Monthly and daily patterns of death

Richard Trudeau

Abstract

Objectives

Using Canadian mortality data from 1974 to 1995, this article examines seasonal and daily patterns of death by cause.

Data source

Death records were extracted from the Canadian Vital Statistics Data Base, which is compiled from information provided to Statistics Canada by the Vital Statistics Registries in each province and territory.

Analytical techniques

Components of the time series of deaths by cause were calculated using X-11-ARIMA, developed by Statistics Canada. It combines the X-11 seasonal adjustment method of the U.S. Bureau of the Census and the ARIMA forecasting method.

Main results

For at least the past two decades, the highest number of deaths have occurred in the winter months. By specific cause, notable exceptions were deaths attributable to motor vehicle accidents and suicide. On a weekly basis, Saturday saw the largest numbers of deaths.

Key words

seasonality, cause of death, pneumonia, influenza, cardiovascular diseases, motor vehicle accidents, suicide

Author

Richard Trudeau (613-951-7385), formerly with the Health Statistics Division, is now with the Distributive Trades Division at Statistics Canada, Ottawa K1A 0T6.

While death may happen at any time as a result of illness or accident, to some extent, its timing is predictable. Most obviously, death is likely to occur at older ages. But there is another less obvious element of predictability in the timing of death. Some seasons of the year bring more deaths than do others, and deaths attributable to a number of specific causes tend to follow a yearly cycle.

These seasonal fluctuations are more than a curiosity. Because seasonal upsurges of deaths from specific causes are predictable, preventive health and safety measures may be able to reduce the toll.

This article uses mortality statistics from the Canadian Vital Statistics Data Base to examine how the number of deaths varies by month and by day (see *Methods*).

Methods

Data source

The 1995 figures in this article are taken from *Births and Deaths, 1995* (Catalogue 84-210-XPB).[1] Data on deaths from 1974 to 1994 are from the Canadian Vital Statistics Data Base. The data are adapted from information collected by the provincial and territorial registries of vital statistics, which are responsible for the registration of deaths that occur in their jurisdictions. All causes contributing to a death are entered on the death certificate. In accordance with rules established by the World Health Organization and defined in the Ninth Revision of the International Classification of Diseases (ICD-9), a single, underlying cause of death is selected for each decedent.[2] The ICD-9 codes for the causes of death examined in detail in this article are:

All causes	001-E999
Cardiovascular diseases	390-459
Pneumonia and influenza	480-487
Motor vehicle accidents	E810-E825
Suicide	E950-E959

Population estimates adjusted for net census undercoverage and for non-permanent residents are used to calculate all rates. The reference date for the annual population estimates is July 1.

Analytical techniques

The analysis is based on the average number of deaths per day for each month from 1974 to 1994. The average number of deaths per day is used to adjust for differing numbers of days per month.

The method used to calculate the components of the time series of deaths by cause is X-11-ARIMA, developed by Statistics Canada, which combines the X-11 seasonal adjustment method of the U.S. Bureau of the Census and the ARIMA (Auto-Regressive Integrated Moving Average) forecasting method.[3,4]

In this article, the seasonal component of the time series is expressed as a percentage, and it varies around 100%. For example, a seasonal factor of 110% for a certain month means that the average number of deaths per day is 10% higher in that month than if there were no seasonality in the series. Statistics about the seasonal pattern are the peak (the value of the highest seasonal factor), the trough (the value of the lowest seasonal factor), and the amplitude (the difference between the peak and trough).

The X-11-ARIMA Seasonal Adjustment Program in SAS was used to calculate the multiplicative seasonal adjustment, using the automatic selection process in which the best model from a set of five predefined ARIMA models is used. When processing the time series of average number of deaths per day by month due to all causes with the X-11-ARIMA procedure in SAS, all ARIMA models failed. Therefore, the ARIMA processing was skipped. The X-11 procedure did discern a stable seasonality.

The same X-11-ARIMA procedure in SAS was run for various time series of average number of deaths per day by month due to specific causes. A statistically significant stable seasonality was observed for certain causes, but not for others.

Deaths by day of the week were also analysed. Using deaths that occurred from 1974 to 1994 for which the complete date was available, the hypothesis that the number of deaths was evenly distributed across the seven days of the week was tested.

Limitations

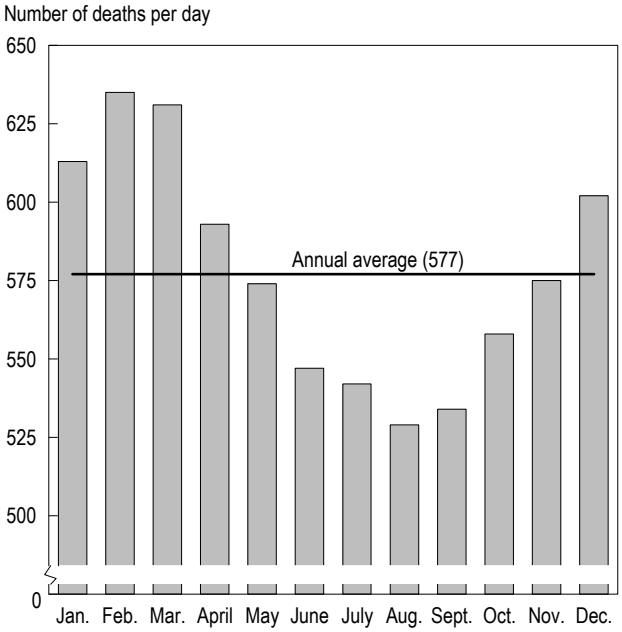
Because of legal reporting requirements, the registration of deaths is considered to be virtually complete. However, records received after the "cut-off" date for data release are missing, as are deaths of Canadians in foreign countries other than the United States. Deaths of non-permanent residents may be excluded if the usual place of residence of the deceased was not Canada.

Hard winters

In 1995, there were 210,733 deaths in Canada, an average of 17,561 per month and 577 per day. However, more deaths occurred in some months than in others. December, January, February and March saw above-average numbers of deaths. The numbers from June through October were well below the monthly average. Adjusting for the number of days in each month, the average daily number of deaths peaked in February at 635 and fell to a low of 529 in August (Chart 1).

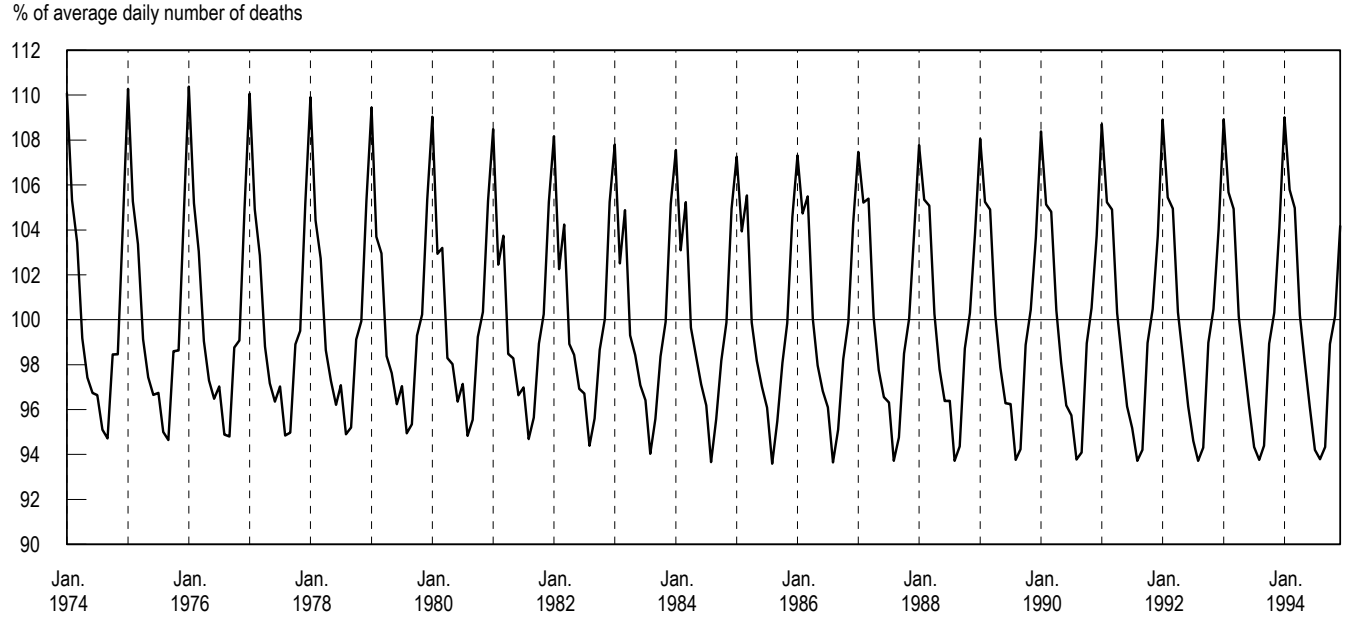
The winter upturn in deaths has prevailed for at least the past two decades. From 1974 to 1994, the seasonal peaks were in January. These peaks were as high as 10% above the average daily number of deaths that would have occurred had there been no seasonality in the series. Seasonal troughs were around 6% below average and occurred in August, yielding a seasonal amplitude of approximately 16% (Chart 2).

Chart 1
Average daily number of deaths, by month, Canada, 1995



Data source: *Canadian Vital Statistics Data Base*

Chart 2
Seasonality of deaths, Canada, January 1974 to December 1994



Data source: *Canadian Vital Statistics Data Base*

Such seasonal patterns in deaths have long been observed.[5-7] They have been related to variations in temperature and humidity that affect the environment, and in turn, have a physiological effect on humans. But normal temperature variations account for only a small part of the seasonal mortality pattern.[8]

Seasonal fluctuations in human activities may result in different levels of exposure to sources of infection. For example, during the winter, more time spent indoors in close proximity to other people may facilitate the transmission of viruses.

And some noninfectious causes of death, such as drownings or skiing accidents, have an obvious seasonal component. On the other hand, seasonal variations in deaths due to causes such as cardiovascular diseases are less readily explained.

Pneumonia and influenza

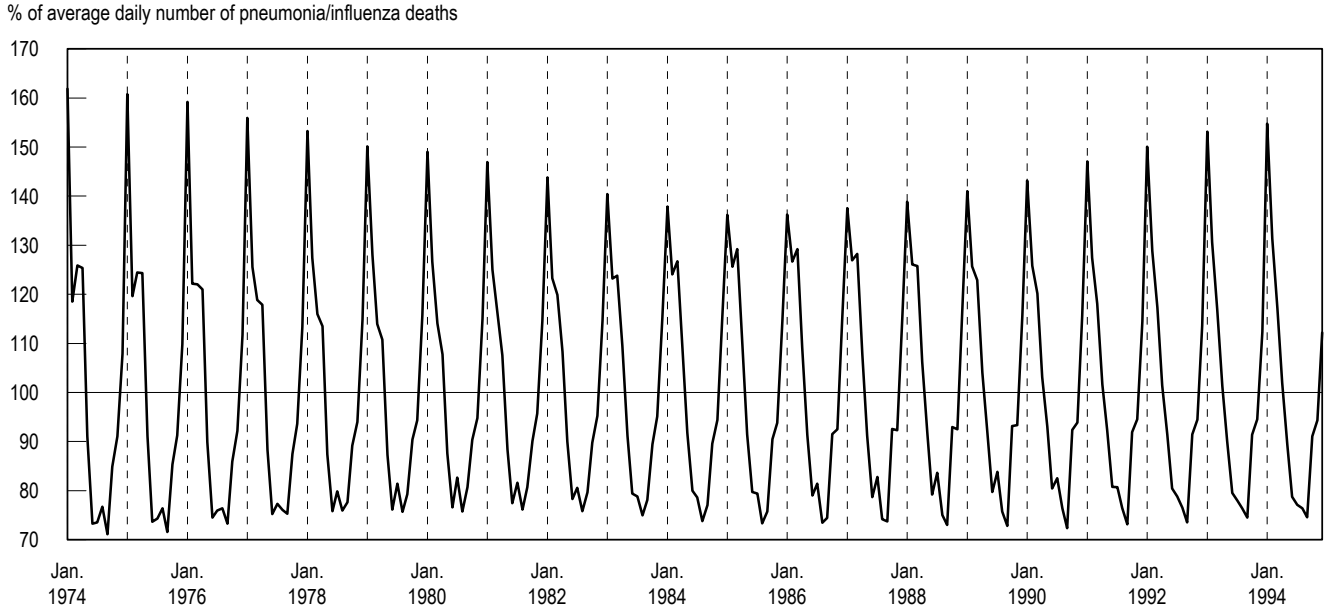
Deaths from pneumonia and influenza are highly seasonal, paralleling the elevated incidence and prevalence of these diseases in the winter months.[9] (This is also true for deaths from bronchitis, emphysema, and asthma.) Pneumonia and influenza accounted for just 3.2% of deaths over the entire 1974 to 1994 period, but the percentage was lower in the summer months and generally much higher in the winter. Throughout the period, the average daily number of pneumonia and influenza deaths peaked in January, and bottomed out in August or September

Despite some narrowing, the seasonal amplitude for these deaths was much greater than that for deaths from other major causes. The seasonal peaks for pneumonia and influenza deaths declined from 62% above the average daily number in 1974 to 36% above average in the mid-eighties, and then rose to 55% above it in 1994. The seasonal troughs varied only slightly from 29% below average in 1974 to 24% below average in the early eighties (Chart 3).

Cardiovascular diseases

Deaths directly attributable to pneumonia and influenza represent only a small share of the winter increase in deaths. In fact, over half of total excess mortality during influenza epidemics

Chart 3
Seasonality of pneumonia and influenza deaths, Canada, January 1974 to December 1994



Data source: *Canadian Vital Statistics Data Base*

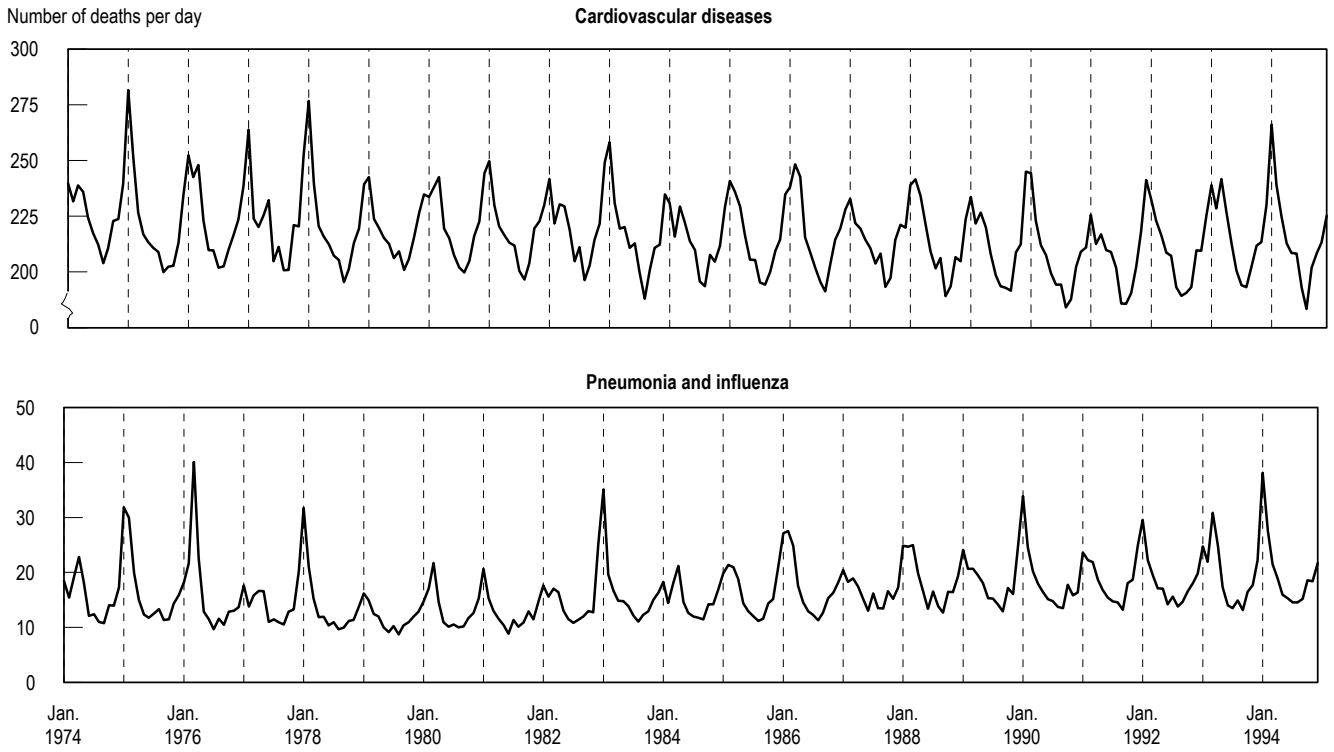
has usually been ascribed to other causes, notably cardiovascular diseases.[10]

According to coding practices in Canada and most other countries, the underlying cause of death is defined as "(a) the disease or injury which initiated the train of morbid events leading directly to death, or (b) the circumstances of the accident or violence which produced the fatal injury."[9] For example, if a patient with a chronic cardiovascular disease contracts influenza followed by pneumonia and then death, the recorded cause of death would be the cardiovascular disease that "initiated" the events leading to death, even though influenza and pneumonia might have been more immediate causes.[11] This suggests that the seasonality of pneumonia and influenza contributes to the seasonality of deaths from other chronic diseases, even in non-epidemic years.

Since cardiovascular diseases account for a large percentage of deaths in Canada (44% over the 1974 to 1994 period), they have a great impact on the overall seasonality of deaths. From 1974 to 1994, the average daily number of deaths attributable to cardiovascular diseases crested in the winter months and bottomed out in the summer. Moreover, with the most notable exception occurring in 1976, whenever there was a pronounced increase in mortality due to pneumonia and influenza, there was usually a corresponding increase in deaths from cardiovascular diseases (Chart 4).

During the 1974 to 1994 period, the average daily number of deaths from cardiovascular diseases was usually highest in January and lowest in August. The seasonal peaks were about 13% above the average daily number, and the seasonal troughs, 10% below it.

Chart 4
Average daily number of deaths due to cardiovascular diseases and pneumonia and influenza, Canada, January 1974 to December 1994



Data source: *Canadian Vital Statistics Data Base*

Other winter peaks

Seasonality is also evident in deaths from several other causes whose occurrence would seem to have little relationship to the time of year. For example, the average daily numbers of deaths due to diabetes mellitus, chronic liver disease and cirrhosis, and diseases of the urinary system showed statistically significant seasonality similar to cardiovascular diseases, with all of them peaking in January. These chronic diseases have multiple systemic effects that can compromise individuals' health and make them more vulnerable to pneumonia and influenza.

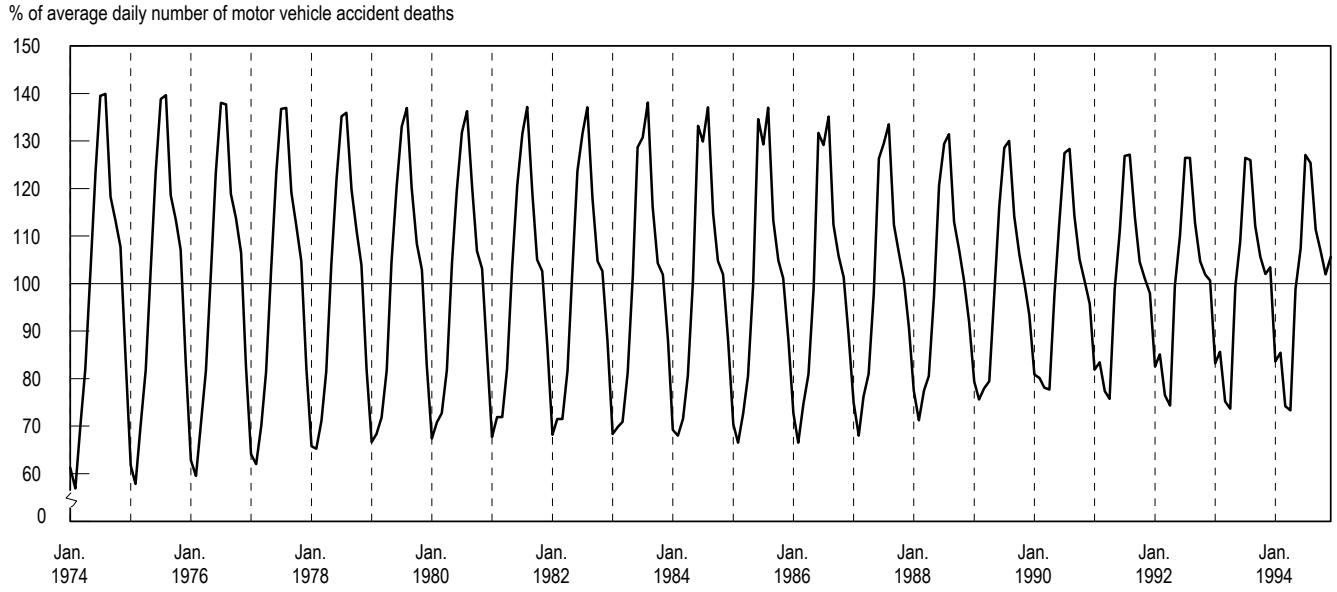
Summer accidents

Motor vehicle accidents accounted for just 2.5% of deaths in the 1974 to 1994 period and so had little effect on the overall seasonality of mortality. In fact, the seasonal pattern for motor vehicle accident deaths was the inverse of the situation for deaths as a whole. Motor vehicle accident deaths crested in July or August and bottomed out in January or February, and in more recent years, in March or April.

Since 1974, the average daily number of motor vehicle accident deaths has declined, and the seasonal pattern has become less pronounced. Seasonal peaks fell from around 40% to 27% above average between the early 1970s and the early 1990s; the depth of the troughs declined from around 43% to about 25% below average. As a result, the seasonal amplitude narrowed substantially from over 80% to around 50% (Chart 5). Technological improvements in the design of vehicles and highways, campaigns against drinking and driving, seat belt legislation, and greater enforcement of traffic regulations may have contributed to the decline in motor vehicle accident death rates and dilution of the seasonal factor in these deaths.[12]

Traffic collision data compiled by Transport Canada reflect these motor vehicle accident mortality figures. For instance, three recent years of data, 1991 to 1993, show that fatal collisions increased in the summer months and decreased in the winter months.[13] The same was true for non-fatal collisions, but the peaks were much less pronounced. On the other hand, the number of

Chart 5
Seasonality of motor vehicle accident deaths, Canada, January 1974 to December 1994



Data source: *Canadian Vital Statistics Data Base*

collisions causing only property damage peaked in December and fell to a low in spring. This would seem to indicate that the higher mortality attributable to summer motor vehicle accidents is not a simple consequence of increased traffic volume leading to more collisions, as might be suspected, but of greater severity of collisions, possibly due to factors such as speed.

Suicides peak in spring

Some seasonality in suicides can be measured, but much less than for several other causes of death. The average daily number of suicides tended to peak in spring. In many years, there was a secondary rise in the fall.

The monthly pattern of suicides has also changed somewhat since the mid-1970s (Chart 6). While recent seasonal peaks were in March, in earlier years the peaks occurred in April through June. Throughout the period, the seasonal peaks were about 9% above average.

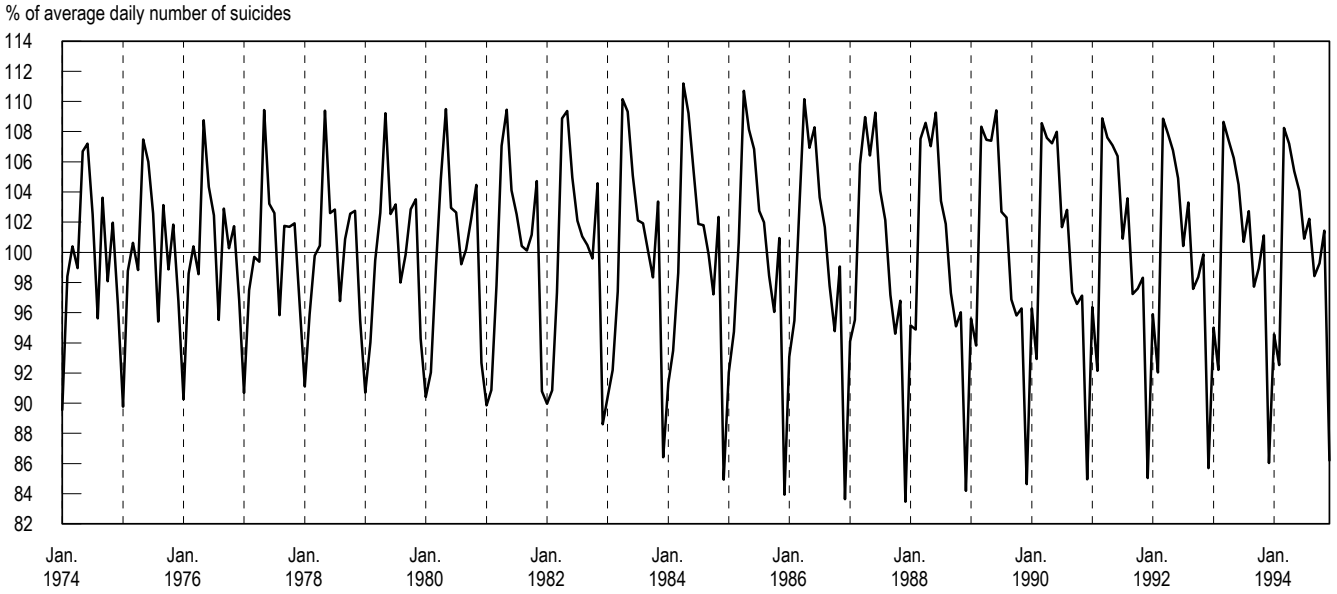
Although the "holiday season" is commonly thought to bring more suicides, this period actually marks the seasonal troughs for suicides. Moreover, these troughs have become slightly more pronounced, increasing from 10% to 14% below average. Consequently, the amplitude widened from 18% to 22%. Suicides, however, accounted for only 1.9% of all deaths during the 1974 to 1994 period.

Weekends dangerous

Not only are deaths more likely to occur in some seasons than in others, but some days of the week tend to be especially hazardous. Throughout the 1974 to 1994 period, Saturday saw the highest average daily number of deaths, and Thursday, the lowest.

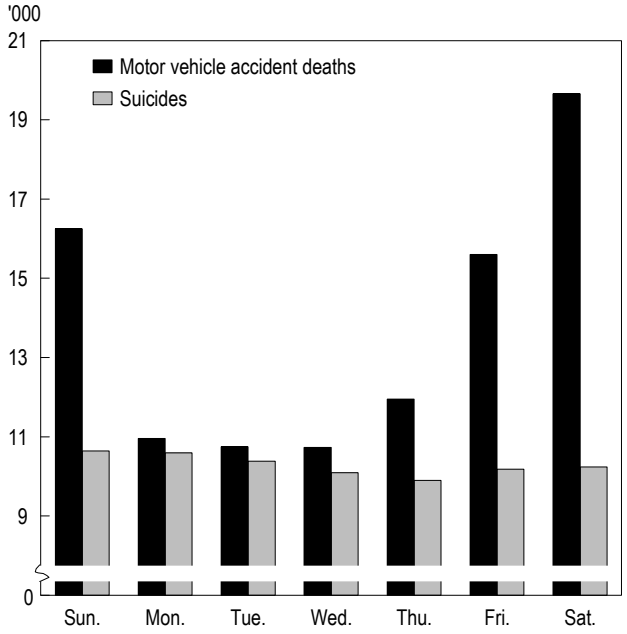
Differences in the average number of deaths across the days of the week also prevail for specific causes. Not surprisingly, motor vehicle accident deaths increase as the weekend approaches, beginning to rise on Thursday, peaking on Saturday, decreasing somewhat on Sunday and dropping sharply from Monday through Wednesday (Chart 7). By contrast, the daily pattern for suicide is relatively stable.

Chart 6
Seasonality of suicides, Canada, January 1974 to December 1994



Data source: *Canadian Vital Statistics Data Base*

Chart 7
Motor vehicle accident deaths and suicides, by day of week, Canada, 1974 to 1994 combined



Source: *Canadian Vital Statistics Data Base*

Concluding remarks

The winter upturn in deaths is associated with the increase in influenza and pneumonia during that season. However, public health measures might be able to mitigate this effect. For example, flu shots, particularly for high-risk groups, might lessen the magnitude of the winter peak in deaths, and in turn, reduce deaths ascribed to other causes that were triggered by pneumonia and influenza.

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