Heart Failure in a Cold Climate
Seasonal Variation in Heart Failure-Related Morbidity and Mortality
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OBJECTIVES
This study was done to determine whether seasonal variation exists in hospitalizations and deaths due to heart failure (HF) and to examine possible contributors to such variability.

BACKGROUND
Although seasonal variation in the incidence of acute myocardial infarction and sudden death is well recognized, it is less well documented in HF.

METHODS
We used the linked Scottish Morbidity Record scheme, which provides individualized morbidity and mortality data for the entire Scottish population.

RESULTS
Between 1990 and 1996, there were a total of 75,452 male and 81,269 female hospitalizations related to HF in Scotland, with an average rate of admissions per 100,000 population of 8.4 and 8.5 per day, respectively. Significantly more admissions occurred in winter compared to summer (p < 0.0001). In women, the peak rate of admission occurred in December (12% more than average) and the lowest rate in July (7% less than average) (odds ratio [OR] 1.14, p < 0.001). The respective figures for men were 6% more, 8% less (OR 1.16, p < 0.001). In both genders, the greatest variation occurred in those aged >75 years—peak winter rates being 15% to 18% higher than average. There was also a winter peak in concomitantly coded respiratory disease; this seasonal excess accounted for approximately one-fifth of the winter increment in HF hospitalizations. Seasonal variation in mortality was also seen in these patients. The number of male deaths in December was 16% higher, and in July 7% lower, than average (OR 1.25, p < 0.001). In women, the equivalent figures were 21% higher (January) and 14% lower (July) (OR 1.21, p < 0.001). Again, the greatest variation occurred in those aged >75 years—peak rates being 23% to 35% higher than average.

CONCLUSIONS
There is substantial seasonal variation in HF hospitalizations and deaths, particularly in the elderly. Approximately one-fifth of the winter excess in admissions is attributable to respiratory disease. Extra vigilance in patients with HF is advisable in winter, as is immunization against pneumococcus and influenza. (J Am Coll Cardiol 2002;39:760–6)

Seasonal variation in the incidence of acute myocardial infarction (AMI) (1–3) and sudden death (4) is well recognized. Environmental temperature has been implicated in this variation as these events peak in winter. Some of the physiologic consequences of reduction in temperature, thought to be involved in increased coronary risk, might also be hazardous in heart failure (HF). Skin cooling has been shown to increase systemic vascular resistance (5), heart rate (6), plasma norepinephrine concentration (7), circulating levels of vasoconstrictor peptides (8) and blood pressure (9). In keeping with this, blood pressure is higher in winter (10). Cold can also induce myocardial ischemia (11). All of these effects could clearly lead to worsening of HF. Other seasonal variations, such as in the incidence of respiratory infections, could also threaten the stability of HF. The aim of this study was to determine whether there is seasonal variation in hospitalizations and deaths due to HF and to examine possible contributors to such variability.

METHODS
Data source. In Scotland, all nonmaternity, nonpsychiatric hospital inpatient and day case discharges are summarized on a discharge record (the Scottish Morbidity Record) and aggregated by International Classification of Disease (ICD) 9 codes, on a national computerized database held at the Information and Statistics Division of the National Health Service in Scotland (12,13). The application of record linkage techniques permits both analysis of the data at the level of the individual patient and the episode of care. Hospital discharge data are also linked to the Register General’s death records. For any given patient, therefore, readmissions, following an index hospitalization, can be tracked (and their nature identified); should the patient die, that outcome is also recorded (14).

We have recently described trends in HF-related hospital activity in Scotland, for the period 1990 to 1996 (15). For the purpose of the current study, we examined all hospitalizations associated with a discharge diagnosis (in any diagnostic position) of congestive heart failure (ICD9 code 428.0 and ICD10 code I110) or left HF/acute pulmonary edema (ICD9 code 428.1 and ICD10 code I111) (14,15).

Hospitalization data. The number of hospitalizations for these diagnoses during the seven-year period 1990 to 1996 was calculated separately for each calendar month on an
age- and gender-specific basis. For each month, a rolling daily average of hospital activity (reflecting the sum total of hospitalizations for that period) was then calculated. Similarly, using a rolling average of the reported population of Scotland during this period (15), we then calculated the population-based rate of hospitalizations per day (stated as the number of hospitalizations per day per 100,000 population) on an age- and gender-specific basis.

**Mortality data.** Using linked data from the General Register Office for Scotland, we identified all deaths occurring in those individual patients who contributed to the above hospitalizations for the period 1990 to 1997 (thus enabling at least one year of follow-up in all patients). As with hospitalization data, we calculated the number of deaths separately for each calendar month on an age- and gender-specific basis in order to derive a daily average of deaths—once again, reflecting the sum total of deaths during this period.

**Seasonal variation.** To determine any seasonal variation in hospital activity, we compared monthly averages with the overall population rate of hospitalization. The extent of deviation specific to each calendar month was quoted as a percentage relative to the overall rate of activity observed during this period (possible range $-100$ to $+100$%). The average number of deaths occurring during each calendar month was similarly calculated.

**Statistical analysis.** We tested the assumption that the rate of hospitalization and death would be constant throughout this period by comparing the “expected” (calculated from the overall daily rate) and observed number of cases recorded for each calendar month using the chi-square goodness-of-fit test.

To determine further the extent of variability in the risk of hospitalization or death, we used the same test to directly compare event rates for those months associated with the highest and lowest values relative to the overall event rate observed. The comparative risk of an event occurring in these two months was then stated as an odds ratio (OR) (95% confidence interval [CI]). For the direct comparison of the risk of inpatient case-fatality between “high” and “low” months, we used gender-specific multiple logistic regression models that included age, comorbidity and social deprivation to calculate adjusted ORs. We also used the Student $t$ test to compare between-month mean length of survival. All data management and analyses were performed using SPSS for Windows version 9.0 (SPSS Inc., Chicago, Illinois).

**RESULTS**

**Overall Admissions and Deaths, 1990 to 1996**

Between 1990 and 1996, there were a total of 75,452 male and 81,269 female hospitalizations in Scotland, with a discharge diagnosis of congestive heart failure or acute HF. Of the 38,875 men and 44,505 women who contributed to all these admissions between 1990 and 1996, a total of 26,033 (67%) men and 30,543 (69%) women died between 1990 and 1997.

*Figure 1.* Average number of heart failure-related hospitalizations per day in Scotland, 1990 to 1996. Figures represent the summed average for each month, during the entire study period.
Seasonal Trends in Hospital Admissions

All HF hospitalizations, 1990 to 1996. Figure 1 shows the daily average number of HF-related hospitalizations between 1990 and 1996. The daily average of these hospitalizations per 100,000 population was 8.4 in men and 8.5 in women, respectively. There was a marked seasonal variation in the number and rate (Figs. 1 and 2), with many more hospitalizations in the winter months compared to summer months. For example, in women, the peak occurred in December (9.2 hospitalizations per 100,000 population, 12% greater than average, \( p < 0.001 \)), whereas the lowest rate occurred in July (7.9 per 100,000 population, 7% less than average, \( p < 0.001 \)). In men, seasonal variation was less marked but still evident—the peak daily rate of hospitalization occurred in December, January and February (8.9 per 100,000 population—6% greater than average, \( p < 0.001 \)), whereas the lowest rate also occurred in July (7.7 per 100,000 population—8% less than average, \( p < 0.001 \)).

In both men and women, the greatest seasonal variation occurred in those aged \( \geq 75 \) years (Fig. 2). In women, this seasonal variation resulted in an absolute difference of 1,111 hospitalizations, comparing the hospital activity in July to that of December (6,455 vs. 7,566), during the entire seven-year period. In men, the equivalent number for July compared to January was 921 (5,925 vs. 6,846 hospitalizations).

Hospitalizations with HF as the principal diagnosis. In hospitalizations where HF was the principal discharge, seasonal variation was similar to that seen when all discharges with a HF coding were considered (Fig. 3).

Concomitant discharge diagnoses. Sixty-five percent of hospitalizations with HF coded as the principal discharge diagnosis had a secondary coding. Respiratory disease was concomitantly coded in 10% of these discharges. Seventy-five percent of respiratory disease codings were for chronic obstructive pulmonary disease and the remaining 25% were for pneumonia. The other major categories of secondary codings were AMI (approximately 20%), other forms of coronary heart disease (13%) and atrial fibrillation (6%).

**RESPIRATORY DISEASE.** There was a winter peak of concomitantly recorded respiratory disease in both men and women, with HF coded as the principal diagnosis—9% of December discharges versus 6% of July discharges (\( p < 0.001 \)). This difference accounted for 220 admissions. It was even more marked in patients aged \( > 75 \) years (12% vs. 8%, \( p < 0.001 \)). Similar differences were noted in hospitalizations with HF coded as a secondary diagnosis (14% in December compared to 10% in July, \( p < 0.001 \)). This difference accounted for 170 admissions. Again, it was most marked in those \( > 75 \) years.

**ACUTE MYOCARDIAL INFARCTION.** Concomitantly coded AMI also showed a seasonal variation in older men. In men \( > 75 \) years of age, the proportions in December and July were 15% and 11%, respectively (\( p < 0.001 \)), compared to 20% and 19.5%, respectively, in men overall. This difference accounted for an excess of 97 admissions. The corresponding proportions for all women were 16% and 16% and in women \( > 75 \) years of age 14% and 14%.

**OTHER CONCOMITANT DIAGNOSES.** No seasonal variation was detected in other manifestations of coronary heart disease, arrhythmias, stroke or alcohol-related problems and depression in patients hospitalized with HF.

Seasonal Trends in Deaths

All deaths, 1990 to 1996. Figure 4 shows the average number of deaths per day for each month during the period
1990 to 1997. A marked seasonal variation was observed in the pattern of deaths in patients hospitalized with HF between 1990 and 1996. The average number of men who died during December was 83 per day compared to 67 per day in July (16% higher and 7% lower, respectively, than the yearly average, \( p < 0.001 \)). In women, the equivalent figure for January was 102 deaths per day compared to 73 in July (21% higher and 14% lower, respectively, than the yearly average, \( p < 0.001 \)).

In women, this seasonal variation resulted in an absolute excess of 922 deaths in July compared to that of January (2,249 vs. 3,171) between 1990 and 1997. In men, the excess in January over July was 507 deaths (1,995 vs. 2,502 deaths).

Figure 5 shows the average rate of deaths per day, categorized by age and gender. As with hospitalizations, the greatest seasonal variation in mortality was in those aged \( \geq 75 \) years.

**Inpatient case fatality and mean survival after hospitalization.** When compared with death at any time after admission, inpatient case fatality also showed clear seasonal variation. In men, this rate was 24% in December versus...
21% in July, an adjusted OR of 1.17 (95% CI 1.01 to 1.25, \( p < 0.001 \)). In men 75 years or older, these rates were 28% versus 24%, adjusted OR 1.15 (95% CI 1.08 to 1.24), \( p < 0.001 \).

In women, the inpatient case fatality rate was 20% in December versus 19% in July, adjusted OR 1.08 (95% CI 1.00 to 1.16), \( p < 0.05 \) (28% vs. 25% in women \( \geq 75 \) years, adjusted OR 1.13 [95% CI 1.03 to 1.24], \( p < 0.001 \)). For men, mean survival in those discharged alive from hospital was worse in December at 533 days versus 563 days if hospitalized in July (\( p < 0.05 \)). In women, the comparable figures were 573 versus 622 days (\( p < 0.001 \)).

**DISCUSSION**

We have identified a significant winter peak in HF-related hospitalizations. These population-based findings are in accord with the results of the only other study to examine this topic (16), which found a similar seasonal variation in discharges from French public hospitals (accounting for approximately 70% of hospital capacity in that country) (16). When analyzing mortality, that study only examined death certification for HF, rather than case fatality specifically in patients hospitalized with HF. Nevertheless, both analytical approaches confirmed an even more pronounced winter peak in deaths.

**Physiologic mechanisms underlying seasonal variation.**

What causes this winter peak in HF morbidity and mortality? Our findings are clearly in keeping with the seasonal variation seen in acute coronary syndromes and sudden deaths (1–4). Consequently, they may share common mechanisms and aggravate the other's seasonal amplitude. For example, the hemodynamic stresses and neurohumoral activation that accompany a reduction in temperature may exacerbate HF, induce myocardial ischemia and precipitate arrhythmias (5–11). Furthermore, both ischemia and arrhythmias could further increase the risk of HF decompensation. Other mechanisms could also underly the seasonal variation in HF-related morbidity and mortality. Respiratory infections, especially those related to influenza, are more frequent in winter and could precipitate HF (17). Alcohol consumption also peaks in December in many countries (18). Because alcohol depresses myocardial contractility and induces atrial fibrillation, it too could aggravate HF (18,19). Consequently, we also examined secondary discharge codes to see whether they could offer insights into the role of any of these potential mechanisms.

**Role of pulmonary infection in seasonal variation.**

Interestingly, respiratory disorders (exacerbation of chronic obstructive pulmonary disease and pneumonia) also showed a winter peak in patients hospitalized with a primary discharge diagnosis (or a secondary coding) of HF. Indeed, approximately one-fifth of the winter excess of hospitalizations could be accounted for by this seasonal increment in respiratory disease. This may even be an underestimate as secondary codings are less reliable than primary ones, and some patients discharged following hospitalization with an exacerbation of HF may not have had an appropriate secondary coding entered for respiratory disease.

**Role of acute coronary syndromes in seasonal variation.**

In contrast, acute coronary syndromes apparently played a surprisingly small role in the winter excess of HF hospitalizations. However, other series from single centers have also suggested that myocardial ischemia is less frequently a
potentially preventable cause of hospital readmission than pulmonary infection in patients with HF (20,21).

**More marked seasonal variation in the very elderly.** We found that seasonal variation was most striking in older subjects. This has also been noted for coronary events and blood pressure changes (22). The elderly are less able to regulate body temperature and, therefore, may be more prone to all the adverse effects of cooling (23). They also appear to be more prone to winter respiratory infection.

Interestingly, a winter admission was associated with not only a higher short-term (inpatient) case fatality rate but also a poorer longer-term survival. Even with the limited adjustment we were able to perform, the increase in short-term case fatality persisted. This suggests that patients with more severe HF (and, therefore, a worse prognosis) may be particularly vulnerable to a winter exacerbation.

**Clinical significance and management implications.** We believe that our findings are of clinical significance. In a population of 5.1 million, with about 13,000 deaths from coronary heart disease annually, seasonal variation accounted for a difference of 1,429 deaths and 2,032 hospitalizations.

Our findings have potentially important management implications. First, increased vigilance in winter is important in patients with HF, especially those in the more advanced stages, in order to detect and correct decompensation at an early stage. Second, pneumococcal and influenza immunization should be strongly encouraged, not just to avoid these infections, but also for their potential role in winter exacerbations of HF (24). Third, the winter peak in morbidity and mortality emphasizes the need to understand better the mechanisms underlying this phenomenon.

**Study limitations.** As with any epidemiologic study of this type, our study has limitations. We have relied on discharge coding, which, though over 90% accurate in the principal position, is less so in secondary positions. However, most secondary HF codings are in the second (of six) positions. Codings in the second position also have a high degree of accuracy. Differentiating an exacerbation of respiratory disease, respiratory infection and decompensated HF is clinically difficult, particularly in the elderly. However, miscoding of pulmonary infection as HF may be as likely as HF miscoded as pulmonary infection. We did not measure other factors known to affect the risk of HF hospitalization, such as environmental concentrations of carbon monoxide, which also interacts with ambient temperature (25). Exercise, which is also of benefit in HF, may be taken less frequently in winter. Depression, which might influence prognosis in HF, may also be worse in winter (26).

**SUMMARY**

In summary, we have shown that there is a substantial seasonal variation in HF hospitalizations and deaths. The winter peak is particularly marked in the elderly. Approximately one-fifth of the winter excess in HF hospitalizations is attributable to a winter increment in respiratory disease. Myocardial infarction contributes a smaller part of the winter excess, especially in older men. These findings argue for extra vigilance in patients with HF in winter and for immunization against influenza and pneumococcal infection. A full understanding of the underlying causes of this variation could result in other management strategies with important public health and economic benefits.

**REFERENCES**


