Short report

Effect of cold winters on the risk of new asthma: a case-crossover study in Finland

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ABSTRACT

Background Cold weather increases respiratory symptoms and provokes exacerbations of asthma, but there are no previous studies on its role in the aetiology of asthma.
Objective We tested the hypothesis that a cold winter increases the risk of developing asthma during the following 1 to 2 years.
Methods We conducted a case-crossover study of 315 newly diagnosed cases of asthma from the population-based Espoo Cohort Study from birth to the age of 27 years. The hazard period constituted 3 winter months preceding the onset of asthma and bidirectional reference periods of 1 year before hazard period and 1 year after onset of asthma. Exposure constituted average ambient temperature during the winter months of December, January and February. The outcome of interest was new doctor-diagnosed asthma. The measure of effect was OR of asthma estimated by conditional logistic regression analysis.
Results The average winter temperature for the study period from winter 1983 to 2010 was −4.4°C (range −10.7 to 0.4). A 1°C decrease in the average winter temperature predicted a 7% increase in the risk of new asthma (OR=1.07, 95% CI 1.02 to 1.13). A cold winter with an average temperature below the climate normal value (−4.5°C; period 1981–2010) increased the risk of new asthma by 41% during the following year (OR: 1.41; 95% CI 1.04 to 1.90).
Conclusions This case-crossover study provides original evidence that a cold winter with below normal average temperatures increases the risk of developing new asthma during the following 1 to 2 years.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Short-term and long-term exposure to cold may damage the airway epithelium.
⇒ Though previous studies have showed the effect of cold temperature on asthma exacerbation, evidence about potential role of cold temperature on asthma inception is lacking.

WHAT THIS STUDY ADDS

⇒ A population-based case-crossover study of 315 subjects with new asthma provided evidence that cold winter predicts a significant increase in the onset of asthma during the following 1–2 years.
⇒ This observation was present in males and females in preschool and school children and young adults.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The findings support the hypothesis that cold weather causes asthma. Clinicians should take this observation into account in their clinical practice. For example, air ways protection during cold winter weather may reduce the risk of asthma among subjects with cold weather-related symptoms and hereditary burden of asthma.

INTRODUCTION

Environmental exposures, such as cold air or air pollution, may trigger symptoms or exacerbation of asthma.[1] There is also evidence that long-term exposure to air pollution increases the risk of developing new asthma.[2] Based on a systematic literature search, there are no previous studies on the potential role of long-term exposure to cold weather in the aetiology of asthma. We hypothesised that a cold winter increases the risk of developing asthma during the following year. We studied the population-based Espoo Cohort Study in Southern Finland by using the cold winter temperature as the exposure and applying a case-crossover study design.

METHODS

Study design and population

We applied a case-crossover design to estimate the relation between average winter temperature and the onset of asthma. In a case-crossover design, the study subjects are selected from cases, here those who have experienced an onset of asthma. The inference is based on a comparison of each subject's exposure, here the average temperature, during a time period relevant for the causation of the outcome, here the winter preceding the onset, which is referred to as a hazard period, and during one or more reference (control) periods.[3] We decided to apply a bidirectional selection of reference periods, one before the hazard period and the other after the onset of asthma. This design has been previously proposed appropriate for studying the effects of varying short-term air pollution exposures on health outcomes with an abrupt onset, such as asthma attack.[3 4] The timing of the onset of asthma is difficult to measure exactly due to usually a longer induction period needed for the diagnosis. We postulate that the health outcome in the case-crossover study does not necessarily need to be abrupt if the hazard period is sufficiently long for the studied relation. In the present study on the

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onset of asthma, we used the three winter months, December, January and February, as the hazard period and the three winter months a year before hazard period and after onset of asthma as two bidirectional reference periods.

The study population comprised all the 315 subjects of the Espoo Cohort Study,[5 6] born between 1 January 1984 and 31 March 1990 who developed asthma during the first 27 years of their life.

Health outcome

The outcome of interest was the development of asthma during the study period. The information on doctor-diagnosed asthma and the age of onset, as well as on its potential determinants, was collected at the baseline survey in 1991 and at a 6-year and 20-year follow-up surveys,[5 6] which were conducted at the ages of 0–6, 7–13 and 20–27 years. Questionnaire information on asthma was verified and complemented by a telephone survey and register data from the National Hospital Discharge Register and the Finnish Care Register (HILMO).[5 6]

Exposure assessment

We used 3 month (December–February) average temperature (°C) at the Helsinki-Vantaa weather station to define characteristics of the winters from the winter 1982–1983 to winter 2009–2010 (online supplemental eFigure 1). In this study, we defined winter as cold when the average temperature was lower than the climate normal value (−4.5°C) in the 30 year climate normal period 1981–2010. Temperature data were obtained from the Finnish Meteorological Institute (FMI). Helsinki-Vantaa weather station, located 15 km from Espoo, which is the nearest station from which homogenous long time series of the meteorological parameters are available, can be considered meteorologically representative for the Helsinki Metropolitan Area including Espoo.

Hourly or daily temperatures may differ between the location of the weather station and the other parts of the metropolitan area, but the 3 month averages are similar across this area.

The winters are defined as deviations from statistical normal temperature values, and these do not depend on absolute values.

Statistical analysis

We used OR as the measure of effect of a cold winter on the onset of asthma. We applied conditional logistic regression analysis to estimate the ORs with their corresponding 95% CIs. Sex and age may modify the effect of temperature on the onset of asthma.[7] Therefore, we conducted a priori subgroup analyses by gender and age. Heterogeneity between stratified estimates was assessed using the Breslow-Day test.[8] We compared models and conducted sensitivity analyses (online supplemental eMethod in the Supplement). All statistical analyses were conducted using Stata V.16 (StataCorp).

RESULTS

Characteristics of the study population

Exposure distributions are presented in online supplemental eTable 1. The average winter temperature was −4.5°C (±3.0) during the hazard period and −4.0°C (±2.7) during reference periods. The study population included 150 females (48.6%) and 165 males (52.4%). Most cases (53.7%) developed asthma during the first 6 years (online supplemental eTable 2).

Winter temperature and the onset of asthma

Figure 1 illustrates that the relation between average winter temperature (x-axis) and the risk of asthma (y-axis) during the following calendar year appears linear. In conditional logistic regression, a 1°C decrease in the average winter temperature predicted a 7% increase in the asthma risk (OR=1.07, 95% CI 1.02 to 1.13). The risk of asthma was 41% (OR: 1.41; 95% CI 1.04 to 1.90) higher after exposure to colder than average preceding winter compared with control periods (online supplemental eFigure 2). We conducted a sensitivity analysis with a

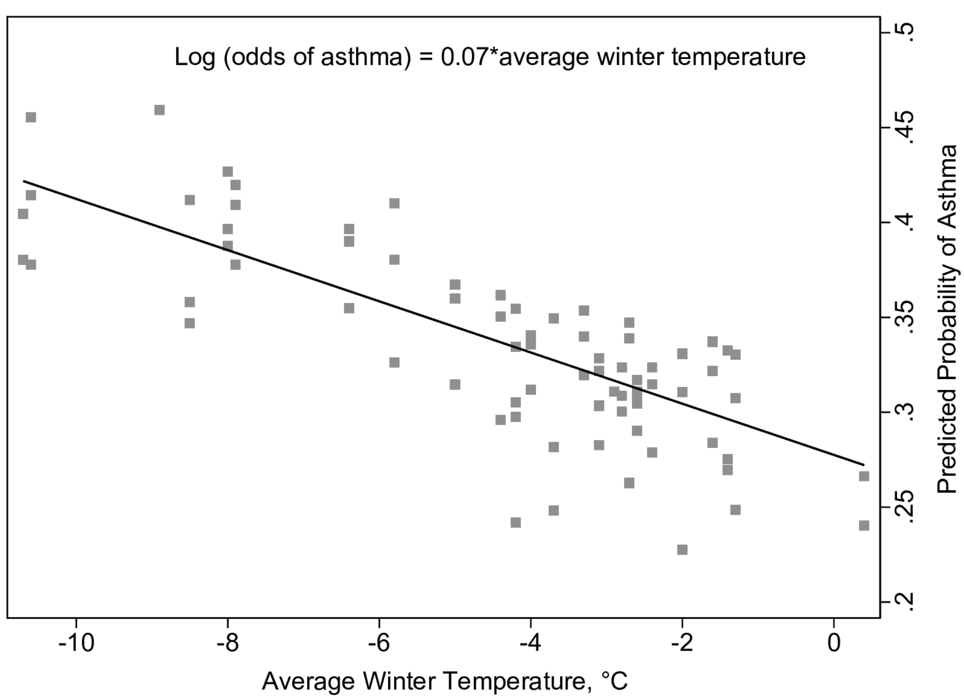

Figure 1 Predicted probability of asthma by average temperature of the previous winter.

hazard period of two winters. The results were robust (online supplemental eFigure 3). We also assessed potential influence of age and sex on the association between cold temperature and asthma onset but based on test of homogeneity of OR across the categories of age (X^2=0.89, df=2, p=0.642) and sex (X^2=0.75, df=1, p=0.388), the effect estimates were homogeneous (online supplemental eTable 3).

DISCUSSION

Our case-crossover study from Espoo, Finland, showed that low average winter temperature (December–February) predicts the onset of asthma during the following 2-year-long period during the first 27 years of life. The relation between average winter temperature and asthma risk was linear: a 1°C decrease in average winter temperature predicted a 7% increase in the odds of asthma in the winter average temperature range of −10.7 to 0.4°C. A cold winter increased the risk of developing asthma by 41% (95% CI 4% to 90%) during the following calendar year. This association was present in males and females in all age groups.

We calculated the average ambient temperature during the 3 winter months based on the FMI's weather monitoring data at the Helsinki-Vantaa weather station that can be considered representative for Espoo. The outcome assessment was based on self-reported doctor-diagnosed asthma. Finland has an affordable public healthcare system complemented by private sector healthcare and a high coverage of occupational health service. The costs are subsidised up to 60% by public funds and these are often all covered by private insurance, resulting in easy access to medical consultation. Furthermore, the National Social Insurance Institute covers all residents of Finland and provides 75% reimbursement of asthma medications for those with asthma fulfilling their diagnostic criteria. This is a strong financial incentive for getting a doctor's diagnosis of asthma. The diagnoses are approved centrally by the National Social Insurance Institution when applying for subsidies, which reduces heterogeneity in diagnostic practices. The diagnoses are based on national guidelines.

We used a bidirectional referent selection strategy that can take into account trends in both exposures and outcomes.[4] Following this strategy, for a hazard period of 3 winter months during the preceding winter in relation to the onset of asthma, and corresponding winter-month periods 1 year before the hazard period and 1 year after the onset of asthma were used as reference periods (n=2). This strategy also limits the possibility of selection bias due to long time interval between the hazard and referent periods and allows us to select the reference (control) periods from the study period where the cases have already occurred.[9]

This is the first study that provides evidence that the risk of developing asthma is related to cold winter conditions during the preceding winter. There is compelling evidence that short-term exposure to low temperatures increases respiratory symptoms, especially among subjects with asthma.[10] Controlled experiments have provided evidence that nasal breathing in cold air causes short-term nasal responses such as rhinorrhoea, congestion and sneezing.[11] Long-term exposure causes damage to the airway epithelium and even changes in the airway wall structure and function.[12] It is biologically plausible that these damages may further lead to the development of airway inflammation and clinical symptoms and signs of asthma. Although long-term exposure to cold weather is a biologically plausible cause of asthma, we cannot exclude the possibility that other environmental exposures related to a cold winter, such as an increase in ambient and indoor air pollution due increased heating using fossil fuels, could contribute to the increased risk of asthma. Thus, the overall effect of cold winters on asthma may constitute both low temperatures and changes in environmental exposures and behaviour.

CONCLUSION

This population-based case-crossover study provides new evidence that a cold winter increases the risk of developing new asthma during the following 1 to 2 years.

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Contributors JJKJ had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: JJKJ. Acquisition of data: AKR, MJ, TTH, RR and JJKJ. Analysis and interpretation of data: all authors. Drafting of the manuscript: ABB and JJKJ. Critical revision of the manuscript for important intellectual content: AKR, MJ, TTH, RR and JK. Statistical analysis: ABB, AKR, RR and JJKJ. Obtained funding: JJKJ, MJ and JK. Study supervision: JJKJ.

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Competing interests None declared.

Patient consent for publication Consent obtained directly from patient(s).

Ethics approval The study protocol was approved by the Ethics Committee of Oulu University Hospital, Oulu, Finland (EETTMK: 75/2013). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. The datasets generated and/or analysed during the current study are not publicly available due to issues of confidentiality, but are available from the corresponding author on reasonable request.

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