

# When Throughout the Year Is Coronary Death Most Likely to Occur?

## A 12-Year Population-Based Analysis of More Than 220 000 Cases

Robert A. Kloner, MD, PhD; W. Kenneth Poole, PhD; Rebecca L. Perritt, MS

**Background**—Previous studies have suggested that there is an increase in cardiac events in the morning. Fewer data relate cardiac events to months of the year and season.

**Methods and Results**—We analyzed all monthly death certificate data from Los Angeles County, California, for death caused by coronary artery disease from 1985 through 1996 (n=222 265). The mean number of deaths was highest in December at 1808 and January at 1925; the lowest rates were in June, July, August, and September at 1402, 1424, 1418, and 1371, respectively. December and January had significantly higher rates than would be expected from a uniform distribution of monthly deaths ( $P=0.00001$ ). The percent of yearly coronary deaths was defined by the quadratic U-shaped equation [percent=13.1198−1.5238(month)+0.0952(month<sup>2</sup>), where January=1, February=2, etc]. When monthly deaths were plotted by year, there was a decrease from 1985 through 1996. Monthly mortality correlated inversely with temperature. During the months with the highest frequency of death (December, January), however, there was an increase in deaths that peaked around the holiday season and then fell, which could not be explained solely on the basis of the daily temperature change.

**Conclusions**—Even in the mild climate of Los Angeles County, there are seasonal variations in the development of coronary artery death, with ≈33% more deaths occurring in December and January than in June through September. Although cooler temperatures may play a role, other factors such as overindulgence or the stress of the holidays might also contribute to excess deaths during these peak times. (*Circulation*. 1999;100:1630-1634.)

**Key Words:** cardiovascular diseases ■ circadian rhythm ■ coronary disease ■ death, sudden ■ heart diseases

Recent studies have suggested that ischemic events, including acute myocardial infarction, can be triggered by certain stressors. One such stressor is wake-up time; hence, a circadian pattern to ischemia has been observed.<sup>1,2</sup> Angina pectoris, silent myocardial ischemia, acute myocardial infarction, and sudden cardiac death typically increase in frequency between 6 AM and noon.<sup>1,2</sup> Most commonly, these events occur within the first few hours of patients' waking and moving around. Fewer data are available on the effects of months of the year, seasons, temperatures, and holidays on cardiac events. Although some studies have suggested an increase in cardiac events during the winter months,<sup>3–6</sup> others conducted in cities in the southern half of the United States have suggested an increase in cardiac events during the summer.<sup>7,8</sup> Fewer data have shown whether these patterns change over a long period of time, have indicated the effect of seasons in areas where the weather is very mild, or have concentrated on daily deaths during the time of year when death caused by cardiac disease is the highest. The purpose of our study was to determine when throughout the year death resulting from coronary artery disease was highest in an area

of the country where temperatures are mild throughout the year (Los Angeles County, California), whether these patterns have changed over a 12-year interval, and whether these patterns correlate with changes in temperature and the winter holiday season.

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### Methods

All monthly death certificate data from the Los Angeles County's Department of Health Services Data Collection and Analysis Unit for heart disease due to coronary artery disease were analyzed from 1985 through 1996. We used the International Classification of Diseases, 9th revision (ICD-9), codes for ischemic heart disease and atherosclerotic heart disease and chose the following specific codes: 410 through 414, ischemic heart disease, which includes 410 (acute myocardial infarction), 411 (other acute and subacute forms of ischemic heart disease), 412 (old myocardial infarction), 413 (angina pectoris), and 414 (other forms of ischemic heart disease); 429.2 (cardiovascular disease, unspecified with arteriosclerosis, which includes arteriosclerotic cardiovascular disease and cardiovascular arteriosclerosis); and 429.7 (sequelae of myocardial infarction), including 429.79 (mural thrombosis, acquired, after myocardial

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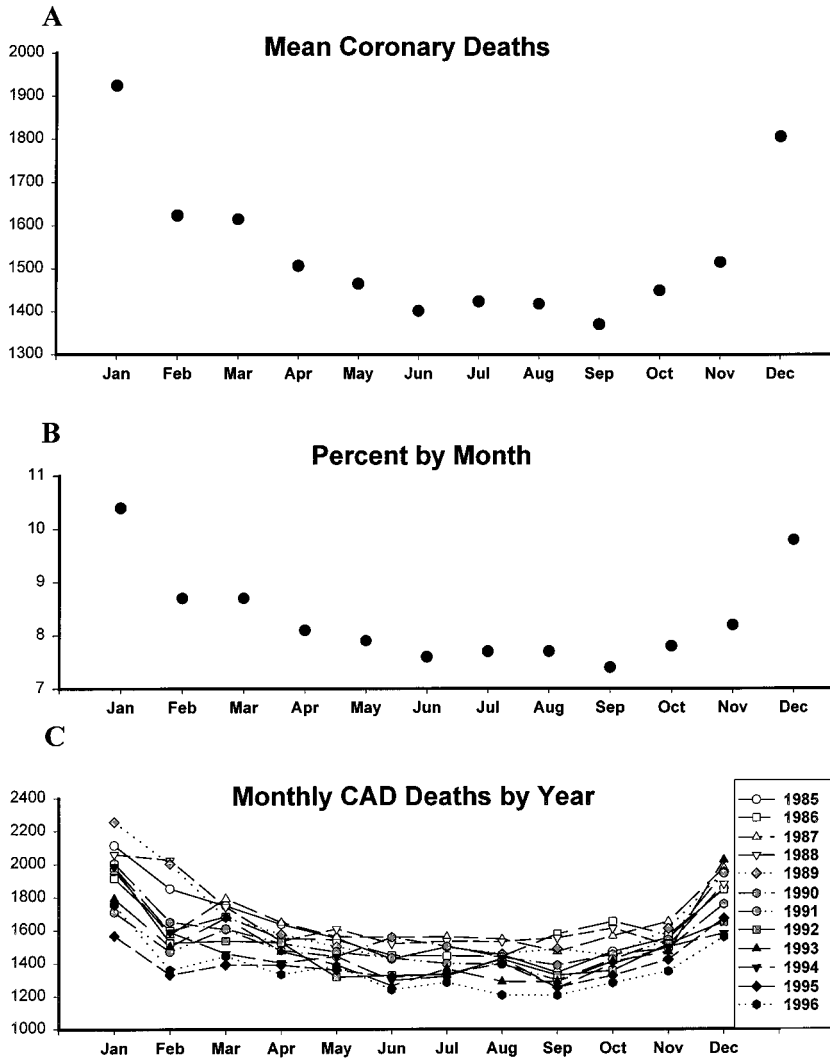
Received May 6, 1999; revision received June 22, 1999; accepted June 23, 1999.

From the Heart Institute Research Laboratory, Good Samaritan Hospital and Section of Cardiology, University of Southern California (R.A.K.), Los Angeles, Calif, and Research Triangle Institute, Research Triangle, NC (W.K.P., R.L.P.).

Correspondence to Robert A. Kloner, MD, PhD, Heart Institute, Good Samaritan Hospital, 1225 Wilshire Blvd, Los Angeles, CA 90017.

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**Figure 1.** A, Mean number of coronary artery deaths (CAD) in Los Angeles County per month (averaged over 1985 through 1996). B, Mean percent of CAD by month. C, Total CAD by month and year from 1985 through 1996. There was a downward trend from 1985 through 1996, but the overall U shape of curves was maintained.

infarction). Data on the number of daily deaths and atherosclerotic heart disease were obtained during November, December, and January to investigate in more detail this time period around the winter holiday season, when death rates appeared to increase.

Average daily minimum and maximum temperatures for Los Angeles were provided by the Western Regional Climate Center (Reno, Nev). Statistical analyses were performed by Research Triangle Institute (Research Triangle, NC).

The average percentage of deaths by month was modeled by use of PROC MIXED in SAS to determine the monthly trend. The months were modeled with month (taking on values of 1 through 12 for January through December, respectively) and month squared as independent variables. A repeated-measures model was run twice with the use of 2 covariance structures, autoregressive and unstructured. The unstructured model proved to be the better model and is the one reported.

**Results**

The mean number of monthly deaths resulting from coronary artery disease averaged over the 12 years is shown in Figure 1A. The mean number of deaths was highest in December at 1808 and January at 1925. The lowest numbers of deaths occurred in June, July, August, and September at 1402, 1424, 1418, and 1371, respectively. Thus, rates in December and January were ≈33% higher than in June through September. December and January had significantly higher rates than

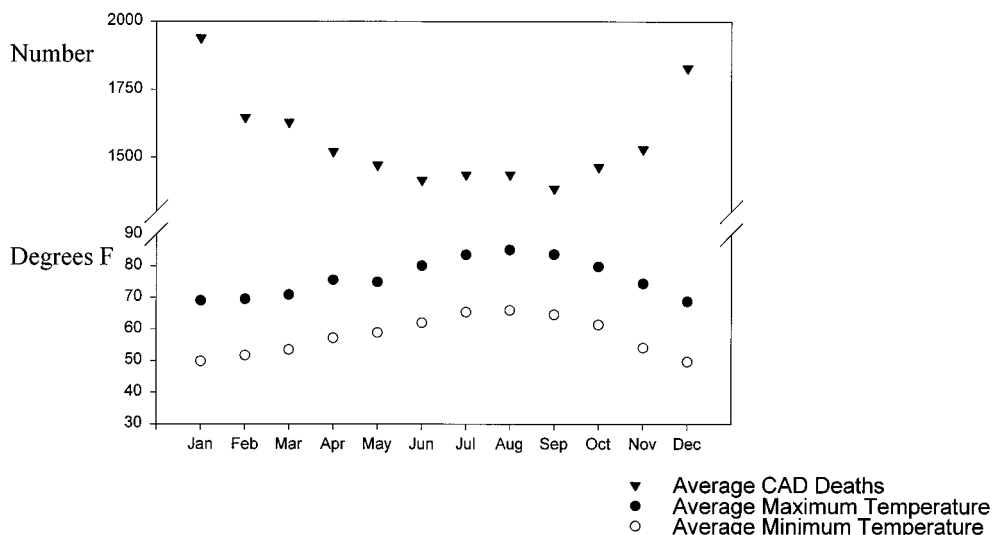
would be expected from a uniform distribution of monthly deaths ( $P=0.00001$ ). Figure 1B shows the percent of yearly deaths from coronary artery disease by month, again showing peaks in January and December, with a nadir from June through September. For percent of yearly coronary deaths, the relationship was defined by this quadratic U-shaped equation:

$$\text{Percent} = 13.1198 - 1.5238(\text{month}) + 0.0952(\text{month}^2)$$

where month=1 for January, 2 for February, etc.

Figure 1C shows monthly deaths plotted by year. There tended to be an overall reduction from 1985 through 1996, but the shape of the curves, ie, a U-shaped quadratic, was maintained over the course of the 12 years. In 1985, there were 19 510 (0.243%) coronary deaths out of a population of 8 018 210; from 1985 through 1996, the number of coronary deaths decreased (16 411 in 1996 [0.174%]) while the population of LA County increased (9 449 563).

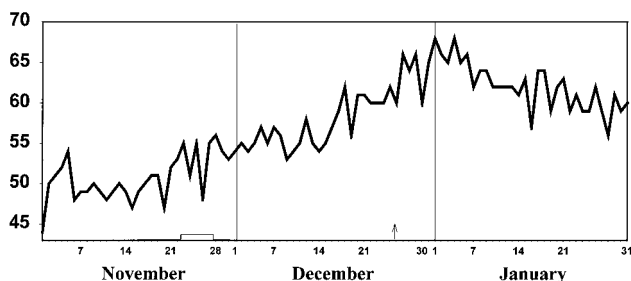
Figure 2 plots average monthly maximum and minimum temperatures throughout the year versus average monthly coronary deaths. Monthly deaths correlated negatively with minimum ( $r=-0.877$ ) and maximum ( $r=-0.843$ ) temperatures.



**Figure 2.** Number of coronary artery deaths (CAD) per month (top) plotted against average monthly maximum and minimum temperatures.

To examine the number of coronary deaths by day during the winter holiday season, when deaths were most frequent, we focused on daily death rates during that time. We plotted daily death during November, December, and January (Figure 3). Thanksgiving, Christmas, and New Year's Day are marked. During the first 3 weeks of November, average deaths were about 48; starting at about the time of Thanksgiving, there was a rapid increase, which continued throughout the month of December, peaking around New Year's Day to about 68 deaths per day and then declining after the first week of the new year.

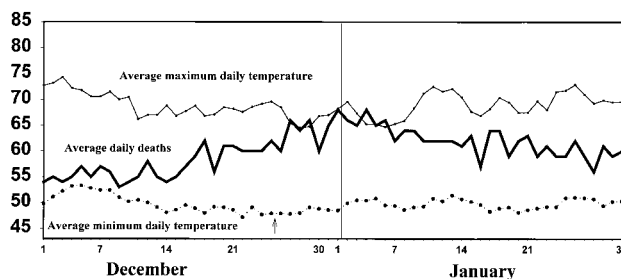
Average minimum and maximum daily temperatures were plotted against average daily deaths caused by coronary disease during the 2 peak months. As shown in Figure 4, the increase in deaths in December and decrease in January did not correlate closely with decreases in temperature during December or increases during January. In fact, minimum temperature remained relatively flat from December 14 to January 31. The correlation between average daily deaths and temperature for December and January was  $r = -0.38$  for average minimum daily temperature and  $r = -0.45$  for average maximum daily temperature.



**Figure 3.** Total coronary deaths by day for November, December, and January (averaged over 12 years). Deaths increased at about Thanksgiving (gray rectangular box), increased through December, and peaked around New Year's Day. They then decline after the first week of new year and continue to decline throughout January. Arrow indicates Christmas.

### Discussion

The results of this study suggest the following. First, there is a temporal relationship of coronary artery death throughout the year, with the highest number of deaths in December and January and the lowest numbers in summer and early fall, despite the relatively mild climate of southern California. Second, the increase in death during the winter peaks around the winter holiday period. Third, deaths on a monthly basis are correlated with cooler temperatures. This could be related to increased cardiac workload during the winter, higher coronary and vascular resistance induced by cold, higher blood pressure during the winter, and higher fibrinogen levels reported in winter. Fourth, during the 2 months with the highest number of deaths, daily temperature correlated weakly with daily coronary death. Specifically, while deaths increased throughout December and then declined throughout January, minimum daily temperature remained relatively flat, and maximum temperature showed minor fluctuations. These observations suggest that during the months of December and January, when coronary death is at its highest, other factors besides temperature could contribute to the increase in deaths in December and the decrease after January 1. Factors such as



**Figure 4.** Average daily coronary deaths in December and January (heavy black line) plotted against average minimum daily temperature (dotted line) and average maximum daily temperature (thin black line). Although average daily deaths increased during December, minimal temperature remained relatively flat, and maximum temperature fell slightly. Arrow indicates Christmas.

superimposed respiratory infections could play a role. Also, the increased deaths from Thanksgiving to New Year's Day could be related to such behavioral changes around the holiday time as increased food, salt, and alcohol consumption. The emotional and psychological stresses<sup>9,10</sup> of the holidays might also contribute. It is unlikely that this phenomenon is due to the migration of elderly populations into Los Angeles County during the winter or the migration out during the summer; the "snowbird" phenomenon seen on the east coast of the United States is not prevalent in Los Angeles, and summer temperatures tend to be mild. In addition, deaths of nonresidents are not counted in vital statistics. Another potential factor that could play a role is an increase in particulate pollution caused by increased wood burning during the holiday season.<sup>11</sup>

Previous studies that have examined the effect of seasons and temperature on cardiac events have shown variable results. Spencer et al<sup>12</sup> recently reported results from the Second National Registry of Myocardial Infarction on seasonal variation on myocardial infarction. Of the 10 geographical areas, 9 reported a seasonable variability in number of cases, with a peak in winter followed by progressively fewer cases in fall, spring, and summer. One area, the west north central states, did not follow this pattern; there, fall was slightly worse than winter. In that study, California was lumped with Washington, Oregon, Alaska, Hawaii, and Guam, so data on southern California alone were not provided.

A study by Marchant et al<sup>5</sup> in England also observed a winter peak in myocardial infarcts (actually peaking in February). In their study, there was an excess of infarctions on colder days during both winter and summer. Admission rate for infarction was inversely correlated to minimum daily temperature. This was not the pattern in our study in Los Angeles, where, despite a fairly flat minimum temperature during December and January, there was a marked increase in coronary deaths toward New Year's Day. Of course, the temperatures in Los Angeles during these months are mild compared with those of England, so other contributing factors besides cold may have a chance to play a greater role.

Beard et al<sup>13</sup> examined sudden cardiac deaths in Rochester, Minn, and observed that they were more common on Saturdays than other day of the week. However, there was no statistically significant difference in frequency of sudden cardiac death by season. Baker-Blocker<sup>14</sup> studied cardiovascular mortality in Minneapolis-St Paul, Minn, and observed that air temperature was not a significant factor in triggering cardiovascular mortality in 4 of 5 winters. During 1 winter (1976 through 1977), 15% of variance in daily cardiovascular mortality was attributable to fluctuations in daily minimum air temperature. They concluded that snow was more important in triggering deaths from heart disease than air temperature. There have been previous reports of increased cardiac events during blizzards; presumably, at least part of this finding was due to snow shoveling.<sup>15</sup>

Speilberg et al<sup>16</sup> analyzed day of the week and seasonable variability in myocardial infarction patients in Germany. Myocardial infarction occurred more commonly from January through March. Interestingly, working patients had a

trend toward an additional seasonal peak in September; perhaps related to the stress of returning to work after the summer holiday. Seasonal changes in hemodynamics might contribute to seasonal variation in acute myocardial infarction. For example, Argiles et al<sup>17</sup> recently reported that blood pressure was higher during the winter compared with summer months in patients with end-stage renal disease. Other studies<sup>3,6,18</sup> have suggested that cold temperatures are associated with increases in myocardial infarction. A recent study by Sheth et al<sup>19</sup> carried out in Canada showed that elderly patients exhibited a greater increase in mortality from myocardial infarction and stroke during the winter compared with younger patients.

As mentioned, not all studies suggest that the winter months are associated with the highest incidence of cardiac events. One older study from Dallas, Tex, involving 283 931 hospital admission reported the highest frequency of myocardial infarcts during the very hot season.<sup>7</sup> A study by DePasquale and Burch<sup>8</sup> observed that the incidence of acute myocardial infarction increases in the summer in New Orleans, La. Finally, Freeman et al<sup>20</sup> showed that in Tasmania, where the weather is temperate, maximum and minimum temperatures accounted for only 9.7% and 12.6%, respectively, of the monthly variation in acute myocardial infarction.

In summary, our study suggests that even in the relatively mild climate of southern California, there is a seasonal variability to coronary death, with rates in December and January  $\approx$ 33% higher than in June through September. There was an overall decrease in mortality due to coronary artery disease from 1985 through 1996, which is consistent with another recent report.<sup>21</sup> Although monthly cardiac death correlated inversely with monthly temperature, during the months with the highest death rates (December and January), there was an increase in cardiac deaths that peaked on January 1 that could not be explained solely on the basis of temperature change. Other factors, including overindulging or the stress related to the holiday season, could be important.

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*Circulation*. 1999;100:1630-1634

doi: 10.1161/01.CIR.100.15.1630

*Circulation* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

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Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:

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