Factors associated with adverse outcomes during influenza outbreaks in aged care facilities

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Abstract

Objective: To explore factors associated with adverse outcomes during influenza outbreaks in residential aged care facilities.

Methods: A retrospective cohort study of all outbreaks reported to three Sydney metropolitan Public Health Units during 2017.

Results: A total of 123 outbreaks affected 1,787 residents and 543 staff. Early notification to a Public Health Unit was associated with shorter outbreak duration ($p<0.001$; B=0.674). Resident attack rates and resident mortality rates were lower in outbreaks notified early, on univariate analysis ($p=0.034$ and $p=0.048$ respectively) but not on an adjusted model. Staff attack rates were significantly associated with resident attack rates ($p=0.001$; B=0.736). Data on staff vaccination rates was incomplete and reported coverage rates were low (median 39%). Resident vaccination coverage ≥95% was associated with shorter outbreak duration in univariate testing but not on an adjusted model.

Conclusions: Early public health notification is associated with improved outbreak parameters; sick staff may pose a risk to residents, yet vaccination rates are low. Resident vaccination may also be valuable.

Implications for public health: Measures that facilitate early PHU involvement in influenza outbreaks should be implemented, such as compulsory reporting requirements and processes that permit easier notification through technology. Actions that enhance staff and resident vaccination coverage should also be undertaken.

Key words: influenza, outbreak, elderly, vaccination, public health notification

Residential aged care facilities (RACFs) are one of the priority clinical settings for influenza control efforts. Influenza can spread rapidly within facilities, impacting both residents and staff.[1] Residents may be at heightened risk of contracting influenza due to close living quarters, shared carers and exposure to other elderly residents who may shed virus for longer than others.[2] Low staff vaccination rates and transfers between facilities and hospitals can facilitate viral spread within facilities.[3,4] Furthermore, elderly residents may respond poorly to vaccination compared with the general population and chronic comorbidities may increase their vulnerability to severe disease and death.[5,6]

In 2017, Australia faced its largest influenza season since 2009, resulting in nearly double the number of expected hospital admissions and a proportionate increase in deaths.[7] The surge was largely driven by influenza A (predominantly H3N2) and the elderly were disproportionately affected.[8] By the end of 2017, 591 outbreaks in RACFs had been reported in the state of New South Wales (NSW), which was more than twice the reported incidence in the preceding year.

In NSW, individual cases of influenza must be notified to public health authorities under the NSW *Public Health Act 2010*.[9] The Communicable Diseases Network Australia have produced Guidelines relating to the management of influenza in RACFs. These recommend that 'high risk settings' such as RACFs contact their local Public Health Unit (PHU) in the event that an influenza outbreak (as defined in Table 1) is suspected or identified.[10] However, it is not mandatory for RACFs to notify public health units of suspected or identified outbreaks. PHUs support RACFs in providing advice on the management and prevention of outbreaks, using a multifaceted approach based upon the CDNA guidelines.[10] The aim is to curtail the outbreak duration and minimise morbidity and mortality among residents and staff. Outbreak prevention measures include vaccination, influenza awareness/education and preparation activities, while outbreak management activities include the use of antiviral therapy for treatment and prophylaxis (chemoprophylaxis) and non-pharmaceutical interventions such as infection control measures.[6,10,11] In addition to these active measures, previous studies have demonstrated that during RACF outbreaks there are a myriad of other factors that may be associated with poor outcomes, some of which are less amenable to change, such as size of the facility, resident comorbidities and dementia.[1,11-14]

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The aim of this study was to explore the relative efficacy of each element of the 'influenza package' implemented by PHUs and to determine whether PHU involvement *per se* mitigates the impact of RACF outbreaks, measured through three key outbreak outcomes. The study was undertaken during outbreaks in RACFs reported within three metropolitan Sydney local health districts during 2017.

Methods

Study population

The state of NSW, Australia, is divided into 15 Local Health Districts (LHDs), each of which has a Public Health Unit (PHU) that has statutory health protection responsibilities for the LHD under the NSW *Public Health Act 2010*.[9] We analysed data from all influenza outbreaks reported to the PHUs in three adjacent LHDs in metropolitan Sydney during the study period of 1 January 2017–31 December 2017 (Sydney, Western Sydney, and South Western Sydney LHDs). These cover an area of 7,149 square kilometres, comprise a total population of more than 2.5 million people and house 189 RACFs[15] (local data).

Data collection and analysis

RACFs are advised to notify influenza outbreaks by telephone to their local PHUs. Following notification, a line listing of all affected residents is requested to be updated daily, outbreak control measures are discussed and testing of some residents is recommended. Outbreak data are routinely collected by all PHUs and entered in standardised form onto the NSW notifiable conditions database 'Notifiable Conditions Information Management System' (NCIMS).

Data for all influenza outbreaks in the three LHDs during the study period were extracted from NCIMS and imported to and cleaned in Microsoft Excel. Data variables extracted from NCIMS included: demographic details, symptom onset dates, outbreak duration, laboratory testing, notification dates, staff and resident vaccination rates, details of chemoprophylaxis use (see Table 1 for definition) and morbidity/mortality rates. Additional data were also collected addressing RACF characteristics, including dependency level of the residents (as defined in Table 1), facility layout and provision of dementia care. When these data were not attainable from NCIMS/original records, additional information from Australian Aged Care Quality Agency reports (also explained in Table 1) was obtained. As it was not possible to accurately determine the extent to which influenza might have contributed to a death, all resident deaths (from any cause) that occurred during the defined period of the outbreak were recorded.

The study was approved by the Sydney Local Health District Ethics Committee (LNR/17/RPAH/25) and site-specific ethical approval was obtained for all three sites.

Outcomes

A variety of covariates were assessed against three outcomes: overall outbreak duration, resident attack rate and resident mortality rate. The definitions for these outcome parameters, case definitions and factors explored are outlined in Table 1.

Statistical analysis

Data were analysed in Microsoft Excel and SPSS v25 (IBM). Pearson correlation was performed to explore relationships between the time to PHU notification and various outbreak parameters (Table 2). Univariate analysis was performed using Mann-Whitney test (for non-parametric data) or student's t-test (for parametric data) to compare medians/means and chi-squared test was used to compare percentages for a number of outbreak parameters (Table 3, Supplementary Tables 2a-c). An *a priori* decision was made to include all variables that were correlated to each outcome at the $p<0.10$ level and/or significant at the $p<0.05$ level in the univariate model in the multivariable models. A linear regression model, using a forward stepwise method, was used to determine factors associated with the outcomes of outbreak duration and resident attack rate (Table 2). A binary logistic regression was performed to determine factors associated with the outcome of resident mortality rate, after conversion of numeric data into binary categories (Table 3). All variables with a Wald χ^2 statistically significant at the P-value of <0.05 were considered significant. Odds Ratios (OR) and 95% confidence intervals (95%CI) for the associations were reported.

Table 1: Definitions and outcome parameters relating to residential aged care facility influenza outbreaks.

Term	Definition
Influenza-like illness* (ILI)	Sudden onset of symptoms + At least one respiratory symptom (of: New/worsening cough; sore throat; shortness of breath) + At least one systemic symptom (of: fever/feverishness; malaise; headache; myalgia).
Confirmed influenza outbreak*	Three or more epidemiologically linked cases of ILI in residents or staff of a facility within a period of 72 hours + At least one cases with a positive laboratory test for influenza OR: At least two cases with a positive point-of-care test.
Residents at risk of infection	Total number of residents within facility at onset of outbreak
Resident attack rate (%)	Total number of cases in residents/Number of residents at risk of infection x 100
Outbreak Duration	Number of days between onset of symptoms in first case (either resident or staff) and onset of symptoms in last case (either resident or staff)
Resident Hospitalisation Rate (%)	Number of residents hospitalised/Number of resident cases x 100
Resident Mortality Rate (%)	Number of residents who died during the outbreak/Number of resident cases x 100
Time to Public Health Unit notification	Number of days between date of first case onset and date that public health unit were notified
Chemoprophylaxis	Use of antiviral medication to prevent influenza acquisition amongst those who may be at risk. This may benefit the individual and prevent transmission amongst the population. Commonly this involves administration of a neuraminidase inhibitor (antiviral medication) at a lower dose than would be used for treatment of influenza
High level care/ Low level care	Patients entering a government funded care home undergo assessment by a multidisciplinary healthcare team, known as an Aged Care Assessment Team (ACAT). High level care refers to residents refers to residents requiring extensive support with activities of daily living such as washing and toileting. Low level care residents are more independent. Facilities may offer only "high level care" beds, or "low level care" beds or a mixture of both. Some facilities now also offer "ageing in place", whereby a person can enter a facility with low care needs and continue to be supported as their needs increase.
Australian Aged Care Quality and Safety Commission	Previously known as Australian Aged Care Quality Agency and the Aged Care Complaints Commissioner, this agency performs accreditation and assessment of all facilities that are subsidised by the Australian government. Up to date accreditation reports are available online and summarise demographic details of RACFs.[43]

Note:
**As per Communicable Diseases Network Australia Guidelines*[10]

Table 2: Factors associated with outbreak duration, resident attack rates and resident mortality rates during 2017 Influenza outbreaks in aged care facilities in three Local Health Districts in Sydney, Australia (n=123).

	OUTBREAK DURATION			RESIDENT ATTACK RATE			RESIDENT MORTALITY RATE	
	Correlation; R (p value)	Univariate Significance; p	Adjusted Significance: Unstandardised Coefficient, B (95%CIs) p Value	Correlation; R (p value)	Univariate significance; p	Adjusted Significance Unstandardised Coefficient, B (95%CIs)	Correlation; R (p value)	Univariate significance; p
FACILITY CHARACTERISTICS								
Resident vaccination coverage, %	-0.133 (*p*=0.158)	NC	NR	0.089 (*p*=0.347)	NC	0.056 (-0.256–0.368) *P*=0.718	-0.042 (*p*=0.658)	NC
Resident vaccination coverage ≥95%	-0.060 (*p*=0.506)	**P=0.004**	NR	0.028 (*p*=0.755)	*P*=0.104	NR	-0.096 (*p*=0.291)	*P*=0.578
Staff vaccination coverage, %	-0.129 (*p*=0.209)	NC	NR	0.106 (*p*=0.303)	NC	NR	0.002 (*p*=0.988)	NC
Facility houses dementia patients	0.095 (*p*=0.295)	*p*=0.346	NR	-0.084 (*p*=0.353)	*P*=0.316	NR	-0.082 (*p*=0.365)	*p*=0.372
Facility for low-care residents only	-0.045 (*p*=0.620)	*P*=0.307	NR	0.111 (*p*=0.220)	*P*= 0.832	NR	-0.134 (*p*=0.138)	***P*=0.004**
Facility for high-care residents only	-0.057 (*p*=0.529)	*P*=0.390	NR	0.007 (*p*=0.942)	*P*= 0.910	NR	-0.113 (*p*=0.213)	*P*=0.213
Facility has single bedrooms only	**0.186 (*p*=0.039)**	*P*=**0.033**	2.390 (-1.107–5.887) *P*=0.178	0.140 (*p*=0.124)	0.125	NR	-0.056 (*p*=0.542)	*p*=0.592
OUTBREAK CHARACTERISTICS								
Influenza A	-0.057 (*p*=0.528)	*p*=0.814	NR	0.196 (***p*=0.029**)	***p*=0.029**	0.154 (-8.813–9.120) *P*=0.972	-0.134 (*p*=0.139)	*P*=0.441
Influenza B	-0.057	*p*=0.528	NR	-0.178 (*p*=0.048)	***p*=0.048**	-3.336 (-13.726–7.053) *p*=0.520	0.063 (*p*=0.490)	*P*=0.402
Mixture of both influenza A and B	-0.103 (*p*=0.259)	*P*=-0.535	NR	0.053 (*p*=0.058)	*P*=0.750	NR	-0.111 (*p*=0.222)	*P*=0.220
Resident attack rate, %	0.166 (*p*=0.066)	NC	0.102 (-0.021–0.225) *p*= 0.103	NA	NA	NA	-0.085 (*p*=0.349)	NC
Resident hospitalisation rate, %	0.249 (***p*=0.005**)	NC	6.371 (-0.933–13.676) *p*=0.086	-0.156 (*p*=0.085)	NC	-1.780 (20.594–17.034) *p*=0.849	0.152 (*p*=0.094)	NC
Resident mortality rate, %	0.175 (*p*=0.053)	NC	0.058 (-0.107–0.224) *p*=0.485	-0.085 (*p*=0.349)	NC	-0.092 (-0.444–0.260) *P*=0.601	NA	NA
Staff hospitalisation rate, %	0.139 (*p*=0.200)	NC	NR	-0.120 (*p*=0.268)	NC	-88.79 (-264.863–87.282) *p*=0.314	0.067 (*p*=0.536)	NC
Staff attack rate, %	0.301 (***p*=0.001**)	NC	0.125 (-0.157–0.406) *p*=0.380	0.338 (***p*<0.001**)	NC	0.736 (0.307–1.165) (***p*=0.001**)	0.053 (*p*=0.562)	NC
Outbreak duration	NA	NA	NA	0.166 (***p*=0.006**)	NC	-0.006 (-0.585–0.572) (*p*=0.983)	0.175 (*p*=0.053)	NC
Onset amongst staff prior to residents	-0.302 (***p*=0.001**)	NC	-1.545 (-2.989– -0.101) *p*=**0.036**	-0.062 (*p*=0.497)	NC	NR	-0.110 (*p*=0.226)	NC

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Table 2 cont.: Factors associated with outbreak duration, resident attack rates and resident mortality rates during 2017 Influenza outbreaks in aged care facilities in three Local Health Districts in Sydney, Australia (n=123).	OUTBREAK DURATION			RESIDENT ATTACK RATE			RESIDENT MORTALITY RATE	
	Correlation; R (p value)	Univariate Significance; p	Adjusted Significance: Unstandardised Coefficient, B (95%CIs) p Value	Correlation; R (p value)	Univariate significance; p	Adjusted Significance Unstandardised Coefficient, B (95%CIs)	Correlation; R (p value)	Univariate significance; p
OUTBREAK RESPONSE								
Time to PHU Notification from onset of symptoms in first case	0.387 *p*<**0.001**	NC	0.674 (0.358–0.991) *p*<**0.001**	-0.004 *p*=0.963	NC	-0.380 (-1.192–0.432) *P*=0.350	0.126 (*p*=0.165)	NC
PHU notified within 72 hours of outbreak onset	-0.170 (*p*=0.006)	*p*=**0.002**	-3.83 (-8.15–0.49) *p*=0.081	-0.154 *P*=0.089	*p*=**0.034**	-3.614 (-5.208–12.436) *P*=0.412	-0.096 (*p*=0.291)	*P*=**0.048**
Any use of chemoprophylaxis	0.018 (*p*=0.841)	0.115	-0.428 (-5.231–4.375) *p*=0.860	0.045 (*p*=0.620)	*p*=0.758	-6.847 (-17.697–4.273) *P*=0.220	0.012 (*p*=0.899)	*P*=0.535
Number of residents given chemoprophylaxis	0.117 (*p*=0.205)	NC	0.045 (-0.006–0.096) (*p*=0.080)	-0.100 (*p*=0.276)	NC	NR	0.035 (*p*=0.702)	NC
Proportion of residents given chemoprophylaxis (of all residents)	0.087 (*p*=0.343)	NC	NR	-0.031 (*p*=0.736)	NC	NR	0.077 (*p*=0.401)	NC
Number of residents who developed symptoms despite chemoprophylaxis	0.208 (*p*=0.041)	NC	0.403 (-0.364–1.169) *P*=0.299	-0.032 (*p*=0.768)	NC	0.004 (-0.196–0.205) *p*= 0.966	-0.027 (*p*=0.789)	NC
Number of sick residents on antiviral treatment	0.180 (*p*=0.051)	NC	NR	0.304 (*p*=**0.001**)	NC	0.461 (-0.015–0.397) *p*=0.058	-0.055 (*p*=0.552)	NC
Local health district (PHU)	0.331 (**<0.001**)	NC	3.887 (0.979–6.794) *P*=**0.009**	-0.066 (*p*=0.470)	NC	NR	0.192 (*p*=0.033)	NC

Notes:

Adjusted significance for outbreak duration and resident attack rates was calculated using linear regression and is included in the table. Adjusted significance for resident mortality rates required binary logistic regression analysis, which is presented in Table 3.

NC = Not calculated; NR = Not reported as was not included in the multivariable model.

Results

Outbreak and facility characteristics

A total of 123 separate influenza outbreaks in 106 RACFs were reported to the three LHD public health units in 2017, comprising 2,330 cases of influenza (1,787 among residents and 543 among staff). Outbreak and RACF characteristics, including details of univariate analyses are provided in Supplementary Table 1. The first outbreak of the season was reported on 7 March and the last outbreak was closed on 19 December. The median number of residents and staff at each RACF was 88 (IQR 60-118) and 105 (IQR 63-150), respectively. At least some high-level care residents were housed by 87.8% of RACFs (see Table 1 for definition of care levels) and 69.9% of RACFs housed at least some dementia patients; among these, some cared exclusively for dementia patients, while others had dedicated dementia beds or wings.

The median resident attack rate overall was 14.6% (IQR 9.5–21.3). Among residents who developed influenza, median hospitalisation rate was 10.5% (IQR <0.001–20.0%). Mean mortality rate was 4.2% (SD 2.5). The median attack rate among staff was 2.9% (IQR <0.001–5.7). One staff member was hospitalised, but no staff deaths were reported. Overall, influenza A was the predominant strain (responsible for 52.8% of outbreaks), with the remainder divided between influenza B strains (25.2%) and mixed strains (22.3%). In 12.3% of outbreaks, a staff member (rather than a resident) was first to develop symptoms.

Vaccination rates were available for residents in 93.5% (n=115) of the outbreaks compared with staff vaccination rates available in 78% (n=96) of the outbreaks. The median reported resident vaccination coverage at outbreak onset was 95% (IQR 87.8–96.1) and staff coverage was 39% (IQR (24.3–62.5); 71.4% of facilities reported having a coordinated vaccination program for residents.

Outcome One: Outbreak duration

The median outbreak duration was nine days (IQR 5–15 days); minimum duration was one day (i.e. all cases had their symptom onsets on the same day) and the maximum was 41 days. Several factors correlated with outbreak duration at the *p*<0.10 level. These included time to PHU notification (R=0.387, *p*<0.001), resident attack rate (R=0.166, *p*=0.066), staff attack rate (R=0.301. *p*=0.001), resident hospitalisation rate (R=0.249, *p*=0.005), resident mortality rate (R=0.175, *p*=0.053), the presence of only single rooms in the facility (R=0.186, *p*=0.039), LHD (R=0.331, *p*<0.001) and the number of residents on antiviral treatment (R=0.180, p=0.051). Outbreaks starting among staff before residents (R=-0.302, p=0.001) and those notified within 72 hours of symptom onset (R=-0.170, p=0.060) were correlated with shorter outbreaks.

On univariate analysis (Supplementary Table 2a), median overall outbreak duration was shorter among outbreaks reported to PHUs within 72 hours (5 days; IQR 2.0–12.3) compared with those notified later (10 days; IQR 6–15); p=0.002. Resident vaccination coverage of ≥95% within facilities was associated with shorter outbreaks (9.9 days; SD 7.9) compared with facilities with lower coverage (13.2 days; SD 8.9), p=0.004. Facilities with only single bedrooms had significantly longer outbreaks (12.6 days; SD 9.4) compared to those with at least some shared bedrooms (9.5 days; SD 6.5), p=0.033.

In the adjusted model, the covariates that remained significantly associated with outbreak duration included time to PHU notification (p<0.001), LHD (B=3.887; p=0.009) and outbreaks starting among staff before residents (B=-1.545; p=0.036). With respect to notification time, the linear regression model yielded a Beta value of 0.674, indicating that for every 24 hours delay in time to PHU notification there was an associated increase in outbreak duration of 0.674 days.

Outcome Two: Resident attack rate

The median resident attack rate was 14.6% (IQR 9.5-21.3; mean=17.6%; SD 12.4) among all outbreaks. The factors that were correlated with resident attack rate at the p<0.10 level were outbreak duration (R=0.166, p=0.066), staff attack rate (R=0.338, p<0.001), influenza A outbreaks (R=0.196, p=0.029) and the number of sick residents on antiviral treatment (R=0.304, p=0.001). Outbreaks notified within 72 hours of first symptom onset (R=-0.154, p=0.089), influenza B outbreaks (R=-0.178, p=0.048) and those with higher resident hospitalisation rates (R=- 0.156, p=0.085) were correlated with higher resident attack rates.

On univariate analysis (Supplementary Table 2b) the median resident attack rate was significantly lower (11.4%; IQR 6.9-19.4) among those outbreaks notified within 72 hours compared to those notified later (15.7%; IQR 10.8-21.6); p=0.034. Outbreaks caused by Influenza A were associated with higher resident attack rates (19.5% ± SD 13.4) compared with outbreaks caused by other types, i.e. Type B or mixed (14.6% ± SD 9.98); p=0.029. Conversely, in this year influenza B outbreaks were associated with significantly lower resident attack rates (13.8% ± SD 10.1) compared to those with other strains (18.9% ± SD 12.8); p=0.048.

In the adjusted linear model, staff attack rate (B=0.736; p=0.001) remained as the only significant predictor of resident attack rate. This means that for every percentage increase in staff attack rate, there was a 0.736% increase in resident attack rate.

Table 3: Binary logistic regression model for factors associated with resident mortality rate during 2017 influenza outbreaks in aged care facilities in three Local Health Districts in Sydney, Australia (n=123).

	Unstandardized Coefficients B (Odds Ratio)	95% confidence Intervals	*P* value (Binary Regression Model)
PHU notified within 3 days of first case	0.398	0.090 – 1.760	0.224
Resident hospitalisation rate ≤5%	UC		UC
Resident hospitalisation Rate 5-20%	UC		UC
Resident hospitalisation Rate ≥20%	UC		UC
Resident attack rate ≥11%	0.253	0.062 – 1.032	0.055
Staff Attack rate ≥ 3%	1.087	0.281- 4.205	0.903
Influenza A	0.745	0.226 – 2.455	0.628
Mixture of both Influenza A and B	0.121	0.020 – 0.732	0.022
Use of chemoprophylaxis	UC		UC
Outbreak duration ≤ 3 days	0.134	0.010 – 1.744	0.125
Outbreak Duration 4-7 days	1.132	0.348- 3.682	0.837
PHU: Sydney Local Health District	3.583	0.796-16.117	0.096
PHU: Western Sydney Local Health District	9.095	2.273 – 36.388	0.002

Note:
UC = Unable to calculate

Outcome Three: Resident mortality rate

The mean mortality rate was 4.2% ± SD 2.5 (median mortality rate <0.001% [IQR <0.001% –5.6%]). Among all residents at risk, on average 0.6% (± SD 1.2) died during influenza outbreaks.

The factors that were correlated with resident mortality rate at the p<0.10 level were outbreak duration (R=0.175, p=0.053), resident hospitalisation rate (R=0.152, p=0.094), facilities catering for both high- and low-care residents (R=0.190, p=0.036) and LHD (R=0.192, p=0.033).

On univariate testing (Supplementary Table 2c), resident mortality rate was significantly lower among those outbreaks notified within 72 hours (2.6% ± SD 7.0) compared with those notified later (4.6% ± SD 8.8); p=0.048. Resident mortality rate was also significantly lower in facilities that only provided low-level care (1.1% ± SD 3.0) compared with facilities that catered fully or partially for high-level care residents (4.8% ± SD 8.8); p=0.004.

In the adjusted model, outbreaks caused by both influenza A and B were significantly less likely to have resident mortality rates above 2.5% (OR 0.121; 95% CI 0.020–0.732). RACFs in South Western Sydney LHD were nine times more likely than those in other LHDs to have outbreaks with lower resident mortality rates (OR 9.095; 95% CI 2.273-36.388). All other variables lost significance in the regression model.

Discussion

This large retrospective cohort study assessed the relative impact of a variety of factors on three outcomes during RACF influenza outbreaks across a large metropolitan area and yielded several interesting findings. Most notably, this was the first study in Australia to demonstrate a link between improved influenza outbreak outcomes and timely notification to a health authority, concurring with findings from other countries.[3,16] Secondly, our data suggest that sick staff pose a risk to elderly residents, yet reported staff vaccination rates are low. We did not find any clear relationship between outcomes and use of chemoprophylaxis but were surprised to find an association between resident mortality rate and local health district the outbreak fell under. Finally, the descriptive findings of this study illustrate the scale and impact of RACF influenza outbreaks, highlighting these outbreaks as a significant health issue for our community more broadly and specifically for aged care.

In our study we found that notification of an outbreak within 72 hours was associated with lower resident attack and mortality rates and the timing of public health notification was the most significant factor associated with outbreak duration. There are several explanations for the observed relationship and the direction of causality is uncertain. It may be the case that facilities that notify earlier are also more familiar with recommended control measures and therefore timely PHU notification is a proxy indicator of good clinical care and knowledge from facilities. Early institution of control measures (arising from active surveillance) has been linked to all of our stated outcomes in previous studies and there is specific evidence for benefit of personal protective equipment (PPE).[11,17,18] Conversely, it is possible that PHU notification serves as an access pathway to a plethora of strategies, efficacious in their own right, producing compounding benefits. Interestingly, early PHU notification has also been linked to shorter outbreak duration in the setting of viral gastroenteritis in a previous study.[19] Advantages of notifying PHUs may include receiving expert advice on the nuances of infection control, facilitating laboratory testing/chasing results, promotion of immunisation and moral support in the face of resistance to social distancing/visitor restriction. Episodes of contact between facilities and PHUs also present opportunities for education about mitigation strategies and establish relationships that may lead to improved outbreak management in future. Furthermore, in our LHDs, PHUs can facilitate access to anti-viral medication. We did not find a clear relationship between use of chemoprophylaxis and outcomes in our study. This is not surprising – previous literature highlights the difficulty in performing adequately powered trials to address this issue, precluding a large evidence base.[2,10,11,20,21] However, some observational studies and several expert guidelines support the use of chemoprophylaxis, so its recommendation by our PHUs may have contributed towards improved outcomes.[10,22]

CDNA guidelines support immunisation as the most important single measure for influenza prevention.[10] Among our facilities, median resident vaccination coverage met the recommended minimum level of 95%. While univariate analysis identified a correlation between facilities meeting this criterion and shorter outbreak duration, this association was not significant in the adjusted model. This loss of significance in the adjusted model may be explained by the fact that the vaccine match in Australia was poor during 2017.[23,24] While we were unable to demonstrate vaccination as a significant predictor of outbreak duration in the current study, several other studies have established this link, although evidence overall is mixed.[10,14,25,26] A recent Cochrane review of vaccines for preventing influenza in the elderly did not purport a strong overall benefit, (due to their assessment of bias in included studies), concluding that immunisation may prevent influenza (number needed to vaccinate to prevent one case=30) and probably reduces risk of ILI.[14] However, this systematic review included elderly subjects from both community and institutional settings. In the RACF setting, the data seems to be more supportive of resident vaccination than for that among the general community. Immunisation has been found to be cost effective and improve quality of life over five years, and may prevent hospital admissions and deaths among residents.[1,25,26] Of relevance to our current findings, a meta-analysis by Darvishian demonstrated the efficacy of influenza vaccination for the elderly in the setting of an epidemic season and even in the face of poor vaccine match.[27]

Reported staff vaccination coverage among the RACFs in our study was poorer than those of residents, concurring with the findings of previous studies.[11,17,28] None of the RACFs in our cohort met the CDNA stipulated target of ≥95% for staff coverage and the median rate across facilities (39%) fell far short of this. In more than one-fifth of reported outbreaks, the staff coverage rates were not recorded at all. This is disappointing given the body of evidence supporting staff influenza vaccination as beneficial in both indirectly protecting RACF residents and in preventing illness-related absenteeism.[29] High staff vaccination coverage rates in RACFs have been linked to a reduction in influenza outbreak incidence.[28] Reductions in ILI-associated hospital admissions and overall resident mortality are associated with vaccination of RACF staff in the setting of moderate-high influenza epidemic activity.[30] Although we did not find a link between staff vaccination coverage and improved outbreak outcomes, our data demonstrates that disease in staff impacts significantly upon residents. Onset of symptoms began in a staff member rather than a resident in approximately one-in-eight (12.3%) outbreaks. Furthermore, there was a significant association between staff attack rates and resident attack rates in both correlation testing and in the adjusted model. Our findings support the assertion made in previous studies that staff are associated with propagation of influenza within facilities (sometimes unwittingly as unvaccinated healthcare workers have been found have higher rates of asymptomatic influenza infection).[17,28-32]

Our univariate and correlation analyses demonstrated that facilities with single rooms only (versus some shared rooms) reported longer outbreaks, although this relationship was not significant in the adjusted model. The univariate findings were contrary to our expectations: it has been previously reported that those sharing a room with an influenza-infected patient have around a three-fold relative risk of disease acquisition.[33] There is supporting evidence (from observational and modelling studies) for social distancing in reducing influenza transmission, and this intervention is incorporated into infection control guidelines.[34,35] Our findings may be due to an unclear confounding relationship, perhaps related to facility size or willingness to report an outbreak. The differences in mortality between local health districts also warrants further consideration as there are several potential explanations including differences in local resources/ability to implement control recommendations, under-reporting of influenza deaths within some districts or local circulation of co-pathogens.

This study had several limitations. Studies in this area are subject to confounding effects from multiple covariates, not all of which can be easily measured.[1,11] One example is that different facility layouts might facilitate outbreak propagation or control, but it is difficult to obtain and analyse meaningful information on this qualitative factor. Although the same guideline-based advice was offered to all affected facilities, there is no way of clearly measuring how stringently that advice was adhered to. We relied upon locally-collected data, the quality of which might vary between facilities due to differences in staff training, staff shortages and internal procedures. Recorded information may be subject to interviewer and/or recall bias. The fact that only 93.5% and 78.9% of facilities could report on resident and staff vaccination coverage, respectively, highlights the difficulty in data collection. Information gathering on staff vaccination and illness may be hindered by high turnover of carers working casually across multiple facilities (a factor that may also drive outbreaks).[10]

This study was subject to reporting bias and it is possible that outcomes of non-reported outbreaks might have had different features. A future research direction may be to compare outcomes between outbreaks that were reported to PHUs compared to those that were not. Boonwaat et al. have demonstrated that unreported outbreaks can be detected by linking the addresses of single notified cases to RACF locations.[36] One of our LHDs (Sydney LHD) is currently working on the implementation of an online system (FluCARE) that automatically recognises outbreaks and facilitates communication between RACFs and Public Health Units.[37,38]

Finally, the case definition of an outbreak requires at least three epidemiologically linked cases of ILI within 72 hours, with one having a positive laboratory test for influenza, or two having positive point-of-care tests.[10] It is recommended that PHUs are contacted at this point. We used first symptom onset date as a proxy for outbreak onset and drew conclusions on timelines based on this, which may not be accurate. Recording of the date when case definition was established may have provided a more reliable measure of whether facilities were meeting reporting recommendations, but this information is not routinely recorded on NCIMS. However, knowledge of this date would still not have accounted for variety within the epidemic curves of each individual outbreak.

Implications for public health

In summary, our findings support early public health notification as a beneficial composite intervention in curtailing the adverse outcomes from RACF influenza outbreaks. Despite this, review of the literature highlights slow or deficient outbreak notification and difficulties encountered by facilities in following national guidelines.[4,18,36,39]

Conclusion

This study provided detailed analysis of a large number of influenza outbreaks that impacted a significant number of individuals within Sydney metropolitan area. Our findings justify initiatives that facilitate rapid communication between facilities and PHUs, a measure that also permits collection of a greater depth of surveillance information.[17,40] In Australia, notification is not currently mandatory under public health legislation in any state or territory. Consideration should be given to making notification compulsory or facilitating earlier and easier notification through technology.

On the basis of our findings, we also recommend that staff working in RACFs should be immunised, and that facilities should hold reliable and contemporaneous information about the vaccination status of their staff. NSW Health has recently introduced a policy mandating influenza vaccination among healthcare workers in the highest risk hospital settings – a similar approach may be justifiable in RACFs.[41] Facility managers can play a key role in advocating and facilitating vaccination among their staff and PHUs can support them in achieving this.[12,39,42]

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Supporting Information

Additional supporting information may be found in the online version of this article:

Supplementary Table 1: Characteristics of Residential Aged Care Facility Influenza Outbreaks Reported to our districts during 2017.

Supplementary Table 2a: Univariate analysis of Factors Influencing Outbreak Duration.

Supplementary Table 2b: Univariate analysis of Factors Influencing Resident Attack Rate.

Supplementary Table 2c: Univariate analysis of Factors Influencing Resident Mortality Rate.