ORIGINAL ARTICLE

Cold snaps, snowfall and sudden death from ischemic heart disease

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The short-term effect of low temperature on the incidence of ischemic heart disease over a 15-year period was examined. To reduce confounding by other seasonal factors the analysis was restricted to the winter months and was based on the change in the daily rate of sudden death at the time of cold snaps (arbitrarily defined as days on which the mean temperature was at least 4.4°C lower than the day before) and around the time of heavy snowfalls. A statistically significant increase in the daily rate of sudden death at the time of cold snaps occurred only in men under 65 years of age, and even in this group the effect was of relatively small magnitude (+16%) compared with the large change in rate following heavy snowfalls (+88%). Among persons aged 65 years or over cold snaps had virtually no effect, and only the men in this group showed an increased daily rate of sudden death following a snowfall. These results suggest that much of the increased frequency of death from ischemic heart disease in winter, particularly among the elderly, must be due to factors other than short-term cold stress.

On a examiné l'effet à court terme des basses températures sur la fréquence de la maladie coronarienne survenue au cours d'une période de 15 ans. Afin de réduire l'influence d'autres facteurs saisonniers, l'analyse a été limitée aux mois d'hiver et s'est appuyée sur les changements des taux quotidiens des morts subites durant les périodes de temps froid (définies comme étant les jours où la température moyenne était au moins 4.4°C inférieure à la journée précédente) et à peu près au moment de fortes chutes de neige. Une augmentation significative au point de vue statistique du taux quotidien des morts subites durant les périodes de temps froid est survenue uniquement chez les hommes de moins de 65 ans, et même parmi ce groupe l'effet a été relativement faible (+16%) par rapport aux changements importants observés à la suite de fortes chutes de neige (+88%). Le temps froid n'a produit virtuellement aucun effet chez les personnes de 65 ans ou plus, et seulement chez les hommes de ce groupe a-t-on observé une augmentation du taux quotidien de mort subite subséquemment à une chute de neige. Ces résultats indiquent que la plus grande partie de l'augmentation de la fréquence des décès par ischémie coronarienne durant l'hiver, particulièrement chez les gens âgés, doit être due à des facteurs autres que le stress de courte durée provoquée par le froid.

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The incidence of ischemic heart disease is higher in winter than in summer. Several studies have shown that over the year there is a strong negative correlation between temperature and both fatal and nonfatal ischemic heart disease.[1-7] It has been suggested that this strong correlation reflects an acute effect of low temperature on the heart, since patients with angina complain of more severe symptoms in cold weather; the same mechanism (coronary spasm or myocardial overload) could presumably also predispose to myocardial infarction and sudden death.[8]

However, there are certain aspects of the seasonal variation in the mortality of ischemic heart disease that are not readily explained on the basis of a short-term reaction to low temperature. Much of the seasonal variation may be due to long-term biologic rhythms or to a "spill-over" effect from respiratory disease mortality.[9-11]

In an attempt to isolate the short-term effect of low temperature from other seasonal factors, we studied the change in the daily rate of sudden death from ischemic heart disease in metropolitan Toronto during the winter months, and specifically when there was an abrupt increase in cold stress (i.e., at the time of "cold snaps"). To provide a reasonable quantity of data, cold snaps were arbitrarily defined as occasions on which the mean temperature dropped at least 8°F, or 4.4°C, from one day to the next.

Changes in the rate of death from ischemic heart disease were also examined around the time of snowfalls of 4 in, or 10.2 cm, or more, which should have been heavy enough to require reasonably strenuous activity in the clearing of driveways and sidewalks.

The study was restricted to sudden deaths from ischemic heart disease since these should show a clearer relation to meteorologic conditions on the day of onset of the acute event than would total deaths from ischemic heart disease, some of which would have been preceded by several days of symptoms.

The 15-year period studied included the years 1960 through 1974; 1974 was the last year in which Canadian meteorologic information was published in non-metric units.

Method

Toronto is on the shore of Lake Ontario, and the moderating effect of this large body of water results in the climate's being less severe than in some other parts of Canada. None the less, December, January and February have average mean daily temperatures below freezing, and daily minimum temperatures frequently drop below −18°C. In this study November was also included as a winter month since, although it has a relatively high average mean daily temperature (4.8°C), it is the first month in which the temperature frequently drops below freezing; the population might be particularly vulnerable to these first cold snaps after several months of mild weather.

Winter days on which the mean temperature was at least 4.4°C lower than it was the day before were identified from annual meteorologic summaries for Toronto for 1960 to 1974, obtained from the Department of Transport. This yielded 222 pairs of days. For each day we then obtained the number of sudden deaths ascribed to ischemic heart disease (ICD 420 to 422[12] until 1968, then ICD 410 to 414[13]), classified by sex and age, reported to the Toronto coroner's office (which serves a population of approximately 2 million). Since deaths occurring in institutions must be reported to the coroner regardless of the suddenness of the event, such deaths were excluded from our study. The remaining deaths would have been reported to the coroner because they were sudden and unexpected.[14] Deaths of women under 65 years of age were so few that they were not included in the analysis.

The dates of snowfalls of 10.2 cm or more were also identified from the annual meteorologic summaries for 1960 to 1974; the number of deaths from ischemic heart disease was obtained for the day preceding the snowfall, the day of the snowfall and the next 4 days. On the two occasions when there was a second snowfall within 4 days of the first the second fall was ignored. There were 52 eligible snowfalls; 38 occurred in winter months (1 in November, 9 in December, 17 in January and 11 in February) and 14 occurred in other months (1 in October, 9 in March and 4 in April). The largest snowfall recorded was 39.9 cm and the mean snowfall was 16.0 cm.

Levels of statistical significance were calculated; however, they must be interpreted with caution, since they were based on two assumptions — namely that the number of deaths each day followed a Poisson distribution, and that this number was independent of the number of deaths on other days. The latter assumption is almost certainly not justified, but the degree of error is unlikely to affect the conclusions of the study.

Results

Cold snaps

On the 222 pairs of days when there was at least a 4.4°C drop in mean temperature from one day to the next, there was a 16% increase in the number of deaths from ischemic heart disease reported to the coroner in men under age 65 years (Table I), a difference that was just statistically significant ($P < 0.05$). The increase in the daily rate of sudden death was greater the more severe the cold snap: there was a 25% increase on days when the temperature fell more than 8.3°C (15°F), compared with only a 13% increase when the drop was between 4.4° and 8.3°C. However, this difference was not statistically significant.

Both men and women aged 65 years of age and over showed smaller changes in the daily rate of sudden death from ischemic heart disease at the time of cold snaps, and none of the changes were statistically significant. In both sexes there was a slight rise in the death rate at the time of the less severe cold snaps, but a slight decline in the rate at the time of the more severe cold snaps.

Daily death rates were also examined within each winter month as a function of the difference in daily temperature from the monthly mean. The results were essentially the same as those for cold snaps; that is, a modest increase in the death rate on the colder days in men under age 65 years, but little or no change in the rate in persons 65 years of age and over.

Table I—Sudden deaths from ischemic heart disease (coroner's cases) per day in metropolitan Toronto on pairs of days when the mean temperature dropped at least 4.4°C from one day to the next, during winter months, 1960 to 1974

Temperature drop from day 1 to day 2	No. of days	Mean no. (and total no.) of sudden deaths from ischemic heart disease								
		Men under 65 years of age			Men 65 years of age and over			Women 65 years of age and over		
		Day 1	Day 2	Change	Day 1	Day 2	Change	Day 1	Day 2	Change
4.4° to 8.3°C	172	1.98 (340)	2.23 (384)	+13%	1.94 (333)	2.05 (352)	+6%	1.34 (231)	1.44 (247)	+ 7%
More than 8.3°C	50	1.70 (85)	2.12 (106)	+25%	2.28 (114)	2.20 (110)	−4%	1.60 (80)	1.38 (69)	−14%
Total	222	1.91	2.21	+16%*	2.01	2.08	+3%	1.40	1.42	+ 1%
Overall no. of deaths	—	425	490	—	447	462	—	311	316	—

*Statistically significant at $P < 0.05$.

Snowfalls

On days when there was a snowfall of 10.2 cm or more the mean daily rate of sudden death from ischemic heart disease reported to the coroner in men under 65 years of age was 2.67, some 88% higher than the "baseline" rate of 1.42 reported the day before the snowfall (Table II). This increase persisted (at 92%) for 1 day after the snowfall, and on both of these days the increase over baseline was statistically highly significant ($P < 0.001$). Over the 3 days following the snowfall the rate declined, until by the fourth day it was only 25% higher than baseline, a difference that was not statistically significant.

Men 65 years of age and over also showed higher mean rates of sudden death on the day of and the day following a snowfall, but the increase was not as striking as in the younger men, averaging about 25% on both days ($P < 0.05$). Death rates for women 65 years of age and over showed no significant changes and actually declined slightly on the first 2 days of the snowfall. The magnitude of these changes relative to those seen in the cold snaps is shown graphically in Fig. 1.

The effect of cold snaps and snowfalls appeared to be additive. Thus, at the time of the 21 snowfalls associated with a fall in mean daily temperature of 2.2°C (4°F) or more the death rate for men under 65 years of age was 113% higher on the day of the snowfall than on the day before. For the remaining 31 snowfalls the increase in the daily death rate was only 59%.

Discussion

Most previous studies on the effect of temperature on the incidence of ischemic heart disease have included data for the entire year; therefore, the short-term effect of low temperature may have been confounded by the effect of other seasonal factors. Because we restricted the analysis to the winter months and used the immediately preceding day as the baseline against which to make comparisons this source of confusion should have been eliminated. Change in temperature should also be a more appropriate measure of short-term physiologic stress than absolute temperature, since there is presumably some degree of acclimatization during periods of sustained low temperatures; persons who are close to their limit of myocardial reserve might well be particularly vulnerable to a sudden drop in temperature, whatever the temperature level to which they have previously become adjusted.

Our finding of a large increase in the number of sudden deaths on both the first and the second day of a heavy snowfall is consistent with the pattern reported by Rogot and Padgett[15] in the United States and suggests that unusual physical activity, such as clearing snow from driveways and sidewalks, may be a more potent risk factor for ischemic heart disease than a drop in temperature. At the same time there is evidence of an additive effect between cold snaps and snowfalls, so that warnings to middle-aged men against excessive exertion when clearing snow should perhaps emphasize the possible added hazard of an associated cold snap.

The different patterns of sudden death in the three

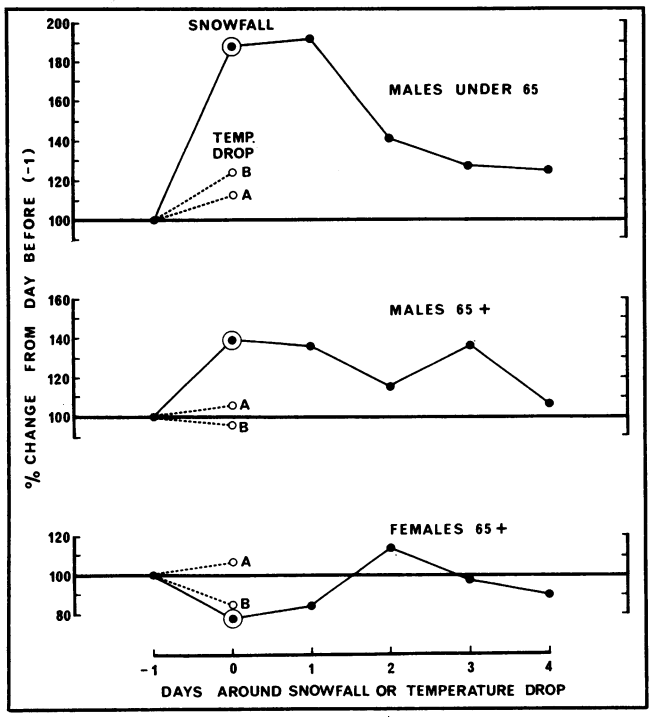

FIG. 1—Daily rates of sudden death from ischemic heart disease (coroner's cases) in metropolitan Toronto expressed as percentages of rates on day preceding cold snap (temperature drop of 4.4° to 8.3°C [A] or 8.8° to 18.3°C [B]) or snowfall of 10.2 cm or more.

Table II—Sudden deaths from ischemic heart disease (coroner's cases) per day in metropolitan Toronto on days around the 52 snowfalls of 10.2 cm or more between 1960 and 1974

Persons	Overall no. of deaths	Mean no. (and total no.) of sudden deaths from ischemic heart disease					
		1 day before snowfall	Day of snowfall	1 day after snowfall	2 days after snowfall	3 days after snowfall	4 days after snowfall
Men under 65 years of age	645	1.42 (74)	2.67† (139)	2.73† (142)	2.00* (104)	1.81 (94)	1.77 (92)
Men 65 years of age and over	651	1.71 (89)	2.38* (124)	2.33* (121)	1.96 (102)	2.33* (121)	1.81 (94)
Women 65 years of age and over	418	1.42 (74)	1.12 (58)	1.21 (63)	1.62 (84)	1.38 (72)	1.29 (67)

*Statistically significant at $P < 0.05$ (compared with 1 day before snowfall).
†Statistically significant at $P < 0.001$ (compared with 1 day before snowfall).

sex–age groups might conceivably reflect the likely differences in behaviour at times of inclement weather. In spite of heated homes and cars men under 65 years of age usually still have to get to work — some by car, but many by bus, streetcar, subway or foot — and usually feel responsible for clearing snow from around their home, either on the day of the snowfall or over the next day or two. Therefore, they are the group most likely to be exposed to the stress of both cold snaps and heavy snowfalls.

Retired persons, on the other hand, can usually avoid going out if the weather is particularly unpleasant, and this might account for the fact that, although both men and women aged 65 years and over showed some increase in the sudden death rate with moderate cold snaps, the rate actually declined on the days of very large drops in temperature.

The pattern for elderly men around the time of snowfalls might be a reflection of the tradition that the man of the house usually clears the snow, whereas for many elderly women a heavy snowfall might well curtail almost all outside activities and thus reduce environmental stress.

Thus, according to these data, low temperatures and snowfalls seem to have a short-term effect on men under 65 years old, but other factors must be responsible for most of the seasonal swing in mortality from ischemic heart disease among older people. For example, although women 65 years of age and over show little or no increase in the rate of sudden death at the time of cold snaps and snowfalls, their rate of death from this disease is some 30% higher in December than in July.[16]

The factors responsible remain obscure. Much of the winter excess of sudden deaths from ischemic heart disease, especially in old people, might be due to a "spillover" effect on death certification of ischemic heart disease from the even more pronounced seasonal variation in respiratory disease mortality.[10,11] This could explain why in England and Wales, and even in Australia, there are much higher winter peaks in mortality from ischemic heart disease than in Ontario in spite of the fact that the winters are much colder in Ontario. However, this hypothesis has not been supported either by studies of variation in the incidence of nonfatal ischemic heart disease[2,4] or by analysis of multiple causes of death on the certificates.[3,5]

It is possible that if comparable data on the rates of nonsudden ischemic heart disease (both fatal and nonfatal) were available, compensatory changes would be seen on days of cold snaps and snowfall; that is, the weather might affect the immediate death rate rather than the total incidence of acute episodes or death or both. However, if this were so, then it would be even more difficult to explain the overall winter peak of episodes of ischemic heart disease in terms of the acute effect of low temperature.

Thus, this study indicates that short-term reaction to low temperatures cannot explain the winter peak in the mortality of ischemic heart disease, especially in elderly people; the factors usually responsible are presumably either unrelated to temperature (such as, perhaps, fewer hours of daylight) or the result of relatively long-term effects of low temperatures.

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