Temperature and Neonatal Mortality in Northern Italy during XIXth Century. An Event History Analysis with Daily Data

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Abstract:
During the *ancient régime* in the Northern Italy neonatal mortality was very high, particularly in winter. Although the connection between neonatal mortality and low temperatures may seem immediate, many research problems are still open.
Recently, some meteorological checked and corrected daily data has been published, concerning temperatures for some European towns in 1700-2000. In order to use this information to study neonatal morality, we have linked birth and death registrations for Casalserugo (a parish near Venice) for 1818-1867.
We study the association between daily data on temperature and mortality using a discrete-time event history logistic model for correlated observations.
Our analysis shows that in Casalserugo during winter, the daily risk of death increased of 5% for each Celsius degree less. The vulnerability to low temperature was maximum during days 1-4 of life. This last result suggests that the main cause of death could be neonatal hypothermia, rather than respiratory diseases.

1. Introduction

During the demographic *ancient régime*, in the Northern Italy, neonatal mortality (i.e., mortality in the first month) was very high, particularly in winter (Breschi and Livi Bacci, 1986). Although the connection between neonatal mortality and low temperatures may seem immediate, many research problems are still open. During the *ancient régime* there were countries, regions, towns and villages where neonatal mortality did not increase during winter, in spite of the frozen climate and the poorness (Scott and Duncan, 2002, pages 262-265). How can these geographical differences be explained? Zooming over Veneto (the region of Venice, in the NE of Italy), the mortality during the first year of life increased during the 18th century, maintaining levels around 40% for the following three decades (Rosina and Zannini, 2004). The most part of the survival drop was determined by the increasing of neonatal mortality in winter (Rossi and Tesolat, 2005). Why during the 18th century was the effect of winter on neonatal mortality stronger than before?

To face these problems, the connection between winter temperatures and neonatal mortality should be preliminarily better known. Recently, some meteorological checked and corrected daily data has been published, concerning temperatures (minimum, maximum, and around noon) and atmospheric pressure, for some European towns in 1700-2000 (Camuffo and Jones, 2002). As for Padova (a town of Veneto) these data are known starting form 1725, it is possible to study day by day the effect of climate on survival. In order to use this information, survival data on children must also be daily known. We have linked birth and death registrations for the parish of Casalserugo, sited about 10 km South of Padua (40 km from Venice), for 1818-1867 ([1]). The death risk during

[1] We used the Civil Registers of births and deaths, that each parish priest had to compile during the Austrian period (1815-61 in Lombardy, 1815-66 in Veneto). These registers were often controlled by civil authoritarians, as testified by their frequent stamps on the register pages. They are pre-printed and easy to be read, and the quality of registrations is

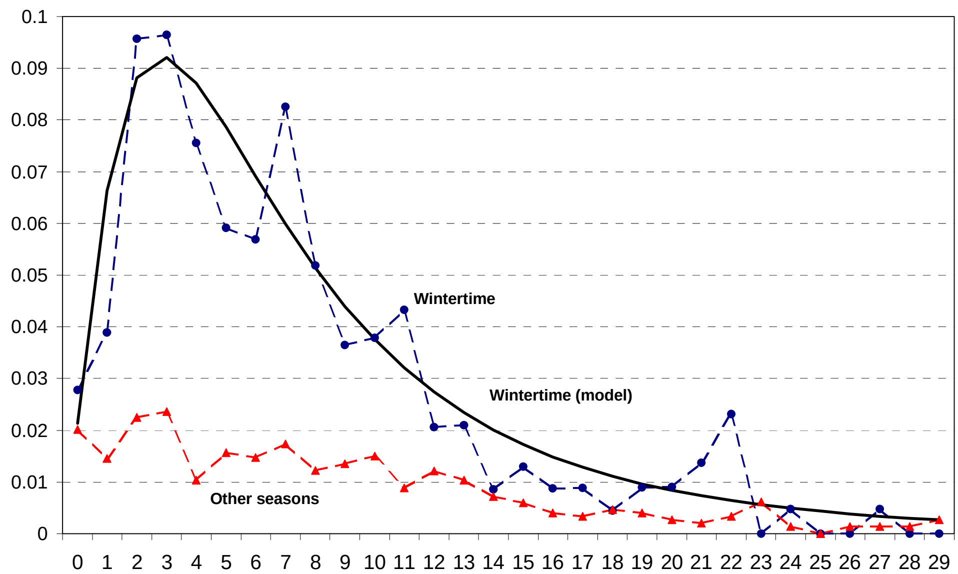
the first month was high (31%), with huge differences between winter (58%) and summer (11%) – see also table 1 and figure 1. Moreover, during that period there were not either mortality decline or differences by social class, contrasting results for Veneto as a whole (Rosina and Zannini, 2004) and Venice (Derosas, 2003). Consequently, we can study the association between the daily temperature and the neonatal daily risk of death in winter, in an area with a severe and stable neonatal winter super-mortality.

Table 1. Neonatal mortality by season in Casalserugo (1818-67)

		Number of deaths	Probability of death	Odds ratio ([1])	95% confidence limits	
Season of birth	Summer (J-J-A)	58	10.7	1	---	---
	Autumn (S-O-N)	142	26.5	3.2	2.2	4.4
	Winter (D-J-F)	294	58.4	11.6	8.3	16.3
	Spring (M-A-M)	239	29.4	3.5	2.6	4.8

([1]) The odds ratios have been estimated by means of a logistic model, where response variable is death versus alive at the end of the first month of life, and explanatory variables are sex, year of birth, work of parents, distance marriage-birth, distance birth-baptism, and season. The statistical significance of the odds ratios is strong (p<0.01). The total number of births is 2,392.

Figure 1. Daily probability of death during first month. Direct and EHA estimates (model 1, see table 2). Casalserugo 1818-1867.



2. Methods

The last fifteen years have shown/known a dramatic growth of event history analyses in historical demography. Particular emphasis has been devoted to the adaptation of the methodology to the specificity of the data sources available (see, among others: Diamond et al. 1993; Gutmann and Alter 1993; Trussel and Guinname 1993; Alter 1998; Billari, Rosina 1998; Rosina forthcoming).
For our analysis we simply use a discrete-time event history logistic model. The survival time (age) is measured in days. Data are organized as a "person-period" dataset, where the period (unit of observation) is every specific day from birth to the end of the first month of life. For a child who

generally very good. Almost all (99%) the death registration of children dead during the first month have been linked to their birth registration using as a keyname and surname of child and parents. In Casalserugo, stillbirths (i.e., not baptized children) are not registered.

still be alive at the end of the first month, the observation is right-censored. In total, the dataset has 503 children born in winter (8,328 person-days) and 294 events (deaths, see the third row of table 1). In order to account for the bell-shaped baseline risk of death in the first month (figure 1), we consider either age as a continuous variable including a quadratic term on the logit scale (model 1) or age as a categorical variable in suitable classes (model 2). Moreover, in model 1 we allow for the correlation among children within the same family using the GEE (generalized estimating equations) approach (Diggle et al. 1994). This last device may be useful, in order to control for unobserved genetic and social characteristics shared by children with the same parents. The main explanatory variable is the minimal temperature of the day, included in the models as a time-dependent covariate. In this specific applications, the other explanatory variables are included only as control factors.

3. Results

The effect of the temperature on the individual survival of children born in winter is substantial and strongly significant. A decrease of one Celsius degree corresponds to a 5% increase of the daily risk of death during the first month of life (table 2). According to model 2, the daily risk of death during the third and fourth day of life varies from 8% to 13% to 22% if the minimum temperature varies from +5° to 0° to –5° ([2]).

Table 2. Discrete-time EHA of daily mortality in the first month. Children born in Dec-Jan-Feb in Casalserugo (1818-67).

	Model 1 Age as a continuous variable and family cluster effect			**Model 2 Age as a categorical variable, interaction age & temperature**		
	Estimate	**SE**	**P-value**	**Estimate**	**SE**	**P-value**
Intercept	-3.75	0.278	<0.0001	-3.16	0.071	<0.0001
ln age	2.09	0.305	<0.0001			
(ln age)^2	-0.74	0.082	<0.0001			
Age 0-1				-0.15	0.160	0.3397
2-3				1.01	0.115	<0.0001
4-6				0.64	0.111	<0.0001
7-13				0.02	0.152	0.9232
14 +				0	---	---
December	0	---	---	0	---	---
January	0.03	0.141	0.8419	-0.03	0.086	0.6902
February	0.05	0.146	0.7410	0.04	0.088	0.6356
Male	0	---	---	0	---	---
Female	-0.05	0.118	0.6960	-0.02	0.06	0.7009
Min. temperature C°	-0.05	0.015	0.0009	-0.05	0.019	0.0163
MIN*Age 0-1				0.00	0.044	0.9635
2-3				-0.04	0.031	0.2654
4-6				-0.03	0.030	0.3688
7-13				0.06	0.038	0.1122
14 +				0	---	---
	Intra-family correlation: 0.0132					

[2] P = exp(a + $\boldsymbol{bX}$) / [1 + exp(a+$\boldsymbol{bX}$)], where a is the intercept, and $\boldsymbol{X}$ and $\boldsymbol{b}$ represent the explanatory variables and regression coefficients.

When the variable “minimum temperature” is included in the model, the effect of month of birth (Dec, Jan or Feb) is not statistically significant. This is a notable result, as some authors suggest that the survival chances of children are related to the conditions of mother during some susceptible periods of pregnancies (particularly the second trimester), and that these conditions may vary seasonally (e.g., because of energy stress induced by the harvests cycle: Scott and Duncan, 2002, chapter 13). This may also be in Casalserugo, but for the unlucky children born during winter it is overwhelmingly a matter of external temperature.

If we allow for correlation among children within the same family (model 1), the standard errors lightly decrease and the significance of estimations increases, but the substantial results do not change (results of model 1 without correlation are not reported here).

Interaction between temperature and age are not significant, but the signs of coefficients are clear: the effect of temperature is stronger during the days 2-6 (i.e., from the 3rd to the 7th day of life). Furthermore, the probability of death is significantly higher during the days 2-6 than during the second week of life (analytical results not shown). If this result is considered together with the shape of the daily-risk function (see again figure 1), it is confirmed that the critical period seems to be the first week, excluding the first day. This may suggest that the main cause of winter super-mortality was neonatal hypothermia rather than respiratory syndromes. This is an important result to orient the following studies on this topic, as the processes being below these two causes of death are deeply different.

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