A TEMPERATURE RISE IS ASSOCIATED WITH AN INCREASE IN THE NUMBER OF ACUTE MYOCARDIAL INFARCTIONS IN THE SUBARCTIC AREA

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ABSTRACT
Objectives: To examine the impact of meteorologic variables on the incidence of and case fatality in acute myocardial infarction (AMI) in the subarctic area of Northern Sweden. ***Study design:*** The MONICA (multinational MONItoring of trends and determinants of CArdiovascular disease) database for northern Sweden was linked to weather report files. We then had information linking the weather condition at the time of each myocardial infarction with each patient. This database was analysed for whether the myocardial infarctions were fatal or nonfatal. We also analysed data on the daily number of myocardial infarctions in the area with day-to-day changes in the weather conditions. ***Results:*** We found that no static weather conditions were linked to an increased risk of dying from a myocardial infarction. A temperature rise was associated with an increase in the number of nonfatal acute myocardial infarctions – a 1 degree Celsius rise was associated with a 1,5 % increase in the number of AMI cases. ***Conclusion:*** No extreme values of either temperature, humidity or air pressure was associated with an increase in the case fatality in AMI. A temperature increase was associated with an increase in the number of nonfatal myocardial infarctions. However, this increase was probably mediated via other risk factors or risk behaviours that also increased with rising temperature. *(Int J Circumpolar Health 2002; 61: 201-207)*

Key words: Temperature, humidity, barometric pressure, weather change, acute myocardial infarction, MONICA Project

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Weather and weather changes have been linked to the manifestations of coronary heart disease. Most often, cold weather has been suspected to be related to an excess morbidity and mortality in acute myocardial infarctions (AMI) (1). Among pathophysiological mechanisms, a higher blood pressure (2), increased blood viscosity due to an increase in serum fibrinogen levels, or increased thrombocyte aggregability have been implied (3), but also influenza epidemics, more common during the winter season. Few studies have related also humidity, barometric pressure, or precipitation or day-to-day changes in these pa-

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rameters to changes in attack rates in ischemic heart disease. Neither has any large epidemiological study been done in the setting of a subarctic area where the record linkage is done on an individual basis. We used the Northern Sweden MONICA Project database, covering all acute myocardial infarctions in the age groups 25 to 64 years in the Swedish counties of Norrbotten and Västerbotten, and individually linked data on meteorological conditions to further explore these relationships.

MATERIAL AND METHODS

Geography

The MONICA-NSW Project area is sparsely populated and covers 154,300 km^2 with 510,000 inhabitants. Because of its size, the meteorological situation varies considerably between different parts of the area. However, from a climatological point of view, the area is fairly homogenous. A change of weather in one part of the area is generally accompanied by the same change in other parts of the area as far as barometric pressure, temperature, and humidity are concerned.

Case ascertainment

All hospitals and general practitioners in the area submitted copies of records from all patients 25-64 years of age, treated for AMI, and for angina pectoris with chest pain typical of myocardial ischemia, lasting for more than 20 minutes. Fatal cases were those who died before day 28.

Cases with sudden death outside hospital were found by checking all death certificates for patients in the appropriate age groups. All death certificates with coronary heart disease diagnoses were validated, based on information on medical history, symptoms, ECG and cardiac enzymes, in the same way as for the surviving cases. In fatal cases (up to day 28; MONICA case fatality definition), information was also obtained from necropsy reports where available.

In this study, only cases classified as definite infarctions have been included in nonfatal events. In fatal events, possible infarction and unclassifiable infarction have also been included. This is in accordance with Definition 1 for coronary events as proposed by the MONICA collaborators (4, 5).

Meteorological information

Information on temperature, humidity, barometric pressure, and precipitation was collected from 36 weather stations every three hours during the years 1985 to 1992. For the survival analysis, the information from the weather station located closest in space and time to the index case was chosen. For the time-series analysis, the information from all the weather stations was collapsed to give a mean value for measured variables each day. The difference between this value and that of the preceding day was used in the analysis. Since the data sources differ between these two analyses, also the numbers of missing values for weather data varies, explaining the discrepancies in numbers between the two analyses.

Statistical methods

The database covering the climate conditions in relation to survival in AMI was investigated with maximum likelihood logistic regression. This method was chosen since the outcome variable (death/survival) is a 0/non-0 variable.
The time-series database, with the number of AMI per day, was analysed with Poisson regression, which is used when the dependent variable is a nonnegative count variable (the number of myocardial infarctions). The analysis was done separately for fatal and nonfatal cases. The Poisson distribution was checked by comparing the mean and the variance of the dependent variable and the fit of the model was tested with a chi^2 goodness-of-fit of each model. To check the robustness of this model, season was introduced as an indicator variable, as was a dichotomous variable for temperatures below and above 0 degrees centigrade, respectively.

When the dependent variable was overdispersed (did not follow a Poisson distribution) and for check of serial correlations, negative binomial regression analysis was used as alternative. This method allows also for extra-Poisson error distribution. The values found in the Poisson regression and in the negative binomial regression were however virtually identical. Thus only the values for the Poisson regression are presented.

The population at risk was not used in any of the models since it was very stable during the time period studied.

Table I. Meteorological data.

	Absolute minimum	Absolute maximum	Maximum day-to-day decrease	Maximum day-to-day increase	Average during time period surveyed
Barometric pressure, hPa	957.9	1049.6	-32.9	28.7	1009.4
Temperature, °C	-38.0	30.0	-14.1	17.5	1.8
Relative humidity, %	21	100	-32.2	33.6	76.6
Precipitation, mm	0	33			

A P value of 0.05 or below was considered significant. We did all calculations with the software Strata (version 7).

RESULTS

Meteorological data

The meteorological data are presented in Table I. They span fairly wide ranges, allowing for a sufficient variation in the independent variables.

Mortality study

We had complete information on 3,322 definite myocardial infarctions, of which 931 were fatal, together with meteorological data. In this analysis, none of the meteorological variables was in a statistically significant way associated with an increased risk of death in acute myocardial infarction (Table II).

Table II. Impact of meteorological data on risk of death in an acute myocardial infarction. CI=confidence interval.

Variable	Odds ratio	95% CI	p value
Humidity	0.999	0.995-1.004	0.81
Temperature	1.004	0.997-1.010	0.26
Air pressure	1.003	0.997-1.008	0.34

Time series study

In this analysis, 2,689 cases of myocardial infarction of which 711 were fatal, together with complete meteorological information were analysed. Only a temperature rise between consecutive days was significantly associated with an increase in the number of nonfatal daily AMI cases on consecutive days with a risk ratio of 1.01 (95% confidence interval 1.0-1.03, p value 0.02) (Table III). A temperature rise of 1°C was associated with an increase in the number of nonfatal daily myocardial infarctions by 1.5 %. The inclusion of indicator variables for season and temperature did

Table III. Time-series study of the relation between meteorological data and the risk of suffering a fatal or nonfatal acute myocardial infarction (AMI). CI= confidence interval.

	Fatal AMI			Nonfatal AMI		
Variable	Risk ratio	95 % CI	p value	Risk ratio	95 % CI	p value
Humidity	1.001	0.992-1.010	0.77	1.002	0.998-1.007	0.29
Temperature	0.999	0.992-1.007	0.89	1.000	0.996-1.003	0.81
Air pressure	0.998	0.992-1.004	0.47	1.000	0.997-1.003	0.83
Humidity change	1.000	0.990-1.010	0.99	0.995	0.990-1.000	0.06
Temperature change	1.003	0.979-1.028	0.79	1.015	1.003-1.027	0.02
Air pressure change	1.006	0.995-1.017	0.29	1.001	0.995-1.006	0.81

not change the relation between the number of AMI cases and the temperature change. There was no significant relation between the number of fatal AMI cases and any meteorological variable, although an increase in humidity between successive days with borderline significance decreased the risk of a non-fatal AMI.

DISCUSSION

An AMI is not a random event, since there exist as well circadian as seasonal differences in the incidence (6), suggesting that factors other than a high cholesterol, smoking, and hypertension are important. Meteorological factors could be contributory to an event but the majority of the studies on weather and weather changes have been on an ecological level. From these studies no causality or temporality can be inferred, nor is there any way of knowing whether those who died or suffered an acute myocardial infarction were those with greater cold exposure. This study links individual data with the concomitant meteorological situation, thus giving more robustness and interpretability to the results.

The increase in the number of nonfatal AMI cases with increasing temperature suggests that a temperature rise is associated with an increase in the incidence, not in case fatality. With a constant case fatality, the incidence increase would also cause an increased mortality, found in studies on the relation between season and climate, and mortality.

The decrease in number of AMI (although not statistically significant) with increasing humidity is more difficult to explain. It occurs independently of a low temperature or a change in temperature, since both variables are controlled for in the model. Other studies most often have found an increase in the number of AMI with increasing humidity (7, 8). The pathophysiological influence of a humidity increase on the body is not known.

Our results differ from those of earlier studies. One reason could be the ecological fallacy (9), our data being individual data, the other could be that the physiological and psychological reactions of people used to living in a subarctic climate differ from those of previously studied populations. It has been shown that populations adapted to a cold climate have favourable changes in blood viscosity, von Willebrand factor (10), in the rate-pressure product (11), and in total and LDL cholesterol (12). A temperature rise could disrupt this adaptation and cause an increase in the susceptibility to atherosclerotic diseases. A few, and small, studies have shown an increase in the number of cases with increasing temperature (13, 14).

A number of ecological observations cast doubt on the causal association between cold weather and temperature variations in cardiovascular diseases. Living at a higher altitude is associated with exposure to a lower temperature, yet there is a reduced incidence of acute myocardial infarctions (15-17) and the seasonal variations in the rate of acute myocardial infarctions is also observed in equatorial countries where the temperature range is much lower (18).

It has been argued that deviations upward or downward from a temperature of 20-25°C cause an increase in cardiovascular mortality (19). To test this hypothesis, the absolute value of the temperature change was substituted for the real value in the model, causing the coefficient for temperature change to become non-significant. Thus it seems likely that it is not the temperature change, irrespective of direction, that is important, but rather the temperature rise. The inclusion of season and temperature in the analysis did not change the results either, suggesting that the increase in incidence of acute myocardial infarctions with a temperature rise is found over the whole temperature change range analysed.

Risk factors other than a cold climate can account for the excess mortality in coronary heart diseases in winter. It has been shown that obesity is more common in winter months (20), possibly caused by a higher winter fat intake (21). Physical activity is associated with a reduced risk of

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coronary heart disease but the benefits are reduced a few weeks after cessation (22). Physical activities only protect against acute coronary events if undertaken throughout the year, whilst activities undertaken on a seasonal basis do not confer any significant benefit (23). The time spent on many outdoors physical activities are much reduced during the winter months. Probably also other lifestyle habits differ between seasons in a subarctic climate.

What, then, is the truth? Many ecological studies suggest that rates of AMI are increased in a cold climate and that they also increase during the cold seasons of the year. This study, linking individual data to the weather condition, suggests that a temperature rise is associated with an increase in the number of nonfatal acute myocardial infarctions. Although some previous studies have found the same temperature dependant increase, it seems unlikely that the increase per se would increase only the number of nonfatal myocardial infarctions. Probably this effect is mediated via other risk factors or risk behaviours that also increase with rising temperature.

Strengths and limitations of study

The main strengths are the relation between the individual myocardial infarction and the temperature, and the external and internal controls of the data quality. The limitations are that no confounders or other risk factors were analysed and that the weather correlation was done to the home address. A few patients were somewhere else at the onset of their AMI.

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