Meteorological effects on the incidence of pneumococcal bacteremia in Denmark

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Introduction

The seasonal nature of invasive pneumococcal disease with peak incidences during winter months is well recognized (Dowell 2003, Talbot 2005, Watson 2006). However few detailed studies of the temporal relationship between actual climatic changes and subsequent pneumococcal disease are available. We perform an 8-year longitudinal population-based ecological study in a Danish county to examine whether foregoing changes in meteorological parameters, including temperature, relative humidity, precipitation, and wind velocity, predicted variations in pneumococcal bacteremia (PB) incidence.

Methods

We included cases of PB that occurred from January 1995 through December 2002 in North Jutland County, Denmark, with a population of 492,845 individuals on average during the period of study. Patients with PB were defined as individuals with a clinical disease episode with Streptococcus pneumoniae detected by blood culture.

Meteorological data were available in terms of daily summaries from a weather station corresponding to the area under study. Daily mean values were calculated for temperature (minimum, mean and maximum), relative humidity, precipitation and wind velocity.

We fitted a harmonic sinusoidal regression model to estimate the exact phase difference in days between changes in each of the meteorological variables and PB incidence. The model was given by $A\cos(2(t-\phi)/365.25)+B$ where ϕ is the phase that indicates the location of the seasonal peak. Since the PB incidence counts were assumed Poisson distributed we took a square root transformation. The differences in days between the phase of PB incidence and each of the meteorological variables were determined together with a 95% confidence interval (CI). The sign and magnitude of the phase difference indicated whether the meteorological variable affected the intensity of pneumonia.

Results

During the eight years of surveillance, 63,166 blood cultures were performed and 714 episodes of PB were detected. We observed 2,329 days with no PB episodes and 493, 82, 15, 3 days with one, two, three and four episodes respectively, giving 2,922 days in the time span.

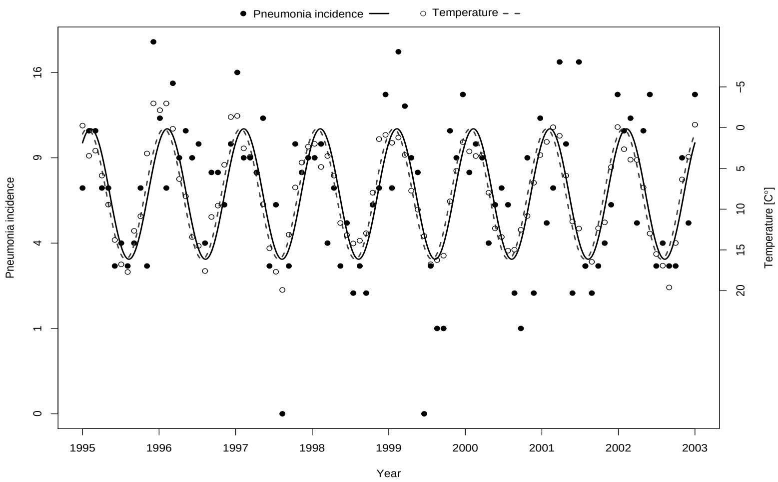

Fig. 1. The observed points with fitted sinusoids superimposed. Temperature is on reversed scale.

The estimated phase differences between PB incidence and the different meteorological variables are given in Table 1.

	Phase difference in days	
Temperature	-16	(-18 ; -14)
Minimum temperature	-13	(-15 ; -11)
Maximum temperature	-19	(-22 ; -17)
Wind velocity	3	(1 ; 5)
Relative humidity	-59	(-65 ; -52)
Precipitation	28	(2 ; 55)

Table 1: Phase differences for pneumonia and the meteorological variables in days with 95%-CI in brackets.

The only negative differences were found for temperature (minimum, mean and maximum) and relative humidity, indicating that these variables were shifted to the left relative to PB and in particular attained their minimum and maximum, respectively, earlier than the PB incidence was at its maximum. A close inverse relationship was found between temperature changes and PB incidence, with an observed time lag of 16 (95% CI, 14-18) days between temperature peaks and troughs and PB activity. Peaks in relative humidity preceded PB peaks by about 2 months. These relationships were seen independently of a strong seasonal pattern of PB. No relationship was found between PB incidence and precipitation or wind velocity.

Figure 1 shows monthly PB incidences together with the monthly mean temperatures during the 8-year study period. Superimposed are the fitted sinusoids showing the lag of approximately two weeks between pneumonia and temperature. Graphical inspection of the residuals indicated that observed PB incidences higher than predicted by the model were seen in months with lower than modeled temperatures.

Discussion

Our analyses confirmed a distinctive seasonal variation in the incidence of PB in Denmark with similar summer troughs and winter peaks as have been reported from several states in the US and from a temperate region in Australia (Dowell, Watson, Talbot). Our findings are in line with one previous study from Australia that examined the relationship between PB and similar specific climatic parameters as in our study, finding a strong inverse relationship between weekly mean maximum and minimum temperature and PB activity in the population, whereas other examined climatic parameters were unrelated to PB (Watson).

We speculate, that the approximately 2 weeks between temperature drops and PB peaks may represent the time lag from increased indoor crowding due to cold weather, increased transmission of respiratory viruses together with exchange of new pneumococcal serotypes among children, transmission to adult contacts of both, increased occurrence of viral upper respiratory tract infection, followed by pneumococcal pneumonia and admission with PB.

Conclusion

We found that changes in temperature closely predicted pneumococcal bacteremia incidence peaks, independently of seasonal patterns.