Neonatal Mortality and Temperature in Two Northern Swedish Rural Parishes, 1860-1899: the Significance of Ethnicity and Gender

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In historical and contemporary populations, infant mortality has been used as an indicator of population health. In Sweden, nationwide data on infant mortality are available from the mid eighteenth century and reveals a downward trend. Although, during the nineteenth century Sweden, infant mortality was associated with large geographical differences (Bengtsson, 1999; Edvinsson, 1992; Sköld et al., 2011; Edvinsson et al., 2001). One of the factors associated with the high infant mortality in the Sápmi area is the long and cold winters with a harsh climate.

In historical and contemporary populations, the male disadvantage in neonatal mortality is well-recognised (Naeye et al., 1971; Yerushalmy, 1938; Zhao et al., 2017; Mizuno, 2000). The generally higher neonatal mortality risk among males is essentially explained by biologically factors, such as a higher risk of congenital abnormalities among male newborns relative females (Zhao et al., 2017). There is a lack of research regarding the influence of temperature on neonatal mortality among boys relative girls.

<u>Objective:</u> we aim to study the association between local temperature conditions and neonatal mortality in two Swedish rural parishes between 1860 and 1899. Further, we aim to study whether the association vary according to ethnicity and gender.

Data and Method

Longitudinal dataset

The population data and temperature data were merged into a longitudinal person-day dataset containing information on a daily basis on each infant born in the two parishes from 1860 to 1899. In the longitudinal dataset, each child is followed from the day of birth to the 28th day from birth (unless the infant died within this period), complemented with temperature at birth (as a constant) or daily temperature varying during each infants neonatal period. The longitudinal dataset includes demographic characteristics on each infant, such as sex, age and ethnicity.

Data analysis

First, we conducted analyses of the association between season of birth and risk of neonatal death according to ethnicity, age and gender. Second, we investigated the association between temperature (at birth and daily temperature) and risk of neonatal death and its interaction with gender and ethnicity during the coldest months (November through March). All analyses were conducted using R statistical software (version 3. 4. 3), packages survival, survminer and stargazer.

Results

Season and neonatal mortality

In a first step, the association between season and neonatal mortality were estimated in a stepwise manner. Estimates of all included parameters in regression models are provided in Table 1. In the base model (Model 1), infants born during winter reveals a higher neonatal mortality compared to summer born (RR 1.40, 95 % CI 1.04 – 1.90). Model V, including all of the parameters (excluding interactive terms) shows that Sami infants had higher neonatal risk relative non-Sami (RR 1.24, 95% CI 1.00-1.55). Male infants had higher neonatal mortality risk compared to females (RR 1.40, 95% CI 1.13-1.73), and the neonatal mortality risk decreased during the following weeks during the first month in life (for age three to four weeks RR 0.48, 95% CI 0.37-0.61). In the last model (Model VI), including the interaction of season and ethnicity indicating that being born during winter had a stronger effect on the neonatal mortality risk among the Sami relative the non-Sami. Compared to ethnicity, no seasonal effect were revealed between the genders.

Temperature and neonatal mortality during the coldest months

As shown in previous models of the association between season of birth and neonatal mortality, being born during winter were associated with higher risks of neonatal mortality. In order to further investigate cold season mortality, next models only include infant born during the coldest months, November through March (Table 2). As for previous models, the association between temperature (at birth and following birth) and neonatal mortality were made in a stepwise manner, including the interactive terms of gender*temp and ethnicity*temp in the last model. For space saving reasons, Table 2 shows a selection of the included models.

The base model (Model I) only including temperature at birth as a time-constant variable reveals no significant effect for temperature at birth for neonatal morality risk. Including daily temperature on the following 28 days (Model II) shows that neither of the two temperatures (time-constant or time-varying) had a significant effect for neonatal mortality. Model VI including all of the parameters (excluding the interactive terms) reveals that Sami infants born during winter months had higher neonatal mortality risk compared to winter born non-Sami (RR 1.48, 95% CI 1.09-2.00). Male neonates had higher mortality risk compared to females (RR 1.42, 95% CI 1.05-1.92) and the risk significantly decreased during the neonatal period and was lowest at the age of three weeks and above (RR 0.46, 95% CI 0.33-0.65). The last model (Model VIII) includes all of the parameters and the interactive terms of temperature (as time-constant and time varying) and ethnicity, and temperature and gender. For the Sami, temperature at birth had a stronger effect on the neonatal mortality risk, where lower temperatures on the day of birth significantly increased the risk of neonatal mortality. For the male neonates, lower temperatures on the following 28 days had a stronger effect on neonatal mortality risk relative females, where lower temperatures after birth were associated with higher risk of neonatal death.

Table 1: Models of neonatal mortality 1800-1899, risk ratios, CI and *p*

	Model I			Model II			Model III			Model IV			Model V			Model VI		
Predictors	*Risk Ratios*	*CI*	*p*	*Risk Ratios*	*CI*	*p*	*Risk Ratios*	*CI*	*p*	*Risk Ratios*	*CI*	*p*	*Risk Ratios*	*CI*	*p*	*Risk Ratios*	*CI*	*p*
(Intercept)	0.00	0.00 – 0.00	**<0.001**	0.00	0.00 – 0.00	**<0.001**	0.00	0.00 – 0.00	**<0.001**	0.00	0.00 – 0.00	**<0.001**	0.00	0.00 – 0.00	**<0.001**	0.00	0.00 – 0.00	**<0.001**
Fall	1.07	0.76 – 1.49	0.709	1.06	0.76 – 1.48	0.721	1.06	0.76 – 1.48	0.736	1.05	0.76 – 1.47	0.754	1.05	0.75 – 1.47	0.766	1.11	0.63 – 1.98	0.712
Spring	1.14	0.83 – 1.55	0.419	1.13	0.83 – 1.54	0.449	1.13	0.83 – 1.54	0.442	1.13	0.83 – 1.54	0.444	1.13	0.83 – 1.53	0.454	1.25	0.74 – 2.13	0.406
Winter	1.40	1.04 – 1.90	**0.027**	1.39	1.03 – 1.88	**0.032**	1.40	1.03 – 1.89	**0.030**	1.39	1.03 – 1.88	**0.033**	1.37	1.02 – 1.86	**0.040**	1.09	0.64 – 1.87	0.751
Sami				1.26	1.01 – 1.57	**0.039**	1.26	1.01 – 1.57	**0.038**	1.24	1.00 – 1.55	0.052	1.24	1.00 – 1.55	0.052	0.80	0.46 – 1.39	0.434
Male							1.40	1.13 – 1.74	**0.002**	1.40	1.13 – 1.73	**0.002**	1.40	1.13 – 1.73	**0.002**	1.66	1.01 – 2.72	**0.044**
Gallivare										1.31	1.05 – 1.64	**0.018**	1.31	1.05 – 1.63	**0.019**	1.31	1.05 – 1.63	**0.019**
Second week													0.69	0.53 – 0.90	**0.006**	0.69	0.53 – 0.90	**0.006**
Third week+													0.48	0.37 – 0.61	**<0.001**	0.48	0.38 – 0.61	**<0.001**
Autumn*Sami																1.44	0.69 – 3.02	0.330
Spring*Sami																1.35	0.68 – 2.68	0.397
Winter*Sami																2.27	1.17 – 4.41	**0.015**
Autumn*Male																0.76	0.39 – 1.51	0.440
Spring*Male																0.73	0.39 – 1.38	0.334
Winter*Male																0.90	0.48 – 1.68	0.746
Observations	225093			225093			225093			225093			225093			225093		
R^2 Nagelkerke	0.001			0.002			0.004			0.005			0.012			0.013		

Table 2: Models of winter neonatal mortality 1800-1899, risk ratios, CI, and *p*.

	Model I			Model II			Model VI			Model VII			Model VIII		
Predictors	*RR*	*CI*	*p*	*RR*	*CI*	*p*	*RR*	*CI*	*p*	*RR*	*CI*	*p*	*RR*	*CI*	*p*
(Intercept)	0.00	0.00 – 0.00	**<0.001**	0.00	0.00 – 0.00	**<0.001**	0.00	0.00 – 0.00	**<0.001**	0.00	0.00 – 0.00	**<0.001**	0.00	0.00 – 0.00	**<0.001**
Tempatbirth	0.98	0.97 – 1.00	0.053	0.99	0.97 – 1.01	0.163	0.99	0.97 – 1.01	0.199	0.99	0.97 – 1.01	0.243	1.00	0.97 – 1.03	0.911
Tempafterbirth				0.99	0.97 – 1.00	0.127	0.99	0.97 – 1.00	0.137	0.99	0.97 – 1.01	0.160	1.01	0.97 – 1.04	0.696
February							1.02	0.66 – 1.56	0.931	1.03	0.67 – 1.59	0.877	1.04	0.68 – 1.60	0.854
March							0.96	0.60 – 1.53	0.856	0.97	0.61 – 1.56	0.908	0.99	0.62 – 1.58	0.953
November							1.09	0.66 – 1.82	0.738	1.09	0.66 – 1.81	0.738	1.07	0.64 – 1.78	0.799
December							0.84	0.52 – 1.37	0.485	0.84	0.52 – 1.36	0.473	0.83	0.51 – 1.35	0.460
Sami							1.48	1.10 – 2.00	**0.010**	1.48	1.09 – 2.00	**0.011**	1.01	0.54 – 1.90	0.974
Male							1.42	1.05 – 1.92	**0.023**	1.42	1.05 – 1.92	**0.022**	0.99	0.53 – 1.83	0.966
Gällivare							1.25	0.92 – 1.72	0.160	1.25	0.92 – 1.72	0.159	1.26	0.92 – 1.72	0.152
2:nd week										0.63	0.43 – 0.92	**0.016**	0.63	0.43 – 0.91	**0.015**
3rd week+										0.46	0.33 – 0.65	**<0.001**	0.45	0.32 – 0.64	**<0.001**
Tempatbirth*Sami													0.96	0.92 – 0.99	**0.018**
Tempafterbirth*Sami													1.02	0.98 – 1.05	0.410
Tempatbirth*male													1.02	0.98 – 1.05	0.349
Tempafterbirth*male													0.95	0.92 – 0.99	**0.016**
Observations	97662			97662			97662			97662			97662		
R^2 Nagelkerke	0.001			0.002			0.008			0.016			0.021		