The Seasonality of Total Hospitalizations in Ontario by Age and Gender

A Time Series Analysis

Eric J. Crighton, MA[1]
Rahim Moineddin, PhD[2]
Ross E.G. Upshur, MA, MD, MSc, FRCPC[3]
Muhammad Mamdani, PharmD, MA, MPH[4]

ABSTRACT

Background: Consistent and predictable seasonal fluctuations in hospitalizations have been demonstrated for diverse communicable and non-communicable health conditions. The objective of this study was to examine the seasonal patterns of all hospitalizations by age and gender in order to determine whether the hospital system for a large geographical area was subject to consistent, predictable temporal variations.

Methods: A retrospective population-based study of approximately 14 million residents of Ontario was conducted to assess temporal patterns in all hospitalizations from April 1, 1988 to March 31, 2000. Time series analysis, using spectral analysis, was conducted to assess seasonal variations and trends over time and to account for autocorrelation.

Results: Conspicuous seasonality in hospitalizations was found in every age group for both sexes with the exception of males between the ages of 20 and 39. The average monthly variability ranged from lows of 15% for the age group 20-29 for both sexes, to highs of 34% in males between 5 and 9 years. For the total population, this represents a 12-year average variability of approximately 20% or 20,000 out of 97,000 hospitalizations. For both sexes, peak hospitalizations typically occurred in the spring and autumn for the youngest and oldest age groups, and in January for the middle age groups.

Conclusion: Seasonal factors play an important role in the utilization of hospital services in Ontario. The determinants of this seasonality, which include environmental and social/behavioural factors, are not well understood.

Seasonal patterns in hospitalizations have been demonstrated for a wide range of communicable and non-communicable health conditions including influenza,[1] pneumonia,[2] stroke,[3] falls,[4] hip fractures,[5] asthma,[6-9] and thrombophlebitis such as deep venous thrombosis and pulmonary embolism.[10] It has further been demonstrated that when seasonal variations in health conditions are examined by gender and age, both the pattern and magnitude of the fluctuations vary between groups.[4,11] In a recent study examining asthma-related hospitalizations, it was found that young males (0-4 years) were hospitalized at rates two to three times those of 5 to 9 year olds and up to thirty times the rate of adult males.[6] The patterns of seasonality also varied in that children were most frequently hospitalized in September and October whereas older age groups were most frequently hospitalized in the winter months. Similar differences by age were found in hospitalizations due to fall-related injuries.[4]

The seasonal patterns demonstrated by such diverse health outcomes raise the possibility that seasonal patterns exist for utilization in a hospital system in total and that these patterns will vary by age and sex. A literature search revealed only one other study examining the seasonal patterns of hospitalizations in the Gampian region of Scotland. Here, no statistically significant seasonality was shown, however, the author suggests that this may be due to the relatively small number of hospitalizations being studied.[12]

This study was conceived to study the seasonal patterns of all hospitalizations by age and gender in order to determine whether the hospital system for a large geographical area was subject to consistent, predictable temporal variations. We hypothesized that the differential seasonal variations between life stage and gender found in discrete disease outcomes also exist for total hospitalizations. Understanding these seasonal variations will inform more rational planning of health services.

METHODS

A retrospective population-based study design was used to assess temporal patterns in all hospitalizations from April 1, 1988 to March 31, 2000. Approximately 14 million

residents of Ontario, Canada eligible for universal health care coverage during this time were included for analysis. Using the Canadian Institute for Health Information (CIHI) Discharge Abstract Database which records discharges from all Ontario acute care hospitals, the total number of discharges was assessed for each month. These data were combined with the Statistics Canada annual census data for each age group for residents of Ontario. Monthly population estimates were derived through linear interpolation. We excluded all transfers from within one acute care hospital to another within this study group.

Time series analysis was conducted to assess seasonal variations. Spectral analysis was conducted to assess cyclical patterns in event occurrence following inspection of the autocorrelation function. The data series was detrended prior to conducting analysis. The Fisher-Kappa (FK) Test was used to detect a major sinusoidal component buried in white noise and the Bartlett Kolmogorov Smirnov (BKS) Test was used to detect departures from the white noise hypothesis over all frequencies.

RESULTS

There were a total of 13,919,867 hospitalizations over the 12-year period. A nonlinear trend and a seasonal pattern within the series of total hospitalizations (p<0.001) is evident from the time plot graph from April 1988 to March 2000 (Figure 1). There is an increase in hospital discharges in spring and autumn and a decrease in summer and winter. Consistent patterns are seen for both males and females although women accounted for approximately 20% more hospitalizations than men. Overall rates of hospitalizations rose from approximately 8 per 1000 to 10 per 1000 or approximately 25,000 hospitalizations, between 1988 and 1993 and then decreased again to 1988 levels by 2000.

Table I shows the variation in hospitalizations within years by age groups and gender. Statistically significant seasonality (p<0.05) in hospitalizations was found in every age group for both sexes with the exception of males between the ages of 20 and 39. The average monthly variability over the 12-year period ranged from lows of 14.9% for the age group 20-29 years for both sexes, to highs of 34% in males

TABLE I
Variation in Hospitalizations by Age and Gender: 1988-2000

Age Group	Mean Monthly Admissions			Mean Monthly % Variation†		
	Male	Female	Both*	Male	Female	Both
0-4	8197	7031	15,346§	25.5	23.7	23.2
5-9	1043	785	1829	34.2	27.0	28.9
10-19	1789	2771	4563	19.2	16.5	15.5‡
20-29	2277	10,215	12,499	17.1‡	15.5	14.9
30-39	3177	10,026	13,210	17.9‡	18.1	17.5
40-49	3595	4721	8320	17.8	27.6	22.9
50-59	4341	4056	8401	19.4	25.4	21.5
60-69	6254	5243	11,502	19.5	21.4	19.6
70-79	6209	6247	12,461	18.2	18.1	17.9
80+	3416	5319	8738	20.4	20.1	20.2
All ages	40,298	56,415	96,870	20.9	21.3	20.2

* In the event of missing gender data, the case was neither added to the male nor the female categories but was still added to the both category.
† The mean monthly percent variation was determined by calculating the differences between monthly minimum and maximum admissions and then pooling them over 12 years. The pooling produced variations for the both sexes category that were sometimes lower than for either the male or female categories individually.
‡ p<0.05
§ The sum of mean monthly admissions for each age category and the mean monthly admissions total for 'all ages' are not equal due to error from the unequal weighting associated with calculating averages from averages.
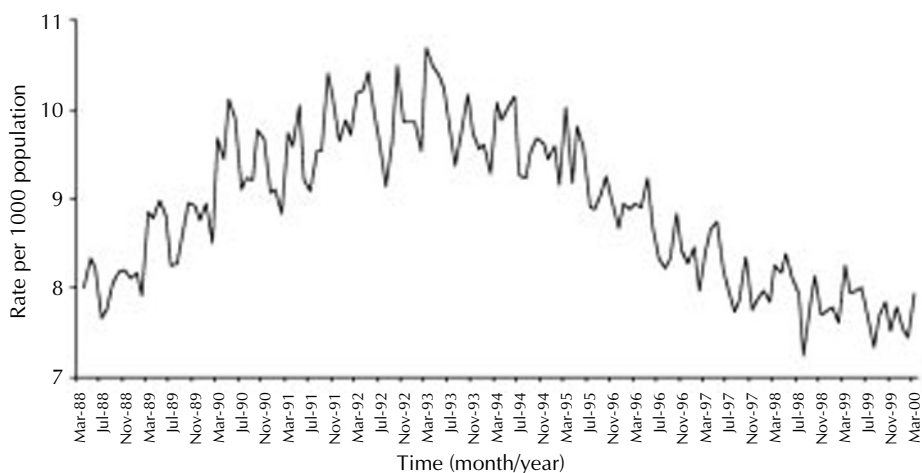

Figure 1. Total hospitalization rates per 1000 population in Ontario (1988-2000)

between 5 and 9 years, and almost 28% in females between 40 and 49 years. Generally, adolescents (10-19 years of age) and young adults (20-39 years of age) demonstrated the least seasonal variability. For all ages and both sexes combined, a 12-year mean variability of 21% was calculated. This represents approximately 20,000 out of 97,000 mean monthly hospitalizations. The peak in hospitalizations over the 12-year period occurs in the month of May and the trough occurs in August.

Figure 2 (A to E) expresses hospitalizations as a percentage change from the yearly hospitalizations average broken down by gender and age groups. In the 0-4 years age group (Figure 2-A), consistent seasonal patterns can be observed over the 12-year period with peaks occurring in the spring months and troughs in the summer

months. There is a mean monthly percent variation over this period of approximately 23% (Table I), however, the range of variation within a given year is frequently found to be higher (i.e., over 50% in 1991 and 1992). Similar variability and seasonal patterns are observed in this age group for both males and females.

In the 5 to 9 year age group (Figure 2-B), a clear and consistent seasonal pattern can be seen with the peaks occurring in the autumn and spring months and the troughs occurring in the summer months as well as December. There is a high degree of variability in hospitalizations, particularly among the males of this age group with an annual variation exceeding 50% (12-year mean = 34%; Table I).

For the 10 to 19 year age group, again a seasonal pattern was found (Table I). Compared to younger age groups, how-

Figure 2. Variation in total hospitalizations as a function of time, gender and age groups

ever, there is significantly less variation. The peaks in hospitalizations for both males and females are in the spring and autumn, and the troughs occur in the winter (December, January and February) (data not shown). The mean level of variation is similar for both males and females at approximately 19% and 17% respectively.

For the 20 to 29 and 30 to 39 year age groups, the seasonal patterns are somewhat less evident (e.g., Figure 2-C). There is a statistically significant seasonal pattern for females with peaks occurring in the spring and troughs in the winter between November and February. The mean number of hospitalizations for females increases from under 3000 in the 10-19 years age group to over 10,000 here (Table I). For males, no statistically significant seasonal pattern was observed (p>0.05). For both males and females, the mean variation in hospitalizations is similarly low, ranging

from approximately 15% to 18% with little change over the 12-year period.

Similar seasonal patterns exist for both sexes in the age groups 40 to 49, 50 to 59, and 60 to 69 years (e.g., Figure 2-D). In each case, seasonal patterns are clear and consistent with the major peaks occurring in January and the major troughs occurring in December. Minor peaks and troughs are seen in the spring and summer months respectively. There is greater seasonal variability among women than men for each of these age groups (Table I). This is particularly evident in the 40 to 49 year age group where the 12-year mean variation for women is 27.6% as compared to 17.8% for men. For the 70 to 79 year age group (Figure 2-E), the pattern of December troughs in hospitalizations is consistent with younger age groups. Admission peaks differ, however, in that they consistently occur in May and

October, with only minor peaks occurring in January.

Finally, for the 80+ age group (Table I), the seasonal hospitalizations pattern is somewhat less evident although still statistically significant (p<0.05). Peaks in hospitalizations most commonly occur in the spring and troughs most commonly occur in the summer (data not shown). This seasonal pattern is similar for both males and females as is the variability of monthly admission. The mean monthly variation for both males and females is approximately 20%.

DISCUSSION

This study has uncovered several important findings regarding the seasonal patterns of total hospitalizations in Ontario. In the approximately 14 million hospitalizations examined over the 12-year period,

there was an average monthly variability of approximately 20% or 20,000 of 97,000 mean monthly hospitalizations (Table I). Distinct non-linear trends and seasonal patterns were found for the total population, both sexes, and almost all age groups. The overall admission rates for the total population were found to be highest in spring and autumn, however, the minimum and maximum admission months vary by age groups. Most variability in hospitalizations can be seen in the youngest age groups (0 to 4 and 5 to 9 years of age) with peaks typically occurring in the spring and autumn and troughs in the summer (Figures 2-A and B). For adolescents and young adults, there is less variation, and in the case of males between the ages of 20 and 39, there was no significant seasonality detected. Variation in hospitalizations increases slightly by middle age (>30 years of age), particularly among women, with maximum and minimum hospitalizations occurring in January and December respectively (e.g., Figure 2-D). From 70 years of age and up, spring and autumn admission peaks were again most common for both sexes (Figure 2-E).

The causes of these seasonal variations in hospitalizations are incompletely understood, are likely complex in origin, vary by age and gender, and entail the broader determinants of health such as environmental and social/behavioural factors. Potential environmental factors may include ambient pollutants,[13,14] aeroallergens,[15] microbial agents such as influenza and meteorological conditions such as humidity and temperature.[12,16-18] Social/behavioural factors may include socio-economic status, holidays[19] and health care system factors such as bed closures.

This is a largely descriptive study of aggregate data and as such does not address the seasonal breakdown of hospitalizations or examine the factors that may be driving the variation. Further research is clearly required to do this. Although these limits make interpretation of the results somewhat difficult, there are several plausible explanations for the major findings. First, the spring peaks among 0 to 4 year olds and women in their childbearing years (20 to 39 years), as well as the high number of admissions for these groups, may be explained, at least in part, by births. According to Ford and Nault,[20] across Canada, approximately 15% more births occur in the spring compared to autumn and winter months, findings that have also been reported in the United States and Europe. Second, the spring peak in hospitalizations seen among the very young (0 to 4 years) and the elderly (70 to 79 and 80+ years) may be due in part to seasonally occurring respiratory diseases including asthma. For children specifically, asthma-related hospitalizations are well known to peak in the spring and autumn,[6] contributing to the seasonal patterns seen in this study. Finally, the consistent pattern of January peaks and December troughs found for both males and females between the ages of 40 and 69 years may be explained by holiday bed closures and reduced Christmas elective surgery schedules in Ontario. The peak seen in January likely represents the backlog created during the December holiday season.

The relevance of this study lies primarily in the domain of health care policy and planning. To our knowledge, no large-scale study employing a macro-level perspective population health approach looking at hospitals as a system has ever been done. The findings represent a dynamic pattern of hospitalizations in Ontario, a pattern closely representative of the true situation in the health care system as compared to the aggregated annual rates more commonly seen. Such findings have the potential to aid in the effective allocation of resources and services based on seasonal and specific population (i.e., age and gender) demands.

Furthermore, these results challenge the general perception that only a handful of health conditions (e.g., influenza) are seasonal.

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RÉSUMÉ

Contexte : Des fluctuations saisonnières régulières et prévisibles du nombre d'hospitalisations ont été constatées pour divers troubles médicaux transmissibles et non transmissibles. Nous avons voulu examiner les schémas saisonniers selon l'âge et le sexe pour l'ensemble des hospitalisations afin de déterminer si l'appareil hospitalier d'une vaste zone géographique faisait l'objet de variations temporelles régulières et prévisibles.

Méthode : Une étude rétrospective fondée sur la population des résidents de l'Ontario (environ 14 millions de personnes) a permis d'évaluer les schémas temporels de l'ensemble des hospitalisations entre le 1er avril 1988 et le 31 mars 2000. Au moyen d'une analyse spectrale, nous avons analysé des séries chronologiques pour évaluer les variations saisonnières et les tendances au fil du temps et expliquer l'autocorrélation.

Résultats : Des cycles saisonniers apparents dans les hospitalisations ont été constatés dans tous les groupes d'âge et pour les deux sexes, sauf chez les hommes de 20 à 39 ans. La variabilité mensuelle moyenne présentait des creux de 15 % dans le groupe des 20 à 29 ans des deux sexes et des crêtes de 34 % chez les garçons de 5 à 9 ans. Pour l'ensemble de la population, ceci représente une variabilité moyenne d'environ 20 % sur 12 ans, soit 20 000 hospitalisations sur 97 000. Pour les deux sexes, on observe en général des crêtes d'hospitalisations au printemps et à l'automne dans les groupes les plus jeunes et les plus âgés, et en janvier dans les groupes d'âge moyen.

Conclusion : Les facteurs saisonniers jouent un rôle important dans l'utilisation des services hospitaliers en Ontario. Les déterminants de ces cycles saisonniers, dont des facteurs environnementaux et socio-comportementaux, sont encore mal compris.

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