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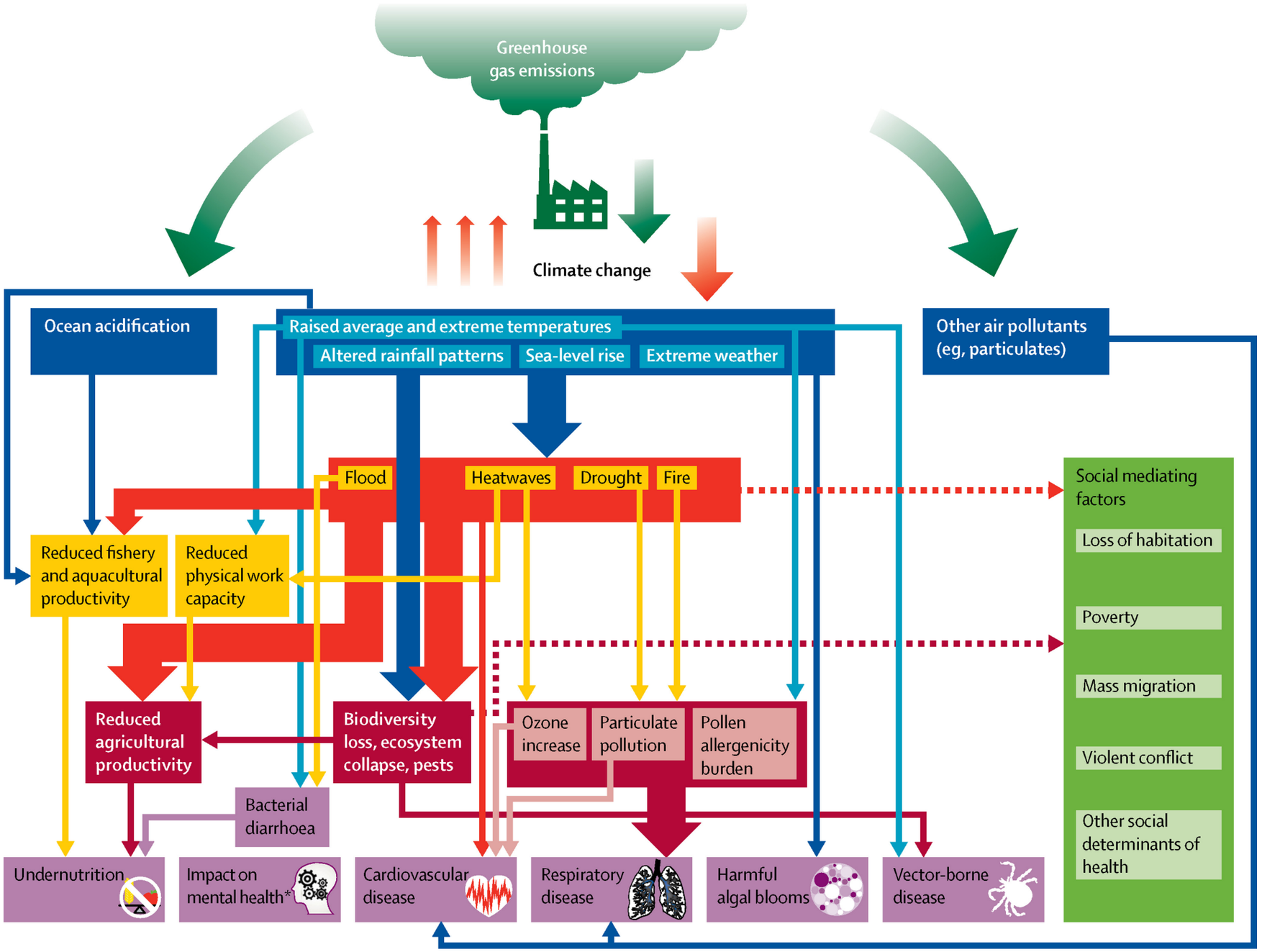
MORTALITY EFFECTS OF CLIMATE CHANGE IN THE UNITED STATES

BACKGROUND

- Each year, human deaths occur from exposure to unusual climatic patterns, even in advanced countries (European heatwave 2003 etc.)
- IPCC has predicted with high confidence more intense and frequent heat anomalies occurring at increasingly higher than normal temperatures (Climate Change synthesis report 2014)
- Key requirement of UN Sustainable Development goals: to understand and manage a changing climate to preserve and improve human health
- Study required to model long-term climate change temperature effects on human health

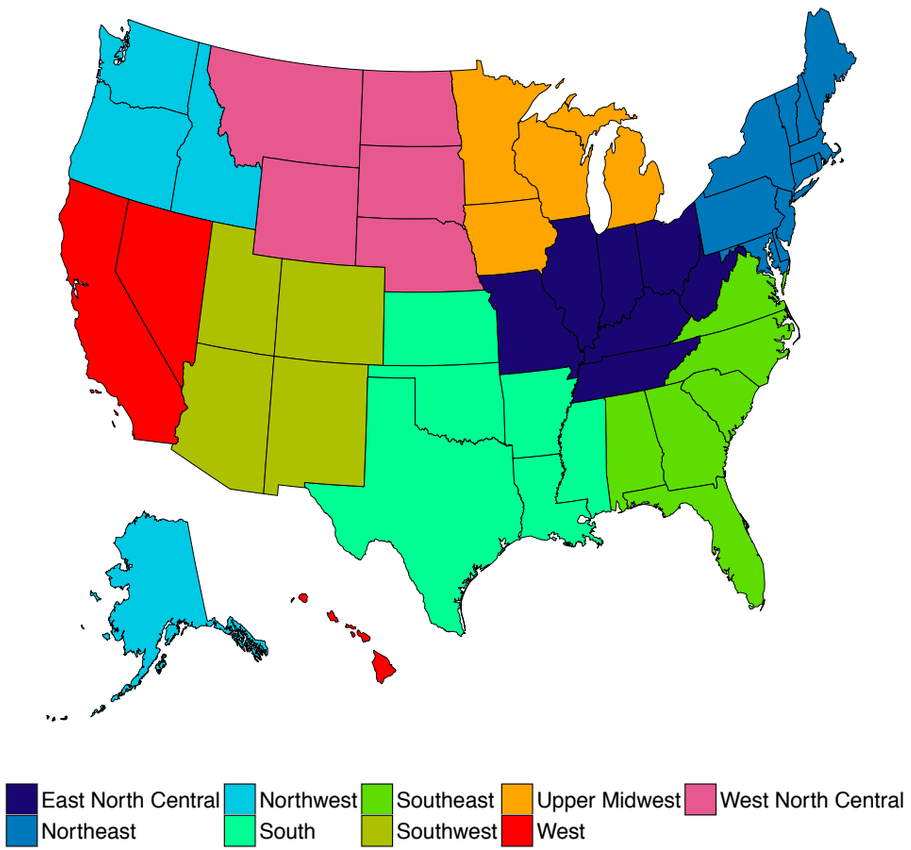
HEALTH IMPACTS OF CLIMATE CHANGE



Lancet Commission 2015

MORATLITY DATA

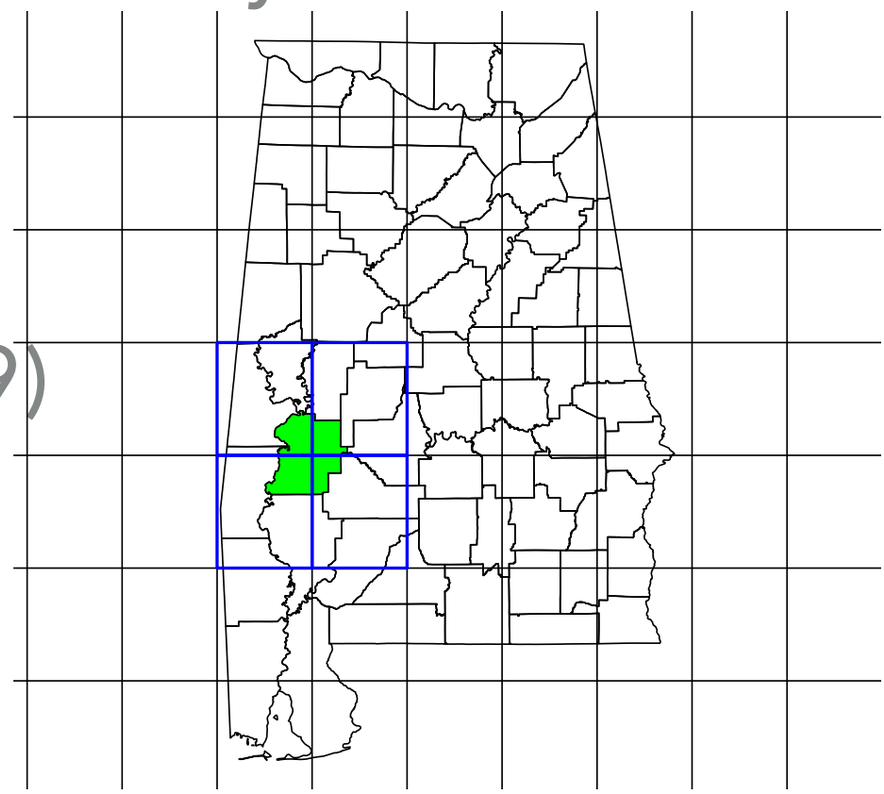
- Data on all 78 million deaths in the USA from 1980 to 2013
- Age, sex, state of residence, month of death available
- Age-sex group monthly death rates calculated by state



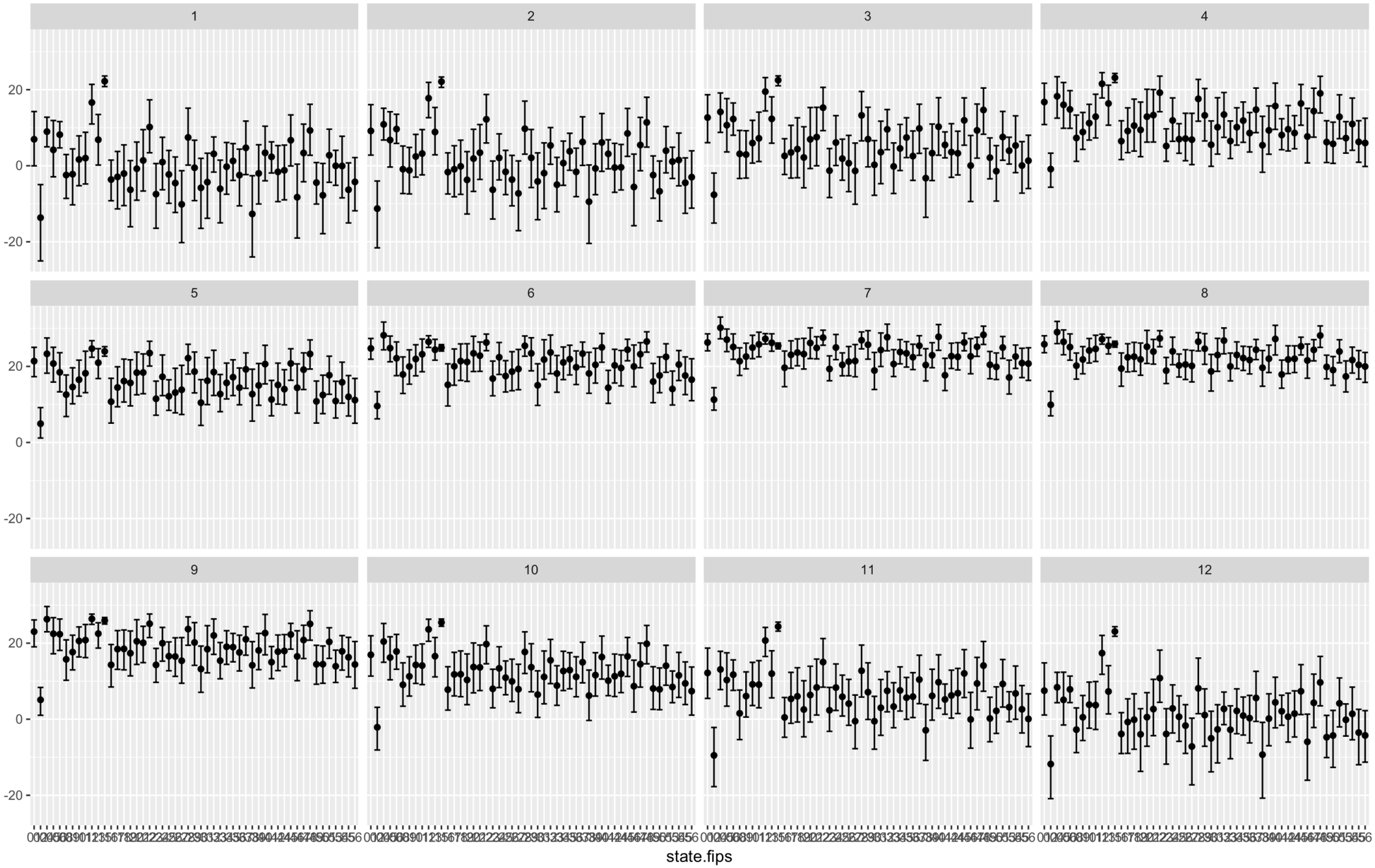
From Karl and Koss 1984

TEMPERATURE DATA

- ERA-Interim reanalysis data (1979-2016 fully available)
- Four-times-daily estimates at a resolution of 80km to generate average daily county temperatures
- monthly population-weighted temperature by state throughout analysis period
- 30-year normal period average values per state-month calculated (1980-2009)



NORMAL PERIOD (1980–2009)



MODEL

1 Climate model

1.1 Equations

Model specification

$$\log(\mu_{m,s,t}) = \alpha_0 + \alpha_{M[m]} + \alpha_{S[s]} + \alpha_{X[m,s]} + (\beta_0 + \beta_{M[m]} + \beta_{S[s]} + \beta_{X[m,s]})t + \gamma T + \pi_t + \epsilon_{m,s,t} \quad (1)$$

1.2 Table of terms except temperature

name	global icpt.	specific icpt. 1	icpt. 2	mixed icpt.	global trnd.	specific trnd. 1	specific trnd. 2	mixed trnd.	RW 1	overd
Model	α_0	$\alpha_{M[m]}$	$\alpha_{S[s]}$	$\alpha_{X[m,s]}$	β_0	$\beta_{M[m]}$	$\beta_{S[s]}$	$\beta_{X[m,s]}$	π_t	$\epsilon_{m,s,t}$

1.3 Climate terms

type	terms	description
National	γT	month-specific climate slope
Climate region	$\gamma_{X[m,s]}$T	climate region-month specific climate slope

METRICS

1 Climate model

1.1 Statistics generated

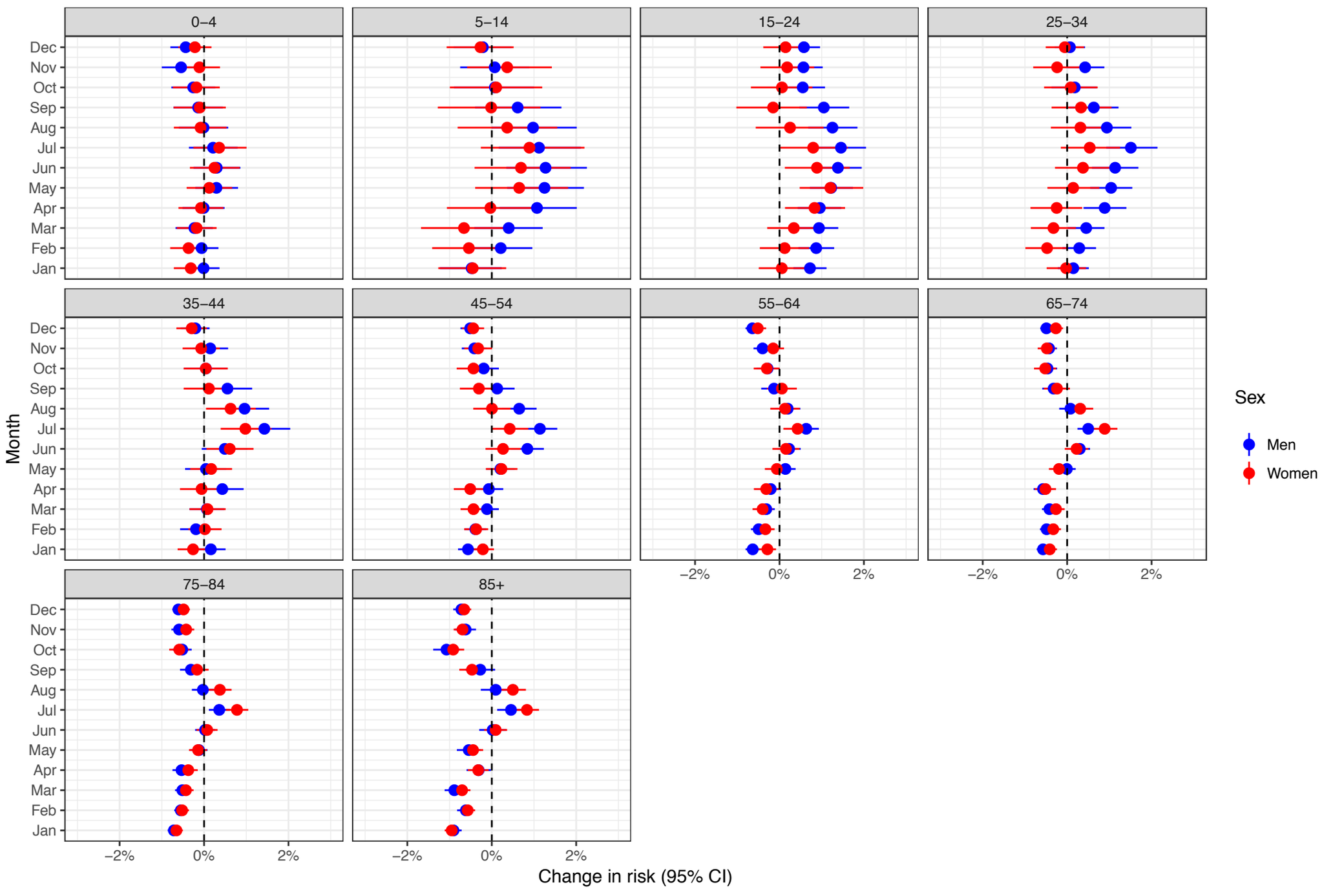
Currently running for 1980-2013 nationally:

Centred mean (around 1980-2009)	(done for all ages 1980-2013 nationally)
Centred position of 10th percentile (around 1980-2009)	(done for all ages 1980-2013 nationally)
Centred position of 90th percentile (around 1980-2009)	(done for all ages 1980-2013 nationally)
Heat anomaly I: number of mininmum 3 days above 90th percentile of normal period	(done for all ages 1980-2013 nationally)
Heat anomaly II: number of mininmum 3 days above +5 of normal period	(done for all ages 1980-2013 nationally)
Heat anomaly III: number of mininmum 5 days above +5 of normal period (based on WMO description)	(done for all ages 1980-2013 nationally)
Cold anomaly I: number of minimum 3 days below 10th percentile	(done for all ages 1980-2013 nationally)
Cold anomaly II: number of mininmum 3 days below -5 of normal	(done for all ages 1980-2013 nationally)
Cold anomaly III: number of mininmum 5 days below -5 of normal period (based on WMO description)	
Number of days changing by 5C	(done for all ages 1980-2013 nationally)
Number of days above 90th percentile of normal period	(done for all ages 1980-2013 nationally)
Number of days below 10th percentile of normal period	

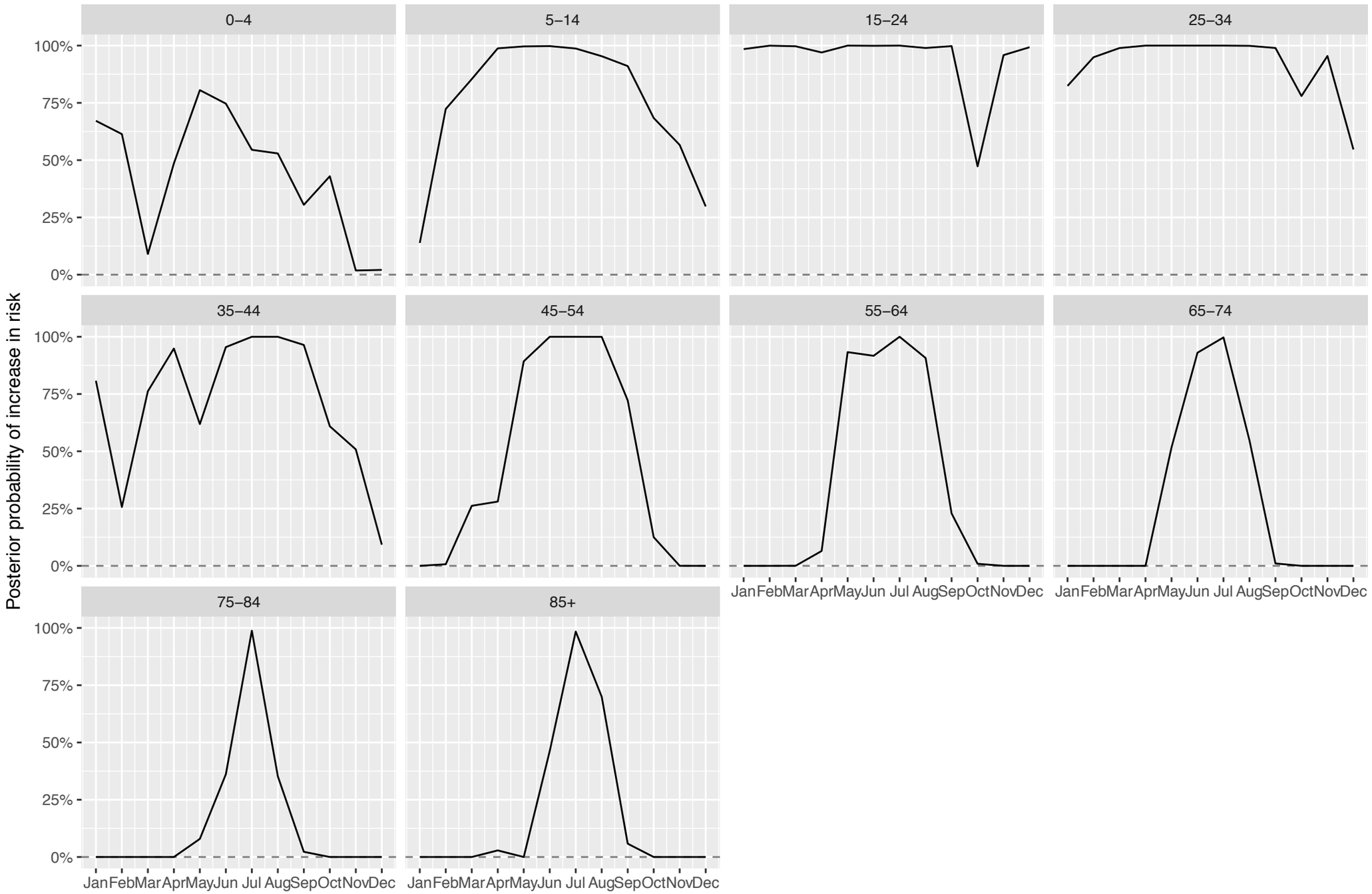
RISK TO ESTIMATED IMPACT

- Death rates = μ
- Modelled in log(μ)
- To calculate rates, exp(log(μ))
- To calculate risk parameter from unit change of variable: R=exp(γ) (γ = climate parameter from model)
- Change in number deaths =
- (R-1) * original death rate * population

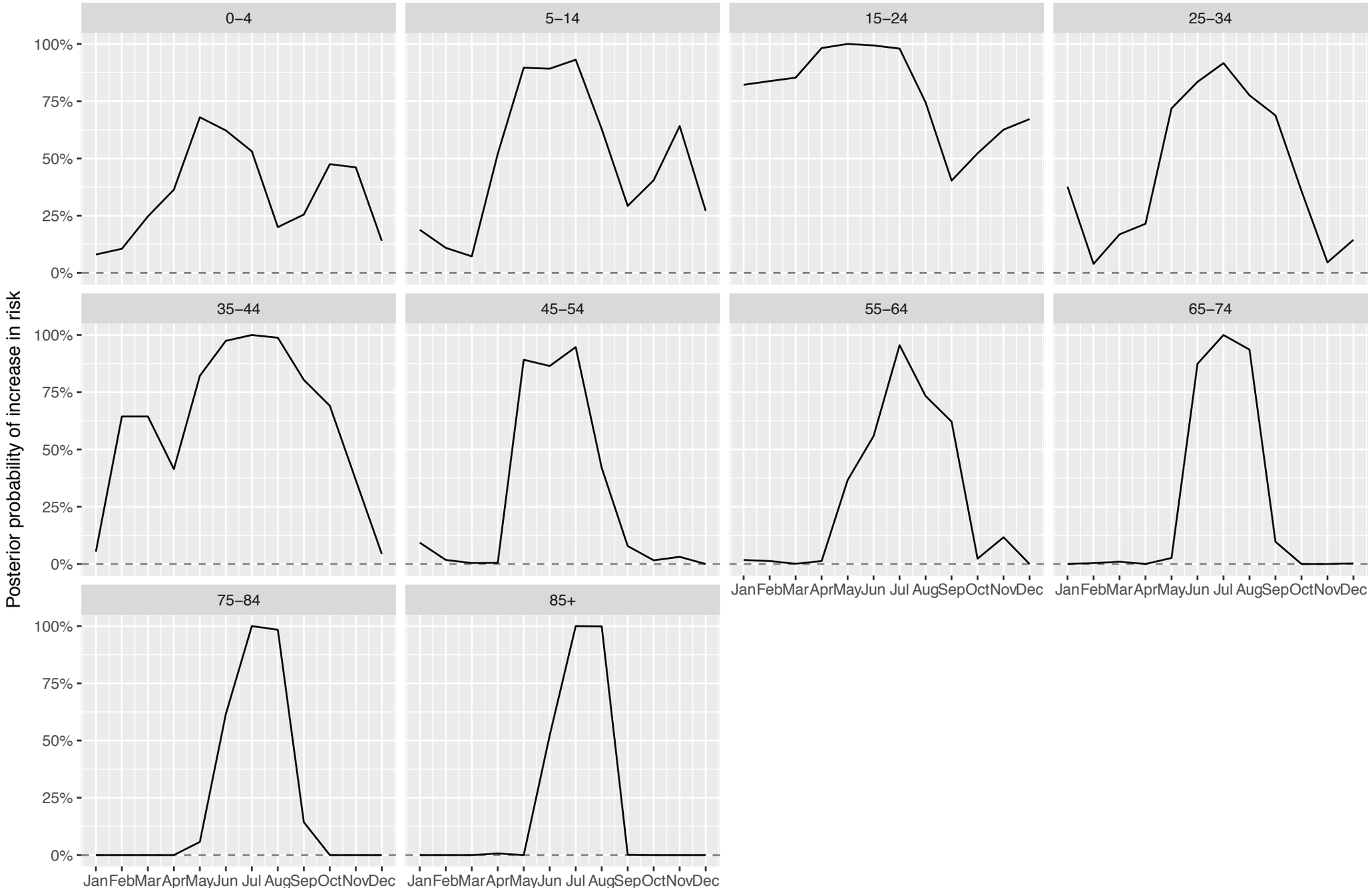
RISK: CENTRED MEAN



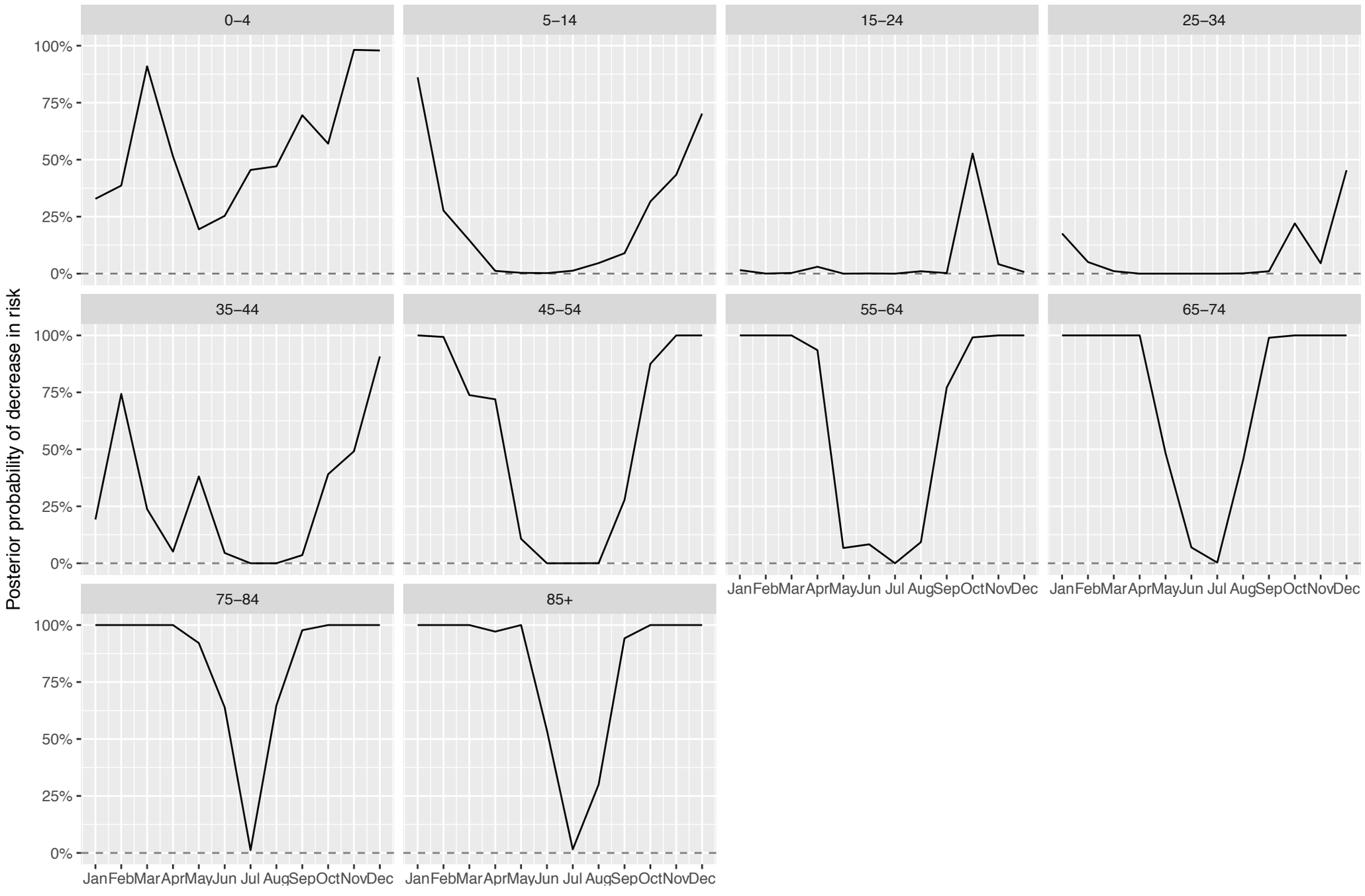
POSTERIOR PROBABILITY OF INCREASED RISK: CENTRED MEAN MEN



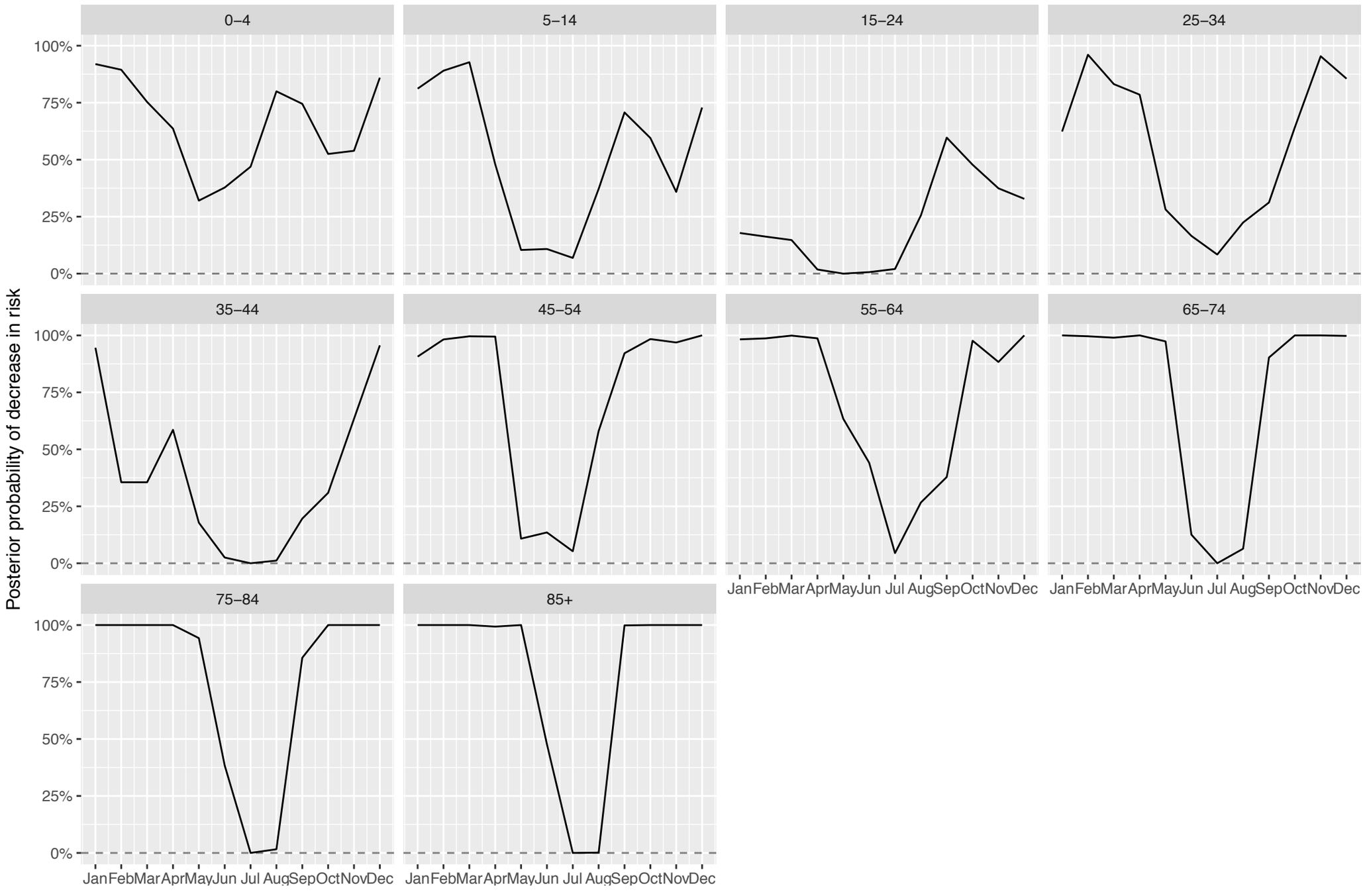
POSTERIOR PROBABILITY OF INCREASED RISK: CENTRED MEAN WOMEN



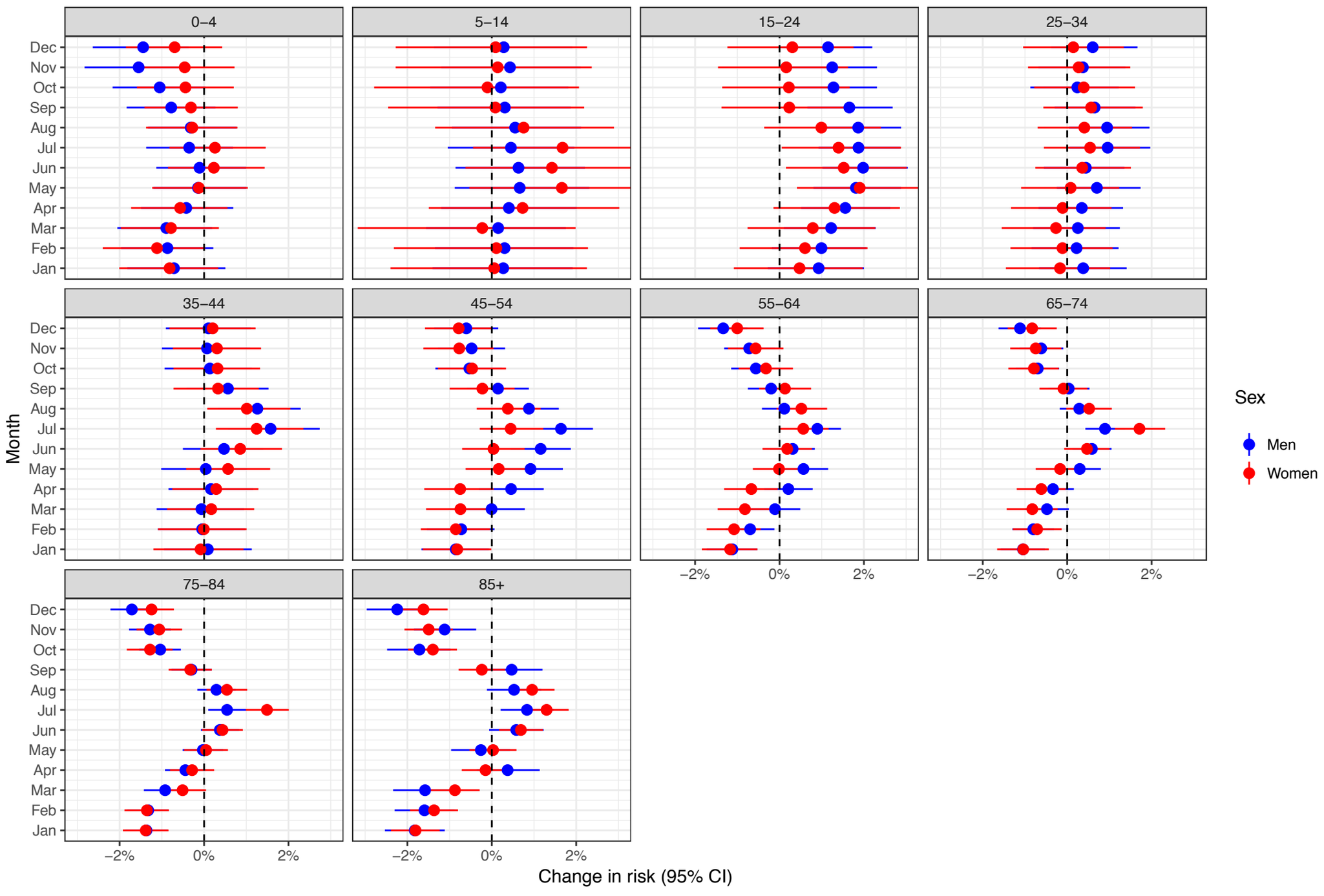
POSTERIOR PROBABILITY OF DECREASED RISK: CENTRED MEAN MEN



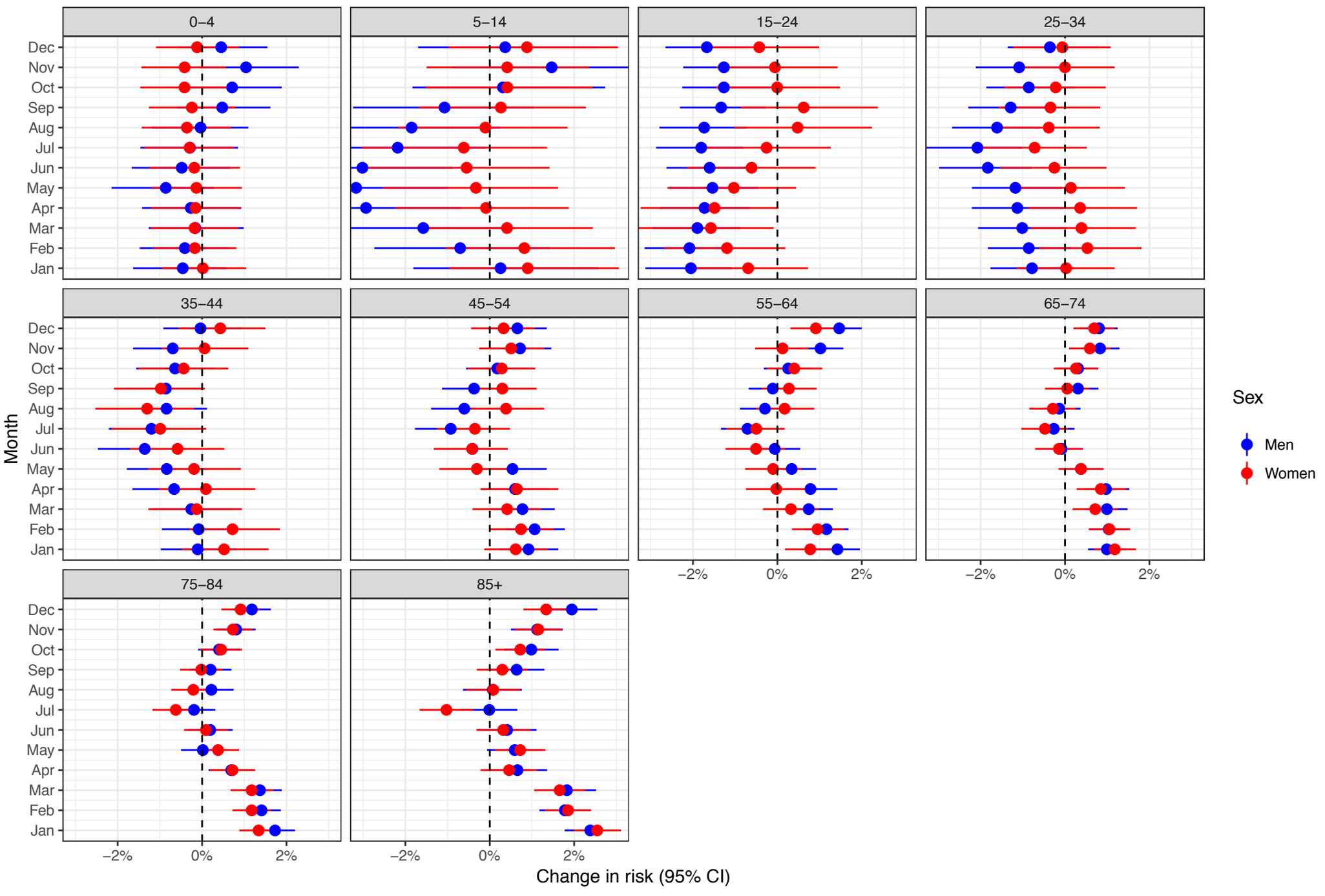
POSTERIOR PROBABILITY OF DECREASED RISK: CENTRED MEAN WOMEN



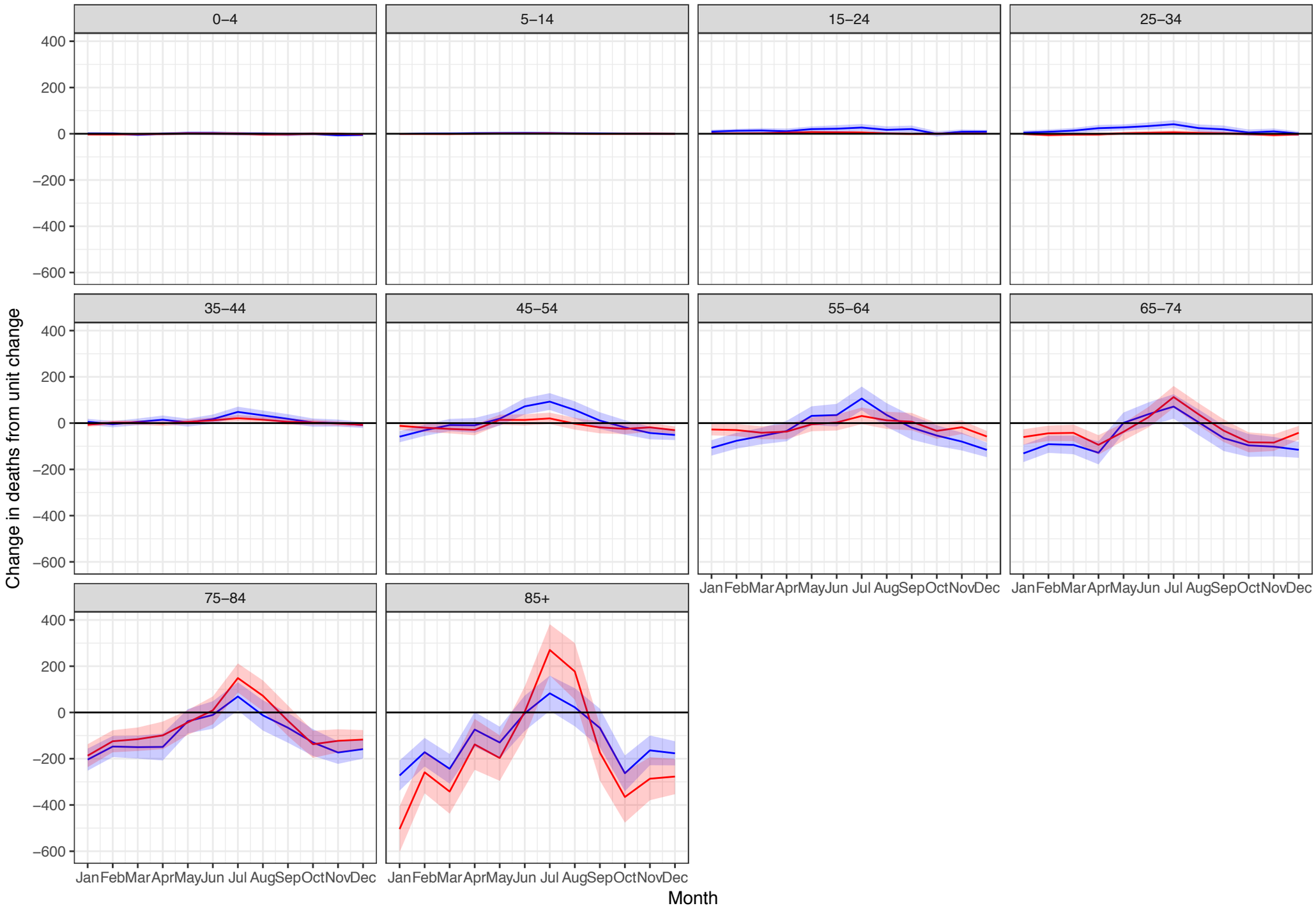
RISK: HEAT ANOMALIES I



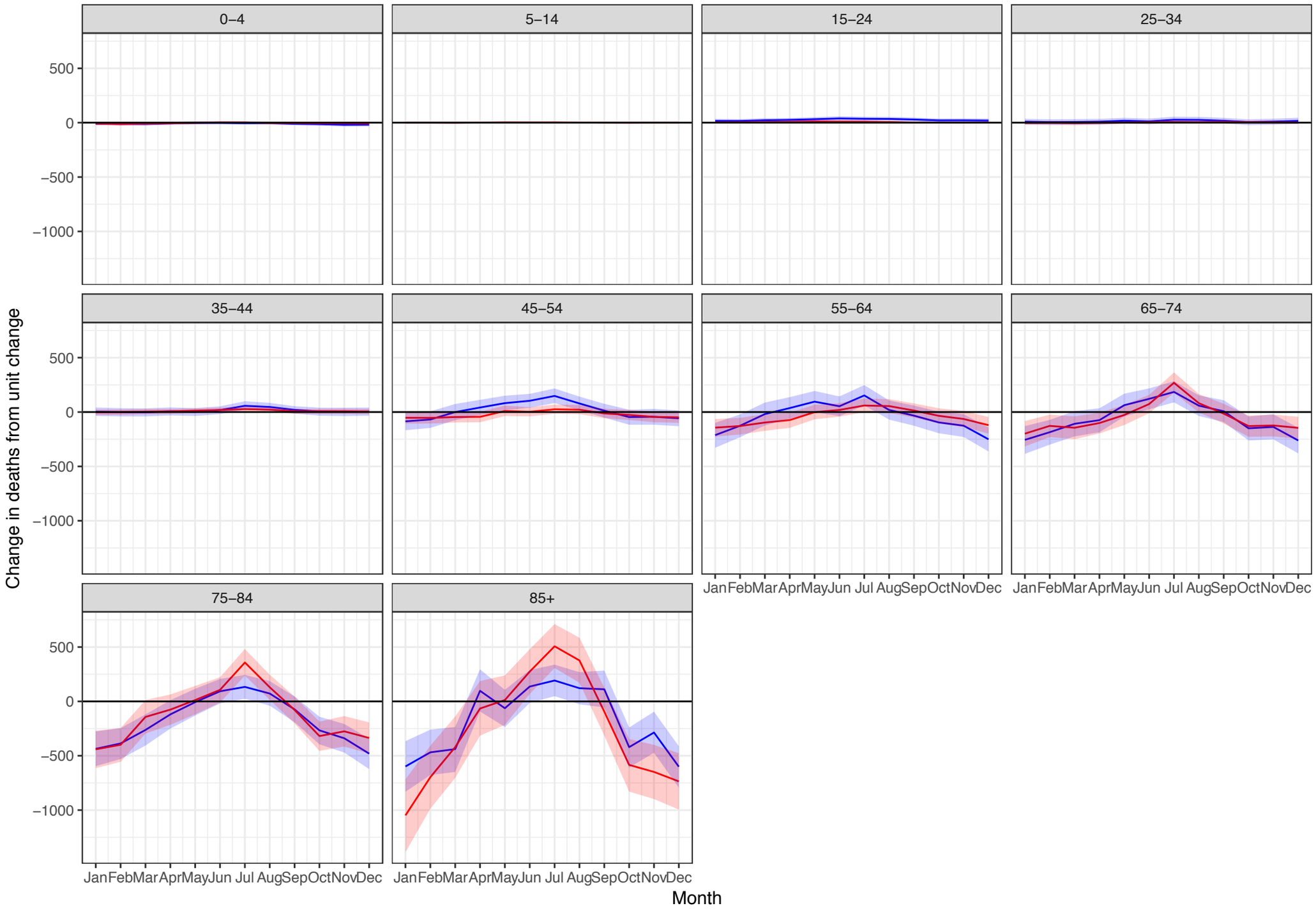
RISK: COLD ANOMALIES I



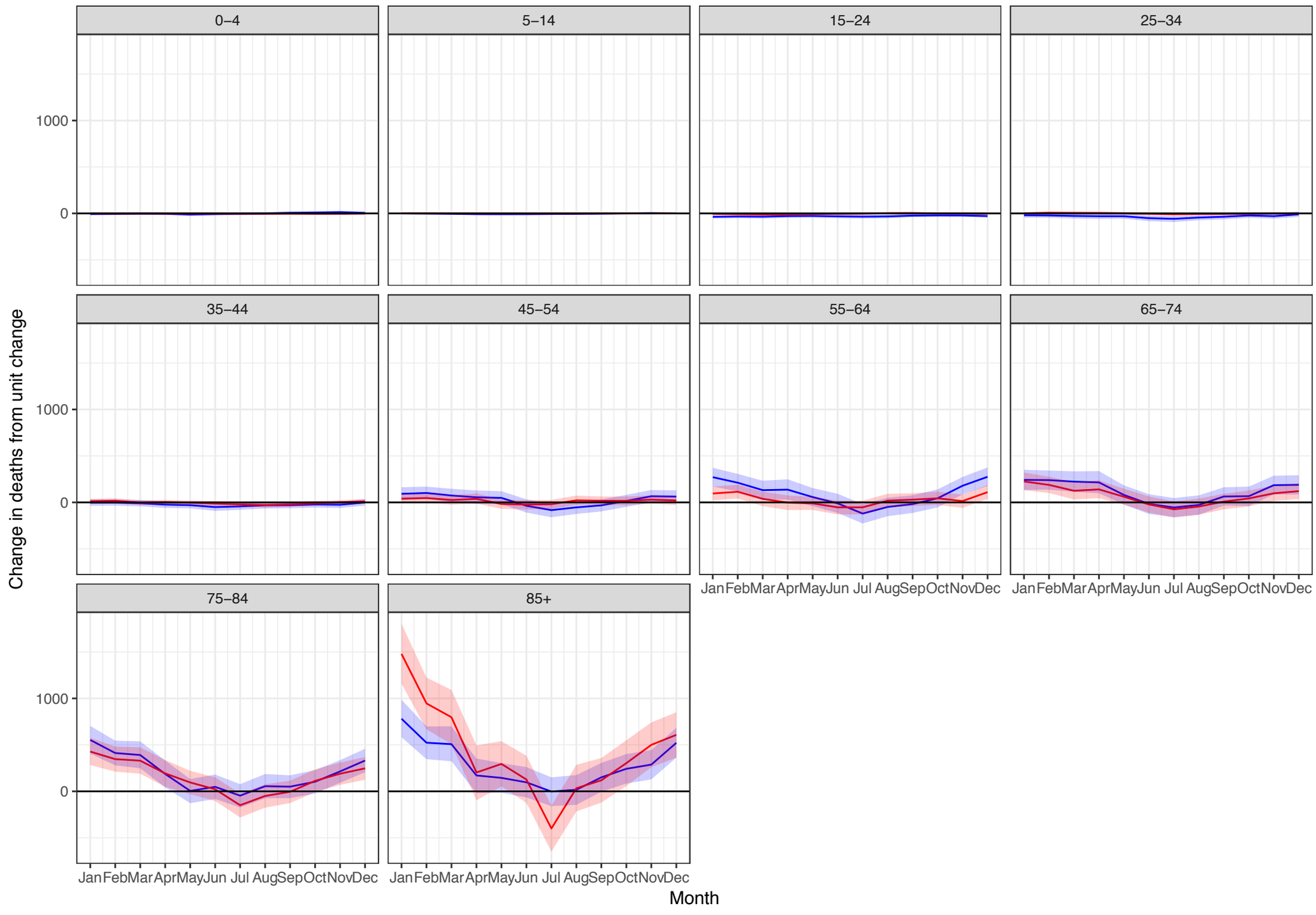
ADDITIONAL DEATHS: CENTRED MEAN



ADDITIONAL DEATHS: HEAT ANOMALIES I



ADDITIONAL DEATHS: COLD ANOMALIES I



INTERPRETATION

- First study of its kind to examine how exactly long-term climate change may impact general human health (i.e. not one-off events)
- Net benefit of climate change with 1 degree of warming? Probably not as simple as that because…
- Heat anomalies in summer cause significant risk increase in older ages
- Cold anomalies in winter cause significant risk increase in older ages
- Even in a highly-industrialised country like the United States, significant relationship found between temperature patterns and mortality