Title: Cause specific infant mortality and ambient temperature in Northern Sweden 1860-1892

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Introduction

Infants are vulnerable to climate variability, especially in pre-industrial societies where infant mortality was high (Junkka et al., 2021; Karlsson et al., 2021). However, little is known about the pathways between ambient temperature and especially extreme cold and infant mortality. The relationship between infant survival and seasonal variations in infectious diseases are well known (Martinez, 2018; Pappas et al., 2008). Food- and waterborne infectious diseases such as infectious diarrhea increases in warm seasons (Liang et al., 2021), and airborne diseases, such as infectious respiratory diseases, correlates with the cold winter season (Hare et al., 1981).

A review from 2014 found overall strong evidence for heat and water- and foodborne infectious diseases (WFID) in arctic and sub-arctic settings. Yet, weak evidence for a link between temperature and airborne infectious diseases, partially due to a lack of studies (Hedlund et al., 2014). Overall, there is strong empirical evidence for a link between temperature and WFID. For example, warm temperatures improve survival for Dysentery pathogens, which in turn increases mortality risks. The effect of warm temperatures can have both an immediate (single-day) effect as well as a cumulative lagged effect on WFID (Liang et al., 2021). The mechanisms linking cold temperatures to cause-specific mortality are more uncertain. The seasonality of respiratory viral infections is related to both seasonal variations in temperature and human behaviours. Temperature affects the immune responses to viral infections, increasing vulnerability to airborne infectious diseases. Seasonal changes in human behaviour affect contact rates, increasing exposure to airborne infections in the winter (Moriyama et al., 2020). Given that infants are especially vulnerable to infectious diseases, it is easy to assume that the observed seasonal patterns in infant mortality were related to seasonal temperature exposures (Hare et al., 1981; Karlsson et al., 2021; Scalone & Samoggia, 2018; Schumann et al., 2019).

We aim to investigate the association between ambient temperature and cause-specific infant mortality, using historical register data from Sweden covering the period 1868-1893.

Method and data

Retrospective study using population data from digitised church records. Data was collected from the POPUM database covering Sundsvall region, 1860-1900 (Extraction ID: U210002) consisting of digitalised parish records (Vikström et al., 2002; Westberg et al., 2016). The sample consisted of all children born over the period, 47 575 births, within the 14 parishes surrounding the town of Sundsvall. We selected information on birthdate, place of birth, date of death, cause of death and last observation date. The town of Sundsvall experienced rapid population growth during the study period. Primarily driven by a growth of the working classes, working at the sawmills in parishes surrounding the Gulf of Bothnia. Infant mortality was overall high in the town of Sundsvall (Edvinsson, 1992).

Cause-specific infant mortality

In the present study, the ICD10h-code system has been applied to code and classify the historical cause of death data from the POPUM database at CEDAR. In the population data base POPUM there is information on causes of death originating from the death and burial registers. Every cause of death has been given an alphanumeric code under the ICD10h coding system together with a reference to the category code in the modern ICD10-EN classification system. The ICD10h system has been developed within the SHiP network, composed of researchers studying the evolution of mortality and health in port cities in Europe. Within the SHiP network, a new international code system (ICD10h) has been developed and designed for use in encoding historical cause of death data. The SHiP system allows for systematic and comparative analyses of historical causes of death while retaining information from historical designations (Janssens, 2021). The modern international ICD10-EN (2016) classification system provided by WHO has been used as a baseline for the international historical ICD10h coding system, which has been adjusted to allow for the coding of the varieties in the medical terms used in historical times.

In the ICD10h code system, a categorisation variable has been added that divides all causes of death among infants into twelve larger groups. A classification system that, in turn, has been condensed into four groups, airborne infectious diseases, water- and foodborne infectious diseases, other causes of death and unknown causes. The majority of infant deaths were not given a cause of death, however, over time the proportion of given causes of death increased to about 50 percent of all infant deaths in the 1890s.

Weather data

Daily temperature data were collected from the Swedish Meteorological and Hydrological Institute (SMHI). We used observational data on temperatures at three points within the day, from the weather station in Härnösand from 1868-1892, located about 40 kilometres north of the town of Sundsvall. From these observations, we calculated average temperature exposures over the past 7 days.

Statistical methods

We applied time-series analysis to model the relationship between daily cause-specific infant mortality and ambient temperature exposure. Data were aggregated to count data of deaths per day. We estimated the effect of ambient temperature on the count of infant deaths using Poisson regressions. Ambient temperature has been shown to have a lagged non-linear relationship to infant mortality (Junkka et al., 2021; Schumann et al., 2019). Thus, the association was modelled as a nonlinear function, specified as a cubic spline with four degrees of freedom, using the Distributed lag linear and non-linear models framework (Gasparrini et al., 2010). In addition to ambient temperature exposure, the non-linear effect of day of year was specified as a cubic spline with six degrees of freedom and year as a cubic spline with three degrees of freedom (Boor, 1978; Hastie, 1991/1997). The models were specified and evaluated within the programming language R (R Core Team, 2021).

Results

Breaking down mortality rates by temperature exposures we see quite different cause-specific patterns (Figure 4). For all-cause infant mortality, there was a u-shaped pattern with a minimum mortality temperature (MMT) around +3.5 - +12 ℃, above and below this range infant mortality increased. For mortality due to airborne infectious diseases there was a linear negative relationship, as temperature increased, infant mortality declined. Mortality due to waterborne diseases show the opposite pattern, as temperatures increase so did infant mortality.

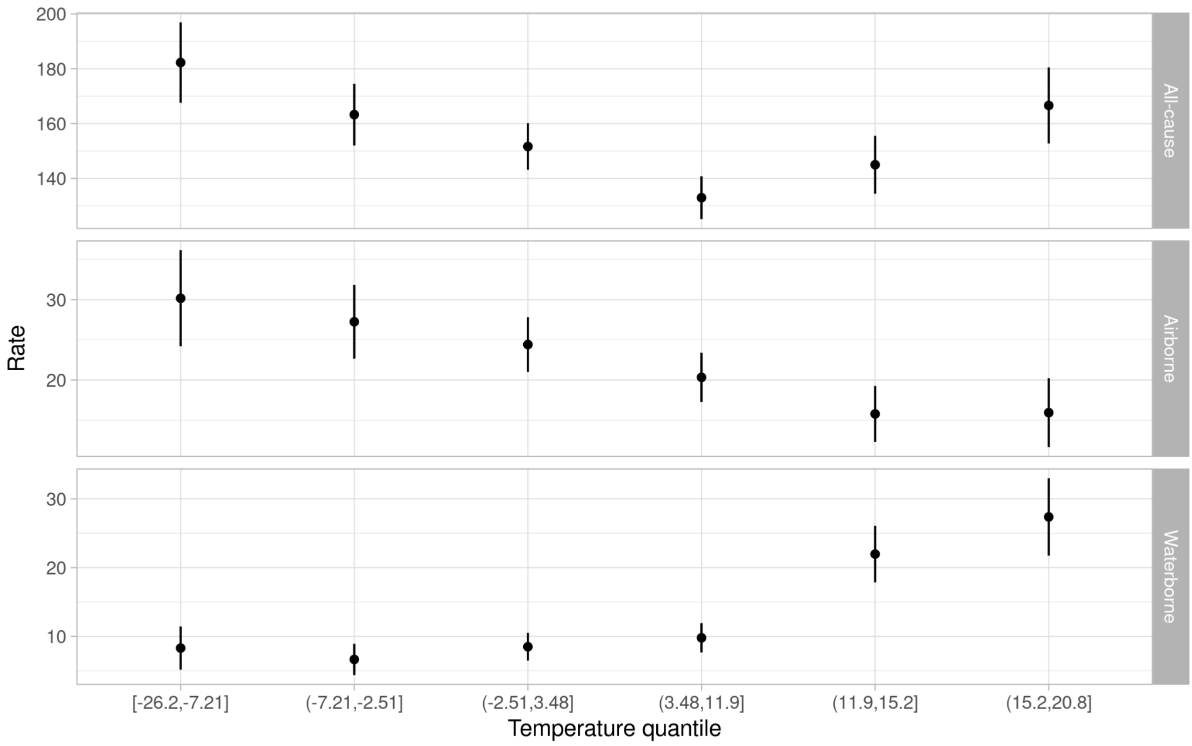

Figure 4*: All-cause and cause-specific infant mortality rate by temperature percentiles (10th,25th,50th,75th,90th). CI based on Poisson standard errors.*

The incidence rate ratios estimated using Poisson regression, show a similar pattern but with increased uncertainty. Adjusting for seasonality, the U-shaped association to all-cause mortality remains, and so did the positive association to waterborne mortality. Although airborne mortality seems to increase as temperatures fall, the uncertainty of the models was greater.

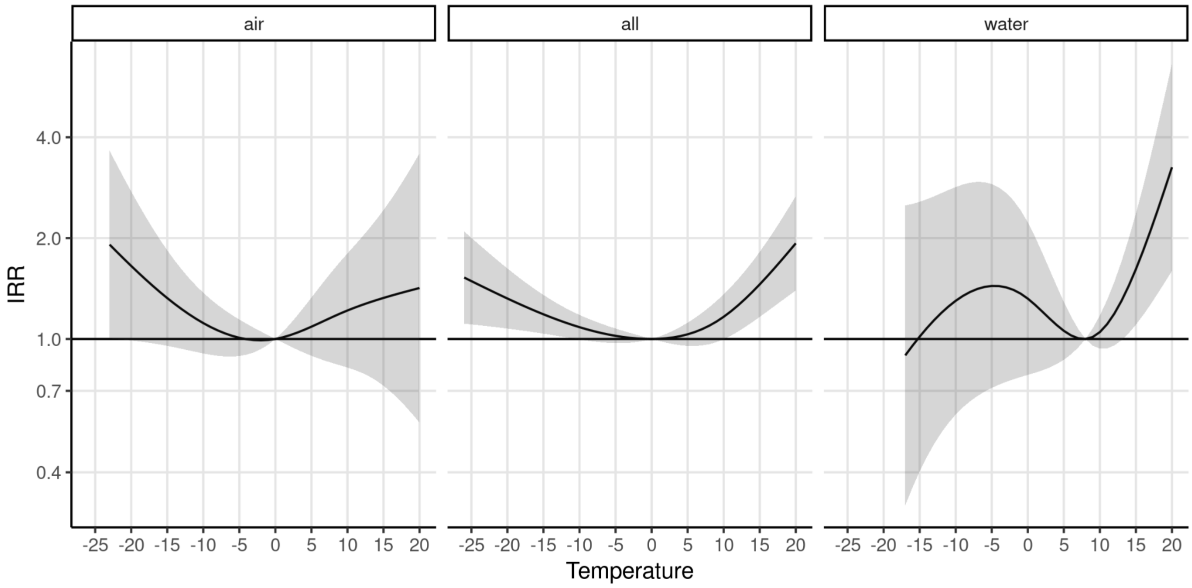

Figure 4: *Incidence rate ratios (IRR) with 95 percent confidence intervals for infant mortality by past 7 days average ambient temperature. IRR on a log scale.*

Conclusions

Preliminary results show a U-shaped association to all-cause mortality, a negative association to mortality from airborne infectious diseases and a positive association to waterborne infectious mortality.

The results suggest a link between high temperatures and water- and foodborne infectious mortality, which was independent of seasonality. Airborne infectious diseases mortality was not related to temperature to the same extent. Instead, the results suggest that the association between the cold season and airborne infectious mortality was an effect of seasonal variations in health behaviours, rather than exposure to cold temperatures.

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