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_Circulation_ 1999;100;280-286

Circulation is published by the American Heart Association. 7272 Greenville Avenue, Dallas, TX 75231
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Seasonal Variation in Chronic Heart Failure Hospitalizations and Mortality in France

Fabrice Boulay, MD; Frédéric Berthier, MD; Olivier Sisteron, MD; Yves Gendreike, MD; Pierre Gibelin, MD

Background—Circannual variation in blood pressure and in the incidence of acute myocardial infarction is well known but has not been investigated in chronic heart failure. This report describes and compares the seasonal variation of chronic heart failure hospitalizations and mortality in the French population.

Methods and Results—All deaths that occurred among French adults over the period 1992 to 1996 (n=138,602) and all discharges by adults in French public hospitals for chronic heart failure over the period 1995 to 1997 (n=324,013) were examined retrospectively. First, chronic heart failure deaths in France occurred with a striking annual periodicity and peaked in winter (December through January), both in the overall population and in subgroups defined by age (>44 years old) and sex. The distribution of cumulative monthly deaths differed by nearly 35%, ranging from a peak of 20% above average in January to 15% below average in August (Roger’s test: P<0.001). Second, hospitalizations for chronic heart failure in French public hospitals followed a similar seasonal pattern (P<0.001), with a winter-spring predominance (+7% to +10% from December through April). Third, for persons ≥85 years old, excess hospitalizations occurred earlier in the year, with marked synchronized peaks in January for both mortality and hospitalizations (P<0.001).

Conclusions—Clear seasonal variations in adult chronic heart failure hospitalizations and deaths were identified. The considerable economic impact on health care services warrants further epidemiological investigations and a more comprehensive approach to disease management. (Circulation. 1999;100:280-286.)

Key Words: heart failure ■ seasons ■ mortality

Over the past several decades, mortality and morbidity from cerebrovascular and ischemic heart diseases have decreased dramatically.1,2 In contrast to these favorable trends for most cardiovascular conditions, the incidence and prevalence of chronic heart failure and the resulting mortality and morbidity have increased dramatically during the period 1980 to 1988.3 This disabling chronic disease may increase further with the increasing proportion of the elderly within the population,4 the expected prolonged survival of patients with coronary heart disease and hypertension given prompt thrombolytic therapy,5 the widespread use of revascularization,6 and the improvements achieved in hypertension treatment.7

A considerable amount of data indicates that circadian rhythms are observed in acute myocardial infarction, sudden cardiac death, thrombotic stroke, and transient myocardial ischemia.8–11 Circannual variation in blood pressure and in the incidence of acute myocardial infarction is well known12,13 but has not been investigated in chronic heart failure.

This report aimed to describe and compare seasonal variation in chronic heart failure hospitalizations and mortality, using 2 population-based information systems, the French Cause-of-Death Statistics (from the Institut National de la Santé et de la Recherche Médicale, INSERM) and the National Hospital Discharge Register (NHDR).

Methods

Study Population
Hospital discharge reports between January 1, 1995, and December 31, 1997 (morbidity data) and death certificates between January 1, 1992, and December 31, 1996 (mortality data) concerning residents of France $\geq$15 years old were examined retrospectively.

Hospitalization Data
Information on hospitalizations was obtained from the Centre de Traitement de l’Information du PMSI, an official organization of the French Ministry of Health. This data set is a national collection of all discharges from public and nonprofit short-stay/acute-care hospitals. These hospitals have 188,960 short-stay/acute-care beds, accounting for ~71% of the hospital capacity in France in 1996.

The NHDR information is abstracted by physicians from information found in the patient’s medical record. This information includes age, sex, month of discharge, discharge status, space for up to 99 medical diagnoses and 99 procedures, and geographic location.

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Circulation is available at http://www.circulationaha.org

Received February 2, 1999; revision received April 19, 1999; accepted April 22, 1999.
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Medical diagnoses were classified according to the International Classification of Diseases, Ninth Revision (ICD9) until 1996 and Tenth Revision (ICD10) in 1997 and thereafter.

**Mortality Data**

Data on chronic heart failure mortality were obtained from the French Cause-of-Death Statistics system. Each year, >530 000 death certificates are filled out, providing information on the deceased’s medical diseases, demographic characteristics, date and place of death, and performance of an autopsy. For each death, the underlying cause of death and other significant conditions are indicated. Beginning in 1968, the Cause-of-Death Statistics published by INSERM have been classified according to ICD9. Mortality rates were calculated and adjusted by use of 1990 annual population estimates by age and sex, from the Institut National des Statistiques et des Etudes Economiques.

In addition, we compared the number of deaths enumerated from the NHDR with the number of deaths recorded on the national INSERM mortality statistics.

**Case Definition**

Both chronic heart failure mortality and hospitalizations were based on the 3-digit ICD9 code 428 and ICD10 code I50. The number of deaths is reported from counts of underlying cause of death. Hospitalizations are reported from the first listed discharge diagnosis.

**Statistical Considerations**

The data collected in this report are not subject to sampling error because hospitalizations and mortality data were obtained from the full set of hospital discharges and death certificates for the study period. These data are subject to random variation and are presented as mean and SD.

Both hospitalizations and mortality data were plotted according to 2 different graphic representations. First, for the purpose of smoothing the data, we used a moving average to present complete 3-year monthly data for chronic heart failure hospitalizations and 5-year monthly data for chronic heart failure mortality. For these plots, each data point (except first and last months) represents an average of 3 months’ data: the current month and both the preceding and following months. Second, we presented 3 years and 5 years of combined data, respectively, as a percentage above or below the average monthly value for the entire study period, the sum of monthly variations being 0.

Total seasonal variations were measured as the sum of the percentage above the mean for the month with the highest value and the percentage below the mean for the month with the lowest value.

The statistical analysis of seasonal variations was based on Roger’s method, which identifies a higher frequency of cases at a circadian period of the year.14 P values of <0.05 were considered significant.

**Results**

**General Trends**

During the 5-year period 1992 to 1996, chronic heart failure was reported as the underlying cause of death for an average of 27 700 deaths annually, with a mortality of 47.5 per 100 000 population. During the 3-year period 1995 through 1997 in French public hospitals, chronic heart failure was reported as the principal discharge diagnosis for an average of 108 000 hospitalizations annually, averaging 13.3 per 1000 hospital discharges. Among these 108 000 annual hospitalizations for chronic heart failure, 11 325 ended in death (10.5%). Both chronic heart failure mortality and hospitalizations increased strongly with age, the highest mortality rate reaching 1413.9 per 100 000 inhabitants and the highest hospitalization rate 65.3 per 1000 hospital discharges for adults ≥85 years old (Table 1).

**Overall Population**

During the 2 periods, death certificate data showed an average of 2310±287 (SD) deaths per month, and public hospital discharge data showed 9000±1315 discharges per month and 944±155 in-hospital deaths per month. Figure 1, which plots the monthly moving average of mortality, hospitalizations, and in-hospital deaths, shows a striking annual periodicity (P<0.001).

The distribution of cumulative monthly deaths showed a marked winter predominance (Figure 2, Table 2). Average monthly deaths for chronic heart failure differed by ~35% throughout the year, ranging from a peak of 20% above average in January to 15% below average in August.

The distribution of cumulative monthly hospitalizations was slightly different and showed a winter-spring predominance (Figure 2 and Table 2). Average monthly admissions for chronic heart failure differed by ~30%, ranging from 10% above average in April to 20% below average in August.

The seasonal variations in total mortality for chronic heart failure and mortality in French public hospitals for chronic heart failure are compared in Figure 3. Deaths occurring in public hospitals followed the same seasonal pattern with a more marked January peak (+28% versus +20%).

**Subgroups**

The same winter predominance of cumulative monthly deaths was observed in subgroups defined by age and sex except for individuals 15 through 44 years old (Table 2). Monthly chronic heart failure deaths for the oldest age group (≥85 years old) differed by as much as 43% (the largest total seasonal variation), ranging from a peak of 26% above average in January to 17% below average in August (Figure 4). The pattern for other age groups demonstrated lower amplitude (total seasonal variation ranging from 32% to 34%), with a peak mortality in December.

As seen in Table 2, a nonsignificant pattern of mortality (P>0.50) was observed within the population 15 through 44 years old (n=683 for 5 years, 0.5% of total deaths) with a second peak in summer (+16% above average in August). Other groups defined by age and sex demonstrated highly significant seasonal variations (P<0.001), except for individuals 45 through 64 years old (P<0.01).

The distribution of cumulative monthly hospitalizations demonstrated some differences by subgroups defined by age and sex (Table 2). Hospitalization peaks were seen in January for persons >75 years old and in April for those 15 to 74 years old. A similar difference in the timing of the peak was found for the sex subgroups, but this difference could be attributed entirely to the older age of the female subjects. In subgroups defined by age and sex, the distribution of cumulative monthly hospitalizations showed a highly significant seasonal variation (P<0.001), except for individuals 15 through 44 years old (P<0.01).

For individuals ≥85 years old, the mortality and hospitalization curves were almost the same, with marked synchronized peaks in January (Figure 4).
Several main findings emerged from this nationwide study. First, chronic heart failure deaths in France occurred with a striking annual periodicity and peaked in winter (December through January), both in the overall population and in subgroups defined by age (≥44 years old) and sex. Second, hospitalizations for chronic heart failure in French public hospitals followed a similar seasonal pattern, with a winter-spring predominance. Third, for persons ≥85 years old, the rise in hospitalizations began earlier in the season, with both

![Figure 1](https://circ.ahajournals.org/figure/1)

**Figure 1.** Monthly moving average of mortality (total population 1992 through 1996), hospitalizations (public hospitals 1995 through 1997), and in-hospital deaths (public hospitals 1995 through 1997) for chronic heart failure.

### TABLE 1. Chronic Heart Failure Mortality (Total Population 1992 Through 1996) and Hospitalizations (Public Hospitals 1995 Through 1997) in France

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of Deaths</th>
<th>Deaths per 100 000 Population*</th>
<th>No. of Discharges</th>
<th>Per 1000† Hospital Discharges</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>26 856</td>
<td>48.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>27 804</td>
<td>48.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>26 783</td>
<td>45.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>28 475</td>
<td>47.2</td>
<td>91 610</td>
<td>12.9</td>
</tr>
<tr>
<td>1996</td>
<td>28 684</td>
<td>47.4</td>
<td>113 776</td>
<td>13.6</td>
</tr>
<tr>
<td>1997</td>
<td>...</td>
<td>...</td>
<td>118 627</td>
<td>13.4</td>
</tr>
</tbody>
</table>

**Annual average**
- All: 138 602 deaths, 47.5 deaths per 100 000 population, 324 013 hospital discharges, 13.3 discharges per 1000 hospital discharges.
- Male: 53 403 deaths, 55.1 deaths per 100 000 population, 165 337 hospital discharges, 14.2 discharges per 1000 hospital discharges.
- Female: 85 199 deaths, 40.0 deaths per 100 000 population, 158 672 hospital discharges, 12.5 discharges per 1000 hospital discharges.

<table>
<thead>
<tr>
<th>Age, y</th>
<th>No. of Deaths</th>
<th>Deaths per 100 000 Population†</th>
<th>No. of Discharges</th>
<th>Per 1000† Hospital Discharges</th>
</tr>
</thead>
<tbody>
<tr>
<td>15–44</td>
<td>683</td>
<td>0.5</td>
<td>8 443</td>
<td>0.9</td>
</tr>
<tr>
<td>45–64</td>
<td>4 658</td>
<td>7.4</td>
<td>38 219</td>
<td>6.7</td>
</tr>
<tr>
<td>65–74</td>
<td>12 925</td>
<td>50.8</td>
<td>73 283</td>
<td>19.8</td>
</tr>
<tr>
<td>75–84</td>
<td>38 158</td>
<td>289.1</td>
<td>107 061</td>
<td>41.0</td>
</tr>
<tr>
<td>≥85</td>
<td>82 119</td>
<td>1413.9</td>
<td>97 007</td>
<td>65.3</td>
</tr>
</tbody>
</table>

* Rates are age- and sex-adjusted to 1990 census population.
† Percentage over hospital discharges for all causes in General Medicine, Surgery, and Obstetrics.
mortality and hospitalizations exhibiting the same marked synchronized peak in January.

Previous Studies
The only mention of seasonality with regard to chronic heart failure found in the literature is a report by Parry et al\textsuperscript{15} from northern Nigeria, who noted that patients with chronic heart failure presented more frequently during the hot wet months than during the cooler dry months. This author reported a limited series (753 patients over a 3-year period) who had cardiac failure mainly in the peripartum period (40.6%).

Present Study
Average annual mortality in France (47.5 deaths per 100 000) differs from rates reported in the literature. It is well known that reliability and comparability of mortality and morbidity statistics are significantly limited by variations in data collection and coding and by differences in the approach to diagnosis of cardiovascular diseases within and between countries and over time.\textsuperscript{16}

One example of differences due to data collection is shown by the 236.5 per 100 000 rate reported for Spain for 1993.\textsuperscript{17} In this study, heart failure deaths were counted from several codes of the ICD9, including code 425 (cardiomyopathy), code 428 (chronic heart failure), and code 429 (ill-defined descriptions and complications of heart disease).

Differences in the approach to diagnosis or certification are illustrated by the latest rates available for the United States, where 11.7 deaths per 100 000 inhabitants are reported for 1995.\textsuperscript{3} Mortality figures usually underestimate the demographic impact of chronic heart failure, because they include chronic heart failure only when it is the underlying cause of death. In the United States, chronic heart failure is 5 to 6 times more likely to be reported as a contributor rather than as the underlying cause of death on the death certificate.\textsuperscript{3} In France, death certificates are filled out somewhat differently than in the United States. For 1994, for example, chronic heart failure was mentioned as the primary cause of death on 26 783 certificates and as the first contributive cause in only 9023 cases.\textsuperscript{18} In the United Kingdom, the death certificate explicitly forbids chronic heart failure to be entered as the primary cause of death, and instead the underlying pathological process is specified, eg, coronary heart disease.\textsuperscript{19}

Potential Mechanisms Underlying Seasonal Pattern
Chronic heart failure is a syndrome that develops as a consequence of many different processes that impair cardiac function. Coronary heart disease and hypertension (either singly or together) account for the vast majority of cases of chronic heart failure within the developed world. Several authors have reported a predominantly winter pattern for blood pressure\textsuperscript{12,20} and myocardial infarction.\textsuperscript{13}

Several studies have searched for factors that could trigger acute exacerbations of chronic heart failure. The factors most frequently cited included fluid-sodium burden, acute episodes of arrhythmia, and poor patient compliance. The infectious factor is also cited, with a frequency in the range of 10% to 20%, depending on the report.\textsuperscript{21,22} In addition to the well-known seasonal pattern of infectious diseases, particularly respiratory tract infections,\textsuperscript{23} acute arrhythmia has also been found to follow seasonal variations.\textsuperscript{24,25}

Many investigators have documented an increase in respiratory and cardiovascular morbidity and mortality during winter, especially during cold weather.\textsuperscript{26,27} The winter excess of cardiovascular mortality has been linked to physiological responses to low temperatures, in which the sympathetic nervous system appears to play an important role.

Izzo et al\textsuperscript{28} studied seasonal changes in hemodynamics and found increases in heart rate and total peripheral resistance but a decrease in cardiac output in winter. Their results

Figure 2. Seasonal variations of monthly mortality (total population 1992 through 1996 combined) and hospitalizations (public hospitals 1995 through 1997 combined) for chronic heart failure.
suggest that a cold climate causes sympathetically mediated vasoconstriction, which leads to an elevation of afterload. Peripheral vasoconstriction induced by the cold may cause acute pulmonary edema by overloading the left ventricle, in particular, in those predisposed to hypertension.29

Another mechanism is the modification of total extracellular volume. When the temperature decreases, loss of water by transpiration and perspiration may influence extracellular volume homeostasis in these patients more than in normal subjects.20

It is also possible that this seasonal variation in cardiovascular function is related to factors other than temperature that change with the season. Yearly variations in cardiovascular function are probably mediated by genetically fixed endogenous rhythms in relation to neuroendocrine and/or metabolic function. A seasonal variation in thyroid and adrenal function and in the function of the sympathetic nervous system has been reported.30,31 Exogenous seasonal effects such as daytime length may affect the endogenous rhythm, altering the shape and timing of seasonal variation.32 The known winter increase in caloric intake may result in an increase in sodium intake.30 Variations in factors such as atmospheric pollution, other climatic factors (atmospheric pressure or rainfall/sun exposure), and use of drugs may also be involved.

In the subgroup of persons ≥85 years old, the mortality and hospitalization curves were almost the same, with marked synchronized peaks in January. Several explanations can be put forward. First, these individuals could have more advanced-stage heart failure more easily aggravated by winter-related triggering factors. Second, these older individuals could be more susceptible to respiratory tract infections. Third, seasonal variations in hemodynamic conditions (afterload) could be more marked in the elderly. It is noteworthy that the seasonal variation in blood pressure appears to be larger in older than in younger subjects.12,33

**Study Limitations**

In addition to the fact that there is no universally accepted definition of chronic heart failure, the retrospective nature of this type of study raises the question of the quality of the mortality and hospital discharge data. There is no reason, however, to believe that any of these limitations have a systematic seasonal element.
Another potential limitation is that our databases do not collect information on all pulmonary and cardiovascular risk factors or possible precipitating factors for relationship between season and chronic heart failure. Because of the well-known underreporting of associated diagnosis, we limited ourselves to the primary cause of death and the primary hospital diagnosis, ignoring various etiological factors.

Because hospital records and death certificates carry an inherent bias toward sicker, hospitalized persons, our results concerned patients who had more advanced-stage chronic heart failure.

Caution must be exercised in the interpretation of hospitalization data. These data, unlike the mortality information, describe episodes of care. Any given individual may experience several episodes of hospital care. Therefore, hospitalization data are not person-based. Also, the hospitalization data do not reflect information on outpatient department use, a much more frequent source of care of mild to moderate chronic heart failure.

However, the fact that similar patterns occurred in different subgroups and appeared in both mortality and hospitalization data would enhance the credibility of these statistics. In addition, the nationwide nature of these large databases limits certain selection biases related to seasonal population variations. Mandatory quality control checks are performed every 6 months by the Medical Information Department of each

Figure 3. Seasonal variations of monthly mortality (total population 1992 through 1996 combined) and in-hospital deaths (public hospitals 1995 through 1997 combined) for chronic heart failure.

Figure 4. Seasonal variations of monthly mortality (total population 1992 through 1996 combined) and hospitalizations (public hospitals 1995 through 1997 combined) for chronic heart failure, within group of persons ≥85 years old.
hospital and every year by physicians from the governmental authorities and the national health insurance system.

The circannual periodicity of chronic heart failure deaths and hospitalizations clearly demonstrated by these epidemiological data, showing a peak incidence in winter months, has important clinical implications. Healthcare systems should adjust the availability of emergency services and other hospital resources to the circannual pattern. Susceptible patients should be informed of the increased risk during winter. These data also offer a means of better understanding the fundamental pathophysiological mechanisms underlying exacerbation of chronic heart failure and could be useful for practitioners to improve causative prevention measures, therapeutic management, and educational strategies.

Acknowledgments

We thank the Conférence des Présidents de Commission Médicale d’Etablissement and the Conférence des Directeurs Généraux de Centres Hospitaliers Universitaires for providing us with data from the National Hospital Discharge Register (PMSI) CHU database for a preliminary study. We thank the Service Commun n°8 de l’Institut National de la Santé et de la Recherche Médicale (INSERM), the Direction des Hôpitaux du Ministère de la Santé, and the Centre de Traitement de l’Information du PMSI, which maintains the databases. We thank Marie-Annie Burette, Dr Michel Arenaz, Dr Max Bensadon, and Christel Schwendimann for helping us with data from the Cause-Of-Deaths Statistics and PMSI. We thank Dr Christine Binquet for critical reading of the manuscript. We are also grateful to Nathalie Bloquet for preparing the manuscript.

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