

## ORIGINAL ARTICLE

# Epidemiology of 2017 influenza outbreaks in nine Australian Aged care facilities

Elmira Hooshmand<sup>1</sup>  | Aye Moa<sup>1</sup>  | Mallory Trent<sup>1</sup> | Mohana Kunasekaran<sup>1</sup> | Christopher J. Poulos<sup>2</sup> | Abrar Ahmad Chughtai<sup>3</sup> | C. Raina MacIntyre<sup>1</sup>

<sup>1</sup>Biosecurity Program, Kirby Institute, University of New South Wales, Sydney, NSW, Australia

<sup>2</sup>Aged Care Clinical Services, HammondCare, Sydney, NSW, Australia

<sup>3</sup>School of Public Health and Community Medicine, University of New South Wales, Sydney, NSW, Australia

## Correspondence

Aye Moa, Biosecurity Program, Kirby Institute, UNSW Sydney, Sydney, NSW, Australia.

Email: moa25@protonmail.com

## Funding information

NHMRC, Centre of Research Excellence in Integrated Systems for Epidemic Response (ISER), Grant/Award Number: 1107393

## Abstract

**Background:** The 2017 A/H3N2 influenza season was the most severe season since the 2009 influenza pandemic. There were over 591 influenza outbreaks in institutions across the state of New South Wales (NSW) in Australia.

**Aim:** To describe the epidemiology of influenza outbreaks in nine Sydney aged care facilities in 2017.

**Methods:** Study data were collected from nine Sydney aged care facilities for 2017 influenza season. Descriptive epidemiological analysis was conducted.

**Results:** From the nine sites included, with a total of 716 residents, four sites reported laboratory-confirmed influenza outbreaks during the study period, with an attack rate in residents ranging from 6% to 29%. The outbreaks resulted in lockdowns in two facilities and hospitalisation of seven residents. No deaths were reported as a result of influenza infection. Influenza A was the most common influenza type reported across the facilities. The duration of outbreak lasted for 1-4 weeks varied by site.

**Conclusion:** The 2017 season was a severe influenza season recorded in Australia. About half of the facilities studied experienced outbreaks of influenza, with a high attack rate among residents. Infection prevention and control measures and outbreak management plans are crucial for aged care facilities, including vaccination of staff and visitors to prevent outbreaks among the vulnerable residents.

## KEYWORDS

2017 season, aged care, Australia, influenza, influenza outbreak

## 1 | BACKGROUND

Influenza is a highly infectious respiratory illness that causes seasonal epidemics.<sup>1</sup> Globally, influenza impacts 3-5 million people per year, resulting in over 650 000 deaths.<sup>2</sup> In Australia, influenza infections result in approximately 18 000 hospitalisations a year, primarily affecting young children, older adults, and those with immunocompromising conditions.<sup>2-4</sup>

Residents in aged care facilities (ACF) are at high risk of influenza infections and respiratory complications.<sup>5,6</sup> Advanced age, frailty and comorbidities can result in reduced immune function.<sup>7</sup> Common clinical signs and symptoms of influenza include fever, cough, sore throat, nasal congestion, muscle aches and pain, and fatigue.<sup>8</sup> However, among elderly populations, the person can be afebrile or may have atypical symptoms.<sup>9</sup> As such, a clinical diagnosis can be missed by nurses and aged care staff. Use of antiviral drugs such as oseltamivir,

The peer review history for this article is available at <https://publons.com/publo/n/10.1111/irv.12811>.

This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2020 The Authors. *Influenza and Other Respiratory Viruses* Published by John Wiley & Sons Ltd.

**TABLE 1** Demographic characteristics of residents in aged care facilities

| Aged care facility & type of aged care provided       | Age of residents (range, y) | Number of male residents, n (%) | Number of female residents, n (%) | Total number of residents (N) | Total number of beds/Number of rooms with single bed |
|---|-----------------------------|---------------------------------|-----------------------------------|-------------------------------|--|
| Facility A (Dementia-specific, low care)              | 62-96                       | 13 (23%)                        | 44 (77%)                          | 57                            | 40/40  |
| Facility B (Aged care)                                | 73-101                      | 7 (11%)                         | 55 (89%)                          | 62                            | 62/62  |
| Facility C (Aged care)                                | 70-99                       | 13 (54%)                        | 11 (46%)                          | 24                            | 24/24  |
| Facility D (Dementia-specific, Residential/Aged care) | 65-92                       | 36 (48%)                        | 39 (52%)                          | 75                            | 57/57  |
| Facility E (High care/ Aged care)                     | 64-95                       | 8 (13%)                         | 52 (87%)                          | 60                            | 60/28  |
| Facility F (Dementia-specific)                        | 77-95                       | 14 (37%)                        | 24 (63%)                          | 38                            | 40/40  |
| Facility G (High care & Low care)                     | 61-97                       | 49 (26%)                        | 140 (74%)                         | 189                           | 124/117  |
| Facility H (Residential care)                         | 65-99                       | Unavailable (-)                 | Unavailable (-)                   | 128                           | 92/92  |
| Facility I (Dementia-specific, high care)             | 57-101                      | 38 (46%)                        | 45 (54%)                          | 83                            | 83/83  |
| Total   | 57-101                      | 178 <sup>a</sup>                | 410 <sup>a</sup>                  | 716                           | -  |

<sup>a</sup>Data not included for facility H.

which if taken within 48 hours after the initial symptoms, can reduce disease severity and influenza-associated complications,<sup>10</sup> and studies have shown impact of using oseltamivir as prophylaxis in preventing and management of influenza in the residential care facilities.<sup>11-13</sup> One study reported that oseltamivir prophylaxis reduces the influenza attack rate of 90% in residents during outbreaks, particularly in high care wards.<sup>11</sup> Furthermore, crowded living conditions and the frequent use of common rooms favour a rapid spread of respiratory infections. If health and safety precautions are not practised adequately, this can result in high infection transmission,<sup>5,6</sup> and as a result, frequent outbreaks of influenza infection can occur in residents in ACF. The introduction of influenza to aged care settings may come from staff working in the aged care home and/or the visitors to the site.<sup>14</sup> In ACF, staff members have frequent contact with the residents, and thus, there is a high risk of transmission to residents.<sup>15</sup>

In Australia, the 2017 influenza season had the highest number of laboratory-confirmed influenza notifications, at a rate of 1021.6 per 100 000 population,<sup>16,17</sup> and resulted in 29 000 hospital admissions and 745 deaths.<sup>16</sup> However, the severity of infection varies with the type of seasonal strain circulating during the season. In 2017, influenza A/H3N2 was the predominant strain in circulation. There was a total of 591 confirmed influenza outbreaks in institutions reported in New South Wales (NSW) alone.<sup>18</sup> Additionally, the influenza vaccine has a lower vaccine effectiveness in older adults<sup>16,19</sup> compared to other age groups in general. To measure the effect of influenza, in this study, we aimed to estimate the impact of the 2017 influenza season in nine Australian aged care homes.

## 2 | METHODS

The study was conducted in nine ACF in affiliation with a multi-site aged care provider in Sydney. The inclusion of study sites was

chosen by all facilities located in metropolitan Sydney. Facilities outside Sydney and in other States were not included. ACF managers were interviewed and managers completed the study questionnaires retrospectively in 2018 about 2017 influenza outbreaks. An outbreak was defined in the study as two or more cases of laboratory-confirmed influenza occurring concurrently within the same facility in a week. Nasopharyngeal swabs were collected for symptomatic residents, and diagnosis of influenza was confirmed by real-time reverse transcription-polymerase chain reaction.

Each site was categorised as dementia-specific low care facilities, regular ACF and high care with advanced dementia ACF. High care facilities were for residents who were considered immobile. For this study, immobile was defined as the resident's inability to perform tasks independently. Low care facilities were for residents who were mobile and might require less assistance with their daily routines.

For the study, de-identified aggregated data were collected for residents and staff from each ACF; thus, individual data were not available. Baseline data and outbreaks information were entered from nine participating sites. Descriptive analysis of influenza outbreaks in 2017 was conducted. Outbreaks were analysed by predictors such as demographics of residents, number of rooms and shared rooms in each facility, the number of outbreaks, outbreak duration, lockdowns during the outbreak, total number of laboratory-confirmed cases, total number of influenza-related hospitalisations and deaths in each facility. We also documented start and end date of outbreak, speculated origin of transmission, vaccination of staff and residents, number of staff and workplace vaccination policy for staff (vaccine service and reimbursement). Staff data were incomplete; thus, data analysis was focused mainly on residents in the study. Attack rate of influenza was calculated for residents using the number of laboratory-confirmed cases of influenza infection and the total number of residents (potentially who were exposed) in the facility.

Ethics approval was granted from UNSW HREC and the research and governance office of ACF (Approval number: HC17996).

### 3 | RESULTS

There were nine facilities in affiliation with an Australian aged care provider included in the study. Each site was independently run with separate staff and managing team. Each site had common kitchen and dining areas where residents can interact daily, and all facilities had a basin and handwashing facilities in common areas and most private rooms. Table 1 described the demographics of residents by the facility. There was a total of 716 residents reported across nine aged care sites. Age of residents ranged from 57 to 101 years, and there were a high number of female residents in the facility (Table 1).

Only 2/9 facilities (E and G) had shared rooms with more than one bed. From 124 beds, Facility G reported seven shared rooms with an average of two beds per room. Facility E had 12 shared rooms, with an average of two beds per room.

Table 2 shows information on vaccination availability for staff by sites. A total number of 689 staff were recorded in all facilities. Facilities D and H were the only facilities that provided onsite vaccination for staff members. It was also reported that influenza vaccination for staff was mostly carried out by the private healthcare providers. However, information was not available for the number of staff who received influenza vaccination in 2017.

Table 3 summarises data on facilities that reported influenza outbreaks involving residents and/or staff during 2017 influenza seasons. Of all nine ACF in the study, facility D, F, G, H and I reported a total of 41 laboratory-confirmed cases of influenza among residents in 2017, with attack rates in residents ranged from 6% to 29%. The other four facilities reported no cases of confirmed influenza infection. Facility D reported two confirmed cases of influenza with unknown viral strains in the study. However, facility D did not meet outbreaks criteria set out for the purpose of this study; thus, the information from facility D was not included in Table 3. Facility

G reported the cause of initial viral transmission to be from a resident. However, facility H reported initial viral transmission from a staff member. The three facilities reported that outbreaks lasted for duration of 1-4 weeks, and two facilities (facility F and G) reported lockdown as a result of the outbreak in the facility (Table 3). Data on vaccination status of residents with seasonal influenza vaccine were not available in the study.

Influenza type A was the most common subtype across all facilities. Facility G had the highest number of influenza infection ( $n = 17$ ) among residents; mostly were influenza type A viruses. It was followed by facility F and H, with the total number of cases ( $n = 11$  and  $n = 6$ ), respectively. The facility I reported a total of five confirmed cases during that time. Among the total, six confirmed cases of influenza B infection were reported by facility F. No other sites reported cases of influenza B in the season. Three facilities, facility D, F and G, reported influenza-related hospitalisations among the residents (a total of 7 cases; 2, 1 and 4 cases respectively). No deaths were reported due to influenza-related illnesses in these outbreaks.

### 4 | DISCUSSION

Outbreaks of influenza in aged care settings are well recognised. We showed a high rate of influenza outbreaks in ACFs in 2017. Our study recorded the influenza attack rate of 6%-29% in residents across the facilities. Consistent to our finding, a literature review of infectious diseases outbreaks reported that the median attack rate of influenza outbreaks in residents was 33% (ranged 4%-94%) in the elderly in long-term care facilities.<sup>20</sup> In 2017, there were 591 institutional outbreaks of influenza in NSW alone.<sup>15</sup> It resulted in a high healthcare burden nationally, which had a significant economic impact on the Australian healthcare system.<sup>16</sup> A high rate of influenza in the community with increased influenza-related hospitalisations and deaths as well as numerous, severe ACFs outbreaks were reported in 2017 across the country.<sup>21-24</sup> In that year, influenza A/H3N2 circulated, and the overall vaccine

| Aged care facility | Number of staff | Is influenza vaccination routinely reimbursed for staff? | Vaccination site                     |
|--------------------|-----------------|--|--------------------------------------|
| Facility A         | 38              | Yes  | Private GP                           |
| Facility B         | 79              | Yes  | Private GP                           |
| Facility C         | Unavailable     | Unknown  | Private GP                           |
| Facility D         | 70              | Yes  | Both through facility and private GP |
| Facility E         | 108             | Yes  | Private GP                           |
| Facility F         | 31              | Yes  | Private GP                           |
| Facility G         | 125             | Yes  | Private GP                           |
| Facility H         | 115             | Yes  | Both through facility and private GP |
| Facility I         | 123             | Yes  | Private GP                           |

**TABLE 2** The availability of seasonal influenza vaccine for staff by facilities<sup>a</sup>

<sup>a</sup>Data not included for facility C.

**TABLE 3** Reported influenza outbreaks in aged care facilities in 2017

|   | Facility F <sup>a</sup>     | Facility G  | Facility H  | Facility I  |
|---|-----------------------------|-------------|-------------|-------------|
| First case of influenza in facility   | Unknown                     | 17/07/2017  | 14/08/2017  | 28/07/2017  |
| Speculated origin of transmission   | Unknown                     | Resident    | Staff       | Unknown     |
| Outbreak (start date)   | Unknown                     | 19/07/2017  | 8/10/2017   | 31/07/2017  |
| Outbreak (end date)   | Unknown                     | 7/08/2017   | 28/10/2017  | 8/08/2017   |
| Duration of outbreak  | Unknown                     | 3 wk        | 4 wk        | 1 wk        |
| Number of times facility was locked down due to outbreak                            | 2                           | 1           | 0           | 0           |
| Number of residents in facility during outbreak                                     | 38                          | 124         | 92          | 83          |
| Number of laboratory-confirmed influenza cases among all residents (attack rate, %) | 11 (29%)                    | 17 (14%)    | 6 (6.5%)    | 5 (6.0%)    |
| Influenza virus   | Influenza A/<br>Influenza B | Influenza A | Influenza A | Influenza A |
| Number of influenza-related hospitalisations in residents                           | 1                           | 4           | 0           | 0           |
| Number of influenza-related deaths in residents                                     | 0                           | 0           | 0           | 0           |
| Number of staff in facility during an outbreak                                      | Unknown                     | Unknown     | 131         | 55          |
| Number of laboratory-confirmed influenza cases among staff                          | Unknown                     | 2           | 4           | Unknown     |
| Number of influenza-related hospitalisations in staff                               | Unknown                     | 0           | 0           | 0           |

Note: No outbreak reported from facility D, thus not included in the table.

<sup>a</sup>Facility F did not provide data on start and end date of outbreaks, the number of residents and staff affected during each outbreak, and speculated origin of transmission.

effectiveness of -3% and -20% for A/H3 was reported in adults ≥65 years in Australia, resulted in a high disease burden in the elderly.<sup>19</sup>

From the study, four of the nine facilities reported influenza outbreaks in 2017. Studies have shown that highly populated residential homes have a higher risk of viral transmission, due to complexity in maintaining infection control practices in the facilities.<sup>25,26</sup> Moreover, many studies reported that transmission from staff members was the most common spread of infection in aged care homes, who then transmit to residents.<sup>27-29</sup> However, in this study, the speculated origin of transmission was reported from both staff and residents in the ACFs. This may have occurred as a result of third party transmission between residents and visiting family members.<sup>28,29</sup> High vaccination rates in staff and family members who regularly visit the sites are crucial in reducing influenza outbreaks in the aged care homes.

With regard to vaccination, low influenza vaccine uptake was reported among aged care staff.<sup>30,31</sup> Poor vaccination uptake among staff may have been due to several factors such as out of pocket expenses for yearly vaccination, inconvenience of

vaccination site for staff, busy working schedules, varied vaccination requirement by sites and individual attitudes towards vaccination.<sup>32</sup> In our study, we found that two out of nine facilities offered onsite vaccination for staff members and the remaining seven sites offered reimbursements for staff once the vaccination was done. However, the provider only reimbursed the cost of the vaccine and none for any associated GP consultation fees. We previously found that higher vaccine uptake was observed for staff in facilities where vaccination is offered onsite.<sup>30</sup> In addition, in facilities where staff who come from low socio-economic backgrounds, low vaccination uptake may be due to initial out of the pocket expenses for staff such as the cost of seeing a private GP, which can be a further barrier in receiving the vaccination.<sup>14,30</sup> resulting in less voluntary uptake of vaccination among staff in facilities that do not offer onsite vaccination. Due to numerous outbreaks of influenza in aged facilities in 2017, the Australian Aged Care Quality Agency took a national survey to review the uptake of seasonal influenza vaccination among staff.<sup>33,34</sup> After the review, in subsequent influenza seasons, Australia's health

policymakers implemented a compulsory vaccination of aged care staff to achieve the targeted vaccination uptake nationally.<sup>33,35</sup>

Numerous studies have shown that the spread of influenza is more rapid in facilities where shared rooms are used.<sup>36-38</sup> This is due to the likelihood of contact transmission through close living arrangements and sharing of utilities and common areas among the residents.<sup>25,26,37</sup> Residents sharing a room with an influenza-infected roommate are about three times more likely to develop symptoms than residents in single rooms.<sup>39</sup> Studies have shown that strict hygiene practices such as the use of PPE among staff can significantly reduce transmissibility of influenza.<sup>40,41</sup> Control of the spread of infection can be challenging to manage in facilities with a higher number of residents.

This study has limitations. First, it only provides a cross-sectional picture of the reported influenza outbreaks among the participating ACFs in 2017, where a higher number of influenza A/H3 virus circulated, resulting in a severe influenza season across the nation. Second, our findings may be underestimated as residents may have been missed due to mild or asymptomatic cases during these outbreaks. Third, we did not have adequate data on staff, thus limiting information and understanding about the staff working in ACFs in the study.

Despite the high vaccination coverage among residents, older adults had been hit hard by influenza infection. About 85% of those that were vaccinated in 2017 and exposed to the virus were affected by influenza in that year.<sup>42,43</sup> In Australia, the 2017 seasonal influenza vaccine was reported to have reduced vaccine effectiveness of 33% overall and only 10% effectiveness against A/H3N2 strain.<sup>19</sup> Additional reasons for low vaccine effectiveness may have been due to genetic diversity in circulating A/H3N2 and the vaccine strain, as well as waning protection against influenza virus especially in older adults following vaccination.<sup>44</sup> For control of influenza outbreaks in the ACFs, high vaccine coverage of staff and residents, training of staff on infection control measures and the use of effective surveillance system are essential to monitor and prevent such outbreaks in these settings.<sup>40,45,46</sup>

## ACKNOWLEDGEMENTS

We would like to acknowledge the managers of nine aged care facilities for their support and assistance during the data collection process in the study. CR MacIntyre is supported by a NHMRC Principal Research Fellowship, grant number 1137582.

## CONFLICT OF INTEREST

CR MacIntyre has received funding for investigator-driven research separate from this study, from Sanofi and Seqirus, and has been on advisory boards for the same for the last 5 years. Other authors have none to declare.

## AUTHOR CONTRIBUTION

**Elmira Hooshmand:** Data curation (equal); Formal analysis (equal); Writing-original draft (lead); Writing-review & editing (equal). **Aye Moa:** Formal analysis (equal); Supervision (supporting); Writing-review & editing (equal). **Mallory Trent:** Supervision (supporting);

Writing-original draft (supporting); Writing-review & editing (equal). **Mohana Kunasekaran:** Data curation (equal); Project administration (lead); Writing-review & editing (supporting). **Christopher Poulos:** Conceptualization (supporting); Supervision (supporting); Writing-review & editing (equal). **Abrar Chughtai:** Supervision (supporting); Writing-review & editing (equal). **C. Raina MacIntyre:** Conceptualization (lead); Supervision (lead); Writing-review & editing (equal).

## ORCID

Elmira Hooshmand  <https://orcid.org/0000-0001-7417-9128>

Aye Moa  <https://orcid.org/0000-0003-4274-6241>

## REFERENCES

- Lambert SB, Faux CE, Grant KA, et al. Influenza surveillance in Australia: we need to do more than count. *Med J Aust.* 2010;193(1):43-45.
- World Health Organisation. Influenza 2015 February. <https://web.archive.org/web/20090505070146/http://www.who.int/media/centre/factsheets/2003/fs211/en/> Accessed July 10, 2018.
- Nair H, Brooks WA, Katz M, et al. Global burden of respiratory infections due to seasonal influenza in young children: a systematic review and meta-analysis. *Lancet (London, England).* 2011;378(9807):1917-1930. [https://doi.org/10.1016/s0140-6736\(11\)61051-9](https://doi.org/10.1016/s0140-6736(11)61051-9)
- Chow EJ, Doyle JD, Uyeki TM. Influenza virus-related critical illness: prevention, diagnosis, treatment. *Crit Care.* 2019;23(1):214-314. <https://doi.org/10.1186/s13054-019-2491-9>
- Loeb M, McGeer A, McArthur M, et al. Surveillance for outbreaks of respiratory tract infections in nursing homes. *CMAJ.* 2000;162(8):1133-1137.
- Rosewell A, Chiu C, Lindley R, et al. Surveillance for outbreaks of influenza-like illness in the institutionalized elderly. *Epidemiol Infect.* 2010;138(8):1126-1134. <https://doi.org/10.1017/s0950268809991440>
- Maggini S, Pierre A, Calder PC. Immune function and micronutrient requirements change over the life course. *Nutrients.* 2018;10(10):1531.
- Powers JH, Guerrero ML, Leidy NK, et al. Development of the Flu-PRO: a patient-reported outcome (PRO) instrument to evaluate symptoms of influenza. *BMC Infect Dis.* 2015;16(1):1.
- Smetana J, Chlibek R, Shaw J, et al. Influenza vaccination in the elderly. *Hum Vaccin Immunother.* 2018;14(3):540-549. <https://doi.org/10.1080/21645515.2017.1343226>
- World Health Organization (WHO). Seasonal Influenza Factsheet. [https://www.who.int/en/news-room/fact-sheets/detail/influenza-\(seasonal\)](https://www.who.int/en/news-room/fact-sheets/detail/influenza-(seasonal)). Accessed August, 2020
- Dronavalli M, Lord H, Alexander K, et al. Effectiveness of oseltamivir prophylaxis in influenza outbreaks in residential aged care. *J Epidemiol Glob Health.* 2020;10(2):184-189. <https://doi.org/10.2991/jegh.k.200402.001>
- Ye M, Jacobs A, Khan MN, et al. Evaluation of the use of oseltamivir prophylaxis in the control of influenza outbreaks in long-term care facilities in Alberta, Canada: a retrospective provincial database analysis. *BMJ Open.* 2016;6(7):e011686. <https://doi.org/10.1136/bmjopen-2016-011686>
- Booy R, Lindley RI, Dwyer DE, et al. Treating and preventing influenza in aged care facilities: a cluster randomised controlled trial. *PLoS One.* 2012;7(10):e46509. <https://doi.org/10.1371/journal.pone.0046509>
- Huhtinen E, Quinn E, Hess I, et al. Understanding barriers to effective management of influenza outbreaks by residential aged care facilities. *Australas J Ageing.* 2019;38(1):60-63. <https://doi.org/10.1111/ajag.12595>

15. Bennett N, Bradford J, Bull A, Worth LJ. Infection prevention quality indicators in aged care: ready for a national approach. *Aust Health Rev.* 2019;43(4):396.
16. DoH. Australian Government. Department of Health. 2017 Influenza Season in Australia; A summary from the National Influenza Surveillance Committee, 2017 [https://www1.health.gov.au/internet/main/publishing.nsf/Content/097F15A91C05FBE7CA2581E20017F09E/\\$File/2017-season-summary-22112017.pdf](https://www1.health.gov.au/internet/main/publishing.nsf/Content/097F15A91C05FBE7CA2581E20017F09E/$File/2017-season-summary-22112017.pdf). Accessed April 10, 2020
17. DOH. Australian Government. Disease notification rates by State and Territory, 2017. [http://www9.health.gov.au/cda/source/rpt\\_2.cfm](http://www9.health.gov.au/cda/source/rpt_2.cfm). Accessed April 10, 2020
18. NSW. NSW Government. Health. 2017 Influenza reports. <https://www.health.nsw.gov.au/Infectious/Influenza/Pages/2017-flu-reports.aspx>. Accessed April 10, 2020
19. Sullivan SG, Chilver MB, Carville KS, et al. Low interim influenza vaccine effectiveness, Australia, 1 May to 24 September 2017. *Eurosurveillance.* 2017;22(43):17-00707. <https://doi.org/10.2807/1560-7917.ES.2017.22.43.17-00707>
20. Utsumi M, Makimoto K, Quroshi N, et al. Types of infectious outbreaks and their impact in elderly care facilities: a review of the literature. *Age Ageing.* 2010;39(3):299-305. <https://doi.org/10.1093/ageing/afq029>
21. Harriet Aird. ABC News. Influenza epidemic: six deaths confirmed at Tasmania's Strathdeven aged care home. <https://www.abc.net.au/news/2017-09-02/six-flu-nursing-home-deaths-in-tasmania/8866068>. Accessed 17 August, 2020
22. The Guardian. Flu outbreak kills seven residents at Victorian aged care home. <https://www.theguardian.com/australia-news/2017/sep/01/flu-outbreak-kills-seven-residents-at-victorian-aged-care-home#top>. Accessed August 17, 2020
23. Monery H. The Examiner, News. Deaths in Tasmanian nursing home after an influenza outbreak. <https://www.examiner.com.au/story/4896576/flu-outbreak-causes-deaths-in-tasmanian-nursing-home/>. Accessed August 17, 2020
24. Kennedy J. ABC News. Flu outbreaks on rise in NSW aged care facilities; state sees worst seven months of influenza. <https://www.abc.net.au/news/2017-08-01/flu-outbreaks-in-nsw-aged-care-facilities/8764420>. Accessed August 17, 2020.
25. Tang J, Li Y, Eames I, et al. Factors involved in the aerosol transmission of infection and control of ventilation in healthcare premises. *J Hosp Infect.* 2006;64(2):100-114.
26. Kak V. Infections in confined spaces: cruise ships, military barracks, and college dormitories. *Infect Dis Clin North Am.* 2007;21(3):773-784.
27. Curran E. Infection outbreaks in care homes: prevention and management. *J Nurs Times.* 2017;113(9):18-21.
28. Petrignani M, van Beek J, Borsboom G, et al. Norovirus introduction routes into nursing homes and risk factors for spread: a systematic review and meta-analysis of observational studies. *J Hosp Infect.* 2015;89(3):163-178.
29. Montoya A, Cassone M, Mody L. Infections in nursing homes: epidemiology and prevention programs. *Clin Geriatr Med.* 2016;32(3):585-607.
30. Lai E, Tan HY, Kunasekaran M, et al. Influenza vaccine coverage and predictors of vaccination among aged care workers in Sydney Australia. *Vaccine.* 2020;38(8):1968-1974.
31. Halliday L, Thomson JA, Roberts L, et al. Influenza vaccination of staff in aged care facilities in the ACT: how can we improve the uptake of influenza vaccine? *Aust N Z J Public Health.* 2003;27(1):70-75. <https://doi.org/10.1111/j.1467-842X.2003.tb00383.x>
32. Benin AL, Lockwood G, Creatore T, et al. Improving mandatory vaccination against influenza: minimizing anxiety of employees to maximize health of patients. *Am J Med Qual.* 2018;33(4):372-382. <https://doi.org/10.1177/1062860617748738>
33. DoH. Australian Government. Department of Health. Mandatory vaccine programs to curb aged care influenza. Canberra 2018. Updated 22 April 2018. <https://www1.health.gov.au/internet/main/publishing.nsf/Content/news2018042018>. Accessed April 10, 2020
34. Aged Care Guide. Aged care staff target for new mandatory flu vaccine. <https://www.agedcareguide.com.au/talking-aged-care/aged-care-staff-target-for-new-mandatory-flu-vaccine>. Accessed April 10, 2020
35. CDNA. Seasonal Influenza Infection CDNA National Guidelines for Public Health Units. [https://www1.health.gov.au/internet/main/publishing.nsf/Content/3D622AEAE44DDEB2CA257BF0001ED884/\\$File/influenza-infection-2019.pdf](https://www1.health.gov.au/internet/main/publishing.nsf/Content/3D622AEAE44DDEB2CA257BF0001ED884/$File/influenza-infection-2019.pdf). Accessed April 10, 2020
36. Carolyn Buxton B, Matthew JK, Caroline BH. Transmission of influenza: implications for control in health care settings. *Clin Infect Dis.* 2003;37(8):1094-1101.
37. Bean B, Moore BM, Sterner B, et al. Survival of influenza viruses on environmental surfaces. *J Infect Dis.* 1982;146(1):47-51. <https://doi.org/10.1093/infdis/146.1.47>
38. Siegel JD, Rhinehart E, Jackson M, et al. Guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings, 2007. <https://www.cdc.gov/infectioncontrol/pdf/guidelines/isolation-guidelines-H.pdf>. Accessed April 10, 2020
39. Drinka PJ, Krause PF, Nest LJ, et al. Risk of acquiring influenza b in a nursing home from a culture-positive roommate. *J Am Geriatr Soc.* 2005;53(8):1437.
40. Lansbury LE, Brown CS, Nguyen-Van-Tam JS. Influenza in long-term care facilities. *Influenza Other Respir Viruses.* 2017;11(5):356-366. <https://doi.org/10.1111/irv.12464>
41. Rainwater-Lovett K, Chun K, Lessler J. Influenza outbreak control practices and the effectiveness of interventions in long-term care facilities: a systematic review. *Influenza Other Respir Viruses.* 2014;8(1):74-82.
42. Moa A, MacIntyre R, How bad is the flu in 2017 in Australia?. University of New South Wales, School of Public Health and Community Medicine; <https://iser.med.unsw.edu.au/blog/how-bad-flu-2017-australia>. Accessed August 19, 2020
43. ABC News. Flu epidemic. Experts explain the reasons behind Australia's bad season 2017 October. <http://www.abc.net.au/news/health/2017-09-28/flu-epidemic-your-questions-answers/8992884>. Accessed April 10, 2020
44. Puig-Barberà J, Mira-Iglesias A, Tortajada-Girbés M, et al. Waning protection of influenza vaccination during four influenza seasons, 2011/2012 to 2014/2015. *Vaccine.* 2017;35(43):5799-5807. <https://doi.org/10.1016/j.vaccine.2017.09.035>
45. Kimura AC, Nguyen CN, Higa JI, et al. The effectiveness of vaccine day and educational interventions on influenza vaccine coverage among health care workers at long-term care facilities. *Am J Public Health.* 2007;97(4):684-690. <https://doi.org/10.2105/AJPH.2005.082073>.
46. Tan HY, Lai E, Kunasekaran M, et al. Prevalence and predictors of influenza vaccination among residents of long-term care facilities. *Vaccine.* 2019;37(43):6329-6335.

**How to cite this article:** Hooshmand E, Moa A, Trent M, et al. Epidemiology of 2017 influenza outbreaks in nine Australian Aged care facilities. *Influenza Other Respi. Viruses.* 2021;15:278-283. <https://doi.org/10.1111/irv.12811>