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

Göran Broström and Tommy Bengtsson

2022-02-09 12:01:35

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).

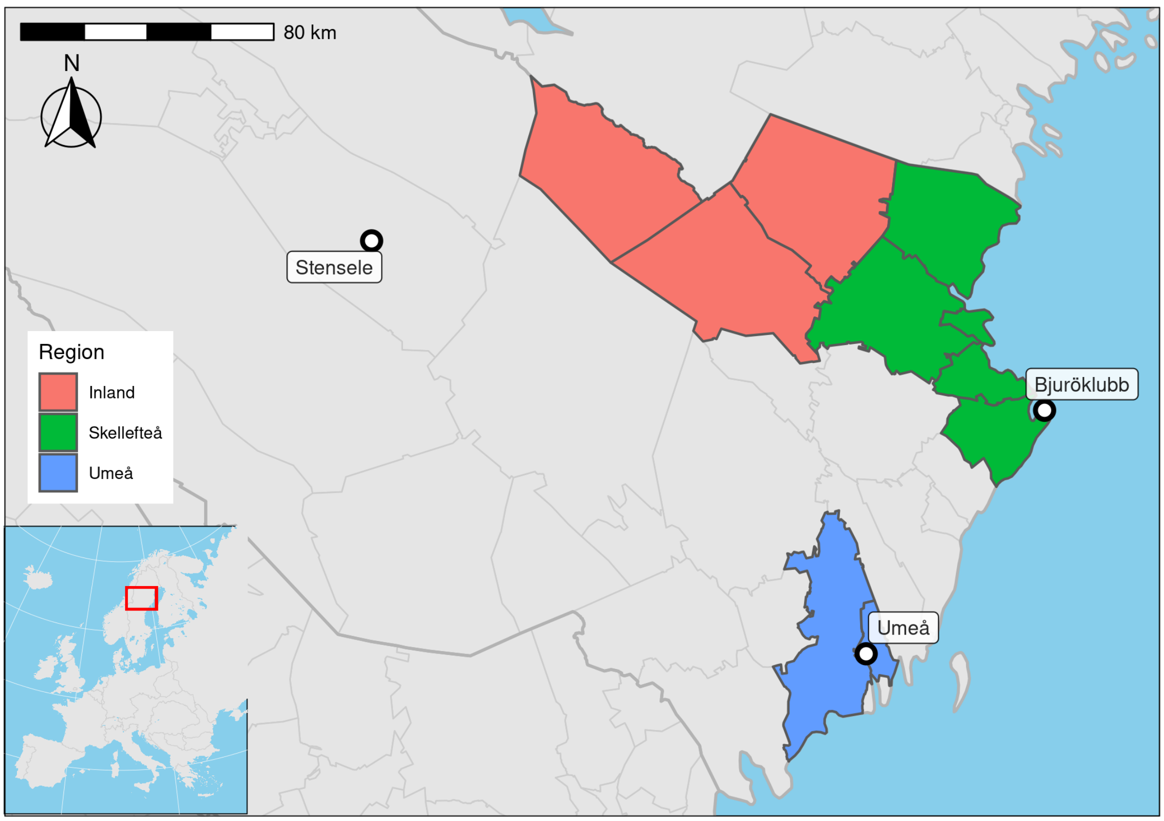

Figure 1: Umeå, Skellefteå (orange) and its inland (green).

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.

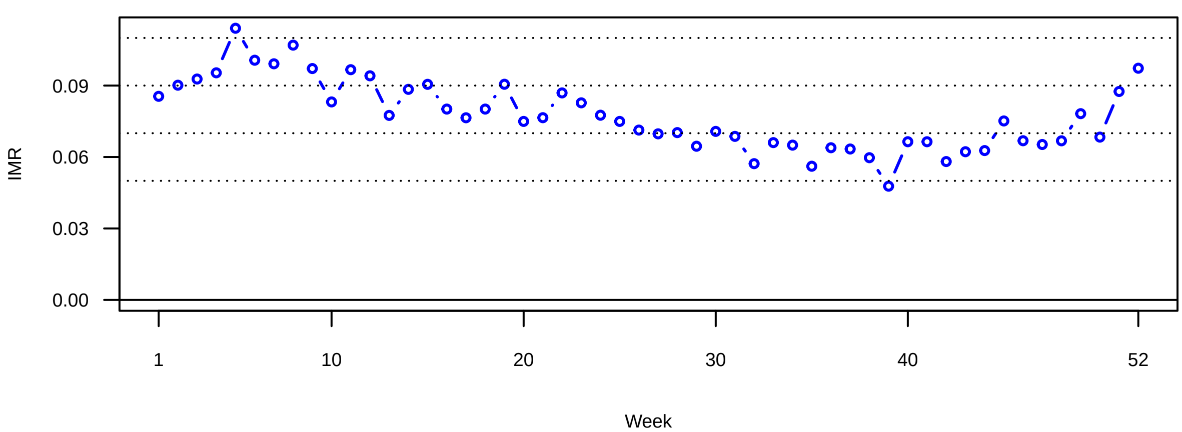

Figure 2: Crude infant mortality by week of year, Umeå/Skellefteå 1895–1950.

The average monthly neonatal mortality is shown in Figure 3.

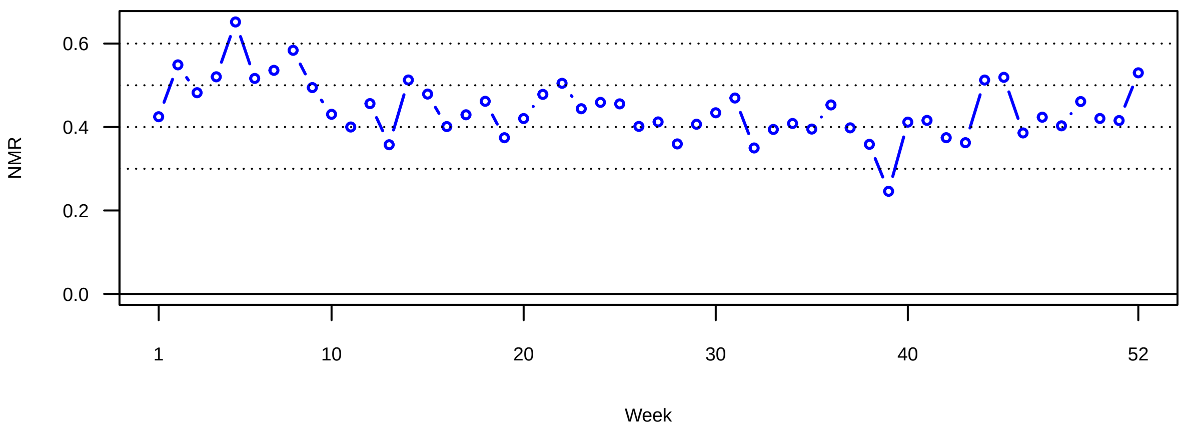

Figure 3: Crude neonatal mortality by week of year, Umeå/Skellefteå 1895–1950.

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

The average monthly postneonatal mortality is shown in Figure 4.

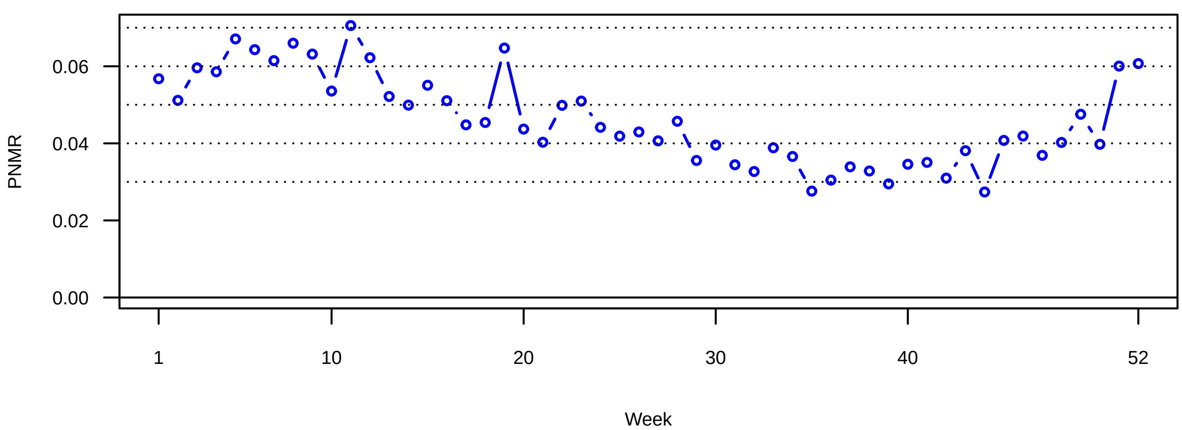

Figure 4: Crude postneonatal mortality by week of year, Umeå/Skellefteå 1895–1950.

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.

[Table 1 about here.]

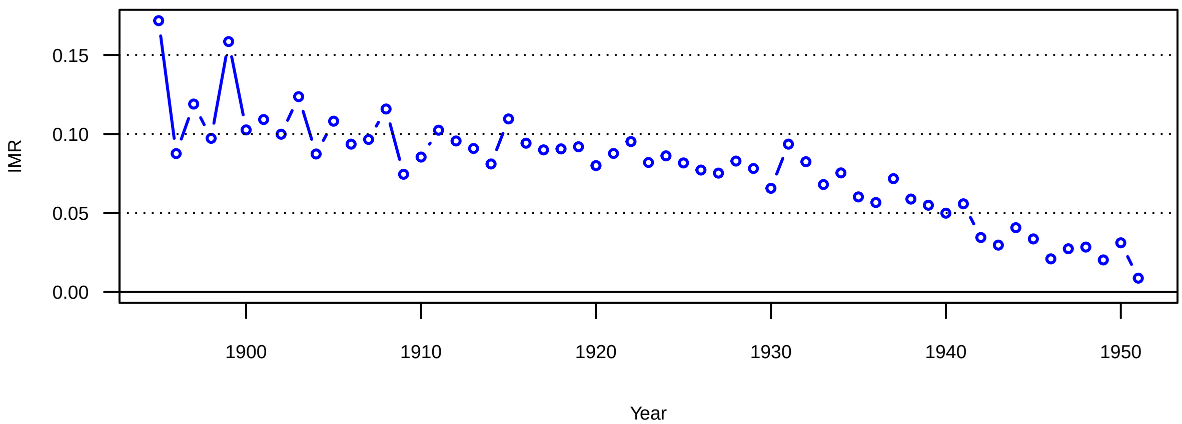

Figure 5: Crude IMR by year, Umeå-Skellefteå 1895–1950.

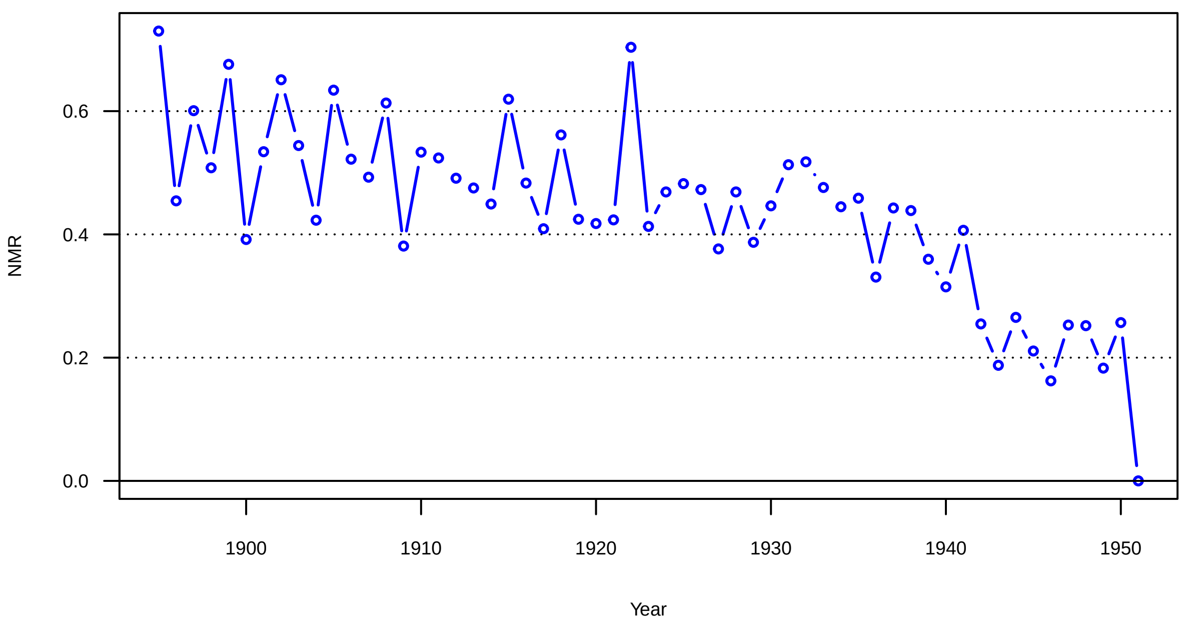

Figure 6: Crude NMR by year, Umeå-Skellefteå 1895–1950.

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.

[Table 2 about here.]

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.

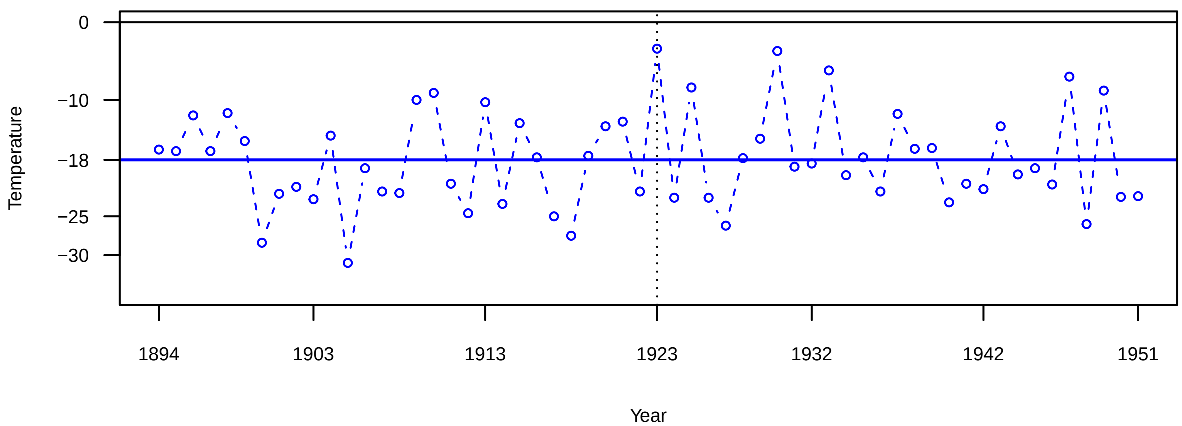

Figure 7: Minimum temperature the first week of each year.

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.

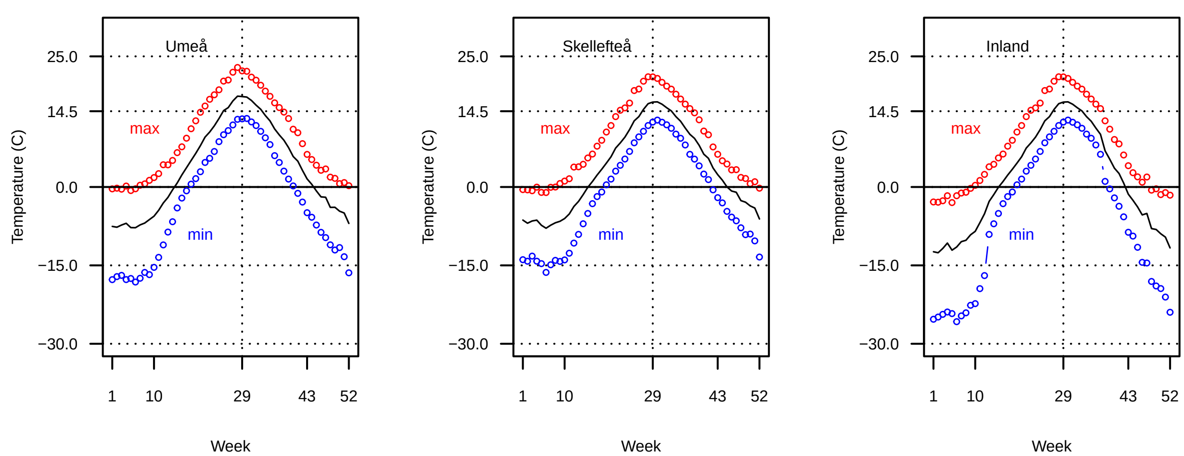

Figure 8: Weekly max, mean, and min temperature averages, 1895–1950.

Time trends of yearly average temperatures, see Figure 9.

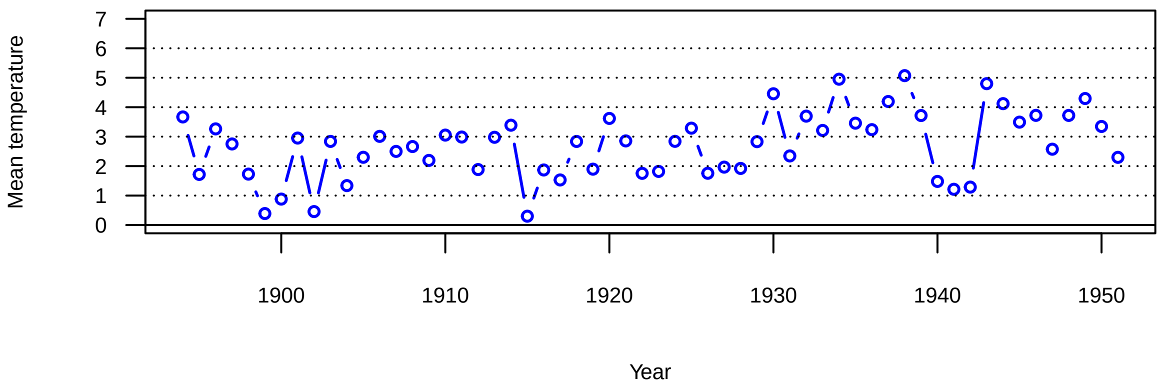

Figure 9: Yearly average temperatures, Umeå and Skellefteå.

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.

[Table 3 about here.]

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 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.

Comments on other candidate covariates:

Birth month is left out in the analyses despite that fact that it is an important factor in neonatal mortality. However, we include *time of year* in terms of *winter* and *summer* as a time-varying covariate, and in the neonatal case it will coincide to a great extent with birth period. For the postneonal case the situation is different, but it turns out that for those infants who have survived the first month of life, birth month does not matter much. We separate the investigation into two parts, *neonatal* and *postneonatal* mortality. But first, a joint analysis.

Socioeconomic status is divided into two factor covariates: *socBranch* and *socStatus*. The latter should be seen relative to actual *socBranch*. We have information on whether the infant was *illegitimate* (mother unmarried), but we incorporate those cases in the category *none* of *socBranch* and *unknown* as category of *socStatus*.

[Table 4 about here.]

From Table 4 we can see that the variables *emeantemp*, *lowTemp*, *socStatus* and *period* all have different effects on mortality in the neonatal case compared to the postneonatal case. In terms of *infant mortality*, we can say that these caovariates have non-proportional effects. As an example, see Figure

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 *extemp* the *excess temperature* the actual week.

[Table 5 about here.]

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 *extemp* the *excess temperature* the actual week.

[Table 6 about here.]

4.2 Postneonatal mortality

4.2.1 Winter

[Table 7 about here.]

The result in Table 7 shows that the temperature effects vary with time period, so we continue with seaparate analyses for the time periods (1895,1914], (1914,1935], (1935,1951].

4.2.1.1 The time period 1895–1913

[Table 8 about here.]

Table 8 shows that

4.2.1.2 The time period 1914–1934

[Table 9 about here.]

Table 9 shows that

4.2.1.3 The time period 1935–1950

[Table 10 about here.]

Table 10 shows that

4.2.2 Summer

[Table 11 about here.]

The result in Table 11 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.

References

Bengtsson, T. and Broström, G. (2010). Mortality crisis in rural southern Sweden 1766–1860. In Kurosu, T., Bengtsson, T., and Campbell, C., editors, *Demographic Response to Economic and Environmental Crisis*, pages 1–16. Reitaku University Press, Kashiwa.

Bengtsson, T. and Broström, G. (2011). Famines and mortality crises in 18th to 19th century southern Sweden. *Genus*, 67:119–139.

Broström, G. (2021a). *eha: Event History Analysis*. R package version 2.9.0. https://CRAN.R-project.org/package=eha.

Broström, G. (2021b). *Event History Analysis with R, Second Edition*. Chapman & Hall/CRC, Boca Raton.

Junkka, J., Karlsson, L., Lundevaller, E., and Schumann, B. (2021). Climate vulnerability of Swedish newborns: Gender differences and time trends of temperature-related neonatal mortality, 1880–1950. *Environmental Research*, 192. article id 110400.

Karlsson, L., Junkka, J., Schumann, B., and Häggström Lundevaller, E. (2021). Socioeconomic disparities in climate vulnerability: neonatal mortality in northern Sweden, 1880–1950. *Population and Environment*, 10.1007.

R Core Team (2021). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org.

List of Tables

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

Table 3: Data with communal covariates.

enter	**exit**	**event**	**lowTemp**	**highTemp**	**extemp**	**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

Table 4: Proportionality tests, neonatal vs. postneonatal.

	Df	AIC	LRT	Pr(>Chi)
<none>	NA	41728.47	NA	NA
strata(ageIvl):extemp	1	41726.48	0.0108	0.9172
strata(ageIvl):emeantemp	1	41736.89	10.4285	0.0012
strata(ageIvl):lowTemp	1	41730.27	3.8069	0.0510
strata(ageIvl):highTemp	1	41727.54	1.0695	0.3010
strata(ageIvl):socBranch	3	41736.33	13.8624	0.0031
strata(ageIvl):period	2	41803.82	79.3497	0.0000

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
lowTemp					0.647
FALSE	0.860	0	1	(reference)	
TRUE	0.140	0.035	1.036	0.077	
highTemp					0.120
FALSE	0.913	0	1	(reference)	
TRUE	0.087	−0.154	0.857	0.101	
extemp	−0.024	−0.004	0.996	0.007	0.565
emeantemp	−4.140	−0.021	0.979	0.006	0.000
socBranch					0.450
office	0.105	0	1	(reference)	
farming	0.471	0.068	1.071	0.091	
none	0.024	0.111	1.118	0.168	
worker	0.400	0.127	1.136	0.090	
period					0.000
(1895,1914]	0.354	0	1	(reference)	
(1914,1935]	0.372	−0.084	0.919	0.052	
(1935,1951]	0.275	−0.617	0.539	0.070	
subreg					0.277
ume	0.296	0	1	(reference)	
ske	0.487	0.057	1.059	0.056	
inland	0.217	−0.040	0.961	0.072	
sex					0.000
boy	0.516	0	1	(reference)	
girl	0.484	−0.228	0.796	0.048	
parity					0.000
1	0.260	0	1	(reference)	
2-4	0.455	−0.332	0.718	0.059	
5+	0.285	−0.061	0.941	0.063	
Events	1806	TTR	3899		
Max. logLik.	−2171				

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**
lowTemp					0.450
FALSE	0.988	0	1	(reference)	
TRUE	0.012	−0.171	0.843	0.231	
highTemp					0.758
FALSE	0.984	0	1	(reference)	
TRUE	0.016	0.064	1.066	0.206	
extemp	0.022	0.002	1.002	0.012	0.877
emeantemp	9.817	−0.007	0.993	0.005	0.134
socBranch					0.016
office	0.107	0	1	(reference)	
farming	0.460	0.229	1.258	0.096	
none	0.026	0.452	1.572	0.157	
worker	0.407	0.160	1.173	0.095	
period					0.000
(1895,1914]	0.333	0	1	(reference)	
(1914,1935]	0.370	−0.139	0.870	0.055	
(1935,1951]	0.297	−0.547	0.578	0.071	
subreg					0.366
ume	0.295	0	1	(reference)	
ske	0.485	0.081	1.085	0.059	
inland	0.220	0.039	1.040	0.071	
sex					0.000
boy	0.511	0	1	(reference)	
girl	0.489	−0.217	0.805	0.049	
parity					0.000
1	0.269	0	1	(reference)	
2-4	0.451	−0.264	0.768	0.060	
5+	0.280	−0.100	0.905	0.066	
Events	1689	TTR	4026		
Max. logLik.	−2026				

Table 7: Interaction tests with temperature and period, postneonatal mortality.

	Df	**AIC**	**LRT**	**Pr(>Chi)**
<none>	NA	17724.60	NA	NA
period:lowTemp	2	17724.79	4.1885	0.1232
period:highTemp	2	17722.23	1.6298	0.4427
period:extemp	2	17724.66	4.0604	0.1313
period:emeantemp	2	17721.49	0.8902	0.6407

Table 8: Postneonatal mortality, October to March 1895-1914. Adjusted for social branch, sex, illegitimacy, parity, and subregion.

Covariate	**Mean**	**Coef**	**H.R.**	**S.E.**	**L-R p**
lowTemp					0.351
FALSE	0.836	0	1	(reference)	
TRUE	0.164	0.085	1.088	0.091	
highTemp					0.106
FALSE	0.944	0	1	(reference)	
TRUE	0.056	−0.245	0.783	0.156	
extemp	−0.273	−0.015	0.985	0.009	0.085
emeantemp	−4.154	−0.051	0.950	0.008	0.000
socStatus					0.076
high	0.638	0	1	(reference)	
low	0.362	0.111	1.117	0.062	
subreg					0.000
ume	0.305	0	1	(reference)	
ske	0.476	−0.381	0.683	0.067	
inland	0.218	−0.528	0.590	0.088	
sex					0.000
boy	0.514	0	1	(reference)	
girl	0.486	−0.271	0.762	0.061	
parity					0.000
1	0.187	0	1	(reference)	
2-4	0.423	−0.022	0.978	0.086	
5+	0.390	0.235	1.265	0.085	
Events	1111	TTR	15642		
Max. logLik.	−3891				

Table 9: Postneonatal mortality, October to March 1914-1934. Adjusted for social branch, sex, illegitimacy, parity, and subregion.

Covariate	**Mean**	**Coef**	**H.R.**	**S.E.**	**L-R p**
lowTemp					0.002
FALSE	0.867	0	1	(reference)	
TRUE	0.133	0.323	1.381	0.100	
highTemp					0.534
FALSE	0.908	0	1	(reference)	
TRUE	0.092	−0.077	0.926	0.125	
extemp	−0.020	0.009	1.009	0.009	0.333
emeantemp	−4.170	−0.053	0.949	0.009	0.000
socStatus					0.000
high	0.600	0	1	(reference)	
low	0.400	0.246	1.279	0.066	
subreg					0.000
ume	0.265	0	1	(reference)	
ske	0.508	−0.275	0.760	0.075	
inland	0.227	−0.380	0.684	0.094	
sex					0.000
boy	0.506	0	1	(reference)	
girl	0.494	−0.232	0.793	0.065	
parity					0.000
1	0.254	0	1	(reference)	
2-4	0.445	0.232	1.261	0.086	
5+	0.301	0.458	1.582	0.090	
Events	967	TTR	17087		
Max. logLik.	−3592				

Table 10: Postneonatal mortality, October to March 1935-1950. Adjusted for social branch, sex, illegitimacy, parity, and subregion.

Covariate	**Mean**	**Coef**	**H.R.**	**S.E.**	**L-R p**
lowTemp					0.054
FALSE	0.883	0	1	(reference)	
TRUE	0.117	0.406	1.501	0.207	
highTemp					0.734
FALSE	0.881	0	1	(reference)	
TRUE	0.119	0.070	1.073	0.206	
extemp	0.397	0.013	1.013	0.018	0.481
emeantemp	−4.129	−0.050	0.951	0.017	0.002
socStatus					0.558
high	0.508	0	1	(reference)	
low	0.492	0.072	1.075	0.124	
subreg					0.587
ume	0.318	0	1	(reference)	
ske	0.473	0.071	1.073	0.150	
inland	0.210	0.182	1.199	0.176	
sex					0.153
boy	0.516	0	1	(reference)	
girl	0.484	−0.176	0.839	0.123	
parity					0.003
1	0.375	0	1	(reference)	
2-4	0.502	0.009	1.009	0.139	
5+	0.123	0.555	1.743	0.175	
Events	268	TTR	13484		
Max. logLik.	−1272				

Table 11: 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					0.750
FALSE	0.988	0	1	(reference)	
TRUE	0.012	−0.060	0.942	0.191	
highTemp					0.088
FALSE	0.985	0	1	(reference)	
TRUE	0.015	0.329	1.389	0.185	
extemp	0.006	−0.003	0.997	0.011	0.792
emeantemp	9.963	−0.020	0.980	0.004	0.000
socBranch					0.000
office	0.107	0	1	(reference)	
farming	0.464	0.366	1.441	0.099	
none	0.025	0.449	1.567	0.171	
worker	0.403	0.490	1.633	0.098	
period					0.000
(1895,1914]	0.340	0	1	(reference)	
(1914,1935]	0.370	−0.234	0.791	0.050	
(1935,1951]	0.291	−1.066	0.344	0.076	
subreg					0.000
ume	0.294	0	1	(reference)	
ske	0.487	−0.350	0.705	0.052	
inland	0.219	−0.360	0.698	0.066	
parity					0.000
1	0.266	0	1	(reference)	
2-4	0.455	0.035	1.036	0.062	
5+	0.279	0.311	1.365	0.065	
sex					0.000
boy	0.512	0	1	(reference)	
girl	0.488	−0.168	0.846	0.046	
Events	1914	TTR	45958		
Max. logLik.	−7655				