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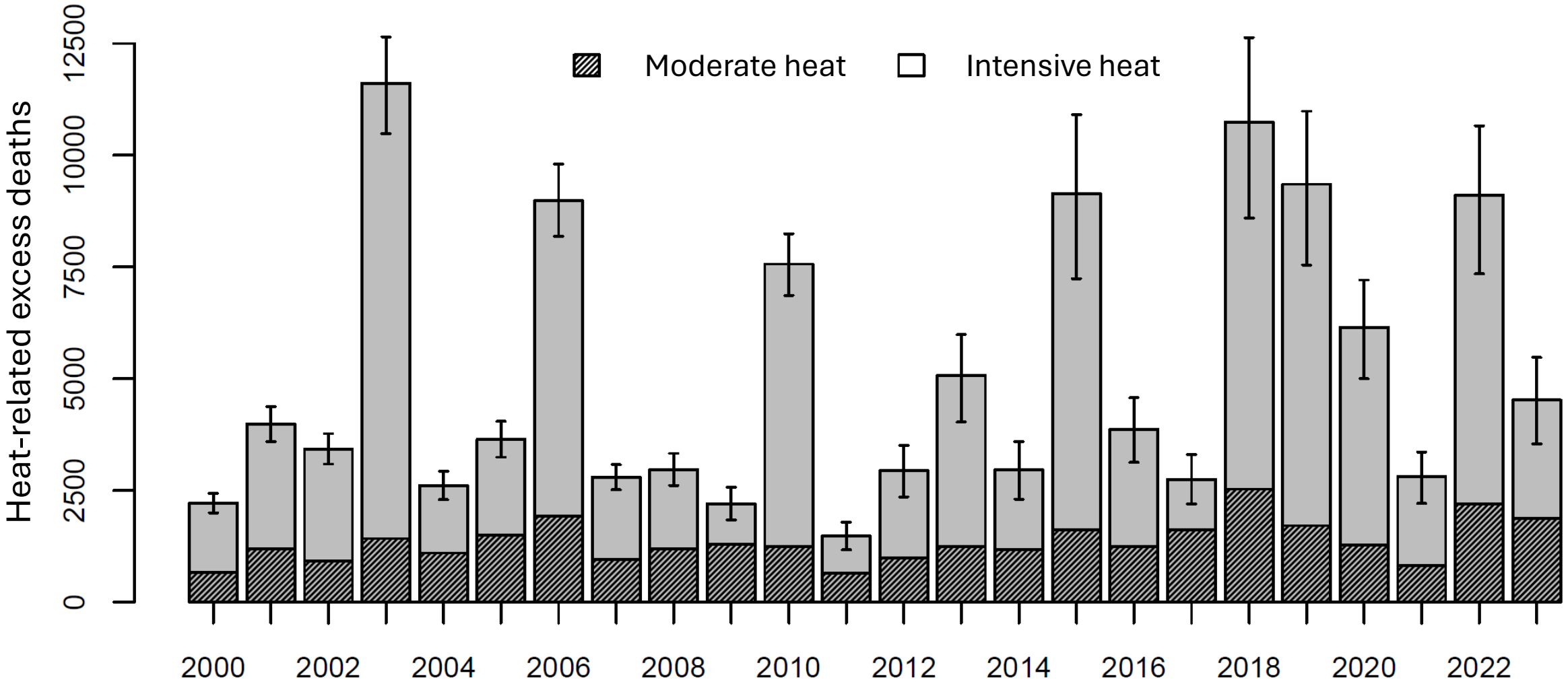
Assessing the effectiveness of the heat health warning system in preventing mortality in 15 German cities: a difference-in-differences approach

Hanna Feldbusch, Alexandra Schneider, Franziska Matthies-Wiesler, Annette Peters, Susanne Breitner-Busch, Veronika Huber

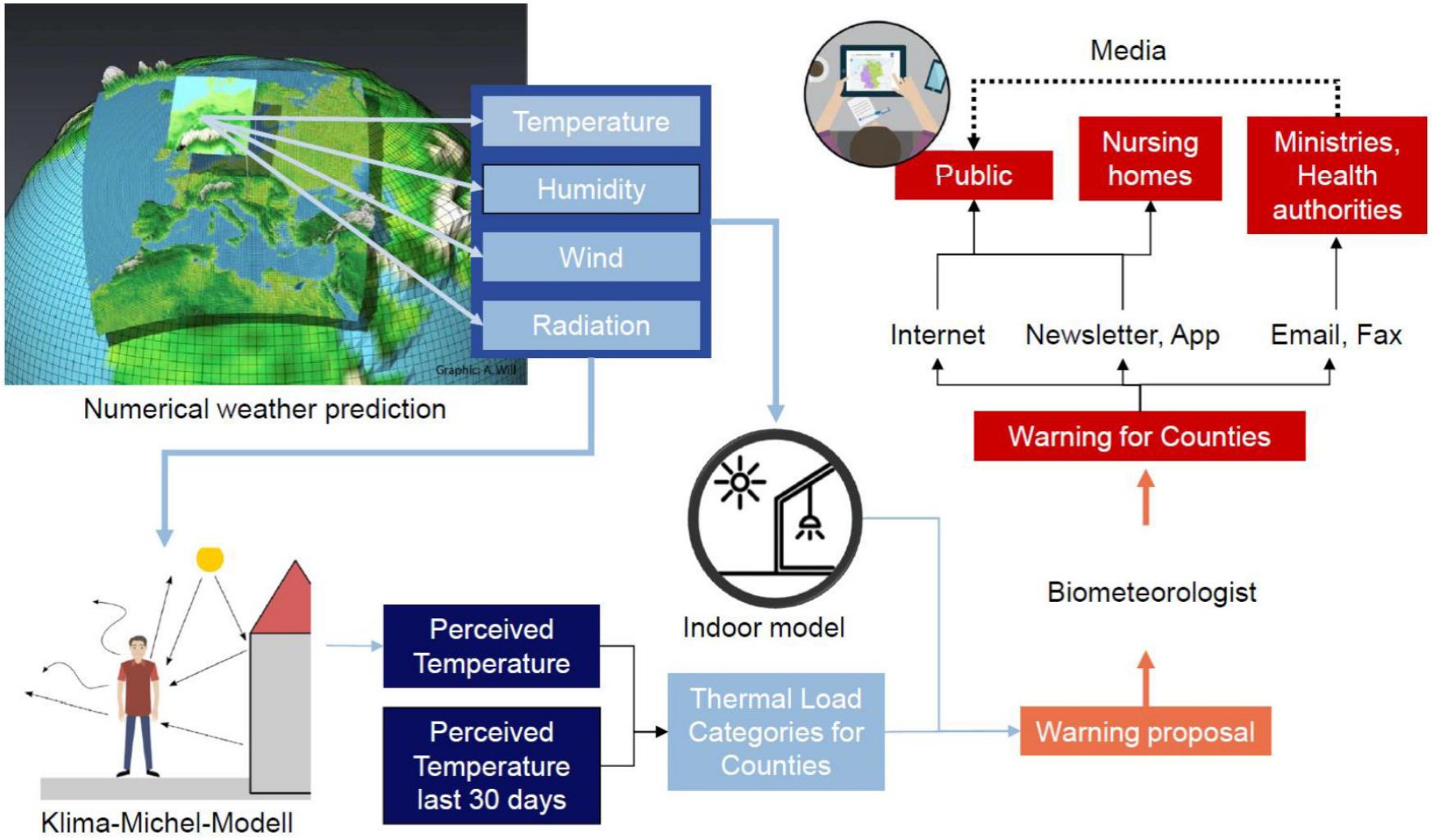
ISIMIP/PROCLIAS Meeting, Potsdam, 24.-26. April 2024

Background: Heat-related excess mortality in Germany



Huber et al. 2024 *Deutsches Ärzteblatt*

Background: The German heat health warning system



Administered by the German National Weather Service (DWD)

Matzarakis et al. 2020 *atmosphere*

Background: Heat alerts issued in German cities since 2005

Matzarakis et al. 2020
atmosphere

Background: Limited knowledge on the effectiveness of heat alerts in preventing mortality

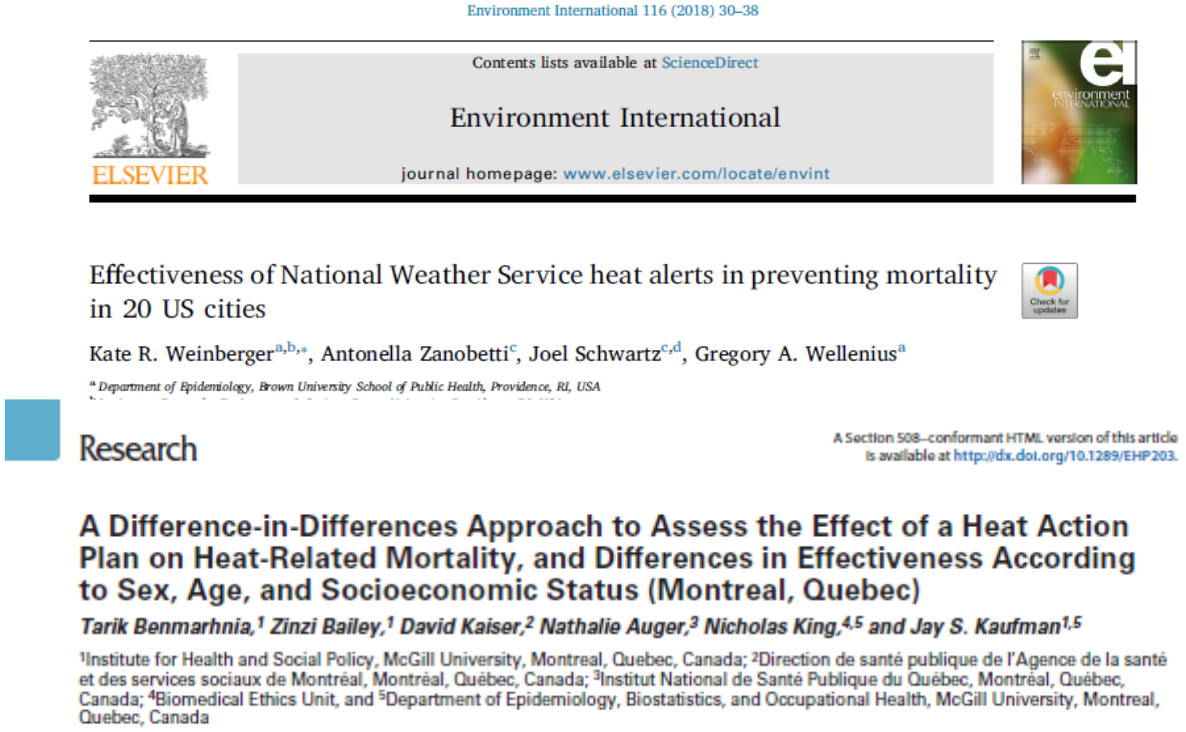
Beiträge zum Themenschwerpunkt

Z Gerontol Geriat 2014 · 47:475–482
DOI 10.1007/s00391-014-0673-2
Published online: 26. Juli 2014

U. Heudorf · M. Schade
Amt für Gesundheit, Frankfurt am Main

Heat waves and mortality in Frankfurt am Main, Germany, 2003–2013

What effect do heat-health action plans and the heat warning system have?



Environment International 116 (2018) 30–38

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Effectiveness of National Weather Service heat alerts in preventing mortality in 20 US cities

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Research

A Section 508–conformant HTML version of this article is available at http://dx.doi.org/10.1289/EHP203.

A Difference-in-Differences Approach to Assess the Effect of a Heat Action Plan on Heat-Related Mortality, and Differences in Effectiveness According to Sex, Age, and Socioeconomic Status (Montreal, Quebec)

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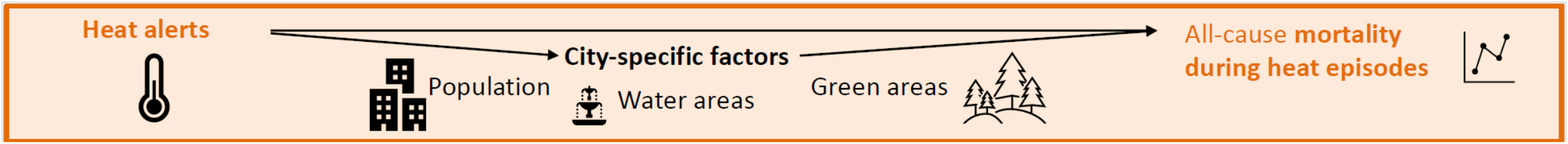
1) So far no systematic assessment of the effectiveness of the heat health warning system in Germany

2) Overall, few studies using quasi-experimental method such as difference-in-differences approaches

Study objectives



Two major objectives:

1) To examine if the heat alerts issued by the German National Weather Service have prevented all-cause mortality during hot days in the 15 most populated German cities

2) To pool the city-specific effect estimates and to assess the heterogeneity among cities based on city-specific socioeconomic, demographic and environmental factors

Feldbusch et al. *in prep.*

Overview of data and methods

Study period: Warm-season months (May-Sep) in 1993-2020

Data: Daily death counts in 15 German cities, linked with heat alert data and meteorological variables; annual data on socioeconomic, demographic and environmental characteristics

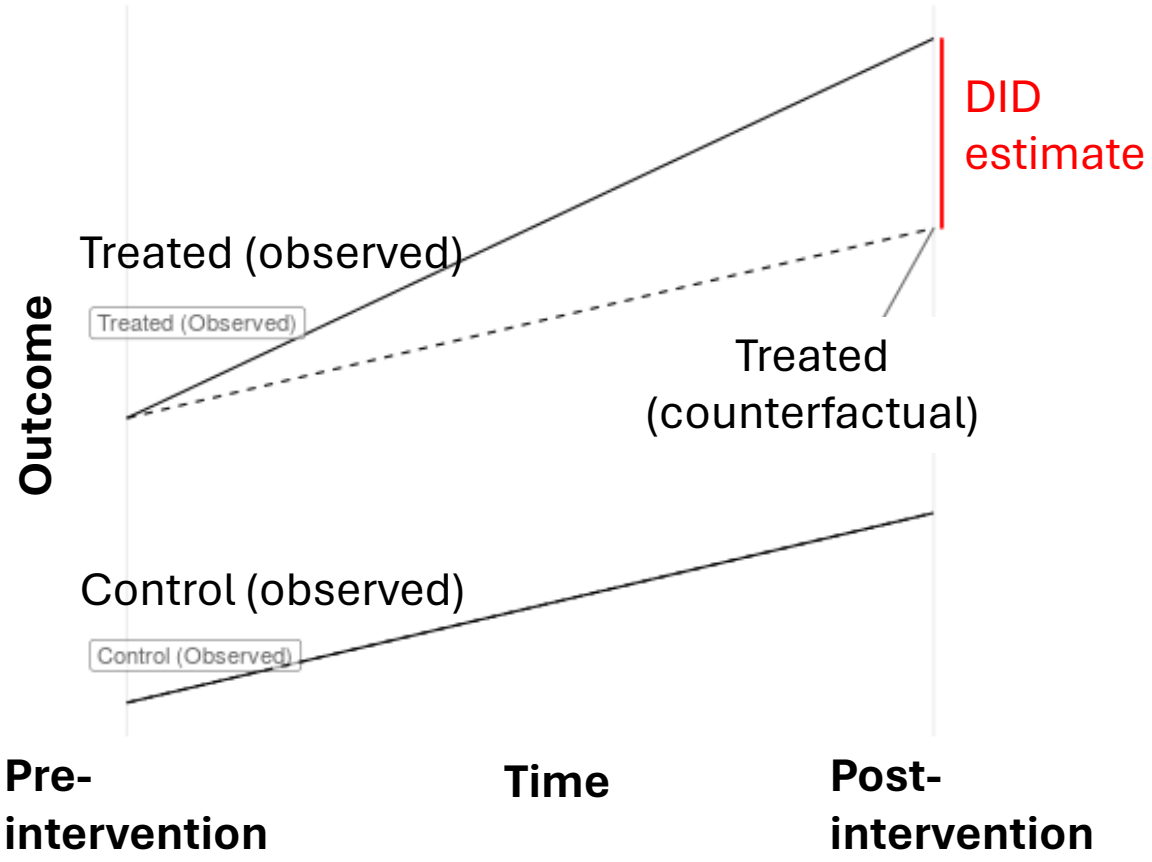
First stage: Estimation of the city-specific effects of heat alerts on mortality using a difference-in-differences (DID) approach

Second stage: Estimation of the pooled overall effect by fitting meta regression models and identification of city-specific factors explaining heterogeneity

Feldbusch et al. *in prep.*

German cities studied (red dots)

Difference-in-differences (DID) approach



https://diff.healthpolicydatascience.org/

Intervention: Implementation of the heat health warning system in 2005.
→ Pre-intervention period: 1993-2004
→ Post-intervention period: 2005-2020

Outcome: Daily death counts

Treated: Days "eligible" for heat alerts (hot days)

Control: Days "non-eligible" for heat alerts (non-hot days)

Days in the pre-intervention period categorized as "eligible"/"non-eligible" using **random forest classification**

First-stage quasi-Poisson regression models

$$\log\left(E\left(D_{t,i}\right)\right) = \beta_0 + \beta_1 H_{t,i} + \beta_2 P_{t,i} + \beta_3 H_{t,i} * P_{t,i} + weekday + seasonal\ and\ longterm\ trends + climatic\ covariates + population\ offset + \varepsilon_{t,i}$$

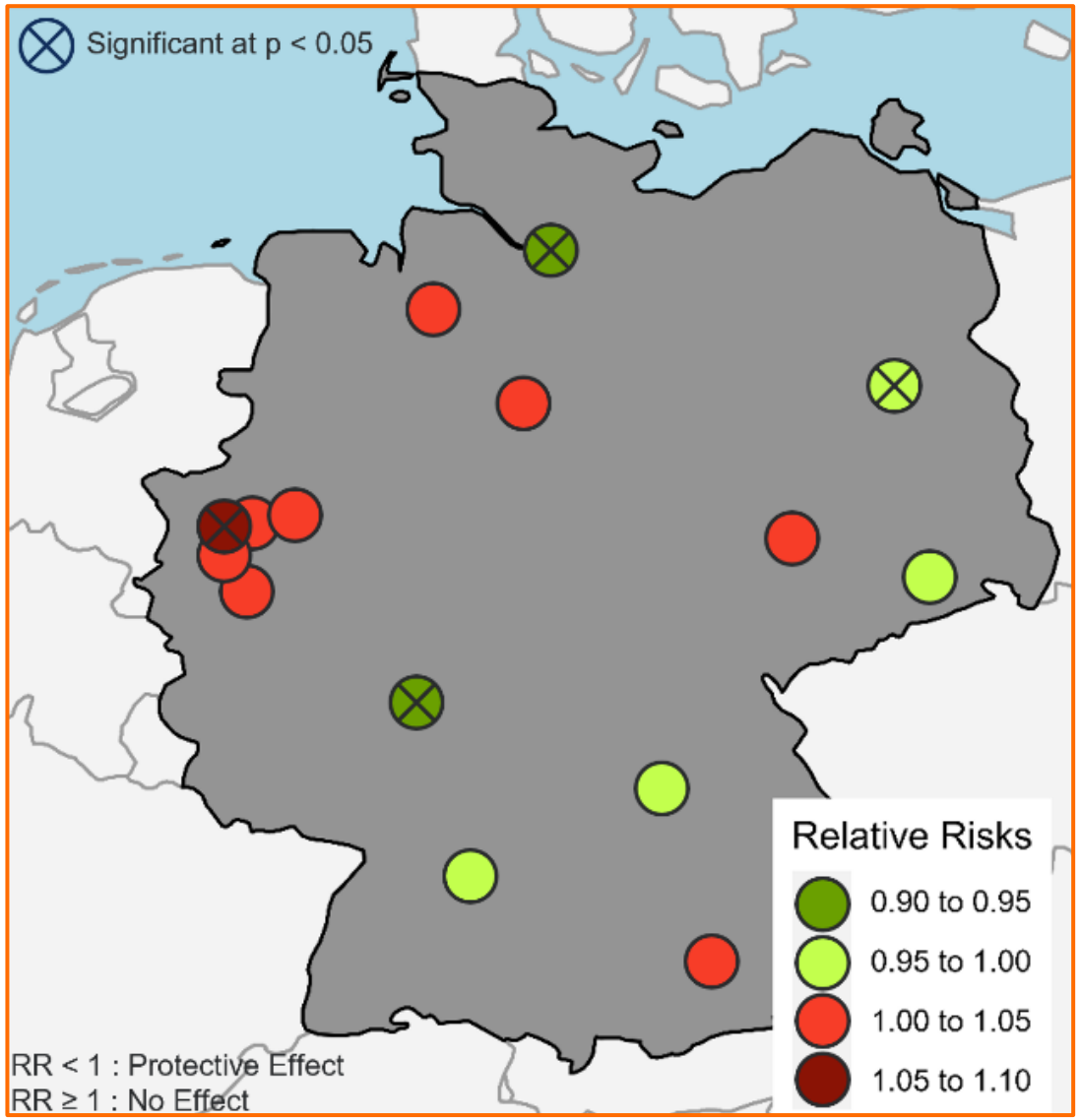
$D_{t,i}$: Total death count on day *t*, in city *i*
$H_{t,i}$: Binary indicator for „eligible“ (hot) and „non-eligible“ (non-hot) days
$P_{t,i}$: Binary indicator for pre-intervention (without heat alerts) and post-intervention (with heat alerts)

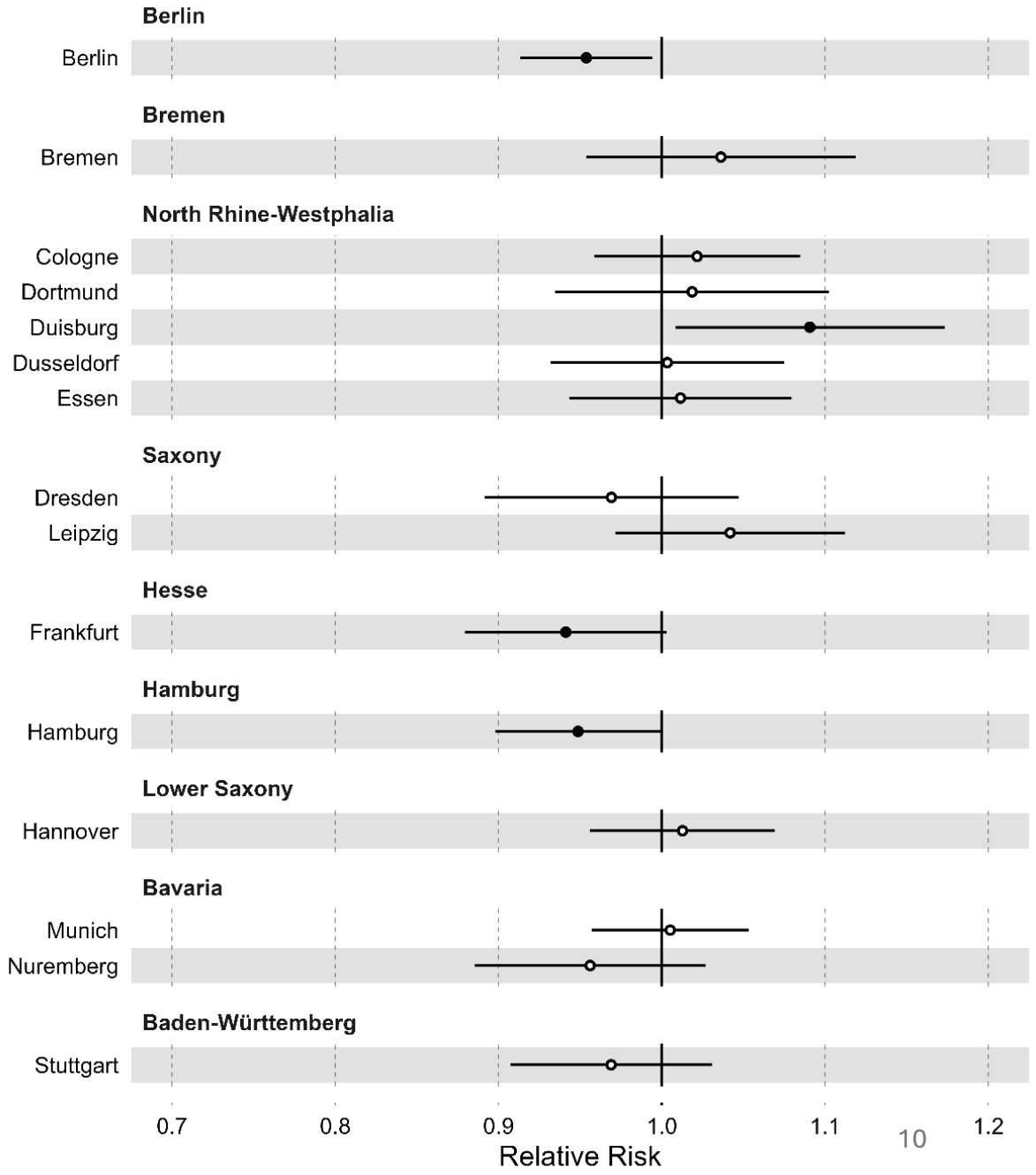
DID estimate reported as relative risk: $RR = \exp(\beta_3)$;

$\boldsymbol{RR < 1}$: **protective effect** of heat alerts
$\boldsymbol{RR \geq 1}$: **no protective effect** of heat alerts

Feldbusch et al. *in prep.*

City-specific results



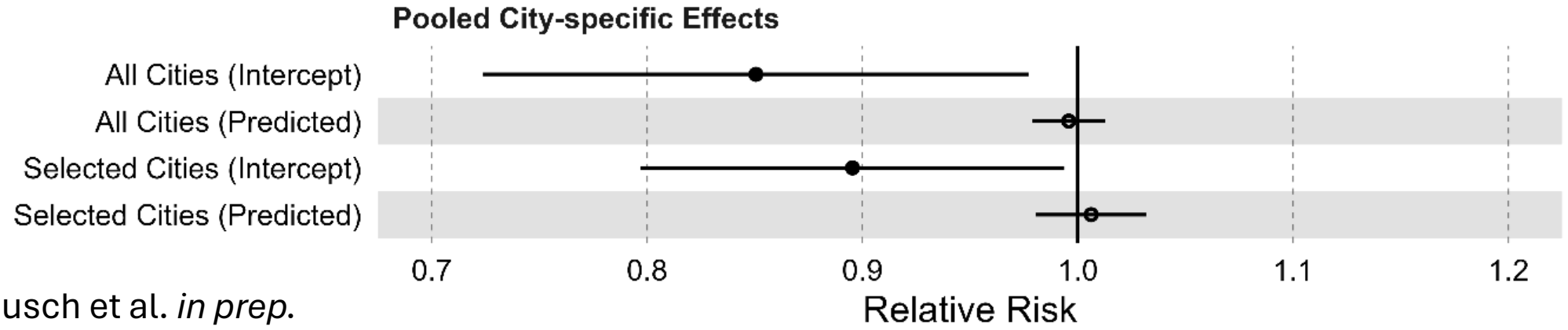


Feldbusch et al. *in prep.*

Results of mixed-effect meta-regression

Basic and final multi-parameter models based on city-specific DID estimators for “all cities” and the seven cities fulfilling the DID parallel trend assumption (“selected cities”)

Model	Coefficient	Estimate	95% CI	p-Value	I^2	AIC	BIC
Basic model (all cities)	(Intercept)	-0.83×10^{-2}	[-2.78×10^{-2} , 1.13×10^{-2}]	0.41	35.24%	- 50.46	- 49.04
Final model (all cities)	(Intercept)**	-1.62×10^{-1}	[-2.89×10^{-1} , -0.35×10^{-1}]	< 0.05	0.00%	- 57.40	- 53.86
	Recreational area	3.27×10^{-3}	[1.14×10^{-3} , 5.40×10^{-3}]	< 0.01			
	Population	-2.62×10^{-8}	[-4.62×10^{-8} , -0.63×10^{-8}]	< 0.01			
	Population density	2.41×10^{-5}	[-0.14×10^{-5} , 4.95×10^{-5}]	0.06			
Basic model (selected cities)	(Intercept)	0.18×10^{-2}	[-2.69×10^{-2} , 3.06×10^{-2}]	0.90	43.18%	- 20.29	- 20.40
Final model (selected cities)	(Intercept)**	$-1.10\ 10^{-1}$	[-2.09×10^{-1} , -0.12×10^{-1}]	< 0.05	0.00%	- 23.98	- 24.20
	Water area	1.78×10^{-2}	[0.54×10^{-2} , 3.01×10^{-2}]	< 0.01			
	Population	0.66×10^{-7}	[-0.16×10^{-7} , 1.48×10^{-7}]	0.12			



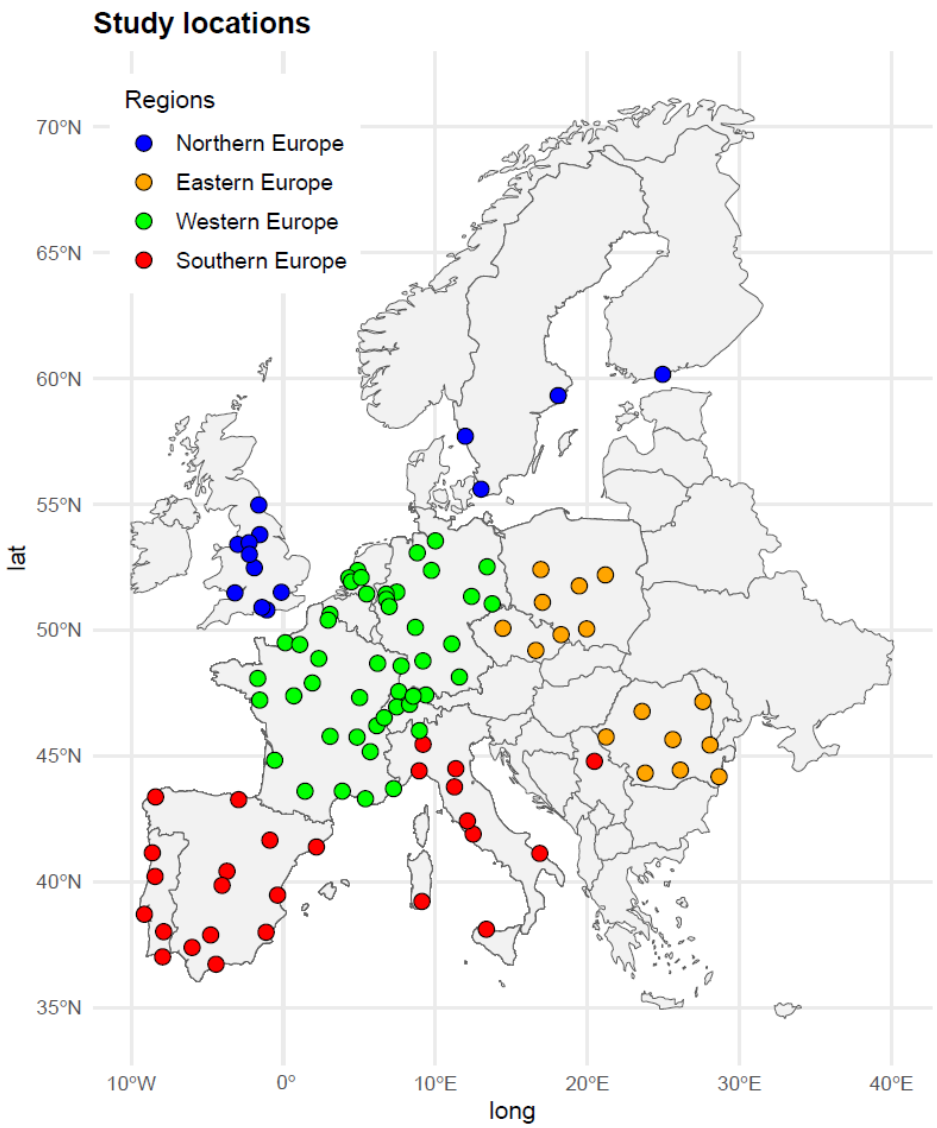
Feldbusch et al. *in prep.*

Conclusions

- Large **heterogeneity** in the **effectiveness of heat alerts** in preventing mortality across cities.
- DID estimates suggest that heat alerts have **reduced mortality during hot days** only in **six of the fifteen German cities** studied.
- The **pooled DID estimate** points to a **small to no protective effect of heat alerts** for the ensemble of studied cities.
- The effectiveness of heat alerts may be influenced by **city-specific characteristics** such as population size, and the presence of blue and green spaces, highlighting the need for **tailored heat health warning approaches**.

Feldbusch et al. *in prep.*

Future research building upon PROCLIAS



In many European countries, data on issued heat alerts is readily available.

This data could be combined with mortality data from the Multi-Country Multi-City (MCC) network.

Expanding the geographical scope of the presented approach might improve statistical power and allow for more robust conclusions on the effectiveness of heat alerts in preventing mortality.

Urban et al. *in prep.*

Thank you
for your attention

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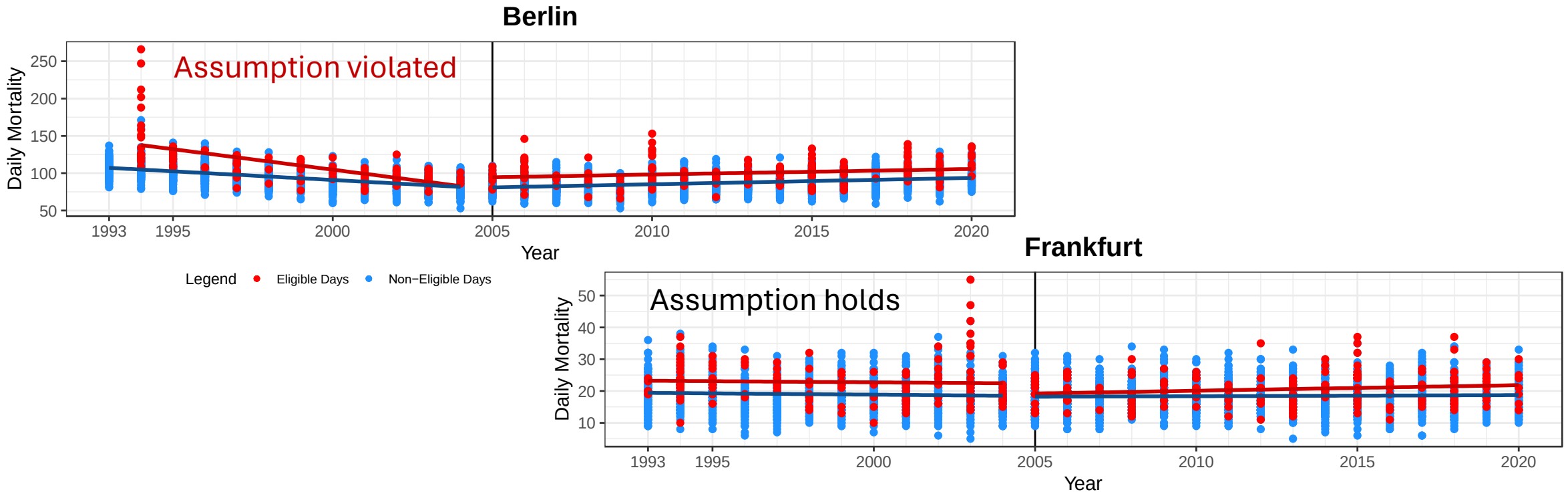
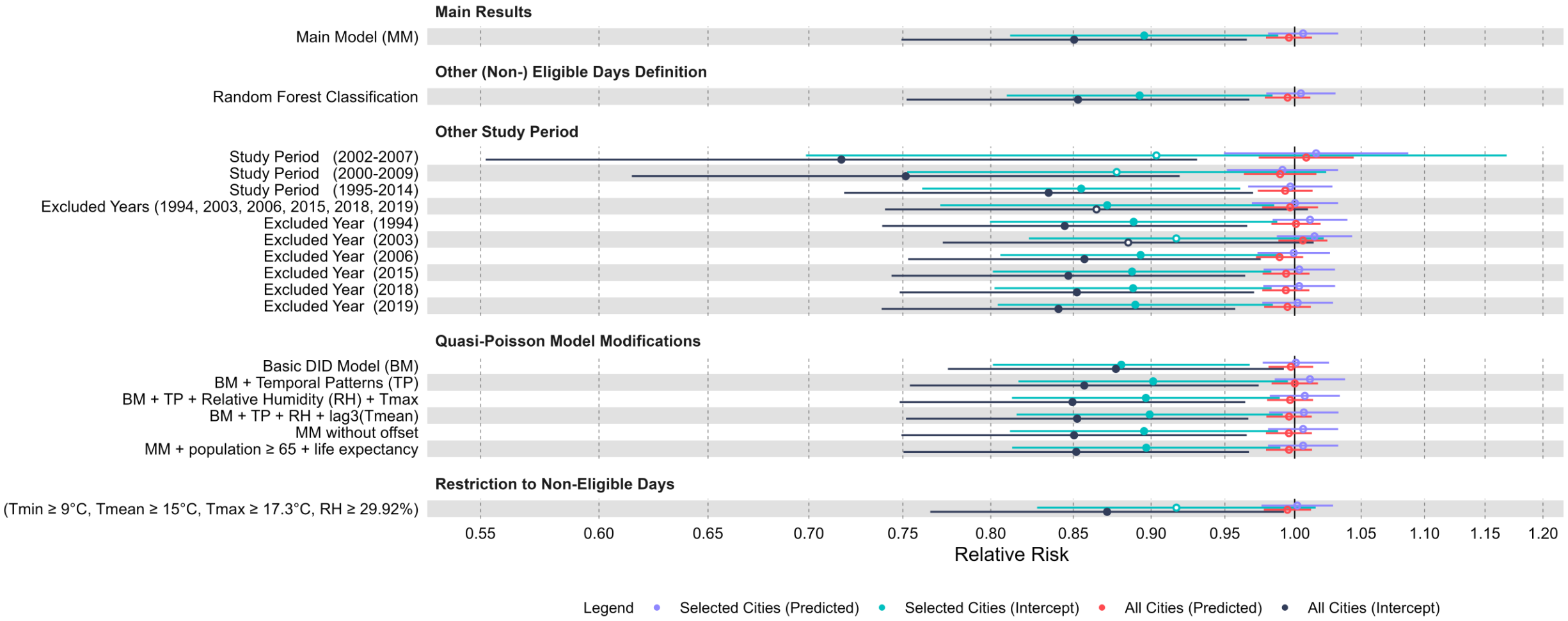
DID parallel trend assumption

- Relevant period: 1993 to 2004 (before implementation of heat alerts)
- Assumption: Parallel trends in the group of „eligible“ and „non-eligible“ days



Scatterplot and linear trendline for daily death counts by city in the pre- and post-intervention periods (before and after the implementation of heat alerts)

Sensitivity analyses



Second-stage mixed-effect meta-regression

Main model:

City-specific DID estimates (β_3) = *socioeconomic, demographic and environmental factors as fixed effects + city-level random effects*

- Stepwise selection of fixed-effect meta-variables based on Akaike Information Criterion (AIC)
- Pooled DID estimates predicted based on city-average of selected meta-variables
- Meta-regression done for all 15 cities („All cities“) and group of 7 cities fullfilling DID parallel trend assumption („Selected cities“)

Feldbusch et al. *in prep.*