



Influenza outbreaks in Ontario hospitals, 2012–2016

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Abstract

Background: Influenza outbreaks in hospital settings affect vulnerable patient populations and pose considerable risk of morbidity and mortality; however, key information regarding these outbreaks is limited.

Objective: To describe surveillance data on influenza outbreaks in Ontario hospitals between 2012–13 and 2015–16 and compare H3N2- and H1N1-dominant influenza seasons.

Methods: Hospital laboratory-confirmed influenza outbreaks occurring between September 1, 2012 and August 31, 2016 were analysed for indicators of outbreak duration and severity (case attack rate, pneumonia rate and fatality rate). Frequency, duration and severity of influenza A outbreaks were compared between H3N2- (2012–13, 2014–15) and H1N1-dominant seasons (2013–14, 2015–16).

Results: Over the four years, there were 256 hospital outbreaks involving 1,586 patients that included 91 cases of pneumonia and 40 deaths. The total number of outbreaks was lowest in the 2015–16 (n=36) and highest in the 2014–15 (n=117) influenza seasons. The 2014-15 season also had the highest number of influenza cases (n=753), pneumonia cases (n=46), fatalities (n=18) and hospital sites reporting ≥ 1 outbreak (n=72). Median outbreak duration ranged from 4.5 days in 2013–14 to 6.0 days in 2015–16. Comparisons of H3N2 and H1N1 seasons did not identify statistically significant differences in outbreak duration or severity; however, significantly more influenza A outbreaks than influenza B outbreaks were reported in H3N2 seasons compared with H1N1 seasons ($p < 0.05$).

Conclusion: While H3N2-dominant years contribute to influenza morbidity and mortality through an increased number of hospital outbreaks, the duration and severity of influenza A outbreaks are not significantly different in H3N2 and H1N1 seasons.

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Introduction

Influenza is a significant cause of morbidity and mortality in Canada where there are approximately 3,500 deaths and 12,200 hospitalizations attributable to seasonal influenza annually (1). As of March 31, 2018, the Public Health Agency of Canada's FluWatch national influenza surveillance reported 1,663 influenza outbreaks in hospitals, long-term care facilities (LTCFs) and other settings during the 2017–18 influenza season (2). While LTCFs account for the majority of nationally reported influenza outbreaks, 10.5% (n=175/1,663) of outbreaks occurred in hospitals (2). Influenza introduced by patients, staff and visitors, poses a concern since many hospital patients are vulnerable to influenza and its complications due to their age, baseline health status and admission illness. For example, a 2002 review of 12 nosocomial influenza outbreak reports in acute care hospital settings in the United States found patient attack rates as high as 50% (range: 3–50%), with notably high mortality rates (range: 33–60%) (3).

Beyond outbreak totals reported in FluWatch, there is very limited information available on the characteristics of influenza outbreaks, such as duration and severity, in Canadian hospitals (4). Jurisdictions that have summarized characteristics of influenza outbreaks typically combine hospitals with other institutions, such as LTCFs, even though these settings differ in terms of patient populations, infection prevention and control standards, respiratory virus testing, and infrastructure differences, which can impact the detection, control and outcomes of outbreaks (5). Compared with LTCFs, where the vast majority of residents are older adults, hospital outbreaks may involve patients of varying ages, including younger adults who tend to be more vulnerable to H1N1 strains (6). Older adults typically experience higher morbidity and mortality in H3N2-dominant years (7-10). Therefore, influenza outbreaks in acute care settings warrant separate consideration and examination.

Further, characteristics of outbreaks may differ based on influenza subtype. In Ontario, H3N2-dominant



seasons are typically associated with greater numbers of laboratory-confirmed influenza A outbreaks in institutions compared with H1N1 dominant seasons; FluWatch reports indicate similar trends nationally (4,11). While there are more total numbers of outbreaks in H3N2 seasons, it is unknown whether hospital outbreaks in these seasons are more severe in terms of duration and complications compared to the hospital outbreaks that occur during H1N1 seasons (3,12). The aim of this report is to describe influenza outbreaks in Ontario hospitals for the four influenza seasons between 2012–13 and 2015–16, including their frequency, duration and severity, and to assess differences by H3N2- and H1N1-dominant seasons.

Methods

Data source

In Ontario, LTCFs, retirement homes, hospitals and other institutional settings must report all influenza outbreaks within their institution to their local public health unit (13). The provincial case definition for an influenza outbreak in a hospital is two or more cases of nosocomially-acquired acute respiratory infection (infection that is acquired during the delivery of health care that was not present or incubating at the time of admission) occurring within 48 hours on a specific hospital unit, with at least one of the cases being laboratory-confirmed influenza (13,14). The area (e.g., unit(s) or ward(s)) declared under outbreak within the hospital is referred to as the “at-risk area”, and includes all patients in those areas.

Outbreak information (e.g., onset date, number of patient cases) is entered into Ontario’s integrated Public Health Information System (iPHIS) (13). Reporting in iPHIS includes the number of outbreak cases, cases with pneumonia (confirmed by chest x-ray), deaths among cases where the fatality is related to the outbreak and the total number of patients in the at-risk area (13). Influenza typing (influenza A and/or B) is available, but influenza A subtyping (H3N2 versus H1N1) is not routinely reported in iPHIS.

On March 20, 2018, we extracted the following from iPHIS: data for reported and closed outbreaks with ‘hospital’ exposure setting or hospital indicated in the outbreak name that occurred between September 1, 2012 and August 31, 2016 that met the provincial case definition for an influenza outbreak. Influenza seasons were defined as the period between September 1 and August 31 of each year. We excluded outbreaks with missing case count data as well as outbreaks with hospital names that could not be matched to a list of 230 Ontario hospital sites from the Ministry of Health and Long-Term Care (15). We included outbreaks with fewer than two patient cases in the analyses if staff cases were also part of the outbreak (thereby fulfilling the Ontario case definition).

Data analysis

For each of the four seasons, we calculated the total number of outbreak cases and medians and ranges for the following outcomes: hospital sites reporting one or more outbreaks; outbreaks per hospital reporting an outbreak; duration of outbreaks; number of cases per outbreak; case attack rate (cases per patients in at-risk area); number of pneumonia cases; and number of case fatalities. Specific analyses for case attack rate and duration per year excluded individual outbreaks with missing data or that have an attack rate greater than 100%.

Outbreak duration was defined as the difference in number of days between the onset date of the index case and the onset date of the last case associated with the outbreak, as entered in iPHIS. This definition ensures consistent measurement of duration across outbreaks as there is hospital outbreak management team discretion on when an outbreak is declared over after illness onset in the last case.

Based on testing performed by Public Health Ontario Laboratory, the Ontario Respiratory Pathogen Bulletin’s annual summary includes the dominant influenza A strain and proportion of all subtyped influenza A specimens (from community, hospital and outbreak) with that subtype: 2012–13 was H3N2-dominant (90.6%), 2013–14 was H1N1-dominant (85.7%), 2014–15 was H3N2-dominant (99.0%) and 2015-16 was H1N1-dominant (89.4%)(11). We aggregated data on influenza A outbreaks occurring in H3N2- and H1N1-dominant years. We compared the number of outbreaks and the proportions of cases with pneumonia and case fatalities between H3N2 and H1N1 seasons using chi-square tests. We compared the median duration of outbreaks, median number of outbreak cases and median attack rate between H3N2- and H1N1-dominant seasons using a Mann-Whitney-Wilcoxon non-parametric test for comparison of medians (16-19). Analyses were performed in SAS 9.4 (SAS Institute Inc., Cary, North Carolina, United States). As these analyses were consistent with routine surveillance, it was determined that they were exempt from Public Health Ontario Research Ethics Board review.

Results

Between 2012–13 and 2015–16, 101 hospitals in Ontario reported one or more influenza outbreaks, for a total of 256 outbreaks. **Table 1** summarizes the outbreak characteristics for each season. Of the 256 outbreaks, 19 had missing or nonsensical duration or case attack rate data and were only excluded from the applicable year-specific summaries. One outbreak included in the count of influenza A outbreaks had both influenza A and B detected.

Table 1: Comparison of hospital influenza outbreak characteristics across the 2012–13 to 2015–16 seasons in Ontario

Outcomes	Influenza season			
	2012–13	2013–14	2014–15	2015–16
Total number of outbreaks	65	38	117	36
– Influenza A: n (%)	63 (96.9%)	16 (42.1%)	112 (95.7%)	27 (75.0%)
– Influenza B: n (%)	2 (3.1%)	22 (57.9%)	5 (4.3%)	9 (25.0%)
Number of hospital sites reporting ≥1 outbreaks (% of total sites)	45 (19.6%)	30 (13.0%)	72 (31.3%)	29 (12.6%)
Median number of outbreaks per hospital site with an outbreak	1.0	1.0	1.0	1.0
– Range	1-6	1-2	1-7	1-4
Median duration of outbreaks, in days (range)	5.0	4.5	5.0	6.0
– Range	0–29	1–20	0–32	0–16
Total number of outbreak cases per season	465	179	753	189



Table 1: (continued) Comparison of hospital influenza outbreak characteristics across the 2012–13 to 2015–16 seasons in Ontario

Outcomes	Influenza season			
	2012–13	2013–14	2014–15	2015–16
Median number of cases per outbreak	5.0	3.0	5.0	5.0
– Range	1–45	2–11	2–60	1–14
Median percent case attack rate by at-risk area	16.1%	18.5%	15.9%	18.0%
– Range	4.1–70.8%	4.4–75.0%	4.1–66.7%	4.5–36.8%
Number of pneumonia cases (% of cases) ^a	25 (5.4%)	15 (8.4%)	46 (6.1%)	5 (2.6%)
Number of fatal cases (% of cases) ^a	12 (2.6%)	3 (1.7%)	18 (2.4%)	7 (3.7%)

Abbreviations: n, number

^aBased on the total number of cases (n=1,586)

The median number of outbreaks per site remained constant at one per season across all four years, though some sites had as many as six (in 2012–13) or seven (in 2014–15) outbreaks. The median duration of an outbreak ranged from 4.5 to 6.0 days. There were a total of 1,586 cases of influenza associated with outbreaks over the four seasons, with 91 cases of pneumonia (5.7%) and 40 deaths (2.5%). The percentages of cases with pneumonia and death both show fluctuations and no consistent trend across seasons. The 2014–15 season had the highest number of outbreaks (n=117), the highest proportion of sites with one or more outbreak(s) (31.3%), the greatest number of cumulative outbreak cases (n=753), the site with the most number of outbreaks in a single season (n=7) and the outbreaks with the most number of cases (n=60) and longest duration (32 days) of the four seasons.

Table 2 summarizes the 218 influenza A outbreaks in H3N2- (n=175) vs H1N1- (n=43) dominant seasons. There were 17 outbreaks that due to missing or nonsensical data, were excluded from either or both duration and case attack rate summaries. There was significantly more influenza A than influenza B outbreaks in H3N2-dominant vs H1N1-dominant influenza seasons ($p < 0.05$). The outbreak duration, number of cases per outbreak, case attack rate, percentage of cases with pneumonia and percentage of fatal case did not differ significantly with the dominant circulating strain.

Table 2: Comparison of hospital influenza A outbreaks in H3N2- versus H1N1-dominant seasons between 2012–13 and 2015–16 in Ontario

Outcomes	H3N2 seasons (2012–13, 2014–15)	H1N1 seasons (2013–14, 2015–16)	p-value
Number of influenza A outbreaks (% of influenza A out of influenza A and B outbreaks)	175 (96.2%)	43 (58.1%)	< 0.0001 ^a
Median duration of outbreaks, in days	5.0	4.0	0.56 ^b
– Range	0–32	0–16	0
Median number of cases per outbreak	5.0	5.0	0.49 ^b
– Range	1–60	1–14	0

Table 2: (continued) Comparison of hospital influenza A outbreaks in H3N2- versus H1N1-dominant seasons between 2012–13 and 2015–16 in Ontario

Outcomes	H3N2 seasons (2012–13, 2014–15)	H1N1 seasons (2013–14, 2015–16)	p-value
Median percent attack rate by at-risk area per outbreak	16.0%	18.8%	0.66 ^b
– Range	4.1–70.8%	4.5–58.3%	0
Number of pneumonia cases (% of cases)	69 (5.9%)	14 (6.2%)	0.85 ^a
Number of fatal cases (% of cases)	30 (2.5%)	9 (4.0%)	0.23 ^a

^a Chi-square

^b Mann-Whitney-Wilcoxon

Discussion

This study identified that hospital outbreaks occur on a regular basis in Ontario and contribute to overall influenza-associated morbidity and mortality. The majority of hospitals did not report any outbreaks during the four influenza seasons studied. Hospitals with outbreaks reported a median of one per season, lasting five days with five cases. A minority experienced a high burden of illness, with as many as seven outbreaks in one season, lasting up to 32 days, and as many as 60 cases in an outbreak; all of these occurred in the 2014–15 season, consistent with other evidence that 2014–15 was particularly severe due to the circulating strain and the low vaccine effectiveness that was documented that year (20). Our comparison of influenza A outbreaks in H3N2- and H1N1-dominant seasons found no significant differences in the median duration, median number of cases, case attack rates, cases with pneumonia or fatal cases.

This is the first surveillance report describing characteristics of hospital outbreaks in Ontario over multiple seasons. We did not identify any published reports comparing the characteristics of influenza A outbreaks in hospitals in H3N2 and H1N1 seasons. The limited comparable published data from other jurisdictions suggests public health surveillance reporting, beyond total numbers of outbreaks, should be leveraged to understand and reduce outbreak-associated morbidity and mortality.

Other published studies using the same definition of outbreak duration as applied in these analyses (i.e., time from the first case to last case), found longer median outbreak durations than observed here. In a 2002 review of acute hospital influenza outbreaks, Salgado et al. (3) reported a median outbreak duration of seven days; however, this was based on 12 outbreak reports from a range of hospital setting types compared with hospital outbreak surveillance in our study. Additionally, in a review of outbreaks of influenza-like illnesses in LTCFs in Winnipeg, Mahmud et al. (9) reported a median outbreak duration of 16 days. The longer duration seen in the present study may be due to the different exposure setting (LTCF vs hospital) and the inclusion of cases of influenza-like illnesses vs only laboratory-confirmed influenza. Notably, we included outbreaks where all of the cases occurred on the same day (i.e., duration of 0 days) in our analyses. It is unclear whether these entries represent the rapid implementation of outbreak control measures such that cases did not occur past the first day, or inaccuracies of data reporting.



The case attack rates in our analyses are consistent with the wide ranges reported in the hospital outbreak literature (3,21). The overall case fatality rate in this study (2.5%; n=40 deaths/1,586 cases) is lower than the 16% median mortality rate in acute and geriatric hospitals reported in the review by Salgado et al. (3), which was based on three outbreak reports from 1960 to 1982. The increased frequency of influenza A outbreaks in H3N2-dominant years is consistent with studies showing that H3N2 infection is more common than H1N1 in hospitalized seniors (12,22).

The primary strength of our work is that we analysed a large number of outbreaks over four influenza seasons and across seasons with both varying levels of community influenza activity and reported vaccine effectiveness (16–19, 23). Limitations of our findings arise from the use of routinely collected surveillance data. Outbreak data in iPHIS does not routinely include influenza A subtyping results, preventing comparisons by actual subtype. It is possible that some influenza A outbreaks in H1N1 years were due to H3N2, which could explain similarities in outbreak characteristics in H1N1- and H3N2-dominant seasons. Other data elements reported in iPHIS had a high frequency of missing data and/or data quality issues that restricted comparing other aspects of hospital outbreaks. Aggregate statistics on staff illness and patient and staff influenza immunization coverage within at-risk areas of the outbreak were subject to varying levels of completeness and accuracy, and were therefore too unreliable to include in these analyses.

The use of provincially reported aggregate outbreak data in iPHIS is also limited as data elements that could illuminate reasons for differences in outbreak characteristics are not captured in iPHIS. Individual case information (e.g., patient age, underlying health status, symptoms, laboratory testing or use of antivirals) is not available to assess its impact on the severity of an outbreak. In addition, information regarding the risk of transmission within the outbreak area (e.g., acuity/type of hospital ward, age of hospital, room/ward layout, level of infection prevention and control resources in the hospital) is not reported.

There are several uncertainties associated with these data; for example, the observation of hospital sites without outbreaks or those with a high number of outbreaks may indicate variation in infection control practices or outbreak reporting. Acute wards, with higher turnover of patients, may be more likely to 'miss' an outbreak if patients are discharged prior to their identification as a nosocomial case, while complex chronic care hospitals have longer patient stays, increasing both the risk of influenza transmission and the probability of influenza detection. Interpretation of how to report outbreak-related information may differ across hospitals and public health units, contributing to variability in reported values; for example, some outbreaks reported the same number of patients in the at-risk area as for the total number of patients in the hospital. It is unclear whether these outbreaks involved the entire hospital or instead represent reporting inaccuracies. Interpretation differences in the patient denominator for the at-risk area (available beds vs total number of patients present at any time during the outbreak) could also impact case attack rates.

These analyses are specific to Ontario and outbreak characteristics are influenced by the provincial guidance on management of influenza outbreaks in hospitals as well as reporting practices (24). Studies of hospital influenza outbreaks from other jurisdictions are needed to compare with our Ontario findings and establish targets for public health action to reduce

the morbidity and mortality associated with hospital influenza outbreaks. Based on the very low vaccine effectiveness reported for the 2014–15 season (23) and other year-over-year differences in influenza seasons, future studies should include multiple seasons to further characterize the range of hospital outbreak activity.

Conclusion

Hospital outbreaks occur on a regular basis and contribute to influenza morbidity and mortality. Overall, we found a number of hospital influenza outbreak characteristics, including median duration, median number of cases per outbreak and patient attack rate, remained fairly consistent across the four influenza seasons studied. This consistency was regardless of the dominant influenza A subtype, although more hospital influenza A outbreaks were reported in H3N2-dominant seasons than in H1N1-dominant seasons. Improvements in completeness, accuracy and consistency of outbreak summary statistics from public health surveillance reporting would strengthen future analyses. Further consideration is also needed to determine the necessary minimum data set of case, outbreak and hospital level information for aggregate reporting to be able to address public health questions with respect to the monitoring, management and evaluation of hospital influenza outbreaks.

Authors' statement

MM – Conceptualization, writing-original draft, writing-review and editing, visualization
MW – Formal analyses, writing-original draft sections, writing-review and editing, visualization
LF – Writing-original draft sections, writing-review and editing
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Conflict of interest

None.

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