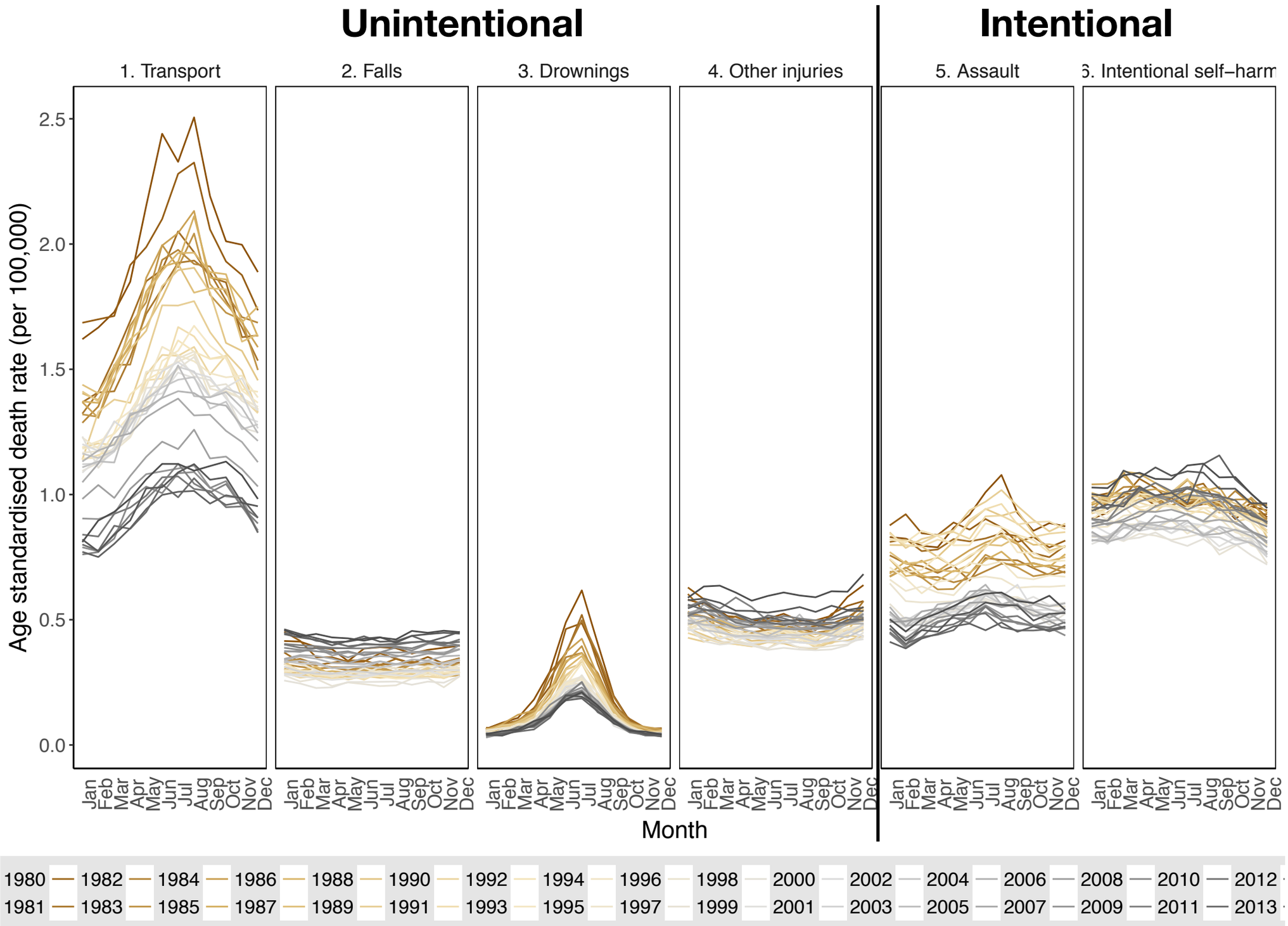
Age	Male						Female					
	Transport	Falls	Drowning	Intentional self-harm	Assault	Other	Transport	Falls	Drowning	Intentional self-harm	Assault	Other
0-4	18973	1813	13801	0	13795	35806	15104	1030	7343	0	11106	24914
5-14	42118	1305	10991	7398	8821	20905	25546	478	3454	2803	5772	10087
15-24	311828	8616	25936	142475	178936	80019	112795	1345	2706	28131	32994	21523
25-34	237642	12297	18055	176812	168154	132277	73841	2044	2664	41543	39082	43518
35-44	171656	17008	13314	169713	99288	142988	62711	3864	2670	52059	29208	60060
45-54	140108	25856	10600	156675	56578	124209	53456	7973	2638	53932	17457	66192
55-64	105468	34437	8043	120020	29419	91568	45715	14507	2316	38080	9937	50117
65-74	75798	48758	5753	88162	14215	75322	46215	32617	2124	21288	7354	49378
75-84	60405	90627	3988	68400	6488	78378	45617	92585	2196	12353	5978	73642
85+	22843	97229	1542	24486	1829	56510	17661	166219	1135	4432	2565	91787

Mortality data: National monthly Age Standardised Death Rates (ASDRs)



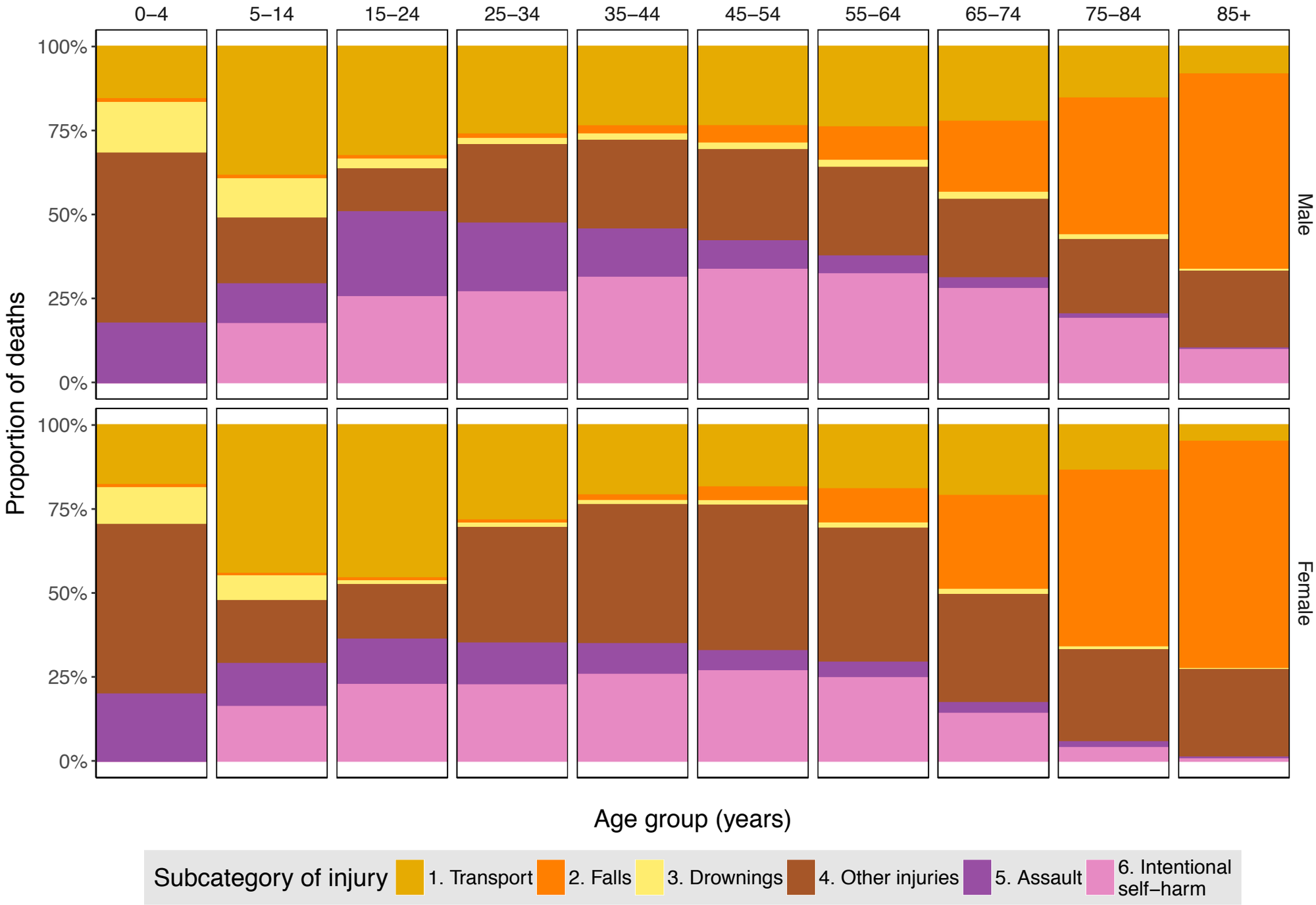
Global Environmental Health

Mortality data: National monthly Age Standardised Death Rates (ASDRs)



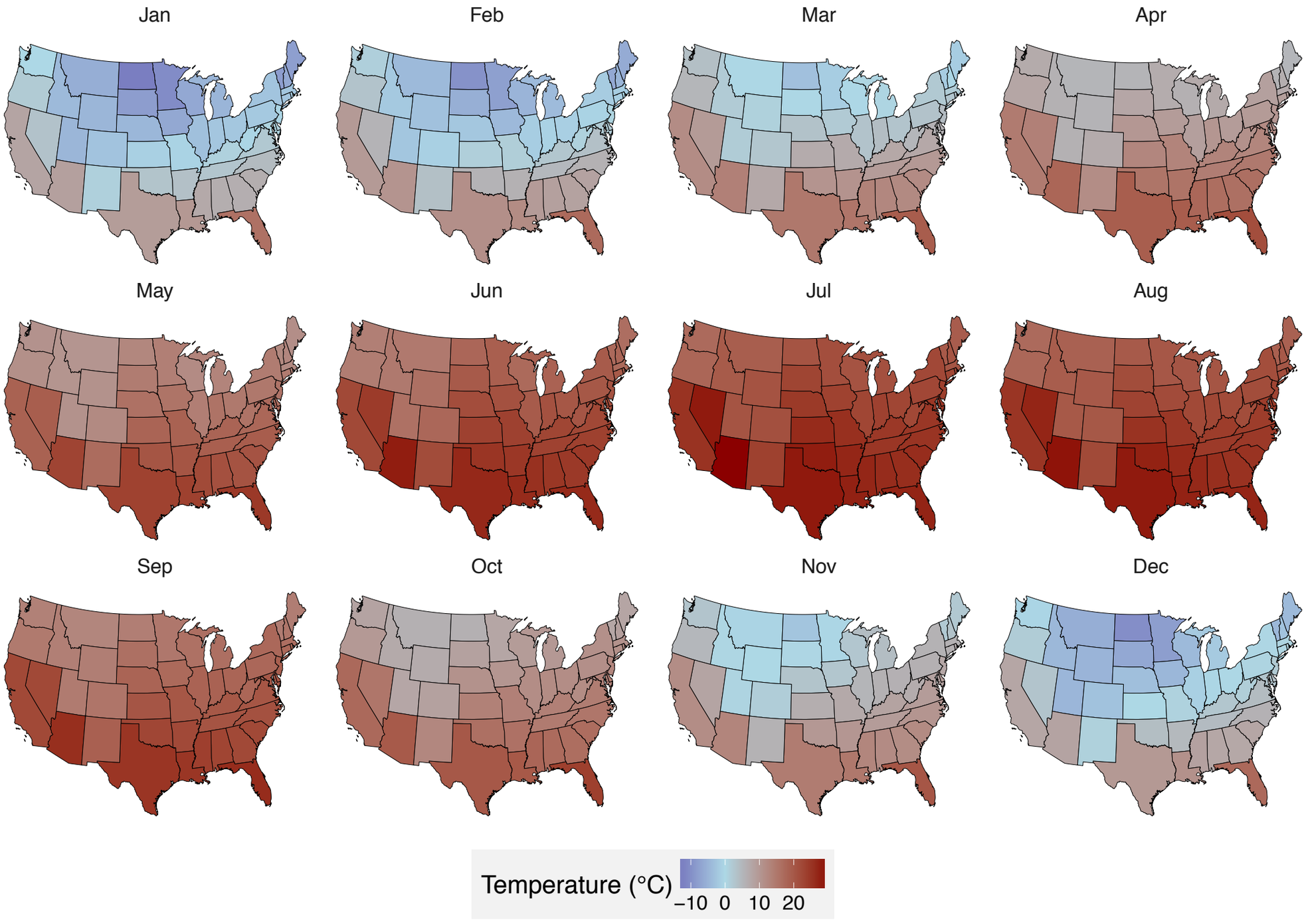
Global Environmental Health

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



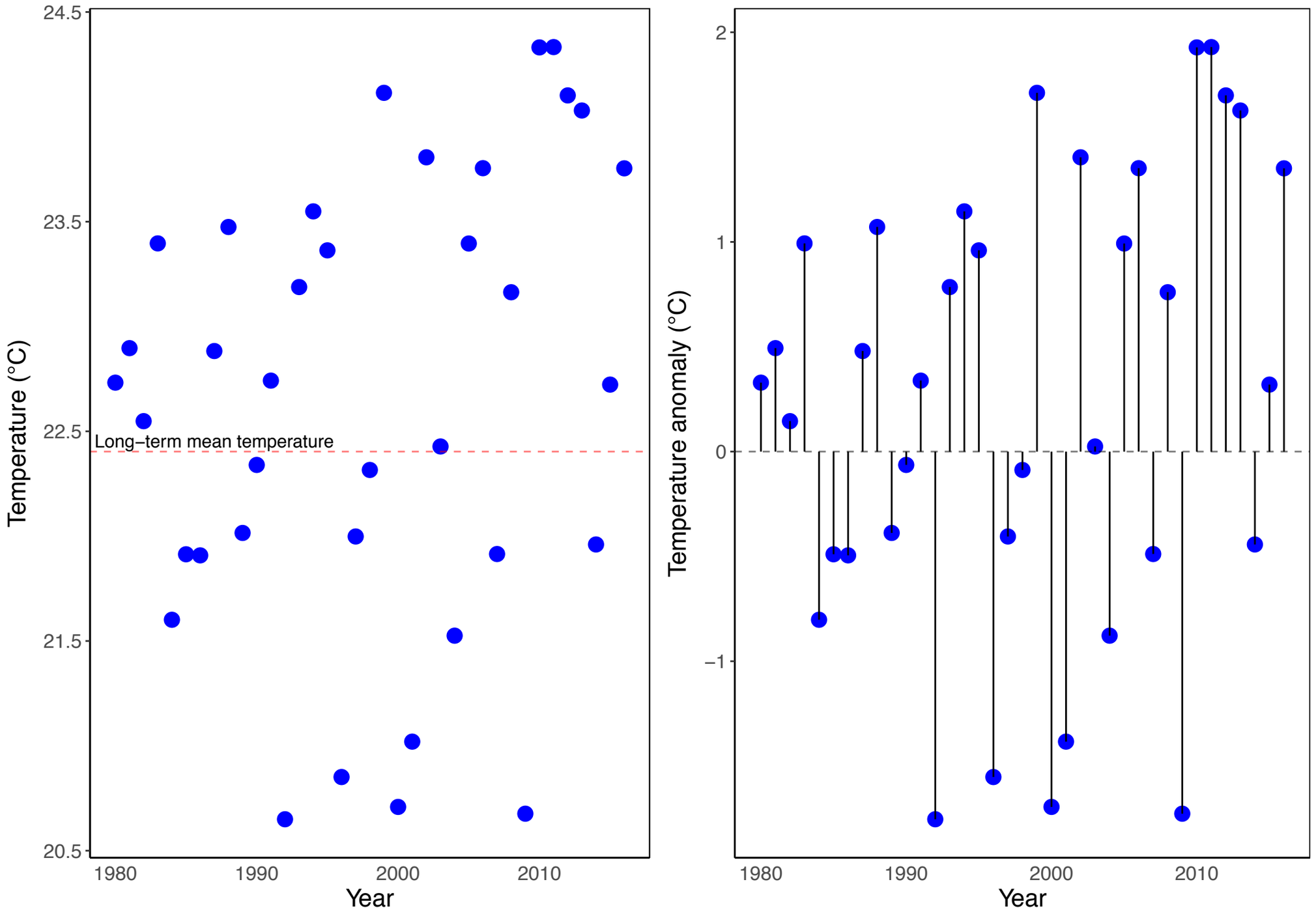
Global Environmental Health

Temperature data: 30-year normals (1980-2009)



Global Environmental Health

Temperature data: Schematic of change from long-term average



Global Environmental Health

Model: Overview

- 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:

$$\text{Deaths}_{[m,s,t]} \sim \text{Poisson}(\text{Population}_{[m,s,t]}.\text{Death rates}_{[m,s,t]})$$

- $\text{Death rates}_{[m,s,t]}$ modelled via log-link function:

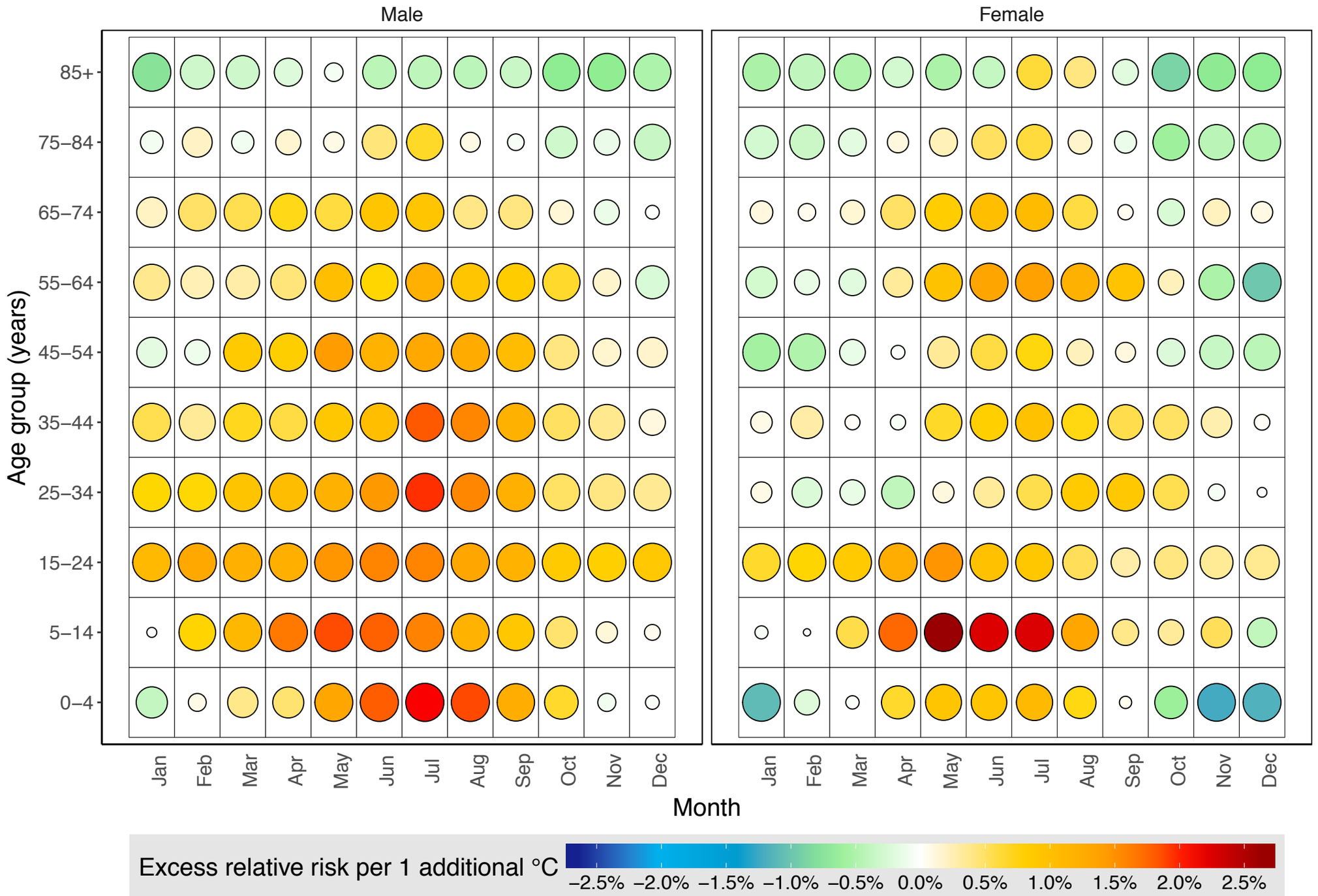
$$\begin{aligned}\log(\text{Death rates}_{[m,s,t]}) =& (\alpha_0 + \beta_0.t) \\ &+(\alpha_m + \beta_m.t) \\ &+(\alpha_s + \beta_s.t) \\ &+\gamma_m.\text{Anomaly}_{m,s,t} \\ &+\xi_{m,s} \\ &+\pi_t+ \\ &+\epsilon_{m,s,t}\end{aligned}$$

where:
α = intercepts, β = time-slopes, γ = temperature effects,
ξ = state-month interaction, π = random walk over time,
ϵ = overdispersion.
Anomaly = Temperature anomaly term (see Fig. 3)

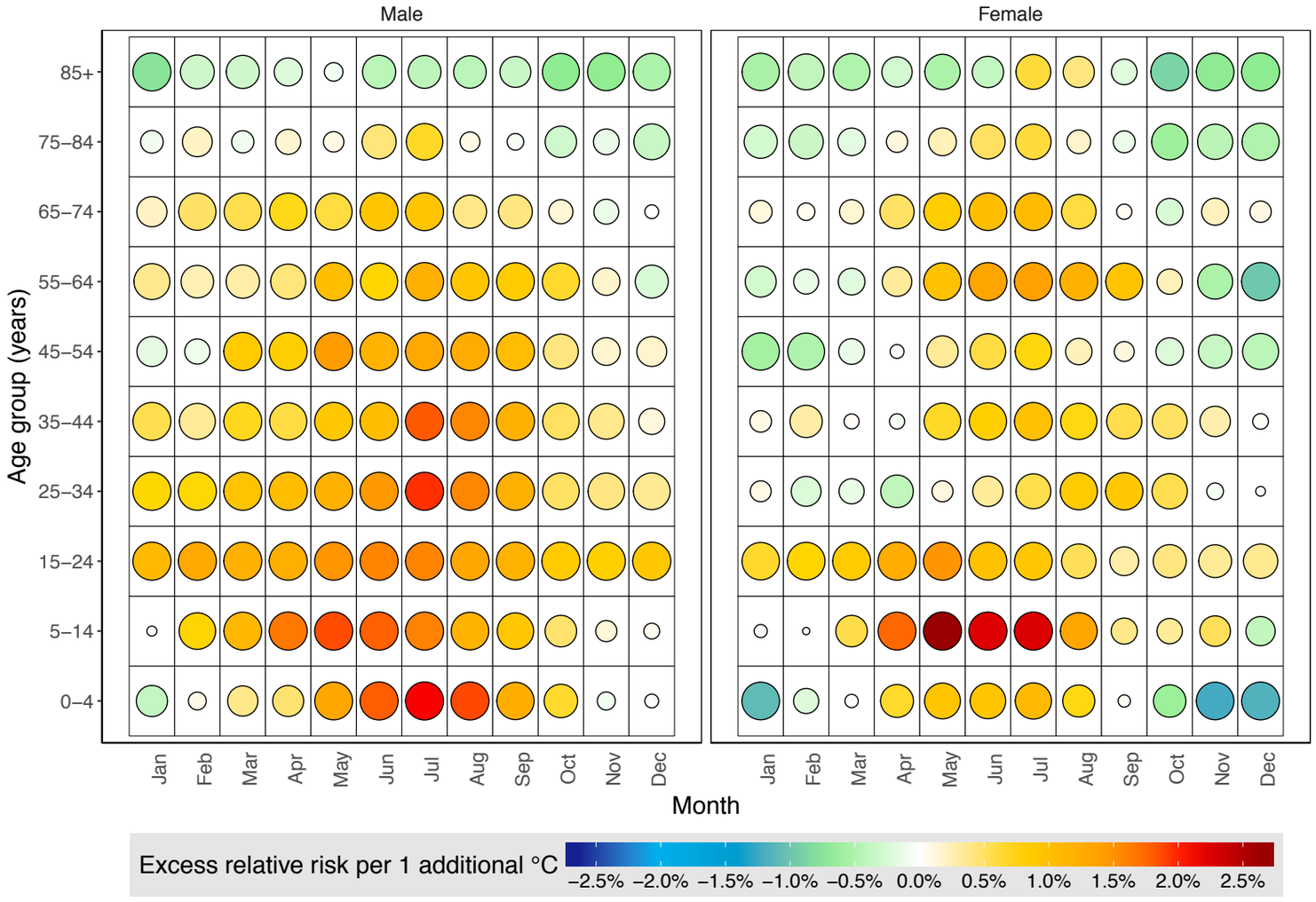
Global Environmental Health

Risk figures

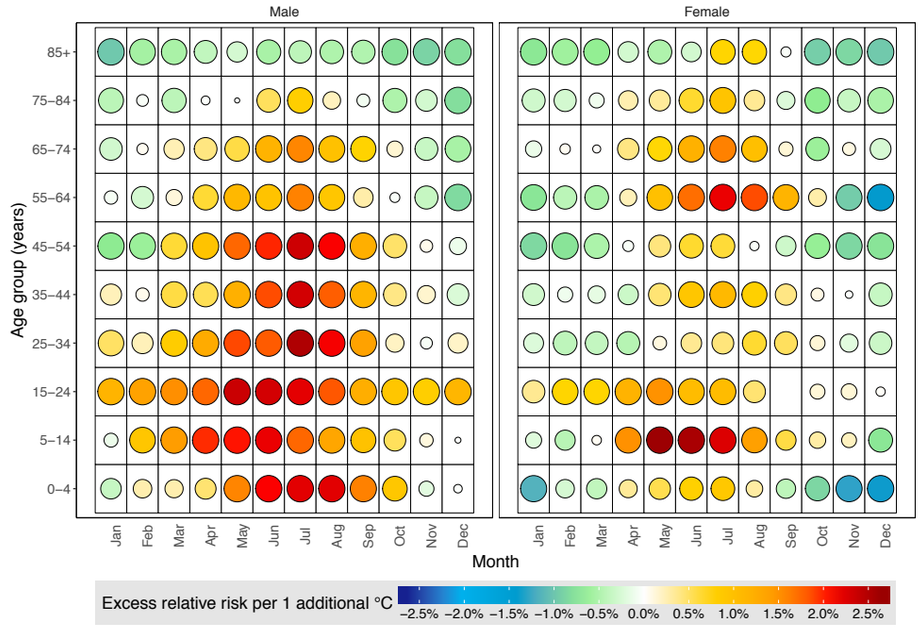
Injury excess risk (2-metre temperature)



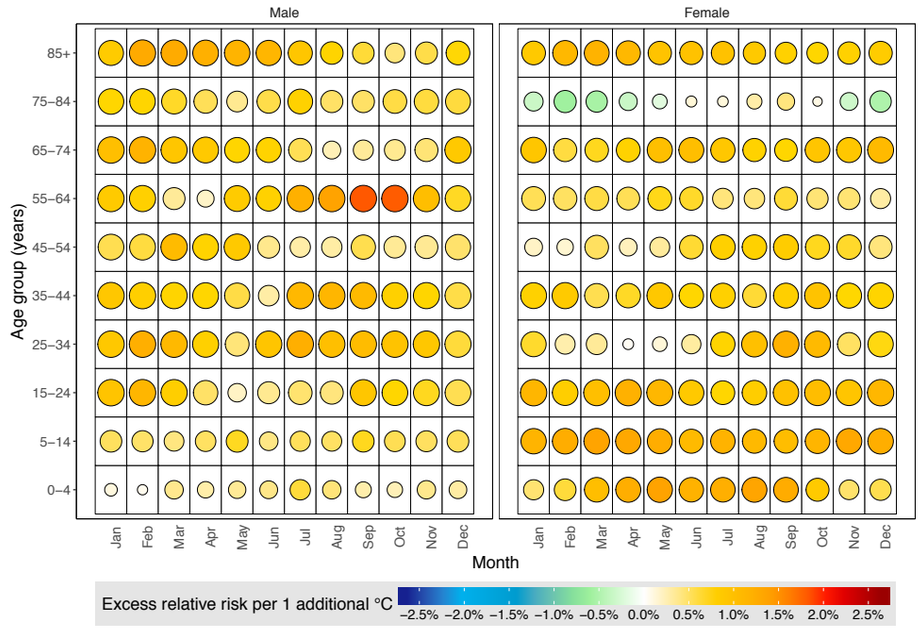
Injury excess risk (2-metre temperature)



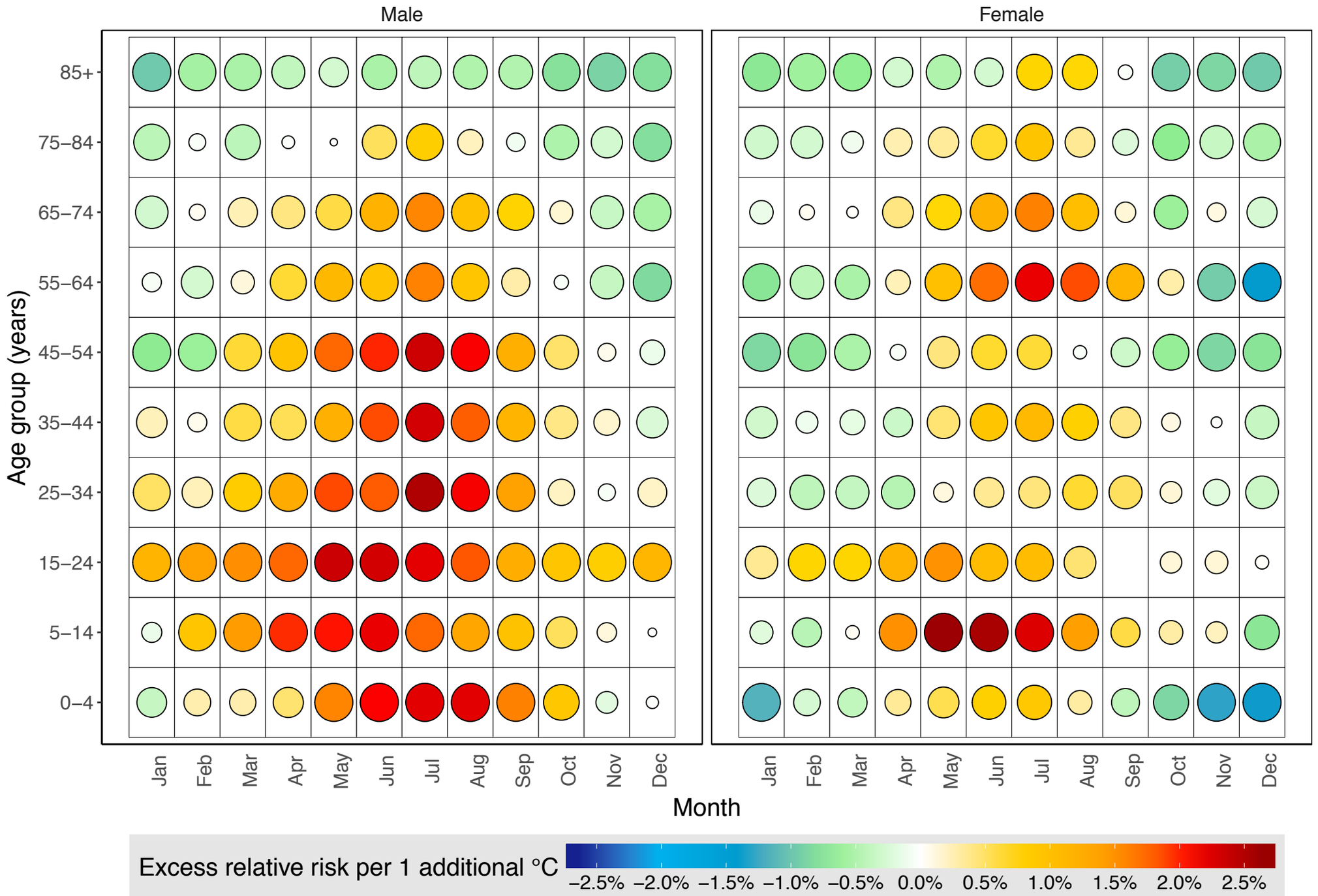
=



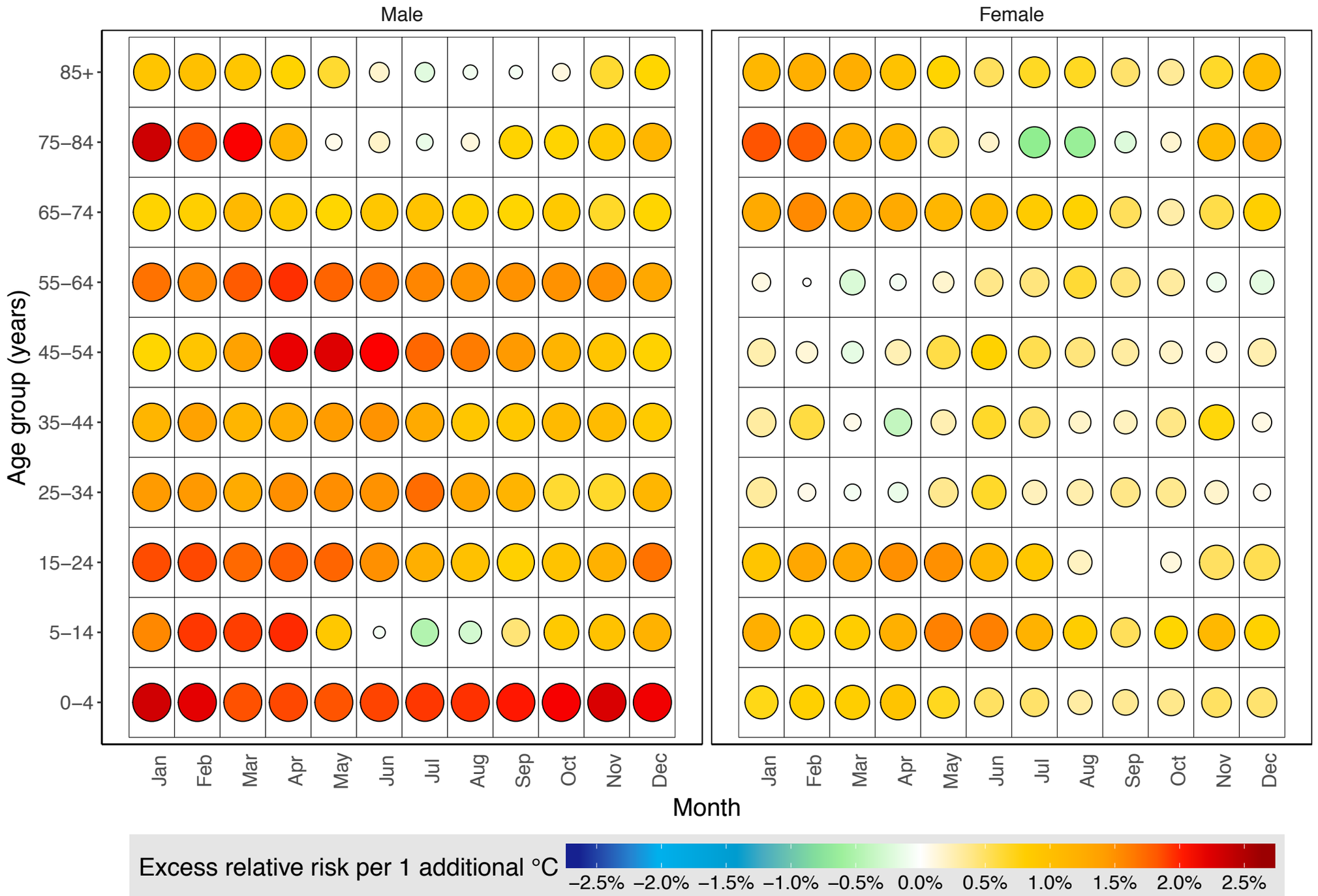
+



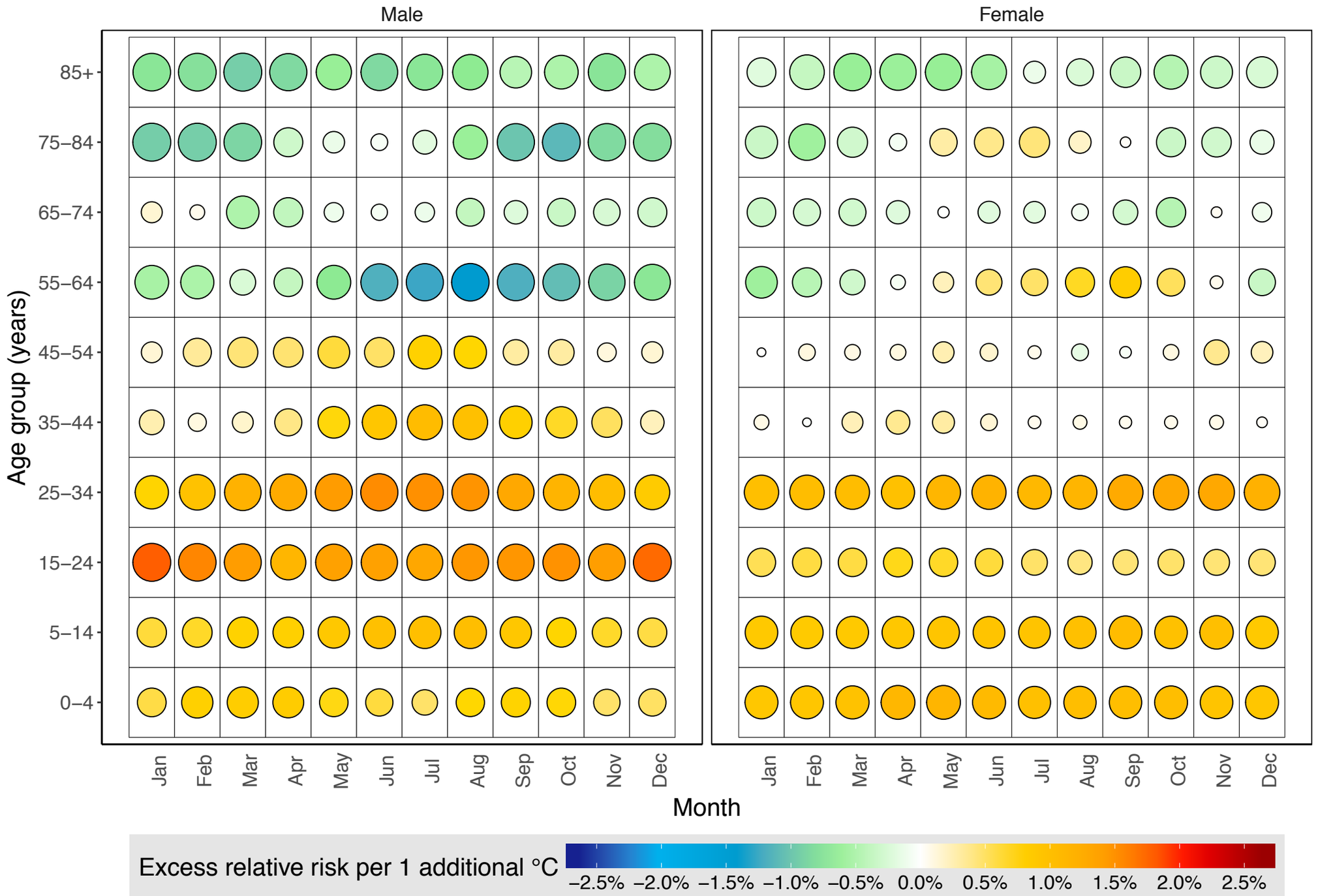
Unintentional injuries excess risk (2-metre temperature)



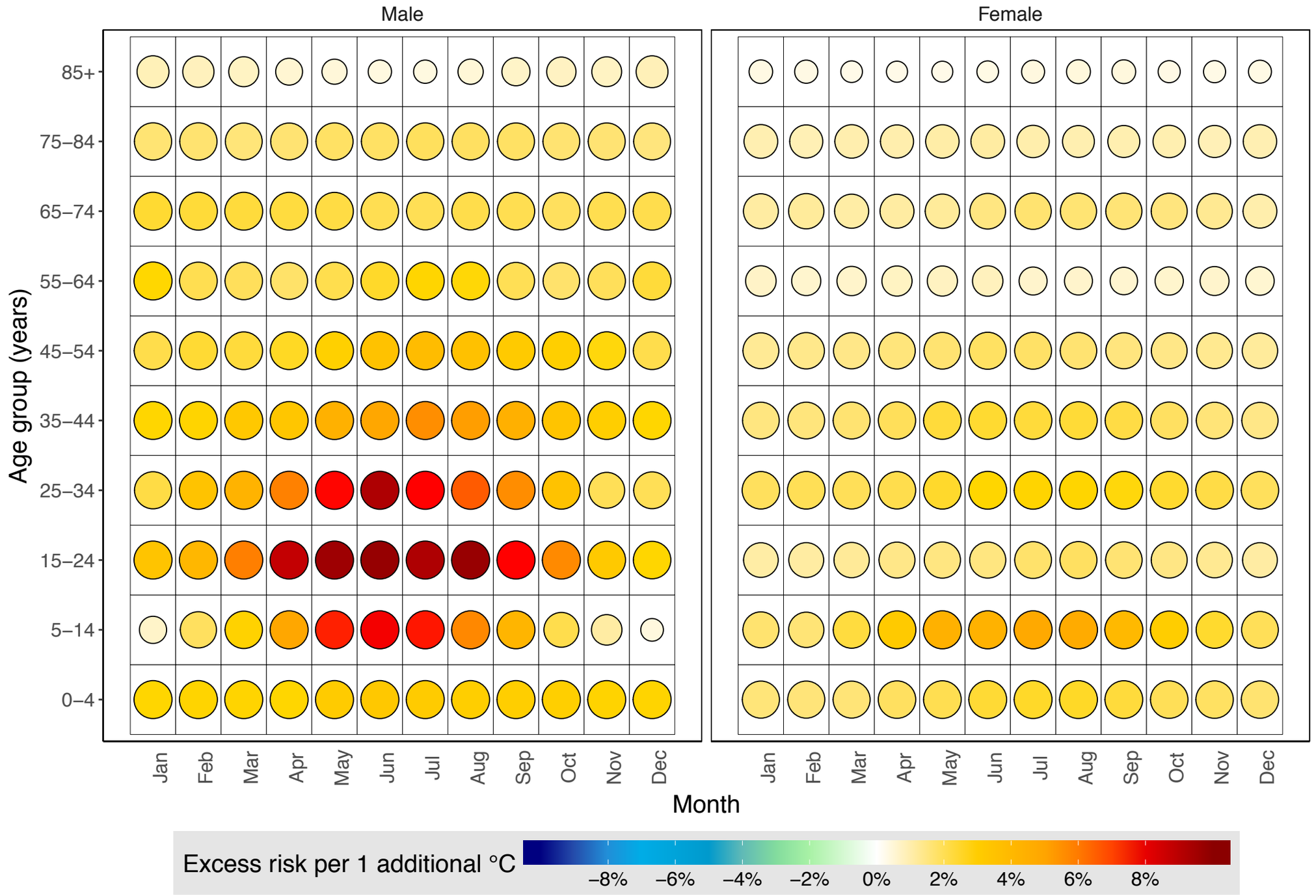
Transport (2-metre temperature)



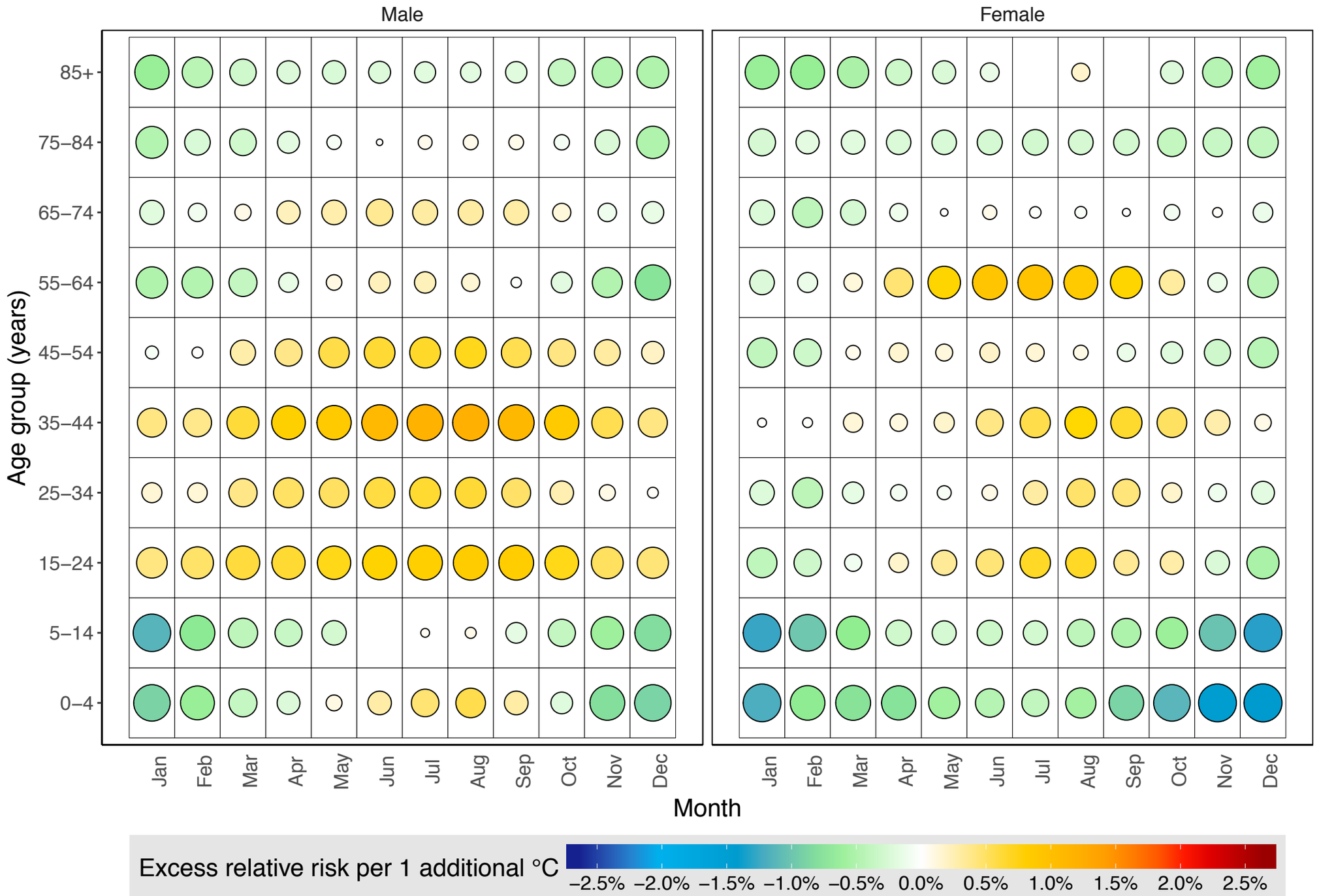
Falls (2-metre temperature)



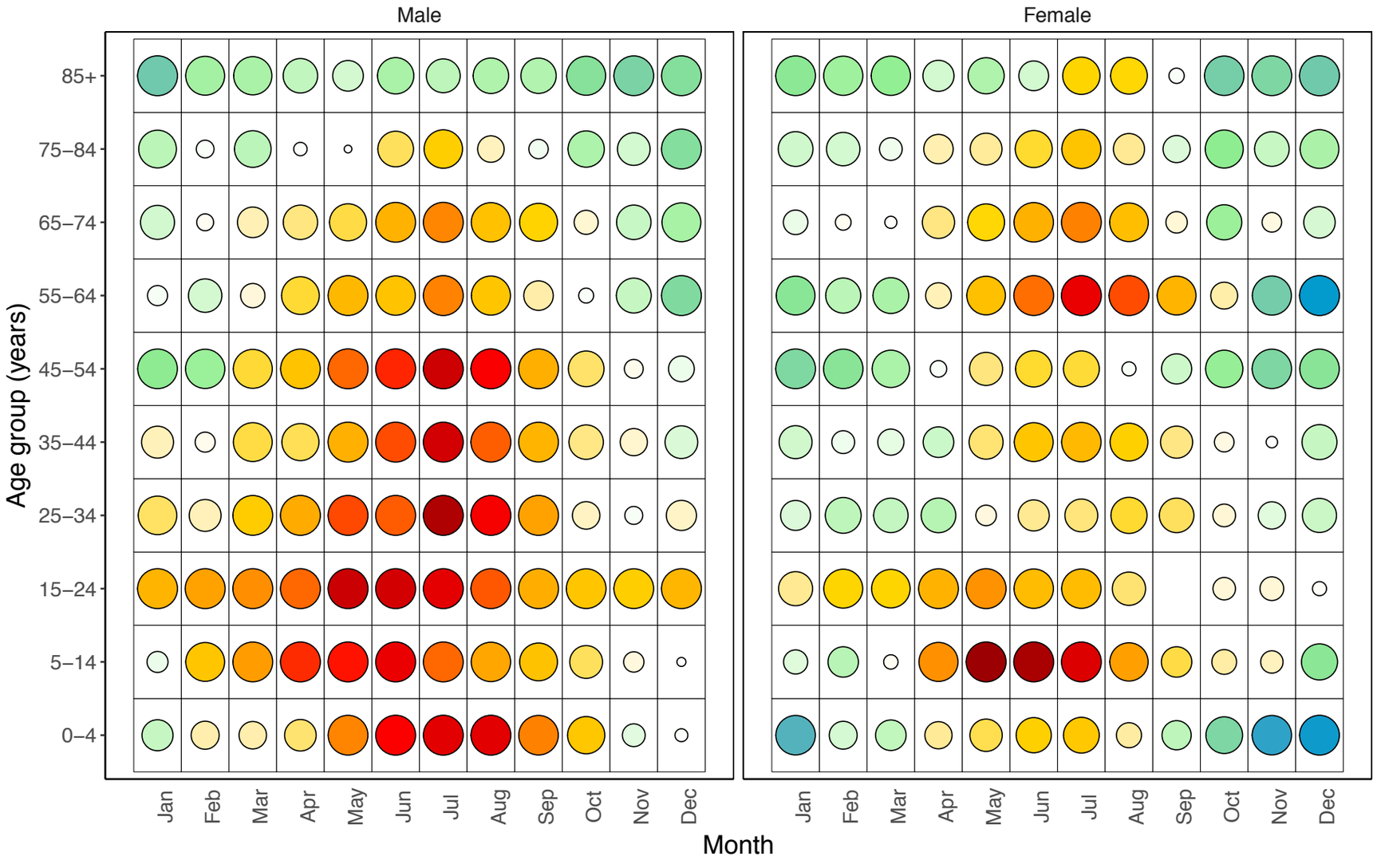
Drownings (2-metre temperature)



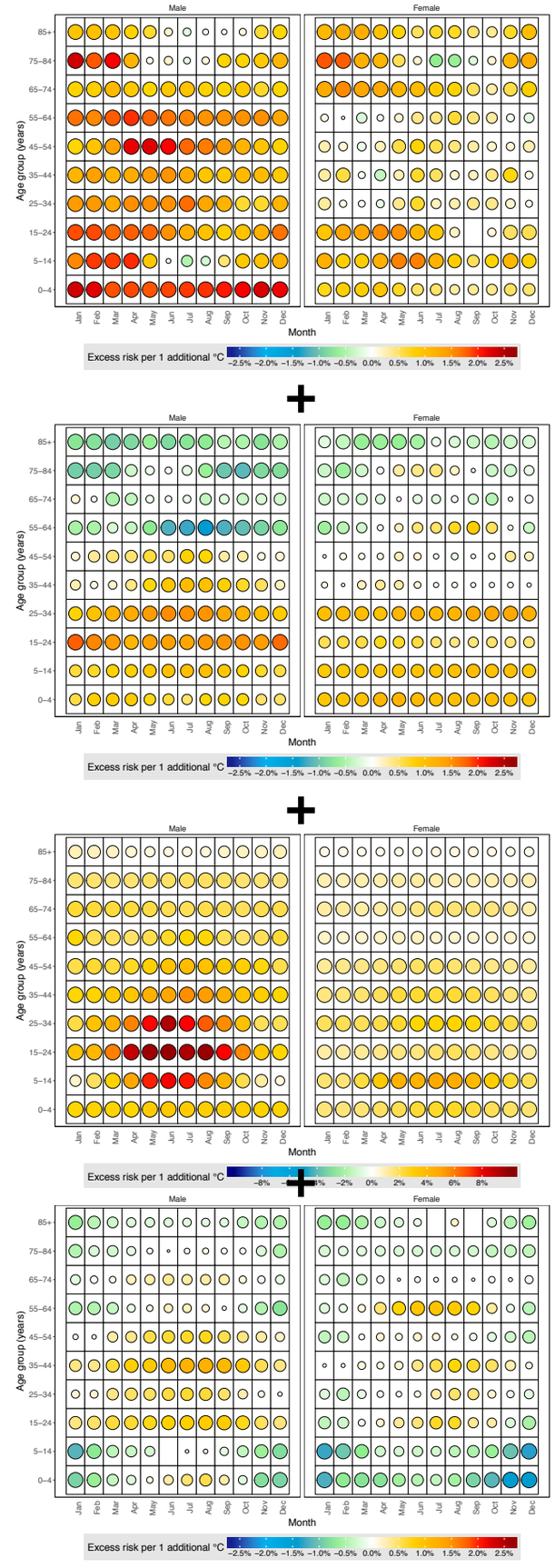
Other unintentional injuries (2-metre temperature)



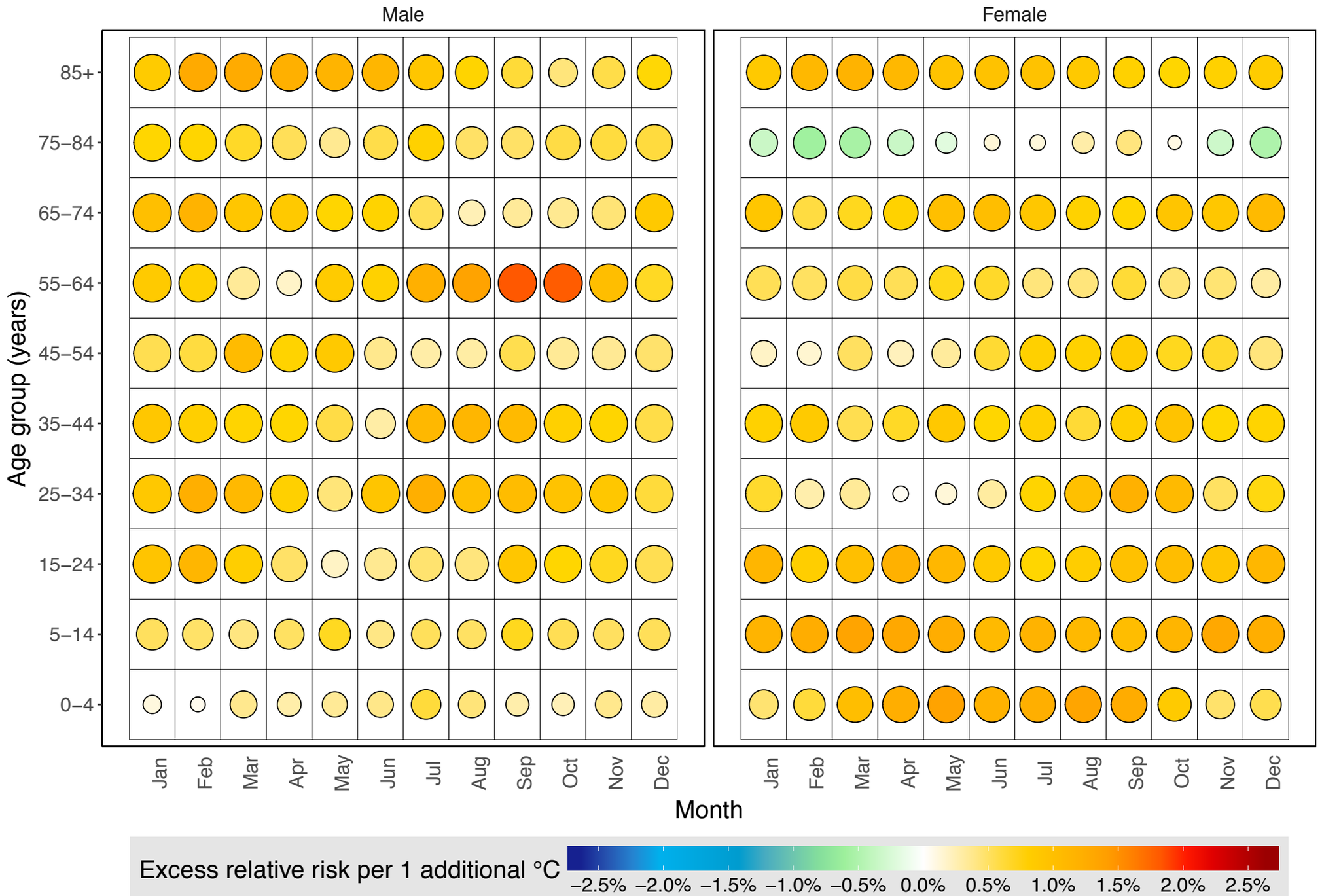
Unintentional injury excess risk (2-metre temperature)



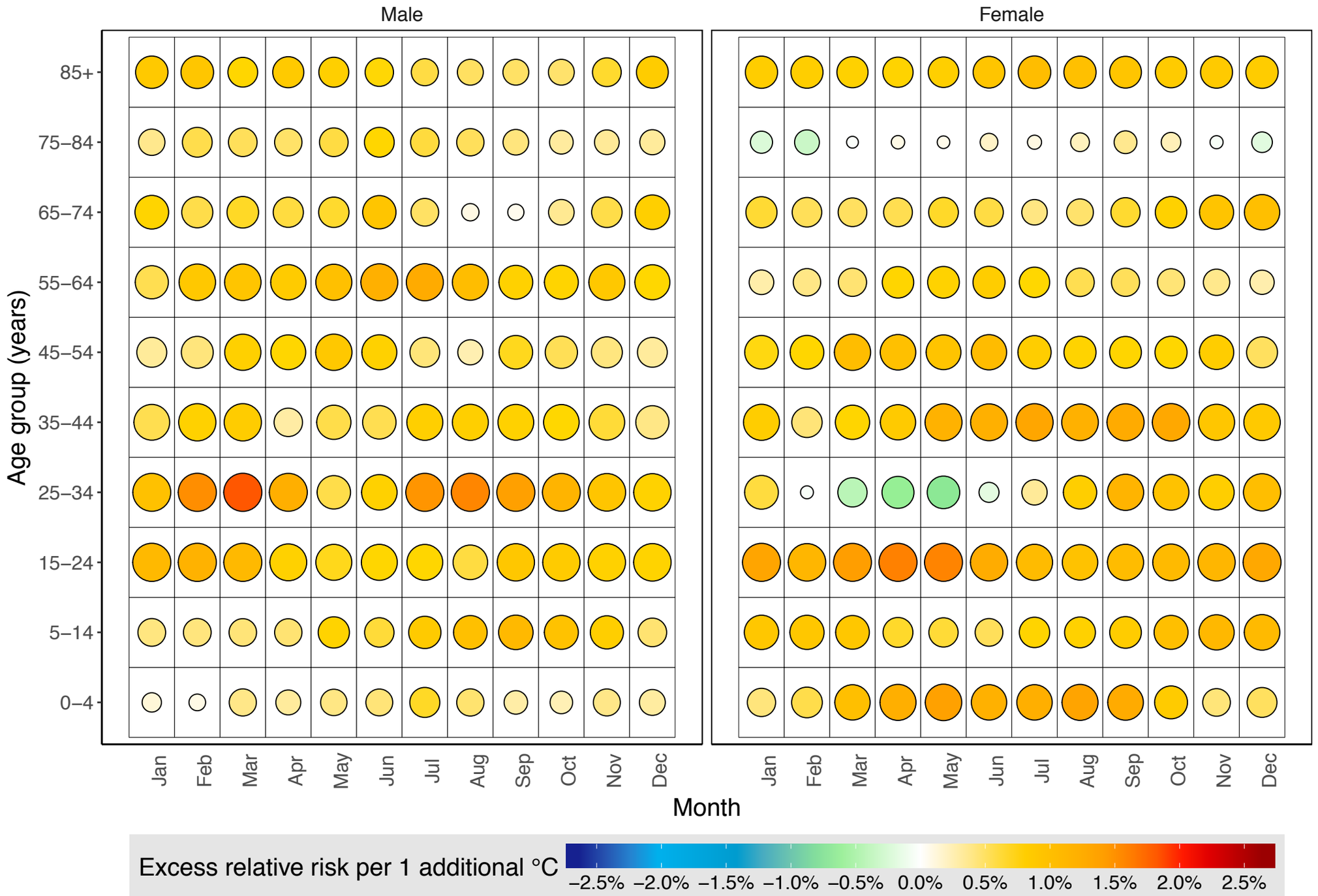
=



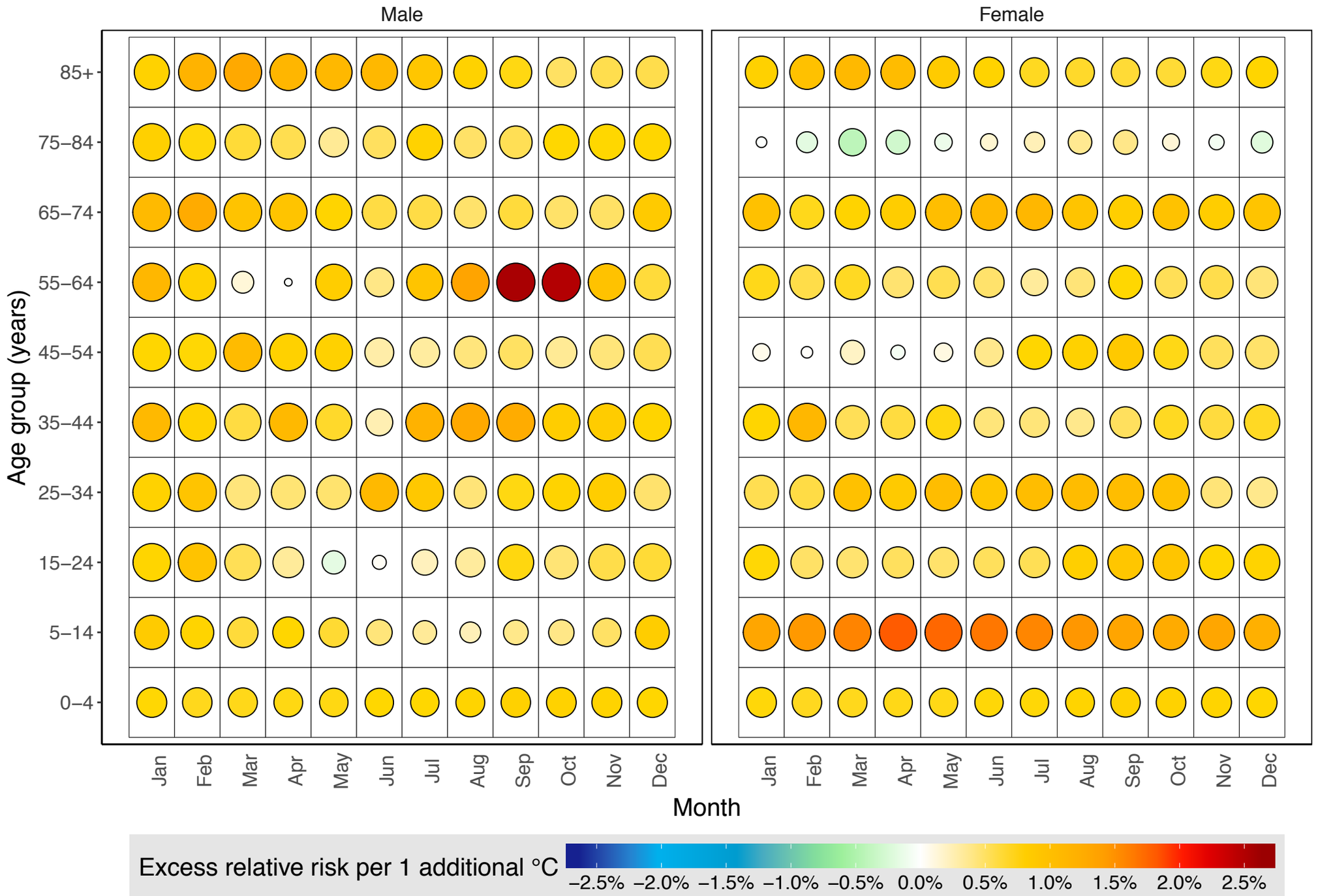
Intentional injury excess risk (2-metre temperature)



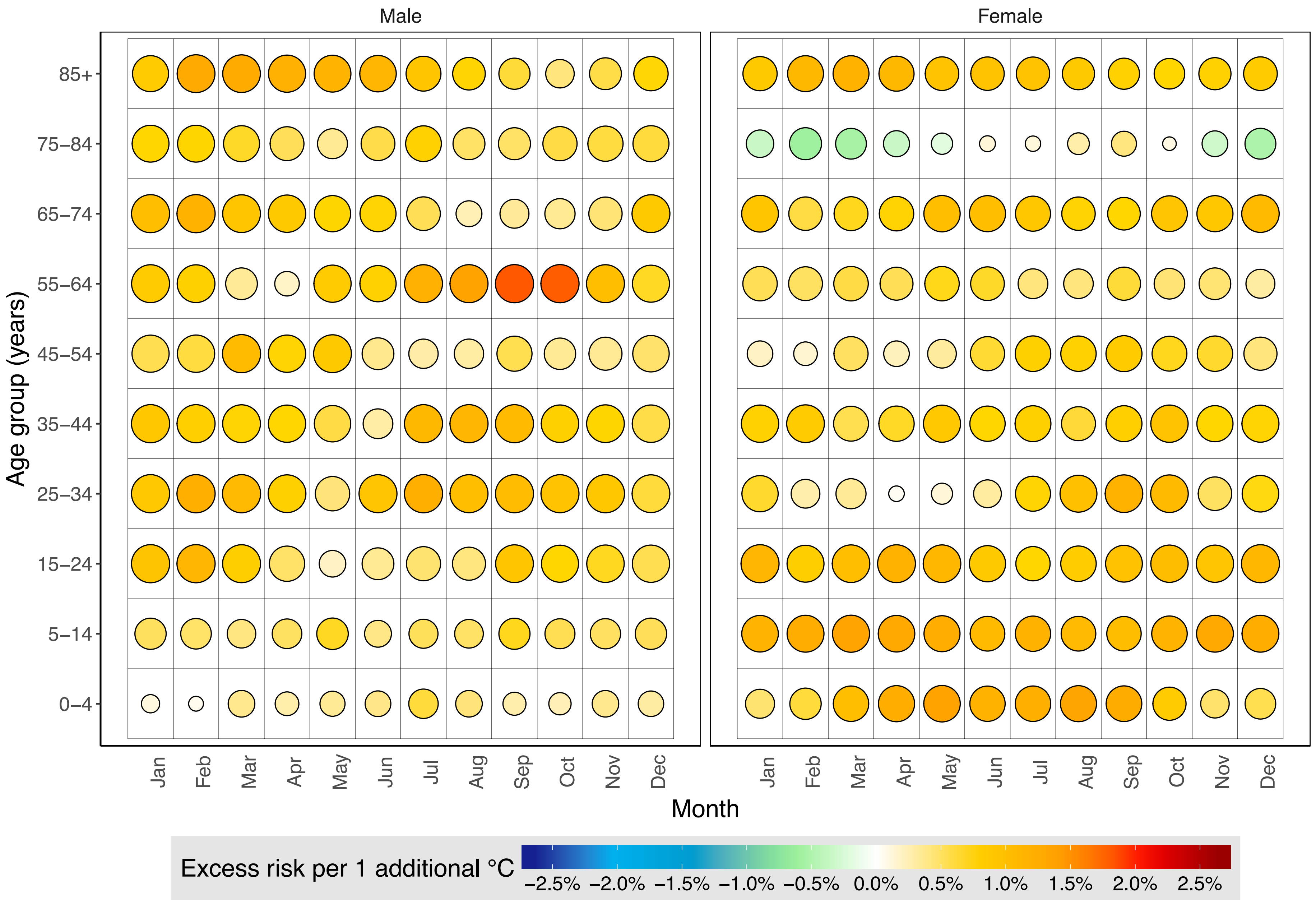
Assault injury excess risk (2-metre temperature)

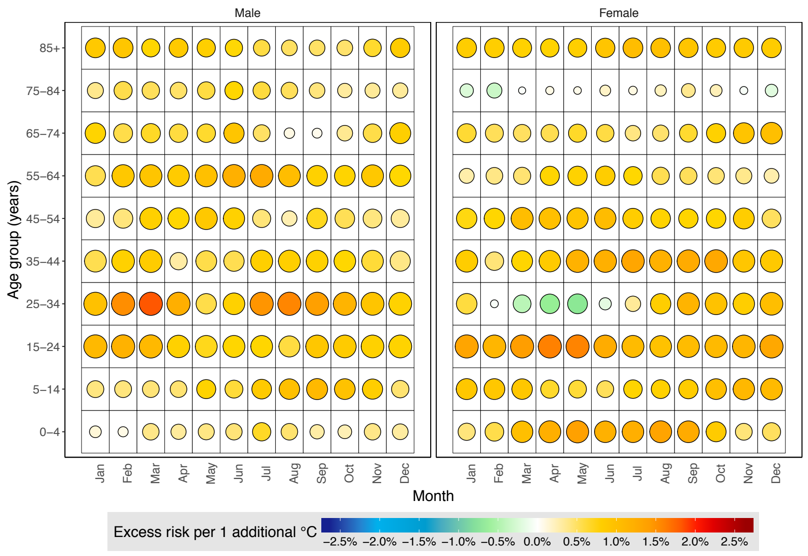


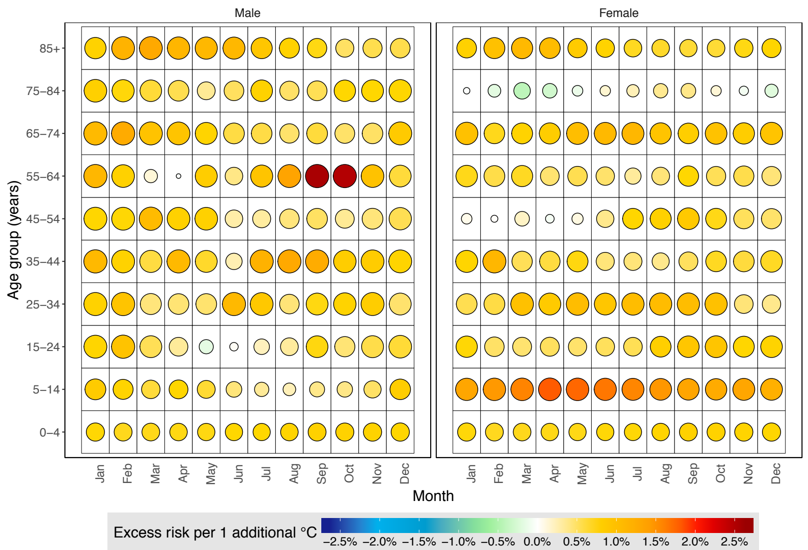
Intentional self-harm injury excess risk (2-metre temperature)



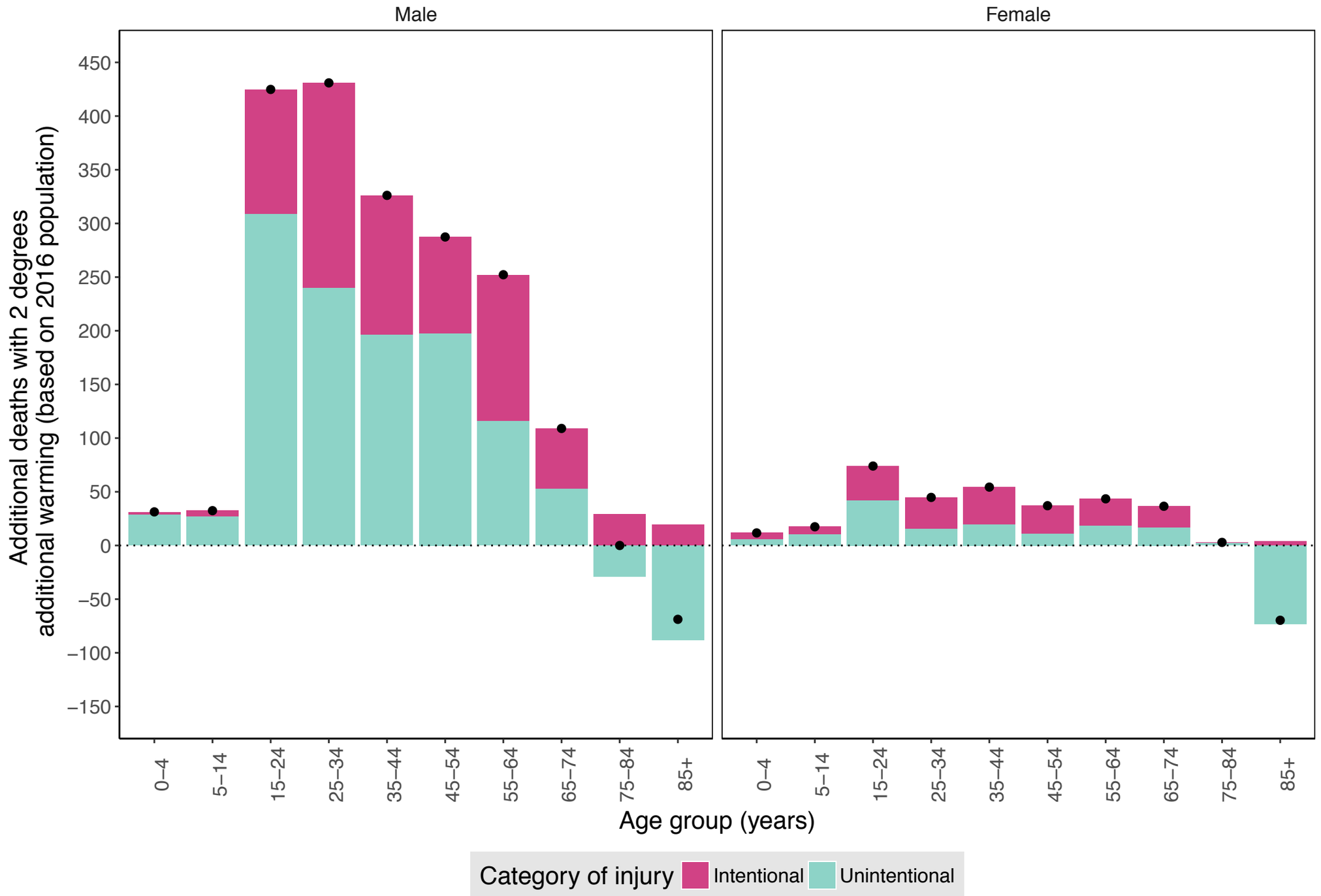
Unintentional injury excess risk (2-metre temperature)



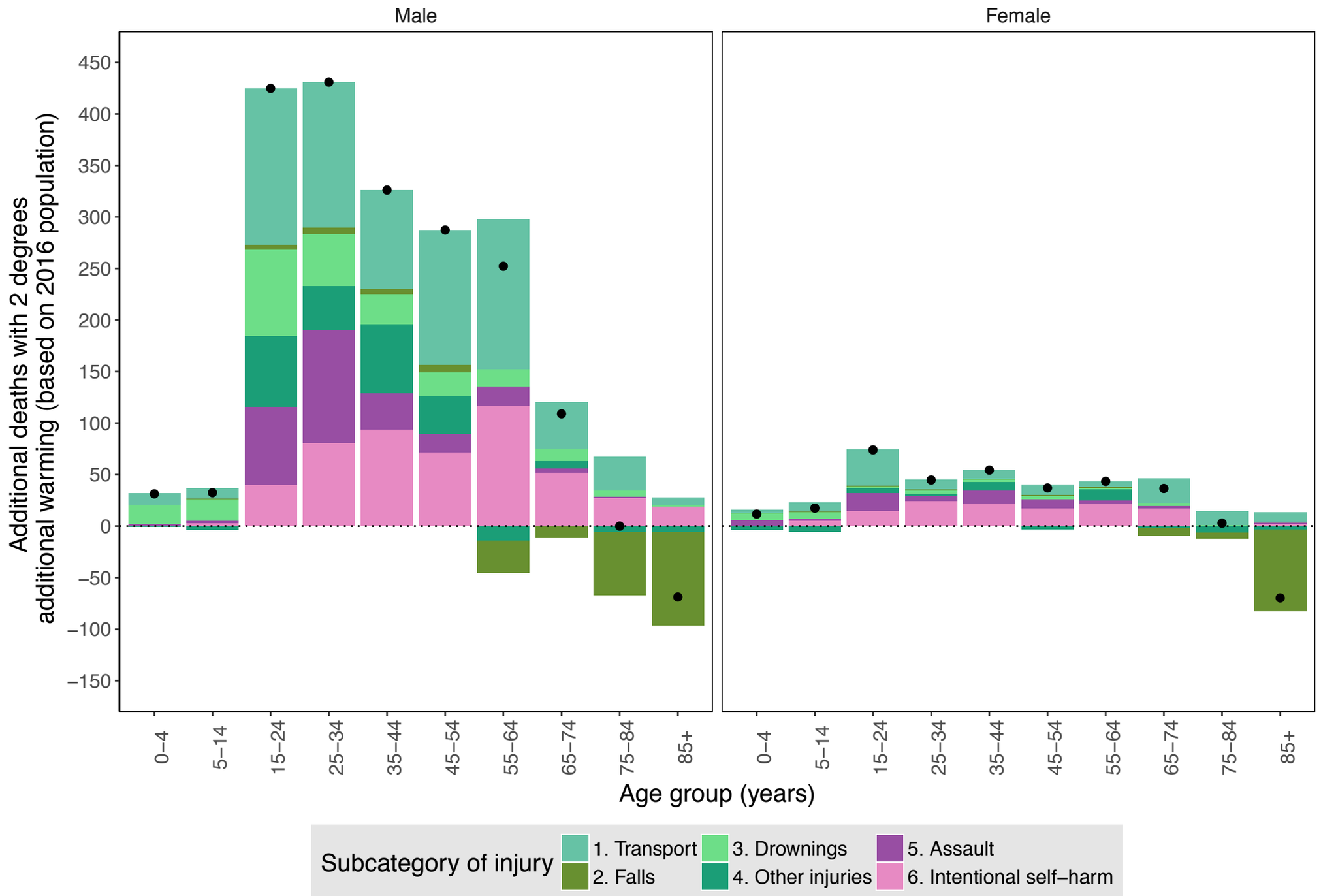




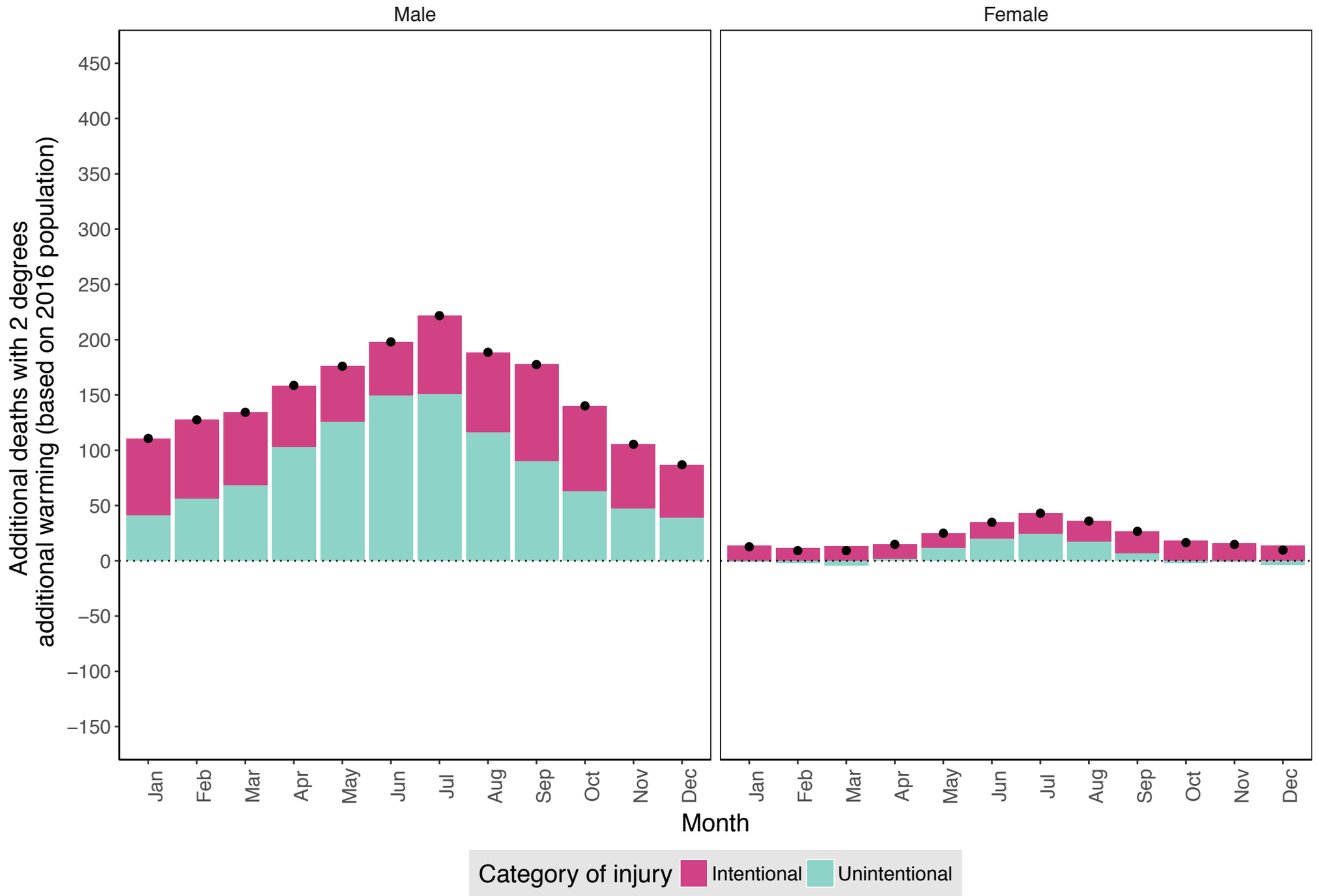
All injuries: Additional deaths with 2deg by age (total=2,078)



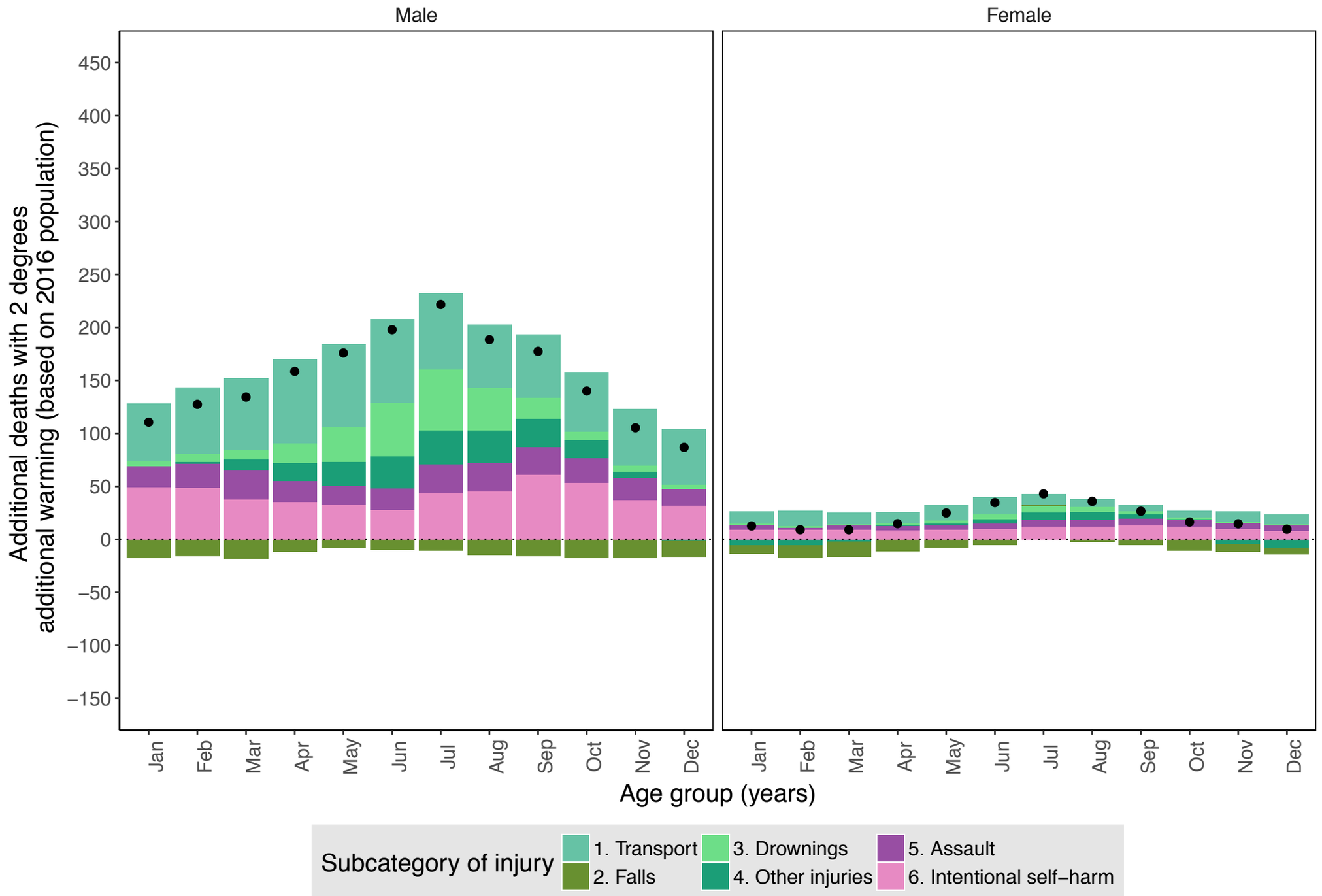
All injuries: Additional deaths with 2deg by age (total=2,078)



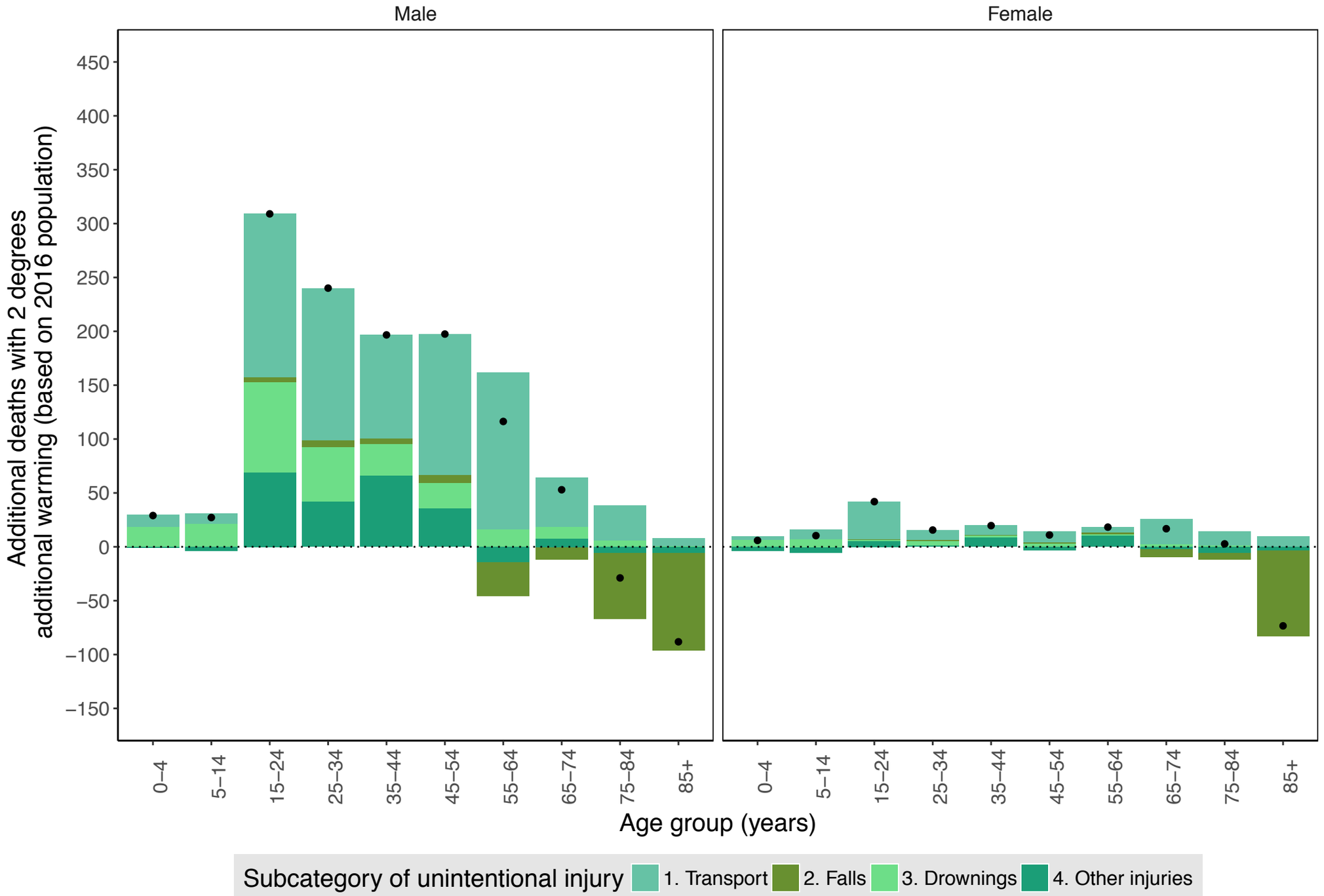
All injuries: Additional deaths with 2deg by month (total=2,078)



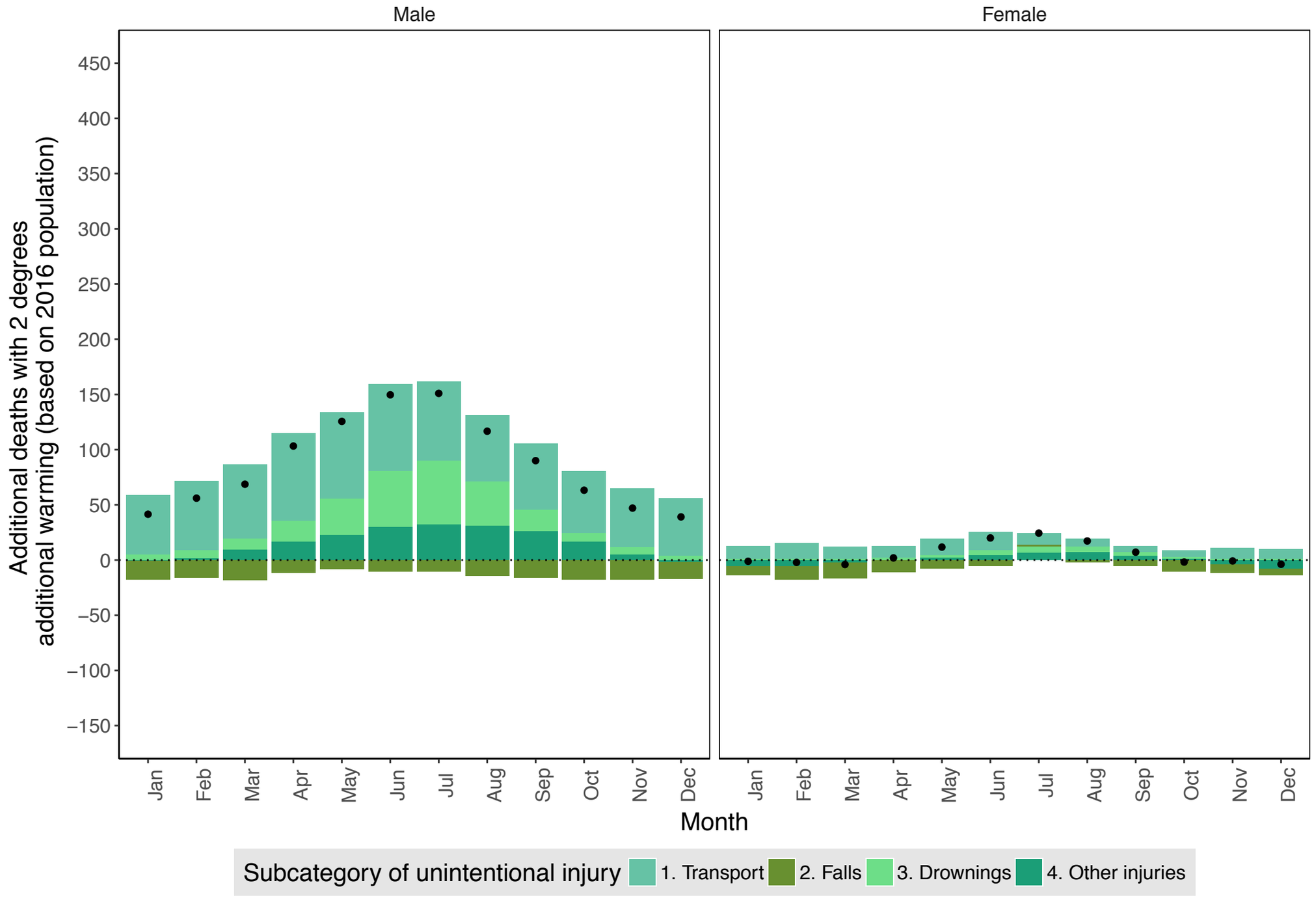
All injuries: Additional deaths with 2deg by month (total=2,078)



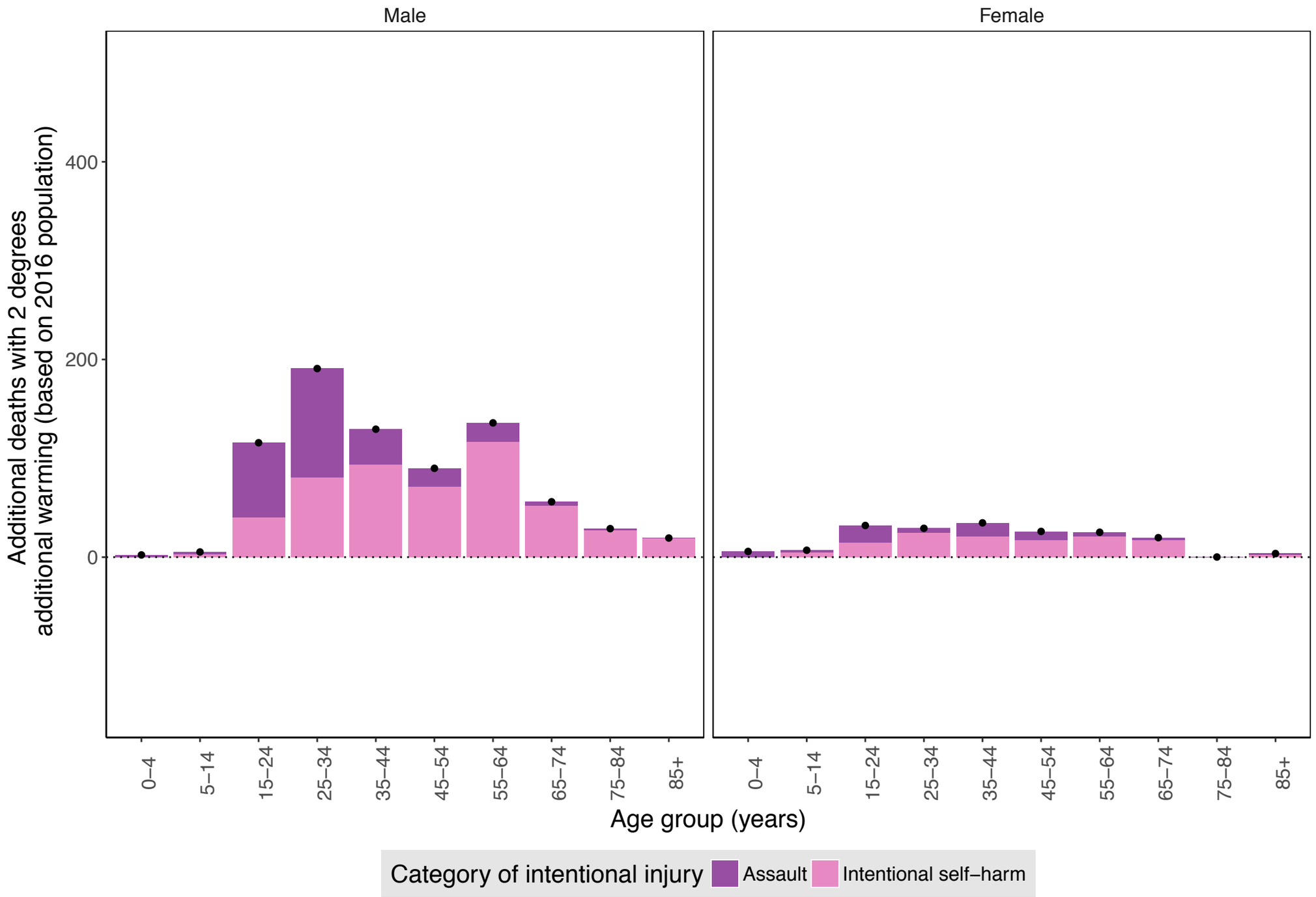
Unintentional injuries: Additional deaths with 2deg by age (total=1,121)



Unintentional injuries: Additional deaths with 2deg by month (total=1,121)



Intentional injuries: Additional deaths with 2deg by age (total=957)



Intentional injuries: Additional deaths with 2deg by month (total=957)