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 region 1895-1950 is studied in a biometric analysis setting. More precisely, the effect of climate and weather, measured by temperature, on infant mortality is investigated. It turns out that climate is more important than weather, low average temperatures are more important than temporary dips in temperature. The investigated geographical region is situated too far north for bad effects of high temperatures to show.

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.

One important reason for studying neonatal and postneonatal mortality separately is the empirical findings by Bourgeois-Pichat (Bourgeouis-Pichat, 1951a,b) about endogenous and exogenous mortality and the log-cube transform.

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 areas of north Sweden, Skellefteå (51560 births) and Umeå (31213 births). They were followed until death or age 365 days, 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 1 shows the average monthly crude infant mortality, and a clear seasonal pattern is visible.

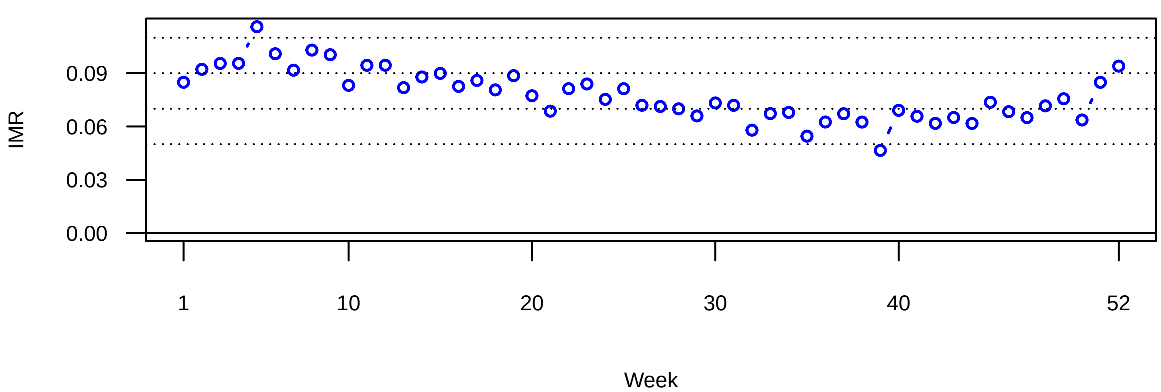

Figure 1: Crude infant mortality by week of year, Umeå/Skellefteå 1895–1950.

The average monthly neonatal mortality is shown in Figure 2.

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

The average monthly postneonatal mortality is shown in Figure 3.

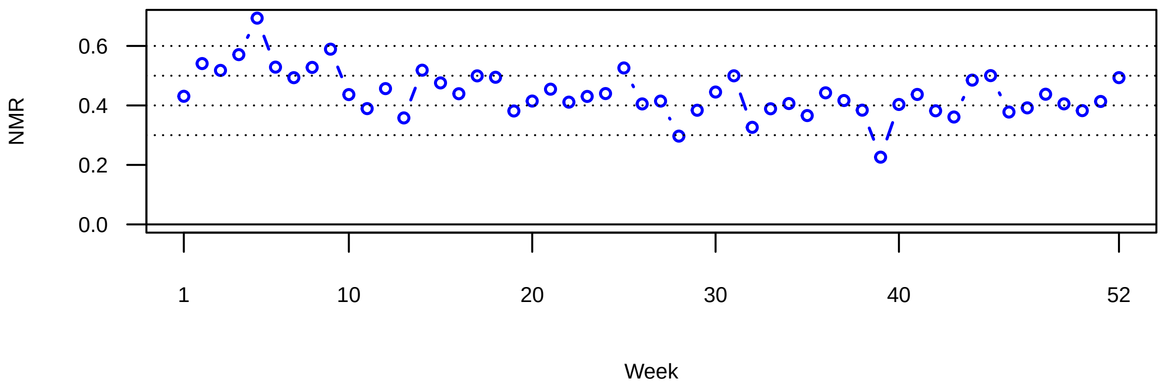

Figure 2: Crude neonatal mortality by week of year, Umeå/Skellefteå 1895–1950.

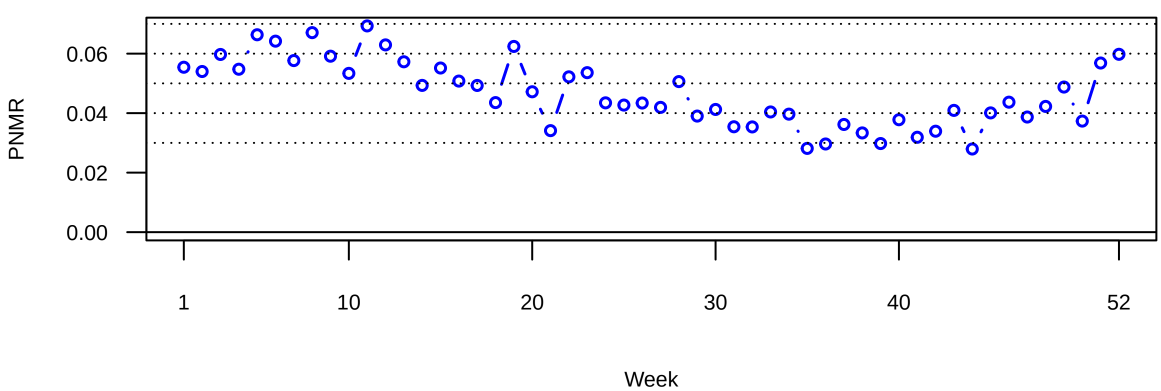

Figure 3: Crude postneonatal mortality by week of year, Umeå/Skellefteå 1895–1950.

The seasonal pattern is once again similar to the one we found for infant mortality. Next, the decline over the years in Figures 4 and 5.

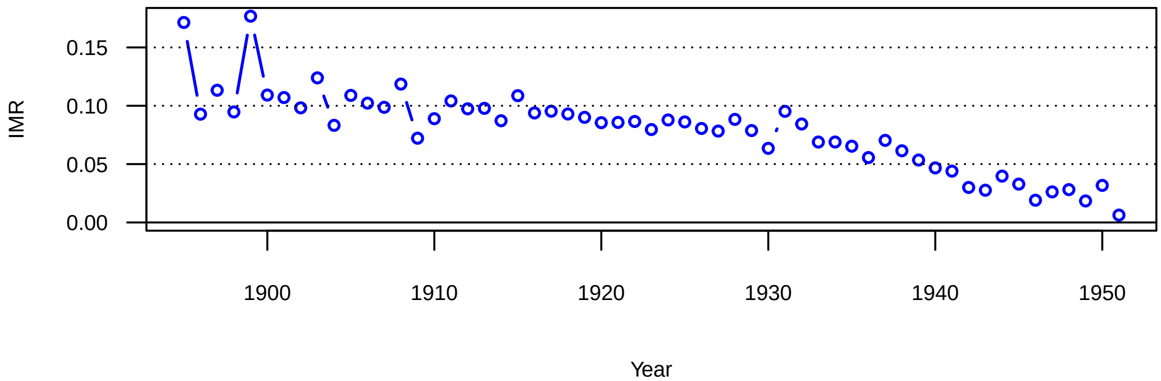

Figure 4: Crude IMR by year, Umeå-Skellefteå 1895–1950.

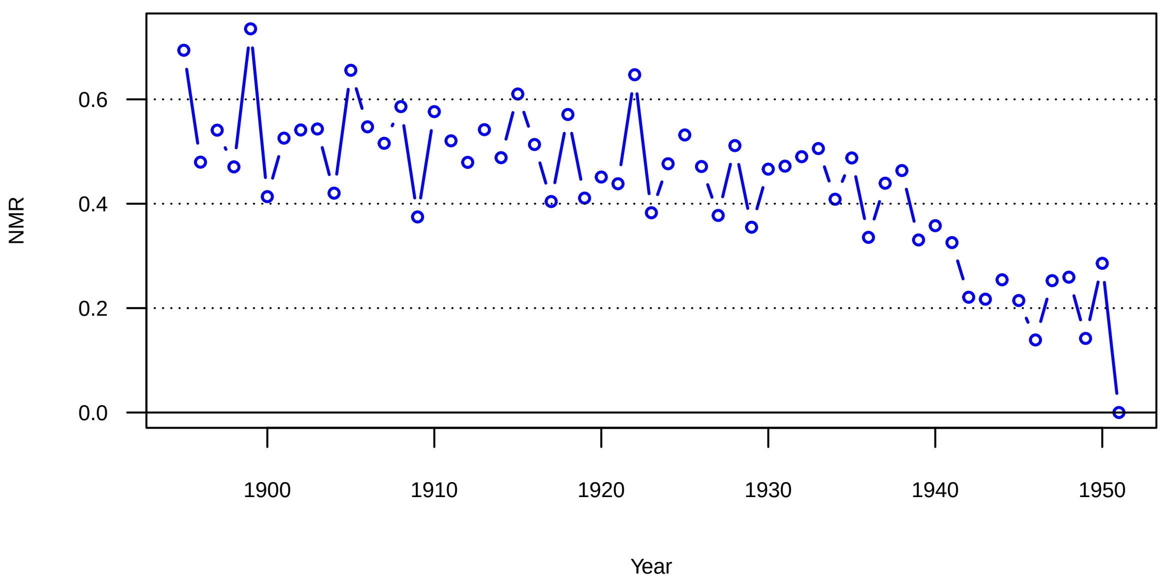

Figure 5: Crude NMR by year, Umeå-Skellefteå 1895–1950.

2.2 Temperature

Temperature data are collected from two weather stations, *Umeå* and *Bjuröklubb* (used with population data from Skellefteå coastal area). Both 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.

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

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

time-varying *communal covariates*. As an example, see Figure 6, where the variation around the average minimum temperature (`emintemp`) week 1 is shown.

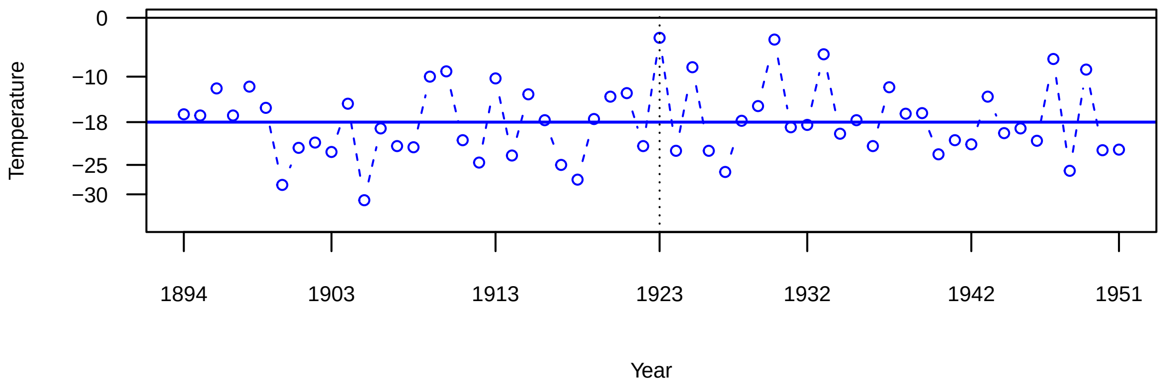

Figure 6: Minimum temperature the first week of each year.

Curiously, our randomly selected year 1923 turns out contain the warmest first week of all years, see Figure 6.

Figure 7 shows the average monthly distribution over all years. The subregional patterns and levels are very similar.

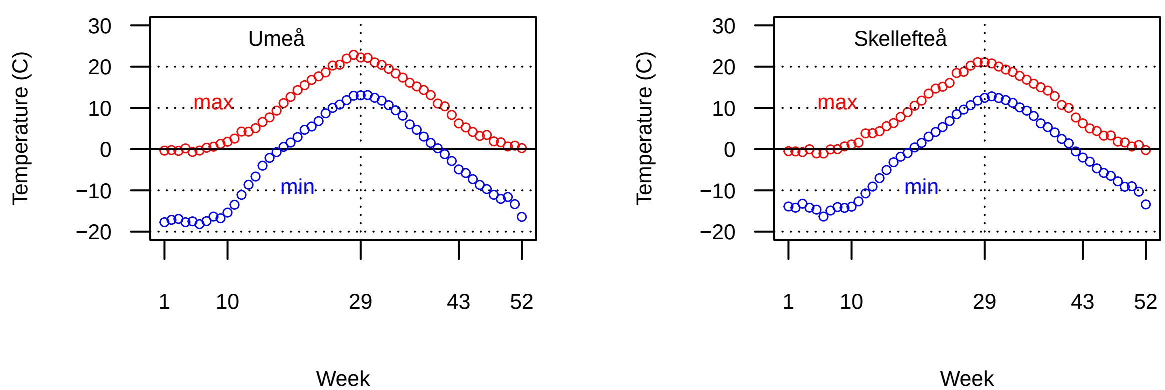

Figure 7: Weekly max and min temperature averages, 1895–1950.

Time trends of yearly average temperatures, see Figure 8.

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.

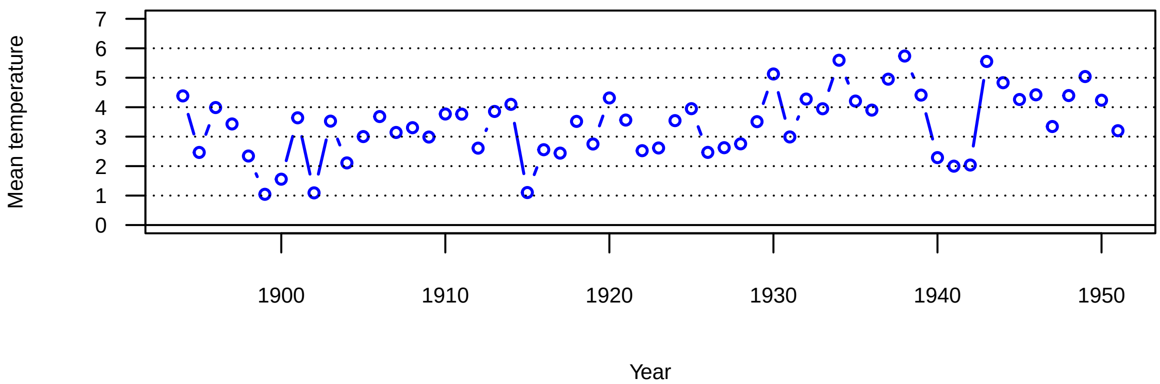

Figure 8: Yearly average temperatures, Umeå and Skellefteå.

Table 3:

subreg	id	sex	enter	exit	event	birthdate	socBranch	socStatus	illeg	parity
ske	48	boy	0.0000000	0.0076195	0	1950.723	official	high	0	1
ske	48	boy	0.0076195	0.0268503	0	1950.723	official	high	0	1
ske	48	boy	0.0268503	0.0460811	0	1950.723	official	high	0	1
ske	48	boy	0.0460811	0.0653119	0	1950.723	official	high	0	1
ske	48	boy	0.0653119	0.0845426	0	1950.723	official	high	0	1
ske	48	boy	0.0845426	0.1037734	0	1950.723	official	high	0	1

3 Statistical modelling

The analyses are performed on the *log-cube* scale, following the hints of Bourgeois-Pichat (Bourgeouis-Pichat, 1951a,b), with proportional hazards modelling. Note that the property of proportional hazards are preserved under a strictly monotone increasing time transform. However, the estimates of baseline distribution characteristics will change, of course.

We start by performing separate analyses for neonatal and postneonatal mortality.

4 Postneonatal mortality

This is the simplest part, because *B-P* predicts that the baseline distribution (given the log-cube transformation) is *exponential*, that is, the hazard function is *constant*.

The result in Table **??** 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).

Table 4: Postneonatal mortality. Adjusted for social status and branch, illegitimacy, parity, time period, season, and subregion.

Covariate	Mean	Coef	H.R.	S.E.	L-R p
excessTemp	0.027	−0.013	0.988	0.004	0.002
emintemp	−2.252	−0.017	0.983	0.002	0.000
Events	3284	TTR	12780378		
Max. logLik.	−29926				

5 Neonatal mortality

It turns out that here we have some significant interactions, with `sex` involved. Maybe surprising. So we run separate analyses for the sexes.

5.1 Girls

Table 5: Neonatal mortality. Adjusted for social status and branch, illegitimacy, parity, time period, and sub region.

Covariate	Mean	Coef	H.R.	S.E.	L-R p
excessTemp	0.010	−0.010	0.990	0.006	0.420
emintemp	−2.198	−0.010	0.990	0.003	0.000
Events	2637	TTR	3e+06		
Max. logLik.	−29607				

Same here, *climate* is more important than *weather*.

5.2 Boys

Table 6: Neonatal mortality, boys. Adjusted for social status and branch, illegitimacy, parity, time period, and sub region.

Covariate	Mean	Coef	H.R.	S.E.	L-R p
excessTemp	0.052	−0.002	0.998	0.012	0.887
emintemp	3.025	−0.007	0.993	0.004	0.125
Events	725	TTR	773144		
Max. logLik.	−7161				

Here, however, boys are sensitive to temperatures below average, in addition to the sensitivity for cold climate.

6 Postneonatal mortality, winter and spring

This is the simplest part, because *B-P* predicts that the baseline distribution (given the log-cube transformation) is *exponential*, that is, the hazard function is *constant*.

Table 7: Postneonatal mortality, winter and spring. Adjusted for social status and branch, illegitimacy, parity, time period, and sub region.

Covariate	**Mean**	**Coef**	**H.R.**	**S.E.**	**L-R p**
excessTemp	0.020	−0.015	0.985	0.004	0.001
emintemp	−9.099	−0.013	0.987	0.003	0.000
Events	1936	TTR	6362768		
Max. logLik.	−17324				

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

7 Neonatal mortality, winter and spring

It turns out that here we have some significant interactions, with `sex` involved. Maybe surprising. So we run separate analyses for the sexes.

7.1 Girls

Table 8: Neonatal mortality winter and spring, girls. Adjusted for social status and branch, illegitimacy, parity, time period, and sub region.

Covariate	**Mean**	**Coef**	**H.R.**	**S.E.**	**L-R p**
excessTemp	−0.021	0.005	1.005	0.008	0.505
emintemp	−9.036	−0.011	0.989	0.006	0.073
Events	613	TTR	731148		
Max. logLik.	−6012				

Same here, *climate* is more important than *weather*.

7.2 Boys

Here, however, boys are sensitive to temperatures below average, in addition to the sensitivity for cold climate.

Table 9: Neonatal mortality winter and spring, boys. Adjusted for social status and branch, illegitimacy, parity, time period, and sub region.

Covariate	Mean	Coef	H.R.	S.E.	L-R p
excessTemp	0.016	−0.009	0.991	0.007	0.194
emintemp	−9.021	−0.007	0.993	0.005	0.165
Events	822	TTR	777881		
Max. logLik.	−8128				

8 Conclusion

Remains to be written. Feels like two papers, one about Bourgeois-Pichat and one about climate and weather. Maybe discuss exogeneity/endogeneity?

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