Articles

# Cold exposure and winter mortality from ischaemic heart disease, cerebrovascular disease, respiratory disease, and all causes in warm and cold regions of Europe

*The Eurowinter Group**


## Summary

**Background** Differences in baseline mortality, age structure, and influenza epidemics confound comparisons of cold-related increases in mortality between regions with different climates. The Eurowinter study aimed to assess whether increases in mortality per 1°C fall in temperature differ in various European regions and to relate any differences to usual winter climate and measures to protect against cold.

**Methods** Percentage increases in deaths per day per 1°C fall in temperature below 18°C (indices of cold-related mortality) were estimated by generalised linear modelling. We assessed protective factors by surveys and adjusted by regression to 7°C outdoor temperature. Cause-specific data gathered from 1988 to 1992 were analysed by multiple regression for men and women aged 50–59 and 65–74 in north Finland, south Finland, Baden-Württemburg, the Netherlands, London, and north Italy (24 groups). We used a similar method to analyse 1992 data in Athens and Palermo.

**Findings** The percentage increases in all-cause mortality per 1°C fall in temperature below 18°C were greater in warmer regions than in colder regions (eg, Athens 2·15% [95% CI 1·20–3·10] *vs* south Finland 0·27% [0·15–0·40]). At an outdoor temperature of 7°C, the mean living-room temperature was 19·2°C in Athens and 21·7°C in south Finland; 13% and 72% of people in these regions, respectively, wore hats when outdoors at 7°C. Multiple regression analyses (with allowance for sex and age, in the six regions with full data) showed that high indices of cold-related mortality were associated with high mean winter temperatures, low living-room temperatures, limited bedroom heating, low proportions of people wearing hats, gloves, and anoraks, and inactivity and shivering when outdoors at 7°C ($p<0·01$ for all-cause mortality and respiratory mortality; $p>0·05$ for mortality from ischaemic heart disease and cerebrovascular disease).

**Interpretation** Mortality increased to a greater extent with given fall of temperature in regions with warm winters, in populations with cooler homes, and among people who wore fewer clothes and were less active outdoors.


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*See Commentary page 1337*

*Coordinating team and participants given at end of paper

**Correspondence to:** Prof W R Keatinge, Department of Physiology, Queen Mary and Westfield College, London E1 4NS, UK

## Introduction

Comparisons of cold-related mortality in different climates are complicated by disparities in baseline mortality rates, age structure, and influenza epidemics. Simple percentage differences in mortality between summer and winter vary substantially within Europe.[1] Mortality from ischaemic heart disease (IHD) and cerebrovascular disease (CVD), which together account for about half of all excess cold-related mortality, increases more steeply with falling temperature in London than in New York.[2] These deaths seem to result from thrombosis due to haemoconcentration in the cold,[3,4] and from other consequences of cardiovascular reflexes that are briefly induced by low temperatures.[5–8] Increase in respiratory disease (RD), which accounts for nearly half of the remaining excess cold-related mortality, is generally attributed to cross-infection from indoor crowding, to the adverse effects of cold on the immune system's resistance to respiratory infection, and to the fact that low temperatures assist survival of bacteria in droplets.[9] The rise in respiratory infections during cold weather further increases numbers of deaths from arterial thrombosis,[10–12] probably owing to increased plasma fibrinogen[13] and endotoxin inhibition of fibrinolysis.[14]

It remains unclear whether protective measures against cold substantially reduce mortality. Certain information would clarify this issue: whether the rises in mortality that accompany falling temperatures differ greatly in extent from one European region to another; whether variations in these increases relate to differences in protection against cold; and how both these factors are associated with the usual winter climate of the region. We are not aware of any previous attempts to relate mortality to extent of personal protection against indoor and outdoor cold, probably owing to a lack of pre-existing data on methods of personal protection in different regions and groups.

The aims of this study were, first, to assess the increases in mortality from all-causes, from IHD, CVD, and RD; to assess the increases per 1°C fall in outdoor temperature with allowance for sex, age, influenza, and baseline mortality; and to relate these increases to the usual winter climate. Second, to measure by active surveys the extent of personal protection against indoor and outdoor cold stress at a standard outdoor temperature. Third, we aimed to relate the summary variables for cold-related mortality to the variables for protection against cold. Separate male and female groups, whose members were of working age (50–59 years) and retired age (65–74 years), were studied in eight European regions with widely varying climates.

## Methods

### *Mortality population and temperature data*

We recorded the deaths per day of men and women separately, in two age groups (50–59 and 65–74 years), and for eight regions. The regions, which were not chosen randomly but because there was an appropriate research team in each, were north Finland (Kuopio, Vaasa, and Oulu provinces), south Finland (rest of Finland), Baden-Württemberg (Germany), Netherlands, Greater London (UK), north Italy (Imola, Bologna, Modena, and Faenza districts), Athens (Greece), and Palermo (Sicily). Data were available for the period 1988–92 except in Athens and Palermo, for which they were available for 1992 only. Cause-specific deaths were extracted with the 9th International Classification of Diseases coding (IHD 410·0–414·9; CVD 430·0–438·9; RD 460·0–519·9; influenza 487·0–487·9; and all causes 0–999·0). Baden-Württemberg provided data for influenza on a monthly basis only to preserve confidentiality; daily data were imputed from monthly data by a lowess procedure.[15] Populations for each sex and age group for each year were obtained from national or regional authorities.

Daily mean temperatures in each region were calculated from measurements taken every 3 h in north Finland (mean of Oulu, Kuopio, and Vaasa), south Finland (mean of Helsinki and Lahti), Baden-Württemberg (mean of Freiburg and Stuttgart), Netherlands (Volkel), Greater London (Heathrow), Emilia-Romagna (Bologna), Athens, and Palermo. For Volkel, the data for the first 163 days of 1988 were missing, so these days were excluded from the Netherlands analysis; occasional missing readings were otherwise replaced by interpolation.

### *Indices of cold-related mortality*

Regressions of deaths per day for daily temperatures below 18°C were fitted by means of generalised linear modelling for Poisson distribution of the deaths, with identity link function.[16] The relations in this range are broadly linear.[12] Although extensive data might show minor departures from linearity in many regions, only two of 24 age and sex groups of the six regions with temperatures below 0°C showed significant differences in slope ($p<0·05$), in opposite directions, in the ranges 0–18°C, and below 0°C—a result that could arise by chance.

Percentage changes in mortality with cold have commonly been used for regional comparisons of winter mortality.[1] Percentage changes give a logical basis for comparison, since pre-existing factors such as atheroma or immune responsiveness—which determine baseline mortalities—can also be expected to affect proportionately the number of additional deaths from cold-related haemoconcentration or infection. Indices of cold-related mortality were estimated, therefore, from the regressions of daily deaths on temperature; we calculated the indices as the percentage increase in deaths per 1°C fall in temperature below 18°C. Mortalities were lagged on temperature by 2 days for IHD; 5 days for CVD; 12 days for RD; and 3 days for all causes. These are the delays that gave the highest regression coefficients, and are similar to those days of peak mortalities during the lowest temperature shown in time-series analysis.[17] Indices for each age and sex group were calculated separately from 5 years' data for the six regions, and were used for the main analyses. Year by year indices of all-cause mortality for each of the 24 regional age and sex groups used for multiple regression analysis showed significant change with time in one case only, a result that could have come about by chance. Indices for all-causes were also calculated from data that combined both sex and age groups in each of the eight regions to give a simple measure not adjusted for population distribution. Deaths from influenza, averaged over 20 days (−10 to +10), were included in the regression model as a second explanatory variable to allow for effects of influenza; air quality[18,19] was not included. For points on graphs, data were grouped in 1°C intervals.

### *Lifestyle factors at 7°C outside temperature*

Local market survey companies interviewed 1000 people in each region, with roughly equal numbers (range 231–268) in each of

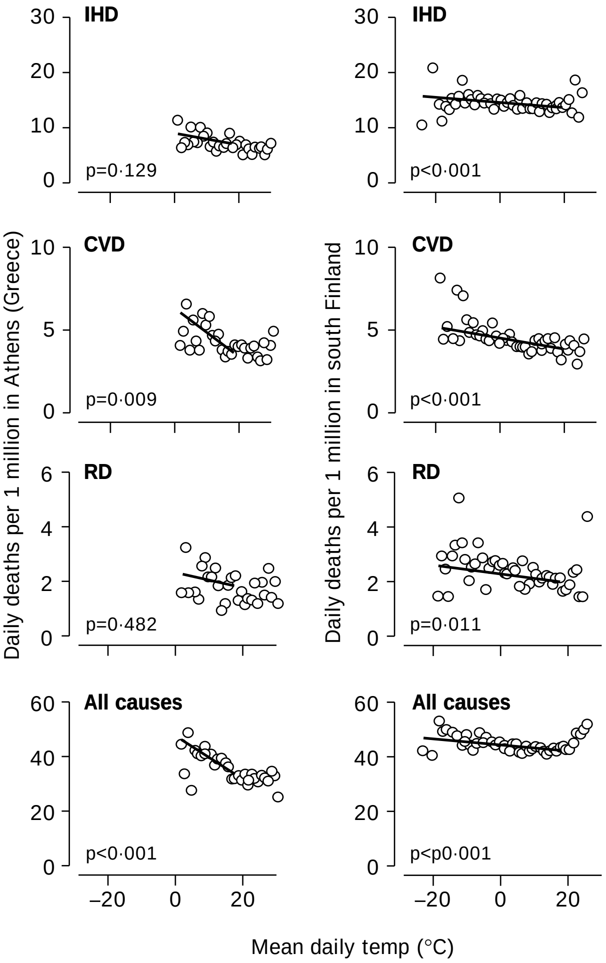


Figure 1: **Deaths per day per 10⁶ population in relation to mean daily temperature in one warm and one cold region**
Lagged on temperature (see methods); no allowance for influenza.

the four sex and age groups monitored for deaths. During interviews, carried out after 1700 h in the living-room, temperature was measured by Thermax strips (interval 1°C; Thermographic Measurements Ltd, Burton, UK) 0·5–1·2 m above the floor. Questionnaires to find out the hours of bedroom and living-room heating, the duration and number of outdoor excursions, clothing items worn and physical activity during the excursions, were prepared in English initially, and translated into local languages. In each region, interviewees were selected by a two-stage process rather than randomly;[20] primary sampling areas (typically 5% of total) with sampling points representative of population density, social composition, and related factors (such as type of accommodation), were designated from census data. Each interviewer was allocated a sampling area for each day. Rules to prevent clustering included separation of interviews by at least four addresses, and the limitation of each street to two interviews (we treated apartment blocks as streets). Interviews were spread evenly during all 7 days of the week from November, 1994 (October in Finland) to the end of February, 1995. Samples of responses were checked by telephone or post for quality control. We calculated clothing protection from the list of garments worn, and from surface areas reported for specific parts of the body of men and women, as a fraction of total surface area.[21] Each survey variable was adjusted by regression to standardise for 7°C outdoors, which was the coldest temperature common to all regions during the surveys. We used least-squares regression for living-room temperature and clothing area, generalised linear modelling[16] for Poisson-distributed data, and logistic regression for binary data.

## Results

### *Mortality related to coldness of winter*

Mortality rates in each region from IHD, CVD, RD, and all causes, were at or near their minimum value when mean daily temperature was 18°C, and rose in a broadly linear way as the temperature fell. Figure 1 gives examples, with data combined for men and women and both age groups, in Athens and in south Finland. The increases in deaths per 1°C fall from 18°C were greater in the warm region than in the cold region, both absolutely and as a percentage of mortality at 18°C.

Table 1 shows data on winter climate and distribution of population according to age and sex group in the regions. Mean temperature during the winter months (October–March) varied from −2·8°C in north Finland to 15·4°C in Palermo. The number of days per year colder than 18°C was not directly related to mean winter temperature; the most striking discrepancy was between London (345 days) and north Italy (248 days), despite almost identical mean winter temperatures. Populations had similar sex ratios for the 50–59 age group, but in the 65–74 age group, there were fewer men than women in every region. Baseline (18°C) estimated deaths per day per $10^6$ people, pooled for both age and sex groups, varied from 31·0 in Baden-Württemberg to 43·0 in south Finland. Excess annual deaths above this baseline on days colder than 18°C—obtained by subtracting the expected number of deaths if the daily rate remained at baseline from total deaths per $10^6$ people on days colder than 18°C—varied from 408 in north Italy to 1617 in London, though both regions had similar mean winter temperatures. By use of these pooled data for sex and age groups of each region, we calculated indices of all-cause mortality (percentage increase per 1°C fall in temperature from 18°C) to be significantly greater than zero for all regions except Palermo, where only 1 year's data and a small population resulted in wide confidence limits. These indices for all-cause pooled age and sex group mortality were lower in northern European regions with cold winters than in south and west Europe; the regression coefficient of these indices on the region's mean winter temperature was significant (p=0·01).

Table 2 shows that with allowance by multiple regression for age and sex in the six regions with sufficient deaths for such analysis, cause-specific indices of cold-related mortality from RD and from all causes were significantly (p<0·01) lower in regions with low mean winter temperatures. The relation was similar but did not achieve significance for indices for IHD and CVD cold-related mortality, whose sizes were less than half those for RD at the average winter temperature of the regions and with equal sex and age groups. These indices of cold-related mortality showed little relation to sex and age, though those for all-cause mortality were higher in the 65–74 than in the 50–59 age group; and those for RD mortality were higher in women than in men. Baseline mortality rates at 18°C for all except RD deaths were significantly higher in the colder countries and older age groups, as expected. In regions with average winter temperature, and equal sex and age groups, IHD was the largest single cause of death (26%) at the baseline

| | North Finland | South Finland | Baden-Württemberg | Netherlands | London | North Italy | Athens | Palermo |
|---|---|---|---|---|---|---|---|---|
| **Mean temperature** | | | | | | | | |
| Oct–March (°C) | −2·8 | −1·0 | 5·1 | 6·2 | 7·6 | 7·7 | 12·7 | 15·4 |
| **Number of days per year below 18°C** | 360 | 354 | 330 | 315 | 345 | 248 | 214 | 202 |
| **Population (×10³)** | | | | | | | | |
| Men 50–59 | 59 | 191 | 645 | 756 | 335 | 80 | 174 | ·· |
| Women 50–59 | 59 | 202 | 624 | 752 | 336 | 86 | 194 | ·· |
| Men 65–74 | 37 | 108 | 276 | 483 | 236 | 58 | 103 | ·· |
| Women 65–74 | 53 | 173 | 461 | 615 | 294 | 74 | 139 | ·· |
| **Total annual deaths*** | 3444 | 11 056 | 23 910 | 36 707 | 19 639 | 3814 | 8045 | 1647 |
| **Deaths per $10^6$ population†** | | | | | | | | |
| Per day at 18°C | 42·8 | 43·0 | 31·0 | 36·5 | 40·3 | 34·3 | 34·4 | ·· |
| Excess per year on days colder than 18°C | 826 | 658 | 596 | 676 | 1617 | 408 | 888 | ·· |
| **Mean (95% CI) % increase in mortality for each 1°C fall from 18°C†** | 0·29 (0·10, 0·48) | 0·27 (0·15, 0·40) | 0·60 (0·48, 0·72) | 0·59 (0·47, 0·69) | 1·37 (1·20, 1·54) | 0·51 (0·15, 0·87) | 2·15 (1·20, 3·10) | 1·54 (−2·10, 5·12) |

*1988–92 for all regions except Athens and Palermo (1992 only). †Allowance for influenza on these deaths only. Matching population data not available for Palermo.

Table 1: **Winter climate, populations, and mortality rates in each region**

| | Regression coefficients (95% Ci) | | | Predicted value of index or baseline mortality in region with mean winter temperature 3·8°C (average winter temperature in six regions), with equal sex and age groups |
|---|---|---|---|---|
| | Mean winter temperature | Sex (M=0, F=1) | Age (50–59=0, 65–74=1) | |
| **Index of cold-related mortality for:** | | | | |
| IHD | 0·15 (−0·09, 0·39) | 0·91 (−1·06, 2·88) | −0·46 (−2·43, 1·51) | 1·0 (0·02, 2·00) |
| CVD | 0·06 (−0·01, 0·13) | 0·37 (−0·98, 0·24) | 0·33 (−0·28, 0·94) | 0·94 (0·64, 1·25) |
| RD | 0·30 (0·14, 0·45) | 1·36 (0·05, 2·67) | −0·42 (−1·73, 0·89) | 2·46 (1·81, 3·12) |
| All causes | 0·05 (0·02, 0·08) | 0·03 (−0·24, 0·30) | 0·39 (0·12, 0·66) | 0·52 (0·38, 0·66) |
| **Baseline mortality (18°C) for:** | | | | |
| IHD | −0·91 (−0·34, −1·48) | −11·12 (−6·38, −15·86) | 15·48 (10·74, 20·22) | 11·52 (9·15, 13·90) |
| CVD | −0·17 (−0·08, −0·26) | −1·22 (−0·45, −1·99) | 5·10 (4·33, 5·87) | 3·48 (3·09, 3·87) |
| RD | −0·04 (−0·17, 0·09) | −2·24 (−1·14, −3·35) | 3·54 (2·44, 4·65) | 2·27 (1·72, 2·83) |
| All causes | −0·96 (−2·12, 0·19) | −29·77 (−20·18, −39·36) | 52·23 (42·64, 61·82) | 43·85 (39·04, 48·66) |

Six regions, 24 groups. *% increase in mortality per 1°C fall in outdoor temperature from 18°C. †Daily deaths per $10^6$ of population at 18°C.

Table 2: **Relation of indices of cold-related mortality* and baseline mortality† by multiple regression to mean winter temperature of region, sex, and age group**

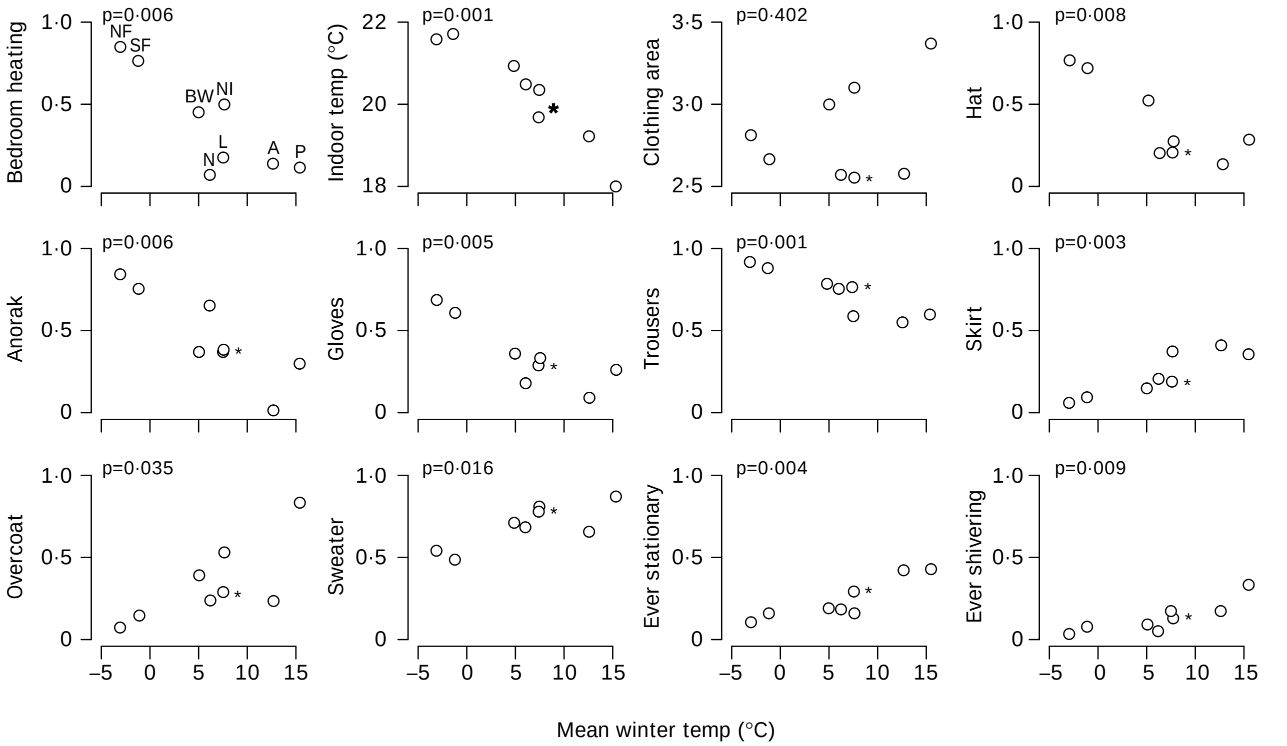


Figure 2: **Personal cold exposure factors at standard outdoor temperature 7°C in relation to mean winter temperature of region**
All values for previous 24 h. Indoor temperature in living-room after 1700 h; bedroom heating ⩾4 h=1, <4 h=0; clothing area=total area of clothing / body surface area;[23] other variables 1·0=yes, 0=no. Skirts worn by women only. Points from left to right: north Finland (NF), south Finland (SF), Baden-Württemberg (BW), Netherlands (N), London (L), north Italy (NI), Athens (A), Palermo (P). London given asterisk to distinguish from north Italy. Mean winter temperature in latter only 0·1°C higher than London.

temperature of 18°C, whereas RD accounted for fewest deaths at 5%.

### *Personal exposure factors in relation to coldness of winter*

Personal cold exposure factors at a standard outdoor temperature of 7°C also varied with mean winter temperature of the regions (figure 2). Bedroom heating was less common and living-room temperatures (eg, 19·2°C in Athens, 21·7°C in south Finland) were lower in regions with warm winters. Outdoors at 7°C, people living in regions with warm winters were less likely to wear a hat (13% Athens, 72% south Finland), an anorak, gloves, or trousers (among women), though total clothing area was similar; they were more likely to wear a skirt (women), an overcoat, or a sweater, and more likely also to stand still and to shiver, and less likely to sweat.

### *Relation of mortality rates to personal cold exposure factors*

In the 24 sex and age groups in the six regions with sufficient data for multiple regression analysis, indices of all-cause mortality showed significant associations (table 3) with several indoor and outdoor cold exposure factors at the standard outdoor temperature of 7°C. With allowance for sex and age, these indices were significantly (p<0·05) higher in regions where bedrooms were seldom heated through the night (negative relation); where living-room temperatures were low; and where few people (as a fraction of those who went out) wore hats, anoraks, gloves, long-sleeved vests, or long underpants, when outdoors. The indices were positively related to the fraction who kept still for at least 2 min or who shivered while outside. The indices were positively related also to wearing of a sweater or an overcoat, probably because these items were not usually worn with the more protective anorak (correlation coefficients −0·68, p<0·001; 0·83, p<0·001, respectively). Cause-specific indices of cold-related mortalities showed similar associations, though to different extents. The indices for RD were strongly associated with most of the cold exposure factors associated with all-cause mortality; they were also negatively related to the wearing of trousers outdoors, positively to wearing of less protective skirts (correlation coefficient between wearing skirt and trousers −0·80, p<0·001), and negatively related to heat stress sufficient to cause outdoor sweating. Indices for IHD and CVD were in general similarly, but not significantly, related to these protective factors, indoor or outdoor. Frequency and duration of outdoor excursions showed little relation to indices of mortality, perhaps because people who made frequent or long excursions took more effective measures to avoid cold stress.

In general, personal cold exposure factors at 7°C correlated strongly with each other, both between indoor and outdoor factors, and within each category. In particular, groups with warm living-rooms were very likely (correlation coefficients, >0·67 absolute, p<0·001) to heat their bedrooms, to wear hat and anorak, and to keep active outside at 7°C. The inter-relations of these cold-exposure factors limited our scope to analyse the independent association of each factor to indices of cold-related mortality. However, by use of the proportion of all people in each regional sex and age group who became sufficiently cold to shiver outside at 7°C as an overall variable for outdoor cold stress—with age and sex as additional explanatory variables—indices of all-cause mortality were significantly related on multiple regression

| Cold exposure factor | IHD | | CVD | | RD | | All causes | |
|---|---|---|---|---|---|---|---|---|
| | *R* | p | *R* | p | *R* | p | *R* | p |
| **Indoors** | | | | | | | | |
| Bedroom heating (⩾4 h=1, <4 h=0) | −1·5 | 0·038 | −0·6 | 0·265 | −2·8 | 0·053 | −0·8 | 0·002 |
| Living room temperature (°C) | −0·7 | 0·306 | −0·3 | 0·137 | −1·8 | <0·001 | −0·3 | <0·001 |
| **Outdoors** | | | | | | | | |
| Whether going out* | −2·1 | 0·673 | 0·1 | 0·968 | −2·0 | 0·623 | −1·7 | 0·021 |
| Mean duration (h) | 0·1 | 0·686 | 0 | 0·352 | 0 | 0·922 | 0 | 0·891 |
| Frequency | −0·2 | 0·921 | 0·5 | 0·312 | −1·9 | 0·116 | −0·4 | 0·129 |
| **When out*** | | | | | | | | |
| Clothing area (fraction of body surface) | 0·2 | 0·275 | 0·1 | 0·923 | 2·2 | 0·183 | −0·5 | 0·139 |
| Hat | −2·6 | 0·210 | −1·2 | 0·068 | −4·7 | 0·004 | −1·0 | 0·001 |
| Anorak | −2·9 | 0·209 | −0·9 | 0·223 | −6·7 | <0·001 | −0·8 | 0·029 |
| Gloves | −2·1 | 0·403 | −0·9 | 0·289 | −3·9 | 0·065 | −0·9 | 0·019 |
| Long-sleeved vest | −1·2 | 0·696 | −1·3 | 0·190 | −4·5 | 0·072 | −1·4 | 0·002 |
| Long underpants | −1·3 | 0·541 | −1·1 | 0·093 | −3·8 | 0·022 | −0·8 | 0·011 |
| Long trousers | −6·0 | 0·036 | −0·1 | 0·311 | −6·6 | 0·005 | −0·1 | 0·817 |
| Skirt | 8·8 | 0·040 | 1·0 | 0·211 | 8·3 | 0·005 | 0·1 | 0·911 |
| Overcoat | 4·8 | 0·114 | 1·9 | 0·047 | 7·3 | 0·002 | 0·6 | 0·272 |
| Sweater | 6·0 | 0·091 | 2·4 | 0·026 | 9·5 | <0·001 | 1·3 | 0·020 |
| Stationery (>2 min) | 2·4 | 0·759 | 2·5 | 0·327 | 13·2 | 0·040 | 4·0 | <0·001 |
| Sweat | −7·0 | 0·455 | −5·9 | 0·037 | −17·5 | 0·020 | −2·2 | 0·143 |
| Shiver | 3·6 | 0·696 | 2·9 | 0·327 | 23·8 | 0·001 | 3·2 | 0·027 |

Six regions, 24 groups; allowance for age and sex by multiple regression. *Yes=1, no=0, except for clothing area.

Table 3: **Regression coefficients (*R*) and their significance (p), for cause-specific indices of cold-related mortality on personal cold-exposure factors standardised at 7°C mean daily temperature**

to bedroom heating (regression coefficient, $R=-0{\cdot}7$, p=0·005), or to living-room temperature ($R=0{\cdot}4$, p<0·002), independently of shivering outdoors. Indices of RD mortality were related to shivering outdoors independently of either bedroom heating ($R=23{\cdot}3$, p=0·004) or living-room temperature ($R=15{\cdot}2$, p=0·05); and to living-room temperature ($R=-1{\cdot}3$, p=0·01) independently of shivering outdoors.

## Discussion

The results show that the percentage increases in all-cause and RD mortality with fall in temperature were greater, and that protective measures against a given degree of cold were fewer, in regions with mild winters. The same was generally true of IHD and CVD mortality. The results also show direct associations between mortality indices and protective measures against cold. Evidence of independent associations between mortality rates and specific protective measures was limited by a clear tendency of groups that took one protective measure to take a further measure. However, we found evidence that linked mortality with home heating independently of outdoor cold stress, and outdoor cold stress independently of home heating. Correlations between specific outdoor protective factors were high, but the association of low mortality indices with wearing of hats, anoraks, and gloves, and with physical activity outdoors, was striking. Frequent wearing of these garments, and of trousers by women, was balanced by less wearing of overcoats and skirts, so that there was little difference in the total area of clothing worn. However, certain garments reduce heat loss disproportionately to the area covered. Hats are particularly important since the head has low internal insulation in the cold.[21] Anoraks protect against wind and water; gloves cover otherwise unprotected skin; overcoats and skirts probably provide less insulation than anoraks and trousers. The association of high indices of winter mortality with physical inactivity outdoors is interesting, since personal behavioural factors cannot be attributed to lack of heating or clothing in warm regions. If this relation is causal, it suggests that the benefit of increased heat production outweighed adverse effects of respiratory-tract cooling by increased ventilation during exercise in cold air. The weaker associations with indices of cold-related mortality from IHD and CVD may simply reflect the small values of these indices compared with RD and all-cause mortality (table 2).

Several known effects of cold on the body could account for cold-related deaths. Arterial thrombosis is promoted by the haemoconcentration[3,4] induced by cold, and rapid coronary deaths could result from rupture of atheromatous plaques during hypertension and cold-induced coronary spasm.[5–8,22] Suppression of immune responses by stress hormones during cold exposure is likely to reduce resistance to respiratory infection, as will direct effects of cold on the respiratory tract;[23,24] these direct effects could also cause bronchoconstriction.[25] Acute-phase reactions to such respiratory infection[13,14] can then be expected to increase further the risk of arterial thrombosis. The results do not rule out other factors such as previous temperature experience, or low vitamin C intake in winter.[26,27] However, the associations shown in the results between mortality and protection against cold stress strongly suggest that excess winter mortality could be reduced substantially by improved protection from cold—particularly in countries with warm winters where the need for cold-avoidance was less obvious, and measures taken against it less effective.

Taken with previous evidence of substantial winter mortality in people with fully heated housing but outdoor exposure,[28] the results imply adverse effects of both outdoor and indoor cold on mortality. They do not support speculation that warm housing might on balance be harmful by increasing the cold shock experienced by people when they go outdoors. Cold housing already receives much attention; this should continue, but may leave scope for action to reduce mortality from outdoor cold exposure. Although we know that the middle-aged and elderly should wear protective clothing and keep active in cold weather outdoors, our surveys show that in relatively warm countries they often fail to do so. Steps to promote such personal measures, and such public measures as windproofing of bus shelters, offer ways to reduce outdoor cold stress.

*Eurowinter Group Study Organisation*

*Coordinating team*—W R Keatinge, G C Donaldson.

*Members and Centres*—W R Keatinge, G C Donaldson (Queen Mary and Westfield College, London, UK); K Bucher, G Jendritsky (Deutscher Wetterdrenst, Freiberg, Germany); E Cordioli, M Martinelli (Universitá degli Studi di Bologna, Italy); L Dardanoni (Universitá di Palermo, Italy); K Katsouyanni (School of Medicine, University of Athens, Greece); A E Kunst, J P Mackenbach (Erasmus University, Rotterdam, Netherlands); C McDonald (McDonald Research, London, UK); S Näyha (Regional Institute of Occupational Health, Oulu, Finland); I Vuori (IKK Institute for Health Promotion Research, Tampere, Finland).

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