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Annual report

Influenza epidemiology in patients admitted to sentinel Australian hospitals in 2018: the Influenza Complications Alert Network (FluCAN)

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Abstract

The Influenza Complications Alert Network (FluCAN) is a sentinel hospital-based surveillance program that operates at sites in all jurisdictions in Australia. This report summarises the epidemiology of hospitalisations with laboratory-confirmed influenza during the 2018 influenza season.

In this observational surveillance system, cases were defined as patients admitted to any of the 17 sentinel hospitals with influenza confirmed by nucleic acid detection. Data were also collected on a frequency-matched control group of influenza-negative patients admitted with acute respiratory infection.

During the period 3 April to 31 October 2018 (the 2018 influenza season), 769 patients were admitted with confirmed influenza to one of 17 FluCAN sentinel hospitals. Of these, 30% were elderly (≥65 years), 28% were children (<16 years), 6.4% were Aboriginal and Torres Strait Islander peoples, 2.2% were pregnant and 66% had chronic comorbidities. A small proportion of FluCAN admissions were due to influenza B (13%). Estimated vaccine coverage was 77% in the elderly (≥65 years), 45% in non-elderly adults with medical comorbidities and 26% in children (<16 years) with medical comorbidities. The estimated vaccine effectiveness (VE) in the target population was 52% (95% CI: 37%, 63%).

There were a smaller number of hospital admissions detected with confirmed influenza in this national observational surveillance system in 2018 than in 2017, with the demographic profile reflecting the change in circulating subtype from A/H3N2 to A/H1N1.

Keywords: influenza, public health surveillance, influenza vaccines, vaccination coverage, vaccine effectiveness

Introduction

Influenza is an acute respiratory viral infection caused by influenza viruses. The Global Burden of Disease study has estimated that around 9.5 million hospitalisations and 145,000 deaths were due to influenza in 2017.[1] European studies have suggested that, among 31 common infectious diseases, influenza was responsible for the highest burden of disease, assessed by both disability-adjusted life years and years of life lost.[2] In Australia, administrative data suggest that influenza is diagnosed in up to 10,000 hospital admissions annually, with the highest incidence in children and the elderly.[3] In this report, we describe the epidemiology of hospitalisation with laboratory-confirmed influenza in the 2018 season in Australia.

Methods

The Influenza Complications Alert Network (FluCAN) is a national hospital-based sentinel surveillance system.[4] Since 2011, the participating sites have been Canberra Hospital (ACT), Calvary Hospital (ACT), Westmead Hospital (NSW), John Hunter Hospital (NSW), Children's Hospital at Westmead (NSW), Alice Springs Hospital (NT), Royal Adelaide Hospital (SA), Mater Hospital (Qld), Princess Alexandra Hospital (Qld), Cairns Base Hospital (Qld), Royal Hobart Hospital (Tas), The Alfred Hospital (Vic), Royal Melbourne Hospital (Vic), Monash Medical Centre (Vic), University Hospital Geelong (Vic), Royal Perth Hospital (WA), and Princess Margaret Hospital (now Perth Children's Hospital, WA). In 2018, additional specialist paediatric hospitals (Queensland Children's Hospital (Qld), Women's and Children's Hospital (SA), the paediatric ward of the Royal Darwin Hospital (NT) and Royal Children's Hospital (Vic)) also contributed data, but data from these sites were only included to estimate vaccine effectiveness to facilitate comparisons with previous years (Figure 1). Ethical approval has been obtained at all participating sites and at Monash University. Hospital bed capacity statistics were obtained from each participating hospital, and national bed capacity was obtained from the last published AIHW report.[5]

An influenza case was defined as a patient admitted to hospital with influenza confirmed by nucleic acid testing (NAT). Surveillance is conducted from early April until the end of October (with follow-up continuing to the end of November) each year. Data on a frequency-matched group of test-negative controls were also collected. Admission or transfer to an intensive care unit (ICU) included patients managed in a high dependency unit (HDU). The onset date was defined as the date of admission except for patients where the date of the test was more than 7 days after admission, in which instance the onset date was the date of the test. The presence of risk factors and comorbidities was ascertained from the patient's medical record. Restricted functional capacity was defined as those who were not fully active and not able to carry out all activities without restriction prior to the acute illness.[6]

We examined factors associated with ICU admission using multivariable regression. Factors independently associated with ICU admission were determined using a logistic regression model with no variable selection process, as all included factors were plausibly related to ICU admission.

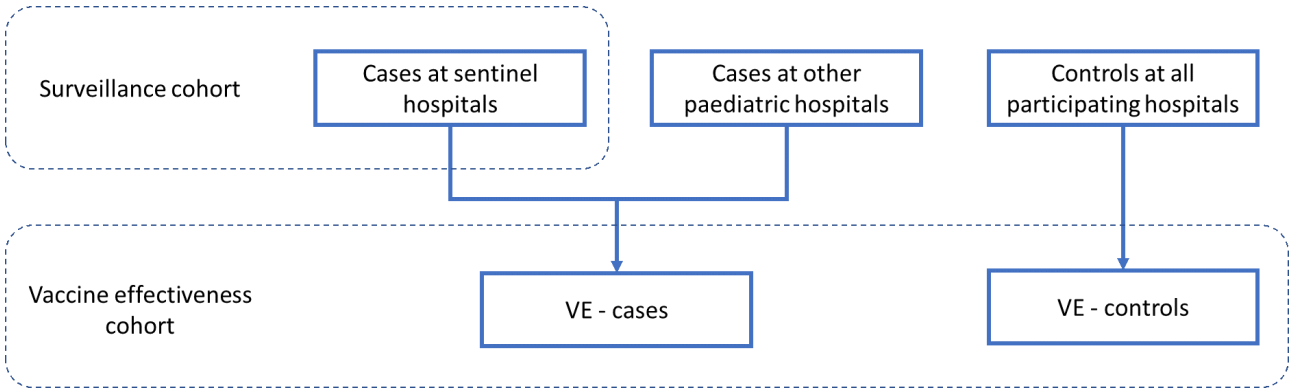
The presentation delay was defined as the time from onset of illness to admission to hospital. The treatment delay was defined as the time from onset of illness to prescription of oseltamivir (in patients that received treatment). Patients were categorised into those that (a) did not receive oseltamivir (b) received oseltamivir within 2 days of symptom onset and (c) received oseltamivir more than 2 days after symptom onset. We modelled factors associated with length of hospital stay, including antiviral use, using a negative binomial regression, where the exponential of the regression coefficient represents the relative increase in hospital length of stay.

Vaccine coverage was estimated from the proportion of vaccinated individuals in test-negative controls in each age group, stratified by the presence of chronic comorbidities. Vaccine effectiveness (VE) was estimated from the adjusted odds ratio (aOR) of vaccination in cases vs control, using the formula VE=1-aOR. The odds ratio was calculated from a conditional logistic regression, stratified by site and month and adjusted for age group, the presence of chronic comorbidities, pregnancy, and Aboriginal or Torres Strait Islander ethnicity.

Results

During the 2018 influenza season (3 April – 31 October 2018), 769 patients were admitted to the 17 FluCAN sentinel hospitals with laboratory-confirmed influenza. The peak weekly number of admissions was in mid-August (week

Figure 1: Participants included in surveillance and vaccine effectiveness cohorts



36) (Figure 2). The majority of cases were due to influenza A (n=666, 87%). The proportion due to influenza B varied across jurisdictions, ranging from 6.1% in NSW and 7.1% in ACT, to 28% in SA.

Of these 769 patients admitted with confirmed influenza, 228 (30%) were >65 years of age, 215 (28%) were children (<16 years), 49 (6.4%) were Aboriginal and Torres Strait Islander peoples, and 505 (66%) had chronic comorbidities (Table 1; Table 2). There were 17 pregnant women representing 15% of the 114 female patients aged 16–49, or 2.2% of the total. Of the 679 patients (88%) where influenza vaccination status was ascertained, 232 (34%) had been vaccinated.

Incidence of hospital admissions with influenza

Overall, the peak incidence of admissions with confirmed influenza was 1.2 per 100 hospital beds (Figure 3; in epidemiological week 36), but varied from a high of 6.2 per 100 hospital beds at the Children's Hospital Westmead to a low of 0.27 per 100 hospital beds at Princess Alexandria Hospital (Figure 4).

Presentation and management

Of all 769 cases, 727 (95%) patients had a documented date of onset of illness documented. Of these, 18 cases (2.3%) were diagnosed more than 7 days after admission and therefore were likely to be hospital-acquired. For the remaining 709 patients with community-onset laboratory-confirmed influenza where the duration of symptoms was known, the median duration of symptoms prior to admission was 3 days (interquartile range (IQR): 2,5 days). In patients that received antivirals, the delay from onset of illness to admission was >2 days in 57%, and was similar in children (58%), non-elderly adults (54%) and the elderly (60%).

Radiological evidence of pneumonia was present in 130 patients (17%). The proportion of patients with pneumonia was similar in children (16%), non-elderly adults (16%) and elderly adults (19%). A higher proportion of patients with pneumonia were admitted to ICU (36/130; 28%) than those without pneumonia (41/639; 6.4%).

Of all cases, 77 (10.0%) patients were admitted to ICU, comprising 66 patients (8.6%) initially admitted to ICU and a further 11 (1.4%) subsequently transferred to ICU after initial admission to a general ward. Pregnant women and patients infected with A/H3N2 subtypes were less likely to be admitted to ICU, but these differences were not statistically significant (Table 3).

Use of antivirals

Of patients where the date of onset was reported, 51% did not receive oseltamivir, 18% received oseltamivir within 2 days of symptom onset and 31% received oseltamivir more than 2 days after the onset of illness. Oseltamivir use was lower in children (6.3% within 2 days; a further 20% more than 2 days) than in non-elderly adults (25%, 32%) and the elderly (19%, 40%) (Table 4).

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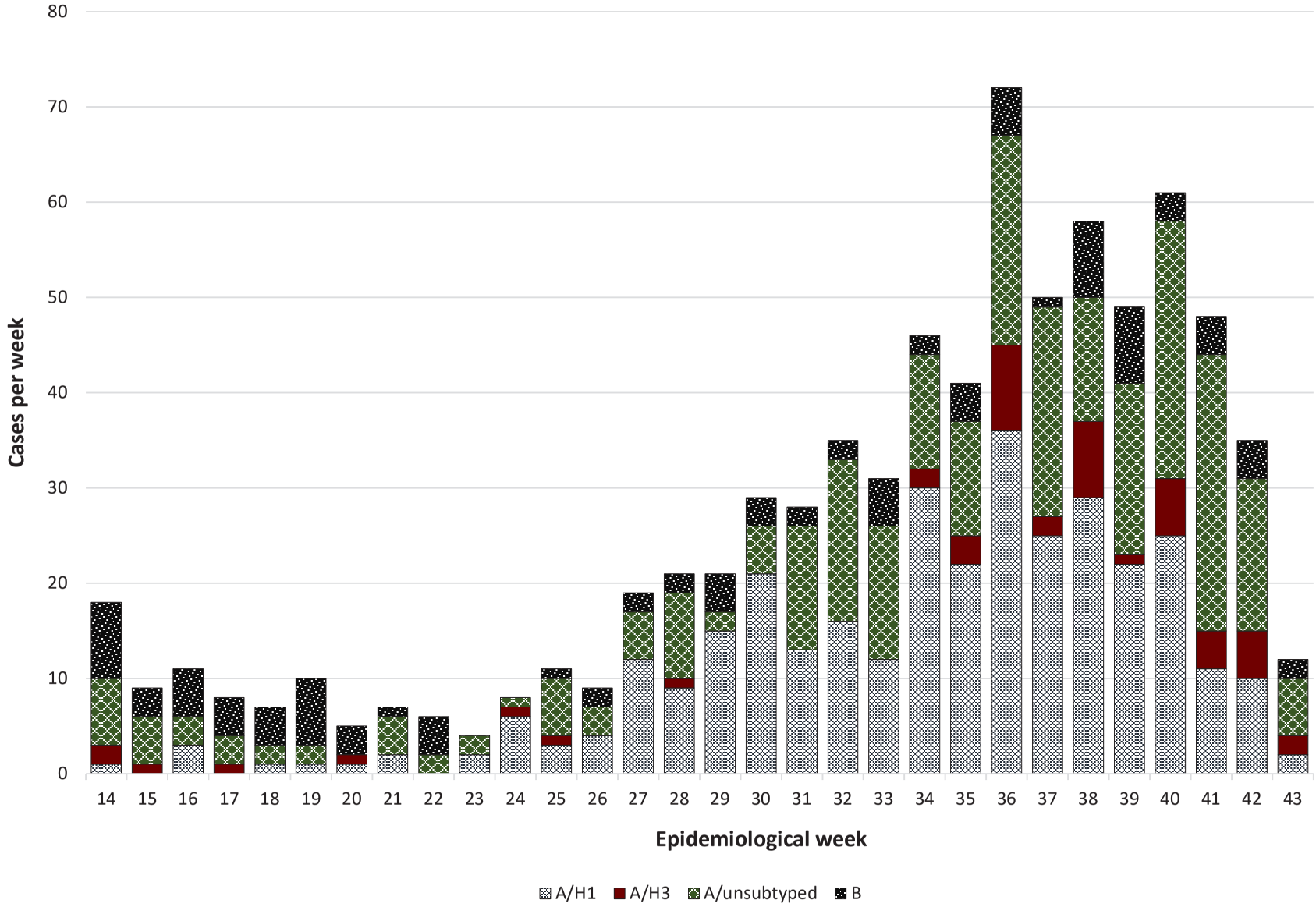
Figure 2: Date of admission in patients hospitalised with confirmed influenza



By week beginning on listed date; representing date of admission (or date of influenza diagnosis if acquired >7 days in hospital)

Table 1: Demographic characteristics of hospitalised patients with confirmed influenza

	Influenza type/subtype				Total
	A/H1N1	A/H3N2	A/unknown	B	
Number	**334**	**50**	**282**	**103**	**769**
Age group					
<16 years	161 (48.2%)	9 (18.0%)	29 (10.3%)	16 (15.5%)	215 (28.0%)
16-49 years	69 (20.7%)	11 (22.0%)	98 (34.8%)	26 (25.2%)	204 (26.5%)
50-64 years	46 (13.8%)	1 (2.0%)	56 (19.9%)	19 (18.4%)	122 (15.9%)
65-79 years	36 (10.8%)	14 (28.0%)	59 (20.9%)	25 (24.3%)	134 (17.4%)
80+ years	22 (6.6%)	15 (30.0%)	40 (14.2%)	17 (16.5%)	94 (12.2%)
Male[a]	170 (50.9%)	23 (46.0%)	132 (47.0%)	43 (41.7%)	368 (47.9%)
Pregnant	8 (2.4%)	0 (0.0%)	9 (3.2%)	0 (0.0%)	17 (2.2%)
Indigenous	12 (3.6%)	0 (0.0%)	27 (9.6%)	10 (9.7%)	49 (6.4%)
Jurisdiction					
ACT	19 (5.7%)	3 (6.0%)	17 (6.0%)	3 (2.9%)	42 (5.5%)
NSW	164 (49.1%)	11 (22.0%)	25 (8.9%)	13 (12.6%)	213 (27.7%)
NT	0 (0.0%)	0 (0.0%)	4 (1.4%)	1 (1.0%)	5 (0.7%)
Qld	12 (3.6%)	6 (12.0%)	60 (21.3%)	22 (21.4%)	100 (13.0%)
SA	0 (0.0%)	0 (0.0%)	41 (14.5%)	16 (15.5%)	57 (7.4%)
Tas	13 (3.9%)	1 (2.0%)	1 (0.4%)	2 (1.9%)	17 (2.2%)
Vic	25 (7.5%)	6 (12.0%)	130 (46.1%)	31 (30.1%)	192 (25.0%)
WA	101 (30.2%)	23 (46.0%)	4 (1.4%)	15 (14.6%)	143 (18.6%)

a Sex missing in one patient

Outcome

The mean length of hospital stay for all patients was 4.3 days. Admission to ICU was associated with a mean hospital length of stay of 10.8 days compared to 3.8 days in those not admitted to ICU. Of the 737 patients where hospital mortality status was documented, 3 patients died (3.7%), all of whom were admitted to ICU.

Length of hospital stay was similar in patients that did not receive oseltamivir (median 2 days; IQR 1, 2 days) and in those that received oseltamivir within 2 days (median 2 days; IQR 1, 2 days), and longer in those who received oseltamivir after 2 days (median 3 days; IQR 2, 3 days; Kruskal-Wallis test $p<0.001$). The crude association between oseltamivir use and longer length of hospital stay was largely accounted for by age, the severity of illness and presence of comorbidities in a multivariate model (Table 5).

Vaccine coverage and effectiveness

A cohort to estimate vaccine effectiveness included cases at the 17 surveillance hospitals together with cases at additional paediatric hospitals (Figure 1). Vaccination status was ascertained in 910 of 1010 cases (90%) and 886 of 990 test-negative control patients (89%).

Estimated vaccine coverage was 77% (187/245) in the elderly (≥65 years) and 45% (71/156) in non-elderly adults with medical comorbidities. Of those elderly patients without influenza, who had received influenza vaccine and for whom

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Figure 3: Incidence of confirmed influenza by week

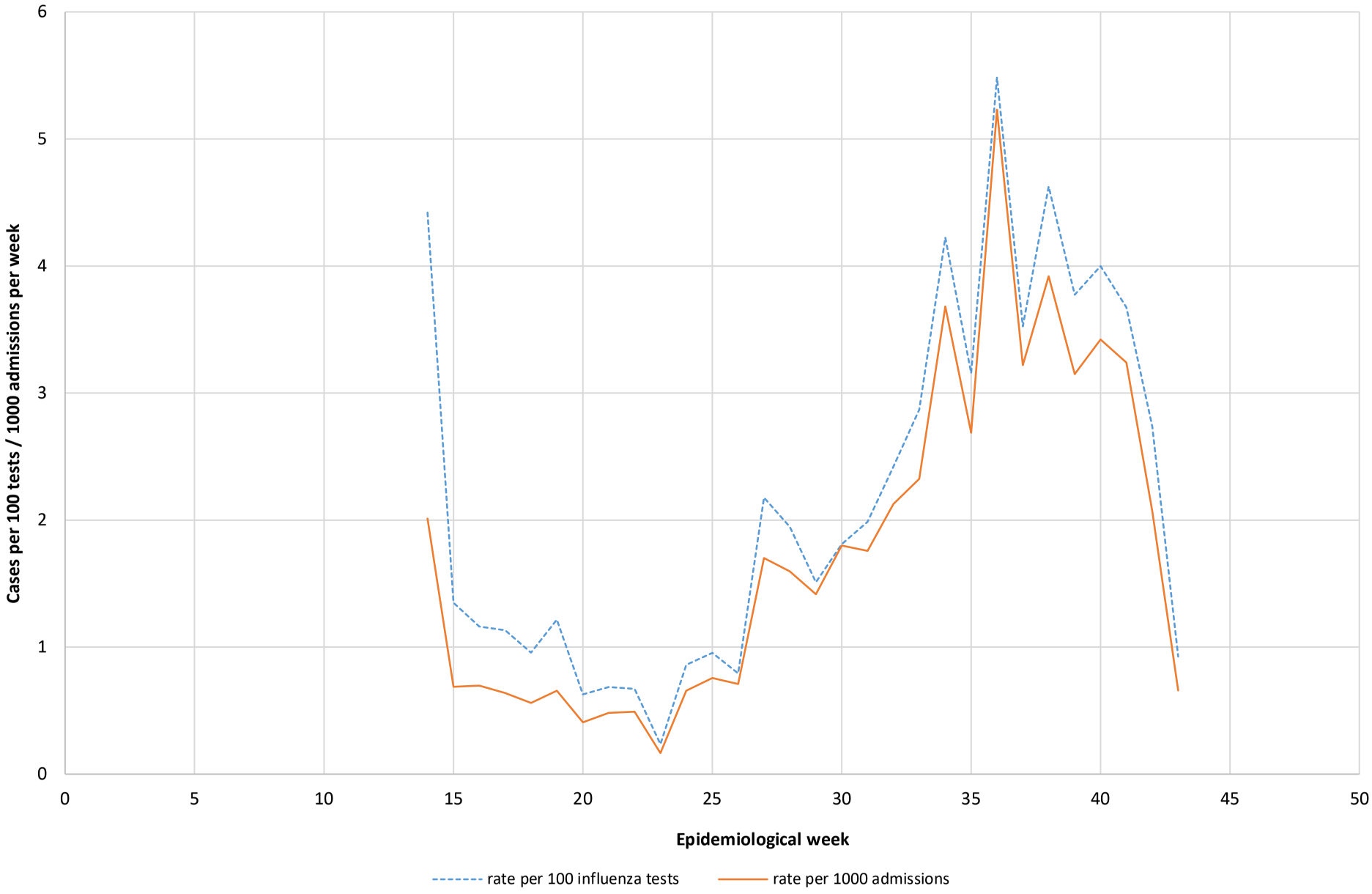


Table 2: Risk factors, severity and outcomes in hospitalised adult patients with confirmed influenza

	Not admitted to ICU	Admitted to ICU	Total
Pregnant	16 (94.1%)	1 (5.9%)	17 (100.0%)
Chronic comorbidities	452 (89.5%)	53 (10.5%)	505 (100.0%)
Chronic respiratory illness	178 (85.2%)	31 (14.8%)	209 (100.0%)
Diabetes	103 (88.8%)	13 (11.2%)	116 (100.0%)
Chronic liver disease	24 (85.7%)	4 (14.3%)	28 (100.0%)
Immunosuppressed	88 (90.7%)	9 (9.3%)	97 (100.0%)
Malignancy	56 (91.8%)	5 (8.2%)	61 (100.0%)
Chronic cardiac disease	153 (90.5%)	16 (9.5%)	169 (100.0%)
Obesity	54 (88.5%)	7 (11.5%)	61 (100.0%)
Chronic neurological illness	89 (88.1%)	12 (11.9%)	101 (100.0%)
Chronic renal disease	54 (91.5%)	5 (8.5%)	59 (100.0%)
Nursing home resident	25 (100.0%)	0 (0.0%)	25 (100.0%)
Received influenza vaccine	208 (89.7%)	24 (10.3%)	232 (100.0%)
Influenza subtype			
A/H1	301 (90.1%)	33 (9.9%)	334 (100.0%)
A/H3	48 (96.0%)	2 (4.0%)	50 (100.0%)
A/unk	250 (88.7%)	32 (11.3%)	282 (100.0%)
B	93 (90.3%)	10 (9.7%)	103 (100.0%)
In hospital mortality	0	3/66 (CFR[a] 4.5%)	3/740 (CFR[a] 0.4%)

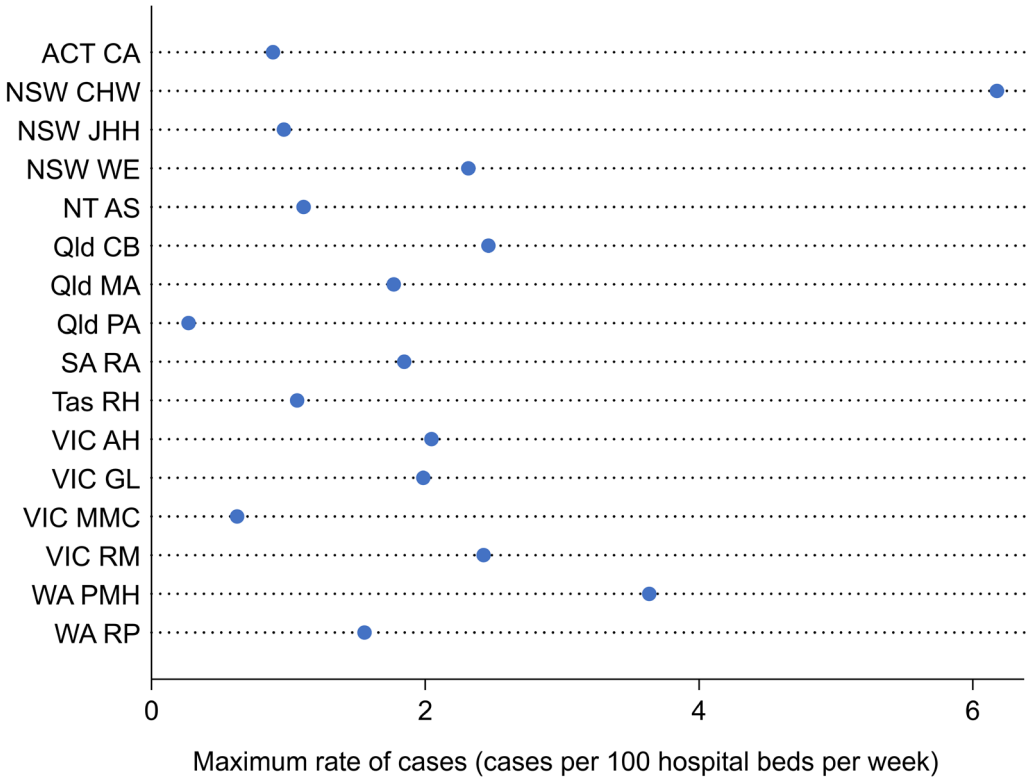
a CFR: case fatality ratio

the vaccine type was known, 52% (71/137) were vaccinated with adjuvanted TIV, 28% (39/137) were vaccinated with high dose TIV, and 8% (12/137) were vaccinated with QIV. Of the 316 participants aged >65 years (both cases and controls) where vaccination status was ascertained, 152 (48%) were recorded in the Australian Immunisation Register (AIR).

Estimated coverage in children was 26% (112/430) but was higher in children with medical comorbidities (42%; 78/185). In children between 6 months and 5 years of age, estimated vaccine coverage was 22%, and was higher in children with comorbidities (28%) than in healthy children (17%).

In the target population, the adjusted odds ratio of vaccination was 0.48 (95% CI: 0.37, 0.63). The estimated vaccine effectiveness in the target population was therefore 52% (95% CI: 37%, 63%). In the elderly (>65 years), estimated vaccine effectiveness was similar (VE 50%, 95% CI: 19, 69%). The estimated vaccine effectiveness (vs no vaccine) of the high dose trivalent influenza vaccine was 56% (95% CI: 14%, 78%) and the estimated vaccine effectiveness of the adjuvanted trivalent influenza vaccine was 43% (95% CI: -6.2, 70). There was insufficient statistical evidence to suggest that there was any difference in protection between the two enhanced vaccines in the elderly (p=0.44).

Figure 4: Peak incidence of confirmed influenza (per 100 hospital beds per week) by hospital



CA: Canberra and Calvary Hospitals, CHW: Children's Hospital at Westmead, JHH: John Hunter Hospital, WE: Westmead Hospital, AS: Alice Springs Hospital, CB: Cairns Base Hospital, MA: Mater Hospital, PA: Princess Alexandra Hospital, RA: Royal Adelaide, RH: Royal Hobart Hospital, AH: Alfred Hospital, GL: University Hospital Geelong, MMC: Monash Medical Centre, RM: Royal Melbourne; PMH: Princess Margaret Hospital; RP: Royal Perth Hospital

Discussion

In the 2018 season, we have documented 769 cases of confirmed influenza requiring hospitalisation, which represents a marked decrease in admissions compared to 2017 when more than 4,300 admissions were reported at the sentinel hospitals. Based on the bed capacity of sentinel hospitals, this represents around 5,700 admissions with confirmed influenza nationally in 2018. However, as influenza testing is not performed on all patients with acute respiratory presentations, and influenza may also trigger delayed presentations, such as secondary bacterial pneumonia or acute myocardial infarction, this should be regarded as a minimum estimate.

The profile of patients admitted in 2018 reflects the shift in influenza subtype from A/H3N2 to A/H1N1pdm, with a younger age profile of hospitalised cases and a smaller proportion with chronic comorbidities. However, unlike previous seasons where A/H1N1 has predominated, there were relatively few pregnant women admitted with influenza in 2018. The clinical severity of patients admitted to hospital, assessed by the proportion admitted to intensive care, was similar to that in recent years.

The peak rate of influenza hospitalisations relative to hospital size provides a measure of impact. The peak rate of admissions was much lower than in 2017 where this ranged up to 14.5 per 100 beds/week. Notably the two paediatric hospitals in the surveillance system, Children's Hospital at Westmead and Perth Children's Hospital, had a higher peak rate. Across all sentinel hospitals, the peak rate of admissions was 1.26 admissions per 100 hospital beds in week 36; based on a mean length of hospital stay of 4.3 days, this suggests that <1% of hospital beds were occupied with patients with confirmed influenza throughout the season.

Table 3: Factors associated with admission to intensive care in patients hospitalised with confirmed influenza

Variable	Crude OR	*p* value	Adjusted OR[a]	*p* value
Age				
<16 years	0.94 (0.52, 1.70)	0.84	0.89 (0.39, 2.04)	0.79
16–64 years	1 (referent)		1 (referent)	
65+ years	1.13 (0.65, 1.97)	0.66	1.22 (0.66, 2.25)	0.52
Medical comorbidities	1.17 (0.71, 1.95)	0.54	1.15 (0.66, 2.03)	0.62
Aboriginal or Torres Strait Islander peoples	1.28 (0.52, 3.10)	0.59	1.22 (0.49, 3.04)	0.67
Pregnancy	0.56 (0.07, 4.25)	0.57	0.48 (0.06, 3.81)	0.49
Restricted functional status	1.01 (0.63, 1.63)	0.95	0.89 (0.48, 1.67)	0.72
Influenza type/subtype				
A/H1	1 (referent)		1 (referent)	
A/H3	0.38 (0.09, 1.64)	0.19	0.36 (0.08, 1.57)	0.17
A/unk	1.17 (0.70, 1.95)	0.56	1.12 (0.64, 1.97)	0.69
B	0.98 (0.47, 2.07)	0.96	0.89 (0.41, 1.93)	0.77

a all variables included in multivariate model

In 2018, the National Immunisation Program provided two new "enhanced" vaccines for use in the elderly. Despite widespread reports of vaccine shortages and an increased volume distributed through the National Immunisation Program suggesting increased demand, we were not able to demonstrate increased vaccine uptake in the elderly. The majority of elderly Australians who received influenza vaccines received one of the two enhanced vaccines, with a small minority receiving QIV. The system did not collect data on patients who may have received multiple vaccines. Our estimates of vaccine coverage have been remarkably stable over multiple seasons, and are similar to those collected using other methods.[7] The AIR commenced recording vaccinations administered to adults in September 2016. While it is not possible to be certain about the veracity of self-report and medical records, our finding that less than half of vaccinated elderly patients were recorded on the AIR suggests that this system is not yet mature in capturing influenza vaccine status.

Both the adjuvanted and high dose vaccines have been shown to be more immunogenic than standard influenza vaccines in the elderly.[8,9] Additionally, clinical trials demonstrated that the high dose vaccine was more effective than the standard vaccine at preventing influenza and influenza-related hospitalisations in the elderly[10] and in preventing respiratory hospitalisations in nursing home residents.[11] Observational studies have generally demonstrated that enhanced vaccines provide improved protection against influenza and influenza-related hospitalisations, compared to standard vaccines.[8,12–14] However, these is considerable heterogeneity in these results, and studies are difficult to compare due to differences in study design, outcome measures and the match between vaccine and circulating strains.

The estimates of vaccine effectiveness in this season are imprecise due to the relatively small number of participants captured in this system, and consequently we did not have evidence to suggest differences in vaccine effectiveness by vaccine type. Our estimates of vaccine effectiveness are higher in the target population (point estimate VE 52%) and in the elderly (VE 50%). In contrast, we estimated vaccine effectiveness

Table 4: Oseltamivir treatment, by age group in patients with confirmed influenza

Factor	Age <16 years	Age 16–64 years	Age 65+ years	*p* value
Number of patients	207	293	212	
Oseltamivir not received	151 (73.7%)	125 (42.8%)	86 (40.8%)	<0.001
Oseltamivir received	54 (26.3%)	167 (57.2%)	125 (59.2%)	<0.001
received <48h of onset	13 (6.3%)	74 (25.3%)	41 (19.4%)	
received >=48h of onset	41 (20.0%)	93 (31.8%)	84 (39.8%)	
Delay between onset and admission, median (IQR)	3 (2, 5)	3 (1, 4)	3 (2, 6)	0.12
Delay between onset and treatment[a], median (IQR)	3 (3, 6)	3 (2, 5)	4 (2, 6)	0.002
Length of stay, median (IQR)	2 (1, 3)	2 (1, 4)	4 (2, 7)	<0.001

a of patients who received oseltamivir

in the target population in 2016 and 2017 at 13% and 8% respectively, and in the elderly (>65 years) at -19% and 8% respectively. This may reflect the effectiveness of the enhanced vaccines or a better match between the vaccine strain and circulating strains, which has been better for A/H1 strains than the A/H3 strains that have circulated in recent years.[15]

Our results are slightly lower than reported estimates of vaccine effectiveness from Canada in the 2018/19 season.[16] In a mid-season report,[16] overall vaccine effectiveness was estimated at 68% (95% CI: 55%, 77%), and was high in children <8 years (88%, 95% CI: 60%, 96%). Interestingly, vaccine effectiveness in the elderly was estimated at 64% (95% CI: 8%, 86%) despite high dose TIV only being available in one of the four participating provinces.

Children, particularly those <5 years of age, have a high rate of hospitalisation[3] and influenza in children can cause rare but clinically significant complications.[17] In 2018, influenza vaccination programs for children aged 6 months to <5 years were initiated in all Australian jurisdictions except the Northern Territory. We found an increase in vaccine coverage in children in this age group, but most particularly in those with medical comorbidities, a group for which vaccines have been provided under the national program for many years. Vaccine coverage in <5 year olds was 22%, which is lower than has been described for childhood vaccine programs elsewhere in the world.[18] However, most programs implemented in the Northern Hemisphere have used the intra-nasal live attenuated vaccine, which is easier to deliver. The high estimated vaccine effectiveness in children reinforces the utility of paediatric immunisation programs.

Modelling studies have shown that paediatric vaccination programs can indirectly reduce influenza hospitalisations and mortality across the population.[19] However, the implementation of paediatric programs in 2018 is not likely to explain the large fall in hospitalisations across all age groups between 2017 and 2018, as coverage in children remains relatively low and the program does not include school age children, which are thought to be a key population in influenza transmission.

The effectiveness of neuraminidase inhibitors in hospitalised patients remains a controversial topic. National guidelines recommend use of oseltamivir based on observational studies.[20] It was noted that oseltamivir was administered in around half of adult patients and a quarter of paediatric patients, and was only administered after the third day of illness in most patients. These findings, consistent over several years, have implications for pandemic planning where the timely administration of antivirals may require pre-hospital community-based clinics or other mechanisms of distribution. The ALIC^{4}E

Table 5: Factors associated with length of stay in patients with confirmed influenza

Variable	Crude rate ratio[a]	*p* value	Adjusted rate ratio[a]	*p* value
Oseltamivir treatment				
No oseltamivir	1 (referent)		1 (referent)	
received <48h of onset	1.54 (0.95, 2.50)	0.079	1.27 (0.85, 1.89)	0.25
received >=48h of onset	1.57 (1.20, 2.07)	<0.001	1.10 (0.93, 1.31)	0.24
Age group				
<16 years	0.56 (0.40, 0.77)	<0.001	0.72 (0.53, 0.98)	0.039
16–64 years	1 (referent)		1 (referent)	
65+ years	1.42 (1.05, 1.93)	0.024	1.38 (1.05, 1.80)	0.019
Comorbidities	2.85 (2.31, 3.53)	<0.001	2.79 (2.31, 3.37)	<0.001
ICU admission	2.08 (1.76, 2.46)	<0.001	1.70 (1.42, 2.03)	<0.001

a Represents relative difference in length of stay; RR>1 indicates longer stay associated with factor

trial, recently commenced in Europe, may provide more data on the feasibility, efficacy and cost-effectiveness of a primary care approach.[21]

There are several limitations to this surveillance system. Not all cases of influenza in hospitals are diagnosed due to the lack of use of laboratory diagnostics, poor quality sample collection, or delayed presentations. Anecdotal data suggests that the 2018 season in many regions continued after November, where our surveillance concluded at the end of October. There are a number of potential confounders when considering the association between influenza hospitalisation and influenza vaccination, including confounding by indication, the healthy user effect, and confounding by frailty. Additionally, there are some concerns that other biases may be inherent to the test-negative study design commonly used to assess vaccine effectiveness.[22,23]

In summary, we detected fewer hospital admissions with laboratory-confirmed influenza in a national observational study in 2018, compared to recent seasons. Vaccination coverage appeared similar to previous seasons in adults, but increased in children. Both enhanced vaccines were used by the elderly in 2018. Vaccine effectiveness in the target population and the elderly was higher than in recent seasons, and was particularly high in children.

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