A biometric analysis of infant mortality and temperature, northern Sweden 1895-1950

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Abstract

The effect of extreme temperatures on infant mortality in the Umeå and Skellefteå regions 1895-1950 is studied in a biometric analysis setting. More precisely, the effect of climate and weather, measured by temperature, average and extremes, on infant mortality is investigated. It turns out that climate (average) is more important than weather (extremes), low average temperatures are more important than temporary dips in temperature.

Contents

1 Introduction

The impact of ambient temperature variations on infant mortality is studied for a northern Sweden coastal area, the Umeå and Skellefteå regions, during the first half of the twentieth century. Two recent papers (Junkka et al., 2021; Karlsson et al., 2021) studied neonatal mortality and temperature variations in a larger geographical area containing the present one during the years 1880–1950. Climate and mortality in general is a research area that has generated great interest over the last years, see Bengtsson and Broström (2010).

The effect of seasonal variation and the occurrence of extreme monthly temperatures is studied and interacted with sex, social class, and legitimacy. Studies are performed separately for neonatal and postneonatal mortality, and for winter and summer seasons, and the classification into endogenous and exogenous factors will be discussed.

Figure 1 shows the study area within Sweden, with the weather stations marked. The map is taken (with permission) from the paper by Junkka et al. (2021).

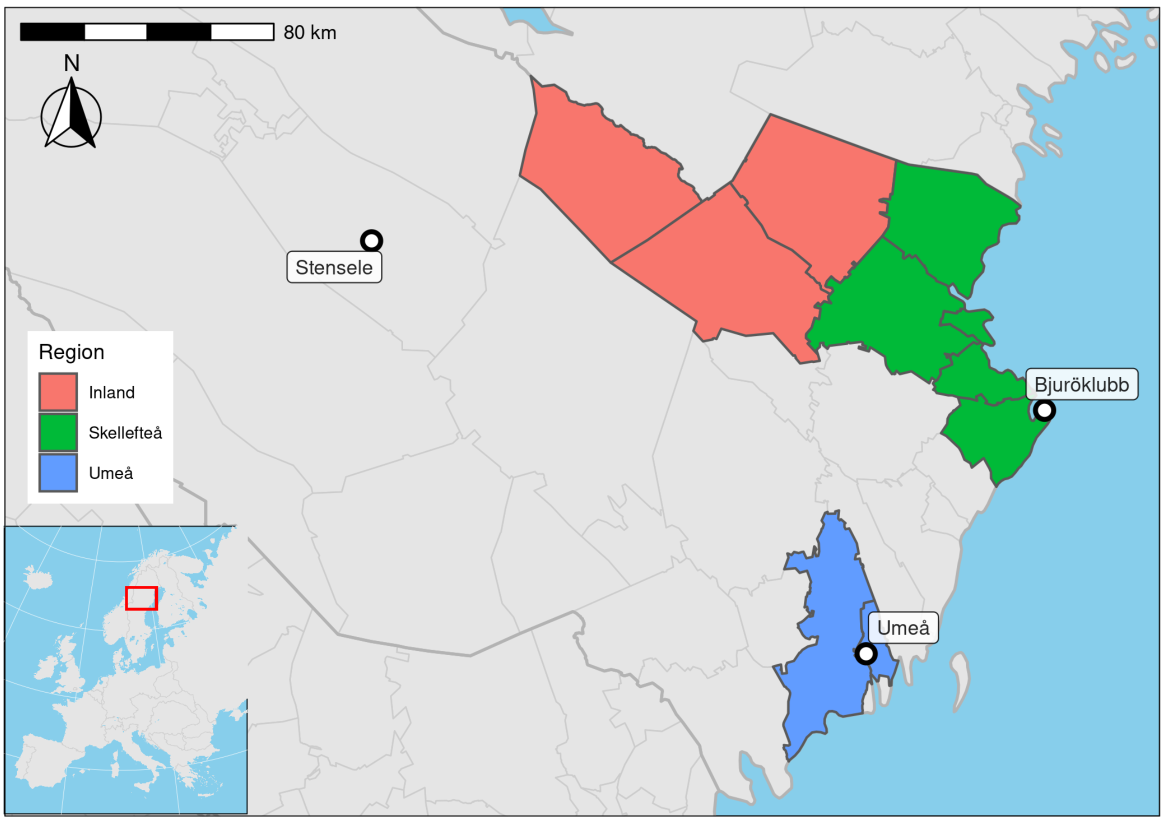

Figure 1: Umeå, Skellefteå (orange) and its inland (green).

2 Data

We have two sources of data which we combine into one data set suitable for our purpose. The first is demographic data obtained from the *Centre for Demographic and Ageing Research* (CEDAR, https://cedar.umu.se), the second is daily temperature measurements obtained from the *Swedish Meteorological and Hydrological Institute* (SMHI, https://www.smhi.se).

2.1 Infant mortality

Individual data with all births between 1 January 1895 and 31 December 1950 in two coastal and one inland areas of north Sweden, Skellefteå (51560 births) and Umeå (31213 births). They were followed until death or age one year, whichever came first. The following *static* characteristics were observed on each child:

birthdate Date of birth.

sex Girl or boy.

exit Number of days under observation.

event Logical, *TRUE* if a death is observed.

socBranch Working branch of father (if any).

socStatus Social status of family, based on HISCLASS.

illeg Mother unmarried?

parity Order among siblings.

Some crude statistics about infant, neonatal, and postneonatal mortality are shown in Figures.

Figure 2 shows the average monthly crude infant mortality, and a clear seasonal pattern is visible.

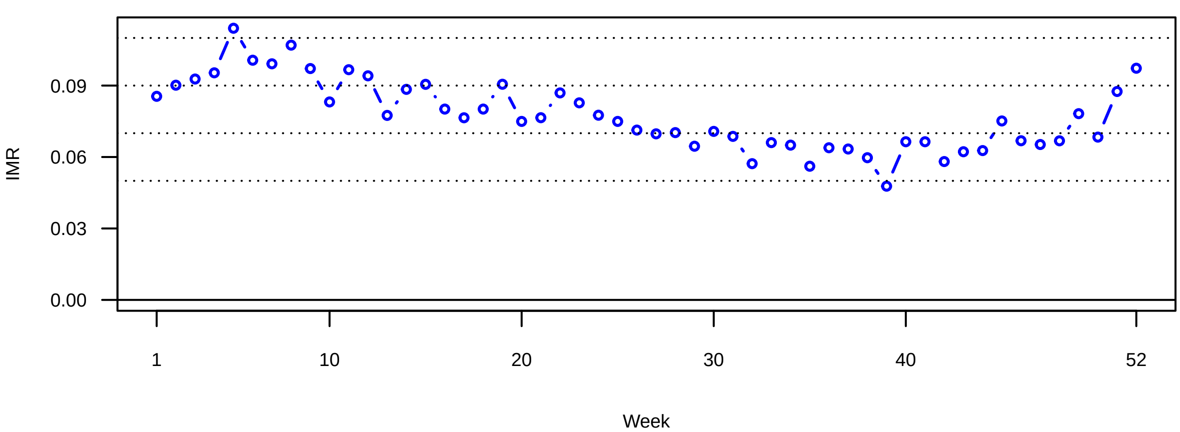

Figure 2: Crude infant mortality by week of year, Umeå/Skellefteå 1895–1950.

The average monthly neonatal mortality is shown in Figure 3.

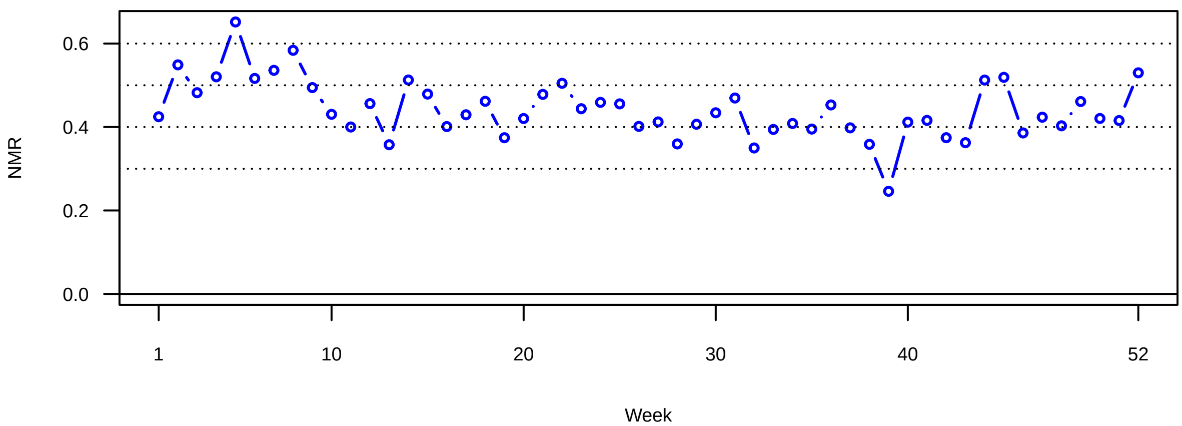

Figure 3: Crude neonatal mortality by week of year, Umeå/Skellefteå 1895–1950.

The seasonal pattern is similar to the one we found above for infant mortality.

The average monthly postneonatal mortality is shown in Figure 4.

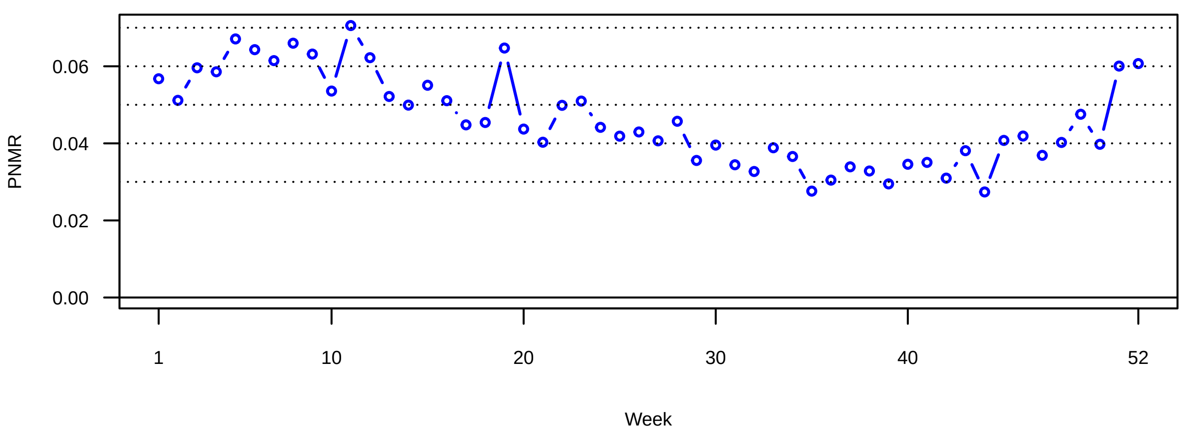

Figure 4: Crude postneonatal mortality by week of year, Umeå/Skellefteå 1895–1950.

The seasonal pattern is once again similar to the one we found for infant mortality. Next, the decline over the years in Figures 5 and 6.

2.2 Temperature

Temperature data are collected from three weather stations, *Umeå*, *Bjuröklubb* (used with population data from Skellefteå coastal area), and *Stensele* (Inland). All stations deliver daily temperature data covering our time period, usually three measures per day, morning, noon, and evening. In Table 1, the Umeå data from the week 1–7 January, 1923 is shown.

There are three measurements per day, or 21 per week. In the forthcoming analyses, the weekly data are summarized in a few measurements, see Table 2.

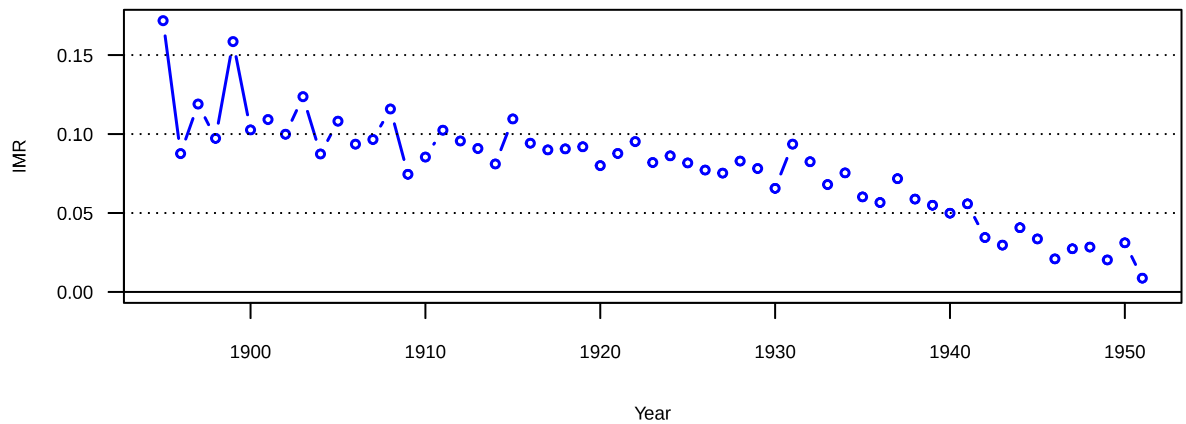

Figure 5: Crude IMR by year, Umeå-Skellefteå 1895–1950.

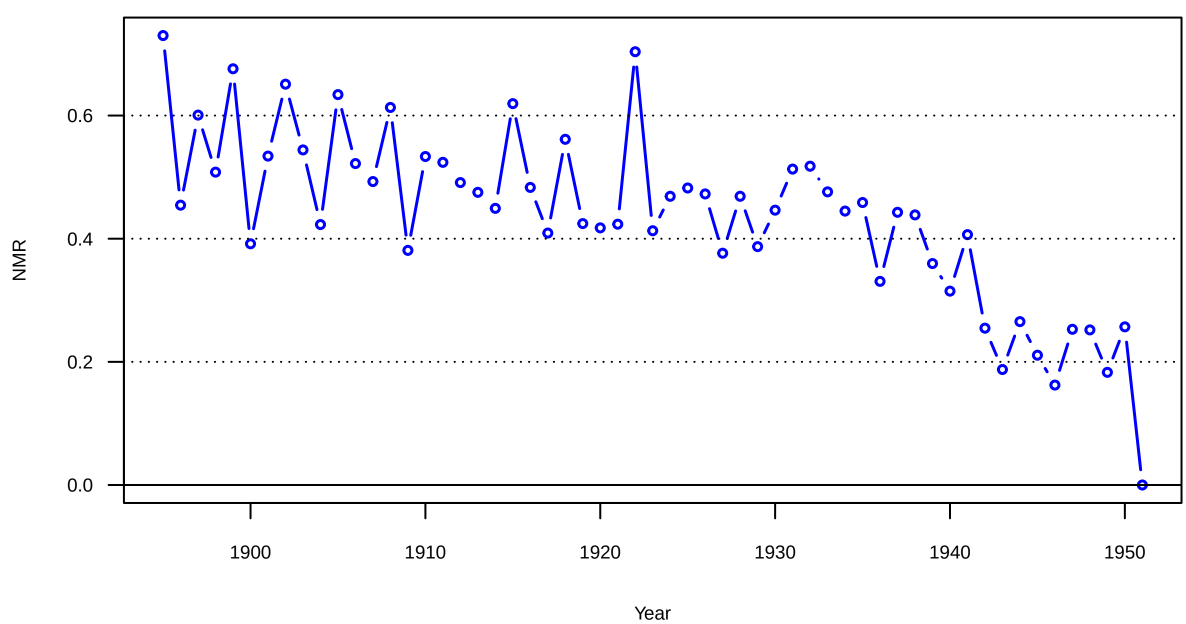

Figure 6: Crude NMR by year, Umeå-Skellefteå 1895–1950.

Table 1: Raw temperature data from first week of 1923, Umeå.

Date	**Time**	**Temperature**	**Quality**
1923-01-01	07:00:00	0.4	G
1923-01-01	13:00:00	0.6	G
1923-01-01	20:00:00	0.0	G
1923-01-02	07:00:00	-1.4	G
1923-01-02	13:00:00	-1.4	G
1923-01-02	20:00:00	-1.2	G
1923-01-03	07:00:00	0.4	G
1923-01-03	13:00:00	0.8	G
1923-01-03	20:00:00	1.2	G
1923-01-04	07:00:00	1.4	G
1923-01-04	13:00:00	1.2	G
1923-01-04	20:00:00	1.0	G
1923-01-05	07:00:00	-1.4	G
1923-01-05	13:00:00	-3.2	G
1923-01-05	20:00:00	-3.4	G
1923-01-06	07:00:00	1.0	G
1923-01-06	13:00:00	0.4	G
1923-01-06	20:00:00	0.4	G
1923-01-07	07:00:00	0.6	G
1923-01-07	13:00:00	0.4	G
1923-01-07	20:00:00	0.4	G

Table 2: Weekly summarized temperature data: Umeå 1923, first week.

week	**year**	**mintemp**	**maxtemp**	**meantemp**	**emintemp**	**emaxtemp**	**emeantemp**
1	1923	-3.4	1.4	-0.1	-17.73	-0.36	-7.54

Weekly averages (`mintemp`, `maxtemp`, `meantemp`) are calculated by week and year, and deviations from the averages (`emintemp`, `emaxtemp`, `emeantemp`) of the weekly averages are used as time-varying *communal covariates*. As an example, see Figure 7, where the variation around the average minimum temperature (`emintemp`) week 1 is shown.

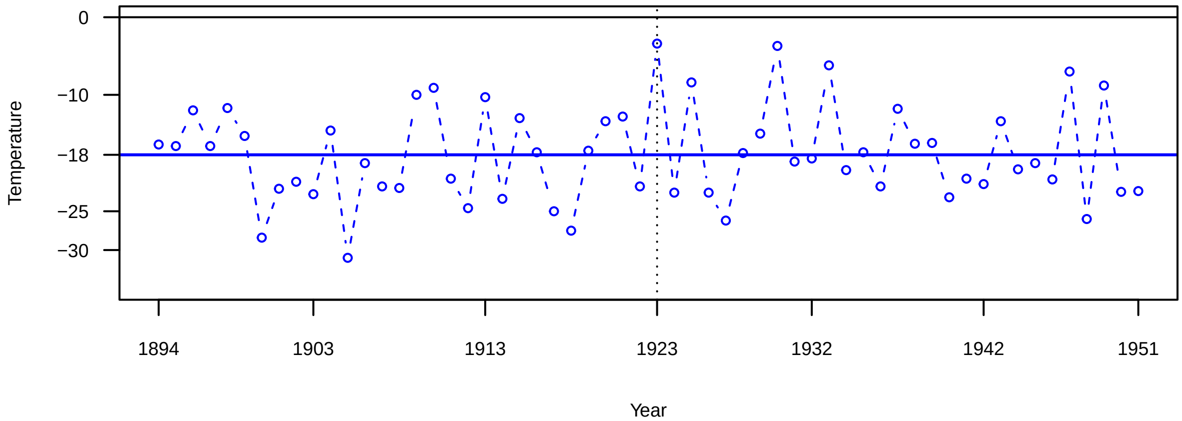

Figure 7: Minimum temperature the first week of each year.

Curiously, our randomly selected year 1923 turns out contain the warmest first week of all years, see Figure 7.

Figure 8 shows the average monthly distribution over all years. The subregional patterns and levels are very similar.

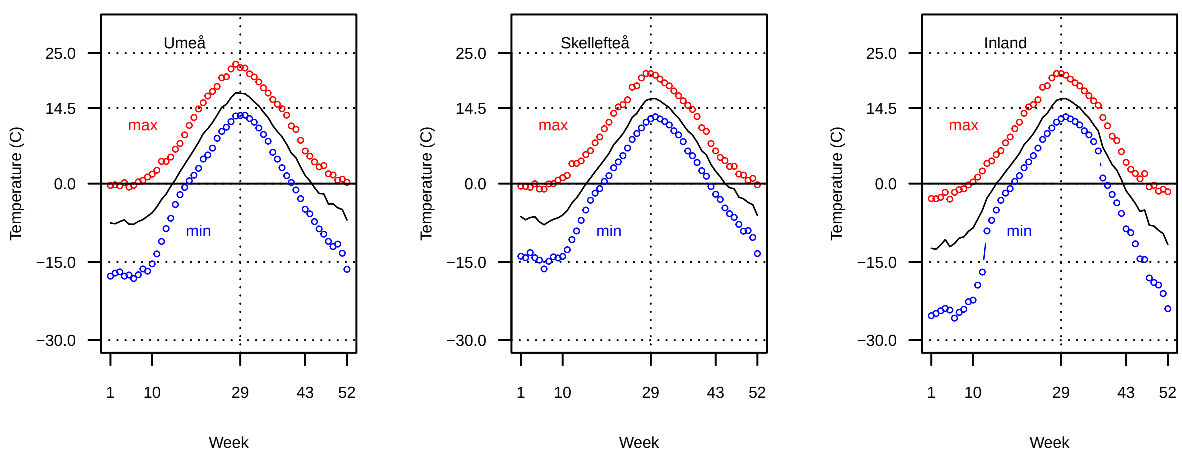

Figure 8: Weekly max, mean, and min temperature averages, 1895–1950.

Time trends of yearly average temperatures, see Figure 9.

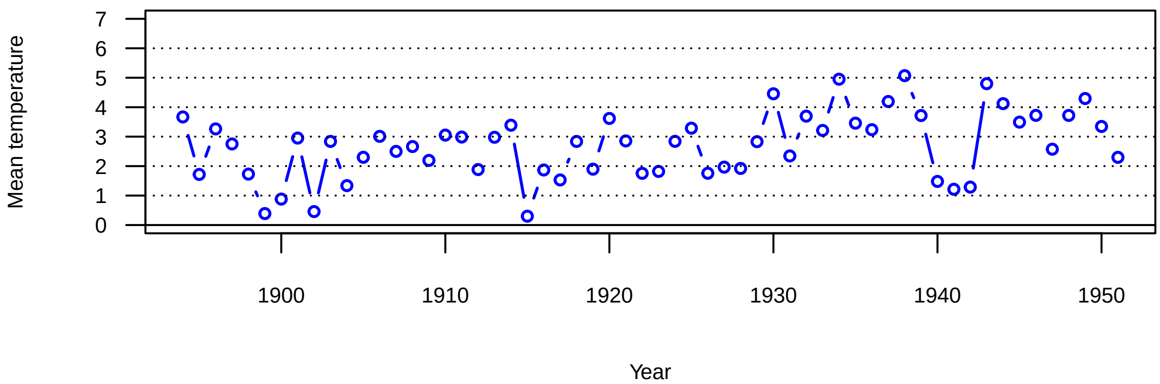

Figure 9: Yearly average temperatures, Umeå and Skellefteå.

Table 3: Data with communal covariates.

enter	exit	event	lowTemp	highTemp	aver	emeantemp	week	year
0.0000000	0.0180327	0	FALSE	FALSE	0	12.584483	35	1900
0.0180327	0.0372634	0	FALSE	FALSE	-4	11.286207	36	1900
0.0372634	0.0564942	0	FALSE	FALSE	-1	10.086207	37	1900
0.0564942	0.0757250	0	FALSE	FALSE	1	6.910345	38	1900
0.0757250	0.0949557	0	FALSE	FALSE	-2	5.315517	39	1900
0.0949557	0.1141865	0	FALSE	FALSE	0	3.610345	40	1900

2.3 Temperature as communal covariates

The two data sets, mortality and weather, are combined into one by treating temperature data as a communal covariate and incorporate it as such in the mortality data set. The function *make.communal* in the **R** (R Core Team, 2021) package *eha* (Broström, 2021a,b) is used for that purpose. Resulting data drame is partly shown in Table 3.

3 Statistical modelling

It turns out that extremely low temperature (`lowTemp`) is bad during all seasons except summer, and extremely high temperature (`highTemp`) is bad during summer, but good otherwise. So we group season into two categories, *summer* and *not summer*. In each case separate analyses for neonatal and postneonatal mortality are performed.

The *summer* half-year is the weeks 14–39, about 1 April to 30 September, and the *winter* half-year is the rest, weeks 1-13 and 40–52, 1 January to 31 March and 1 October to 31 December. This is the division made in Karlsson et al. (2021), and we keep it for comparability reasons.

4 Results

The results regarding neonatal mortality is much in accordance with the results found by Junkka et al. (2021). However, they used temperature in a "hockey-stick" regression with

Table 4: Proportionality tests, neonatal vs. postneonatal.

	Df	AIC	LRT	Pr(>Chi)
<none>	NA	177694.8	NA	NA
strata(ageIvl):aver	1	177692.8	0.0135850	0.9072128
strata(ageIvl):emeantemp	1	177703.1	10.2982469	0.0013316
strata(ageIvl):lowTemp	1	177696.7	3.9232264	0.0476234
strata(ageIvl):highTemp	1	177693.9	1.1024879	0.2937208
strata(ageIvl):socBranch	2	177691.3	0.5485338	0.7601292
strata(ageIvl):socStatus	2	177702.2	11.3863584	0.0033689
strata(ageIvl):sex	1	177692.9	0.0742321	0.7852717
strata(ageIvl):period	2	177772.8	82.0551481	0.0000000

a breakpoint at 14.5 degrees Celsius and a negative slope (decreasing risk) to the left and a positive slope (increasing risk) to the right. Instead, we are using the average weekly temperature for the 52 weeks of a year, for each week averaging over all the years in the study, as our “reference points” (“climate”), adding deviances up and down (“weather”) as “short-term temperature stress”. This is similar to the way prices and mortality were related in for instance Bengtsson and Broström (2011), that is, a time series split into long time trend and short term variation.

We separate the investigation into two parts, *neonatal* and *postneonatal* mortality. But first, a joint analysis.

4.1 Neonatal mortality

The analyses are split into two parts by season, *winter* is one, and *summer* the other. Summer covers the months April to September, and winter the rest of the months.

4.1.1 Winter

This period refers to the months *October to March*. A Cox regression involves as interesting variables *highTemp*, an indicator of temperature at least four degrees above the expected for at least two weeks in a row, *emeantemp* the expected temperature the actual weeek, and *aver* the *excess temperature* the actual week.

4.1.2 Summer

This period refers to the months *April to September*. A Cox regression involves as interesting variables *highTemp*, an indicator of temperature at least four degrees above the expected for at least two weeks in a row, *emeantemp* the expected temperature the actual weeek, and *aver* the *excess temperature* the actual week.

Table 5: Neonatal mortality, October to March. Adjusted for social branch, sex, illegitimacy, parity, time period, and subregion.

Covariate	**Mean**	**Coef**	**H.R.**	**S.E.**	**L-R p**
highTemp					0.124
FALSE	0.913	0	1	(reference)	
TRUE	0.087	−0.153	0.859	0.100	
aver	−0.024	−0.006	0.994	0.006	0.340
emeantemp	−4.140	−0.021	0.979	0.006	0.000
sex					0.000
boy	0.516	0	1	(reference)	
girl	0.484	−0.226	0.798	0.048	
subreg					0.237
ume	0.296	0	1	(reference)	
ske	0.487	0.064	1.066	0.056	
inland	0.217	−0.036	0.965	0.072	
illeg	0.053	0.428	1.534	0.093	0.000
parity					0.000
1	0.260	0	1	(reference)	
2-4	0.455	−0.273	0.761	0.061	
5+	0.285	0.007	1.007	0.065	
socBranch					0.167
office	0.057	0	1	(reference)	
farming	0.471	0.165	1.180	0.114	
worker	0.472	0.204	1.226	0.113	
period					0.000
(1895,1914]	0.354	0	1	(reference)	
(1914,1935]	0.372	−0.089	0.915	0.052	
(1935,1951]	0.275	−0.610	0.543	0.070	
Events	1806	TTR	3899		
Max. logLik.	−19480				

4.2 Postneonatal mortality

4.2.1 Winter

The result in Table 7 shows that *climate* (`emintemp`) is more important than *weather* (`excessTemp`). Moreover, no signs of interaction between weather or climate and the rest of covariates (not shown).

4.2.2 Summer

The result in Table 8 shows that *climate* (`emintemp`) is more important than *weather* (`excessTemp`). Moreover, no signs of interaction between weather or climate and the rest of covariates (not shown).

5 Conclusion

Remains to be written, especially the discussion about temperature and mortality.

Table 6: Neonatal mortality, April to September. Adjusted for social branch, sex, illegitimacy, parity, time period, and subregion.

Covariate	**Mean**	**Coef**	**H.R.**	**S.E.**	**L-R p**
aver	0.007	0.003	1.003	0.008	0.697
emeantemp	9.951	−0.014	0.986	0.003	0.000
sex					0.000
boy	0.512	0	1	(reference)	
girl	0.488	−0.189	0.828	0.034	
subreg					0.001
ume	0.294	0	1	(reference)	
ske	0.487	−0.125	0.883	0.039	
inland	0.219	−0.152	0.859	0.048	
socBranch					0.402
office	0.059	0	1	(reference)	
farming	0.464	−0.046	0.955	0.073	
worker	0.477	−0.081	0.922	0.072	
period					0.000
(1895,1914]	0.339	0	1	(reference)	
(1914,1935]	0.370	−0.211	0.810	0.037	
(1935,1951]	0.291	−0.857	0.424	0.050	
Events	3603	TTR	49984		
Max. logLik.	−9767				

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Table 7: Postneonatal mortality, October to March. Adjusted for social branch, sex, illegitimacy, parity, time period, and subregion.

Covariate	**Mean**	**Coef**	**H.R.**	**S.E.**	**L-R p**
lowTemp					0.001
FALSE	0.861	0	1	(reference)	
TRUE	0.139	0.214	1.239	*NA*	
highTemp					0.314
FALSE	0.912	0	1	(reference)	
TRUE	0.088	−0.086	0.917	*NA*	
aver	0.016	−0.002	0.998	*NA*	0.794
emeantemp	−4.153	−0.051	0.950	*NA*	0.000
sex					0.000
boy	0.511	0	1	(reference)	
girl	0.489	−0.242	0.785	*NA*	
socBranch					0.031
office	0.059	0	1	(reference)	
farming	0.464	0.066	1.068	*NA*	
worker	0.477	0.168	1.183	*NA*	
parity					0.000
1	0.266	0	1	(reference)	
2-4	0.454	0.086	1.090	*NA*	
5+	0.279	0.346	1.413	*NA*	
subreg					0.000
ume	0.294	0	1	(reference)	
ske	0.487	−0.282	0.754	*NA*	
inland	0.219	−0.372	0.689	*NA*	
period					0.000
(1895,1914]	0.338	0	1	(reference)	
(1914,1935]	0.370	−0.163	0.849	*NA*	
(1935,1951]	0.292	−1.164	0.312	*NA*	
summer					1.000
FALSE	1.000	0	1	(reference)	
NA	*NA*	0.000	1.000	*NA*	
FALSE	1.000	*NA*	*NA*	*NA*	
Events	2346	TTR	46214		
Max. logLik.	−8783				

Table 8: Postneonatal mortality, April to September. Adjusted for social branch, sex, illegitimacy, parity, time period, and subregion.

Covariate	**Mean**	**Coef**	**H.R.**	**S.E.**	**L-R p**
lowTemp					0.746
FALSE	0.988	0	1	(reference)	
TRUE	0.012	−0.061	0.941	0.191	
highTemp					0.086
FALSE	0.985	0	1	(reference)	
TRUE	0.015	0.330	1.392	0.185	
aver	0.006	−0.003	0.997	0.011	0.767
emeantemp	9.963	−0.020	0.980	0.004	0.000
sex					0.000
boy	0.512	0	1	(reference)	
girl	0.488	−0.168	0.846	0.046	
socBranch					0.526
office	0.059	0	1	(reference)	
farming	0.464	−0.040	0.961	0.104	
worker	0.476	0.016	1.016	0.103	
parity					0.000
1	0.266	0	1	(reference)	
2-4	0.455	0.032	1.032	0.062	
5+	0.279	0.313	1.368	0.064	
subreg					0.000
ume	0.294	0	1	(reference)	
ske	0.487	−0.322	0.725	0.052	
inland	0.219	−0.339	0.712	0.066	
period					0.000
(1895,1914]	0.340	0	1	(reference)	
(1914,1935]	0.370	−0.247	0.781	0.050	
(1935,1951]	0.291	−1.096	0.334	0.076	
Events	1914	TTR	45958		
Max. logLik.	−7669				