GLOBAL BIOSECURITY

Gall A, Law C, Massey P, Crooks K, Andrews R & Field E. Outcomes Reported for Australian First Nation Populations for the Influenza A(H1N1) 2009 Pandemic and Lessons for Future Infectious Disease Emergencies: a Systematic Review. *Global Biosecurity, 2020; 1(4).*

REVIEWS

Outcomes Reported for Australian First Nation Populations for the Influenza A(H1N1) 2009 Pandemic and Lessons for Future Infectious Disease Emergencies: a Systematic Review

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Abstract

Aims: Enhanced data collection during infectious disease emergencies, such as the COVID-19 pandemic, must inform the clinical and public health responses appropriate for Australian First Nations populations. To inform the design of such data collection protocols, we systematically reviewed the reported outcomes for the First Nations population related to A(H1N1) 2009 pandemic influenza infection.

Methods: We searched PubMed and Google using the search terms: pandemic AND Australia AND 2009 AND (Indigenous OR Aboriginal OR "Torres Strait"). Data extracted included: location; study design; data source(s), number of study participants and the number and percentage that were First Nations; completeness of First Nations status; and reported outcomes (stratified by First Nations status). Each study was also reviewed for documentation of engagement or consultation with First Nation individuals, communities or health services regarding the study design, data collection, analysis, interpretation and reporting.

Results: Our search identified 53 citations, with 13 deemed eligible for inclusion. Most studies were case-series (n=6) and used primary data (n=8) and/or secondary data (n=10). The number of First Nations participants ranged from 13 to 3,966. The proportion of First Nations participants per study varied from 1.8% to 100%. Completeness of reporting First Nations status ranged from 62% to 100%. Reported outcomes stratified by First Nations status included notification rate (n=3), comorbidities/risk factors (n=4), severity of disease (hospital admission (n=8), intensive care unit admission (n=8), death (n=5)) and interventions (anti-viral use (n=2) and vaccination (n=4)). There were no studies that described engagement/consultation with First Nations individuals, communities or health services regarding any aspect of the study process.

Conclusion: Studies identified in this review mostly used secondary data and reported on outcomes relating to severity, and comorbidities and other risk factors. Studies specifically designed for First Nations populations are required to fully understand the contributing factors for the frequency and severity of disease in an infectious disease emergency and inform appropriate responses. First Nations communities and health services need to be adequately engaged and participate in the design, implementation, analysis and reporting of such enhanced data collection studies.

Keywords: pandemic; infectious disease emergency; First Nations; Aboriginal and Torres Strait Islanders

Introduction

The rapid onset of the COVID-19 pandemic is a case study of the need for rapid data collection, analysis and reporting on clinical and epidemiological characteristics of cases and contacts to inform appropriate clinical and public health responses (1). Surveillance systems for detecting such infectious disease emergencies, which includes influenza pandemics and other outbreaks of novel diseases, have been established in Australia (2). However, once an event is detected, information needs for responding to infectious disease emergencies are increased far beyond routine surveillance systems, particularly early on when many clinical and epidemiological factors are unknown. Further, information requirements change over the course of the event, with

a focus first on verification and detection of cases, then risk and severity assessments, and then monitoring the course of the pandemic and detecting any changes in risk and severity (3). Information requirements include, but are not limited to, identification of risk groups, age distribution of cases, clinical features, comorbidities, health care utilisation (e.g. hospital and/or intensive care unit admission), and spread of disease (for example household transmission and geographic distribution) (3).

Early in the influenza A(H1N1) 2009 pandemic, Aboriginal and Torres Strait Islanders, hereafter respectfully referred to as First Nations, were identified as disproportionately affected both in terms of incidence (notifications) and severity (hospital and intensive care unit (ICU) admissions) of infection (4-6). At the time of the influenza A(H1N1) 2009 pandemic, First Nations peoples were 3% of Australia's population, yet accounted for 11% of cases, 20% of hospital admissions and 13% of deaths (7). This difference in severity has been attributed to the higher prevalence of risk factors and comorbidities within the First Nations population (8). During the pandemic an annex to the *Australian Health Management Plan for Pandemic Influenza 2008* was developed to specifically address issues for First Nations population (9). However this annex and the current Australian Health Management Plan for Pandemic Influenza does not include any specific considerations for data collection systems nor special studies to inform the response for the First Nations population (9, 10). While First Nations status is routinely collected for notifiable diseases, and was for the influenza A(H1N1) 2009 pandemic, the completeness of this field is sub-optimal (11).

First Nations Australians are unique and culturally diverse, and are the oldest continuing cultures in the world (12). Due to the collectivist nature of First Nations Australians cultures, people often live in large family groups and place a greater emphasis on the need for family and social connectedness, which could leave families in a more vulnerable position in relation to infectious disease emergencies (12, 13). Collaborative processes for pandemic planning have been identified and participatory approaches to development of responses for the 2009 influenza pandemic for First Nations peoples were documented (13, 14). However, sufficient data on outcomes for First Nations peoples is critical for evidence-based planning and response.

There is a need to ensure that enhanced data collection during an infectious disease emergency, such as the COVID-19 pandemic, includes a sufficient number of First Nations people to ensure meaningful analysis and also meets the needs for both communities and responders. Through understanding the clinical and epidemiological characteristics of an infectious disease emergency within the First Nations population, public health responders and affected communities can develop evidence-based responses. In order to inform the design of such protocols for enhanced data collection, we reviewed what outcomes were reported for the First Nations population during the influenza A(H1N1) 2009 pandemic.

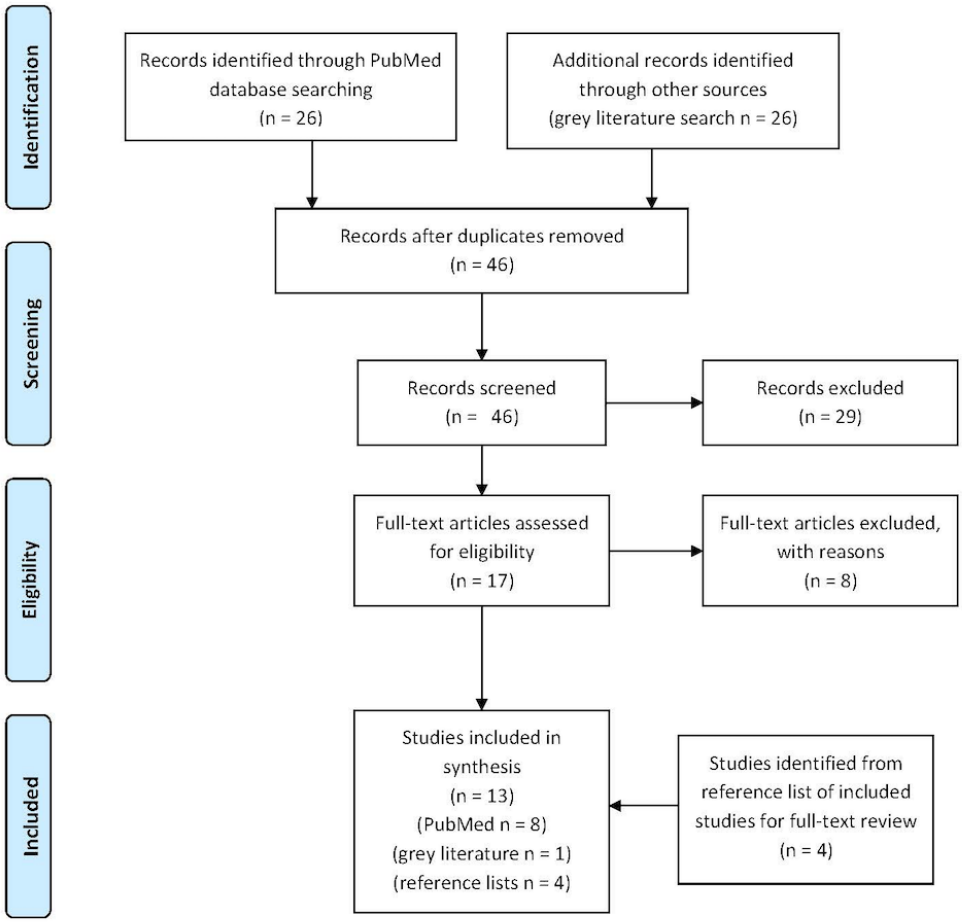
Methods

We conducted a systematic literature review on the outcomes for First Nations populations that were reported during the influenza A(H1N1) 2009 pandemic. The systematic review process was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines as outlined in Figure 1 (15). We searched both PubMed and Google on 27th March 2019 using the search terms: ((pandemic) AND (2009) AND (Australia)) AND ((Indigenous) OR (Aboriginal) OR (Torres Strait)) in PubMed and pandemic AND Australia AND 2009 AND (Indigenous OR Aboriginal OR "Torres Strait") in Google. The first three Google pages were hand searched for grey literature. Grey literature refers to any research or materials produced by organisations published outside the traditional academic channels. This commonly includes publications relevant to our review such as government reports. Lastly, the references of each included study were screened to identify additional studies.

We included all descriptive and analytical studies using primary and/or secondary data. We excluded books, book chapters, commentaries, literature reviews, editorials, poster abstracts, case reports, published languages other than English, and studies where data were not stratified by First Nations status. Studies that only reported the total number of participants by First Nations status, and no outcomes, were also excluded as these studies did not add any results to the aim of this review. The search was limited to publications from 2009 onwards as 2009 was year of the influenza A(H1N1) 2009 pandemic. AG conducted the searches, and then both AG and EF screened titles and abstracts independently. Once decisions were made, AG and EF discussed discrepancies.

The following data were extracted for each article: lead author, year of publication; study location; study design; number of overall participants included in the study and the number and percentage of those that were First Nations; completeness of First Nations status (percentage of study participants with First Nations status reported); outcomes reported in the study that were stratified by First Nations status; results for each outcome, and data source(s). Each paper was also reviewed for any documentation of processes for any type of engagement or consultation with First Nation individuals or communities or First Nations health services regarding the study design, data collection, analysis, interpretation or reporting.

Figure 1. PRISMA diagram



Results

The database and grey literature search identified 53 citations, of which 17 were deemed relevant for full text review after reviewing the title and abstracts. Upon full-text review, 8 studies were excluded. Four studies were excluded because they either had no analyses of data (16) or the analyses were not stratified by First Nations status (17-19). A fifth study was excluded due to only reporting the number and percent of First Nations participants (nil outcomes stratified by First Nations status) (20). Two serosurveys were excluded because their design focussed on serum samples collected prior to and after the pandemic to test immunity, and therefore could not be used to inform action during the pandemic (21, 22). The eighth study, a government report, was excluded because the same dataset was analysed in more detail in an included study (7). Reference lists of included articles were checked for any other relevant articles, from these six additional studies were identified for full text review. Two were excluded as they only reported the number and/or percent of participants by First Nations status (4, 5). In total 13 studies met our inclusion criteria (eight from PubMed, one from Google and four from reference lists) (Figure 1).

Study designs and data sources

Seven studies were cross-sectional (n=7), five were population-based cohort studies and one was a time series study (Table 1). Eight studies collected primary data, employing specifically designed case report forms, phone and face-to-face interviews, and NetEpi, which was specifically designed for use during the pandemic (8, 20, 23-26). Ten of the studies analysed secondary data including data sets held by national and state government health departments and individual health services and hospital data (8, 24-33). Of the 13 included studies, four reported on national level data (26, 27, 31, 33, 34), six on state level data (8, 28-30, 32, 35), and three on sub-state level data (23-25).

Study sample sizes

Total participant numbers ranged from 57 (31) to 75,154 (30). The latter did not report the total number or proportion of First Nations participants (30). The number of First Nations participants ranged from 13 (31) to 3,966 (26) and the proportion of First Nations participants included in each study varied from 1.8% (34) to 100% (24). Nine studies reported on completeness of First Nations status (8, 23-26, 28, 29, 31, 34) where the completeness ranged from 62% to 100%.

Outcomes reported

Demographics

The most common demographic variable stratified by First Nations status was age (8, 24-26, 29). The median age for notification was the same or slightly lower for First Nations compared to non-Indigenous cases (Table 2) (8, 25, 29) as was the median age for hospitalisation, ICU admission and death. The national study by Pennington et al (2016) found the median age of First Nations hospitalised cases slightly older than non-Indigenous cases (32 years versus 30 years)(26). Goggin et al (8) found First Nations cases who were hospitalised were comparatively older than non-hospitalised First Nations cases (39 years versus 21 years).

Three small studies reported no difference in sex between First Nations and non-Indigenous hospitalised cases nor between hospitalised and non-hospitalised First Nations cases (8, 25, 29).The large national study by Pennington (2016) reported lower ratio of males to females First Nations compared to non-Indigenous notifications and hospital admissions (26).

Transmission

The age-standardised notification rates for First Nations were 3.5-5.2 times the non-Indigenous notification rates (25, 26). No studies reported attack rate or household transmission.

Clinical course

Two studies reported First Nations people were more likely to report cough and have adverse initial investigations than non-Indigenous people (8, 25). There was no difference in median days of symptoms and median days of hospitalisation (8, 25).

Outcomes on severity of infection included hospital admissions, reported by eight studies (8, 23, 25-29, 32), ICU admissions reported by eight studies (23, 25-30, 32), and death reported by five studies (23, 26, 27, 29, 32).

The hospital admission rate for the First Nations population ranged from 63 to 269 per 100,000 population with the relative risk compared to the non-Indigenous population ranging from 3.6 to 12 (23, 25-27, 29, 32). One study reported a standardised morbidity ratio of 7 (26). One study, based in North Queensland, found non-Indigenous cases were more likely to be hospitalised while a study in Western Australia reported a higher proportion of First Nations cases hospitalised compared to non-Indigenous cases (8, 23).

The rate of ICU admission for First Nations population ranged from 9 to 15 per 100,000 population with the relative risk compared to the non-Indigenous population ranging from 3.9 to 5.5 (23, 25-27, 29, 32). Two studies reported a standardised morbidity ratio ranging from 4.0 to 7.3 for the First Nations population (26, 29). First Nations status was not associated with ICU admission amongst hospitalised cases two studies, one based on univariate analysis and in another study when initial signs and investigations were included in a multivariate analysis (25, 28). Observed ICU admissions for First Nations populations exceeded predicted values for 2009 for influenza only, influenza/pneumonia and all respiratory illness (30).

The rate of death for the First Nations population ranged from 3 to 5 per 100,000 population with a relative risk range of 3.2 to 5.6 compared to the non-Indigenous population (23, 26, 27, 29, 32). Two studies reported a standardised mortality ratio ranging from 4.5 to 7.6 for the First Nations population (26, 29).

Comorbidities and other risk factors

Four of the 13 included studies reported on some form of co-morbidity and/or risk factors (8, 23, 25, 31). Pregnancy, as a risk factor, was reported by First Nations status for three studies (8, 25, 31). Two studies found no difference in the proportion of hospitalised and non-hospitalised First Nations cases that were pregnant (8, 25). One study found a higher risk of ICU admission for First Nations pregnant women compared to non-Indigenous pregnant women (31).

Two studies reported on smoking and one reported hazardous alcohol use as risk factors.(8, 25) There was no difference in the proportion of First Nations cases that were smokers who were hospitalised or not (8). However, a higher proportion of First Nations hospitalised cases reported smoking compared to non-Indigenous hospitalised cases (25). Similarly, a higher proportion of First Nations hospitalised cases reported hazardous alcohol consumption compared to non-Indigenous hospitalised cases (25).

Three studies reported on co-morbidities for influenza A(H1N1) pandemic cases for First Nations populations, including respiratory conditions, metabolic disorders, cardiac disease, renal disease, neurological disease, chronic liver disease and other medical conditions (8, 23, 25). Two additional studies provided the number and/or proportion of First Nations participants with a co-morbidity but did not include a comparison group (26, 29). Two studies found comorbidities were more prevalent amongst First Nations cases, specifically for diabetes, heart disease, respiratory conditions, obesity, and multiple comorbidities, compared to non-Indigenous cases (8, 23). However, one study of cases in the Northern Territory did not find any difference in comorbidities (asthma, COPD, bronchiectasis, obesity, cardiac disease, diabetes, chronic liver disease, neurological disease, immunosuppression or ≥1 comorbidity) in First Nations and non-Indigenous hospitalised cases, with the exception of chronic kidney disease, which was more prevalent amongst First Nations hospitalised cases (25). In one study that conducted a multivariate analysis that accounted for comorbidities, First Nations status was not associated with hospitalisation (8).

Table 1. Characteristics of included studies (n=13)

Author (year)	Location (state/city)	Study Design	Data Source (Primary/ secondary data)	No. participants (% completeness of First Nations status)	No. First Nations participants (% participants with completed First Nations status who are First Nations)	Outcomes reported for First Nations participants
Australian Institute of Health and Welfare (2010) (34)	Australia	Cross sectional	Primary	6,226 (99.6%)	110 (1.8%)	Influenza A(H1N1) 2009 pandemic vaccination uptake.
ANZIC (2010) (31)	Australia and New Zealand	Cohort	Primary and secondary	57 pregnant & postpartum women (100%) (excluding New Zealand Participants)	13 (22.8%) (excluding New Zealand Participants)	Relative risk of admission to ICU for pregnant women.
Flint et. al. (2010)(25)	Darwin, Katherine, and East Arnhem, NT	Cross sectional	Primary and secondary	Notifications - 918 (91.9%) (54.9%, n=463); 131 hospital admissions (100%) (70.2%, n=92), 28 ICU admissions (NR)	463 (54.9%) notifications, 92 (70.2%) for hospital admissions, NR for ICU admissions	Age-adjusted notification rate, median age for notification, hospitalisation and ICU admission rates; demographics (sex, age, remoteness), duration of symptoms, underlying medical conditions, other risk factors (smoking, harmful alcohol use, pregnancy), vital signs on admission, initial investigations.
Goggin et. al. (2011)(8)	WA	Cross sectional	Primary and secondary	871 (98.3%)	63 (7.4%)	Sex; age; antiviral status; vaccination status; underlying medical conditions, other risk factors (smoking and pregnancy); symptoms; hospital admission; median number of days hospitalised.
Harris et. al. (2010)(23)	North QLD (Townsville Hospital)	Cross sectional	Primary	181 (97.8%)	93 (52.5%)	Hospital admission; comorbidities; ICU admission; deaths; antiviral status.
Kelly et. al. (2009)(27)	Australia	Cohort	Secondary	4,833 hospital admissions (NR), 650 ICU admissions (NR), 186 deaths (NR)	803 hospital admissions (NR), 100 ICU admissions (NR), 24 deaths (NR)	Number, rate and relative risk of hospital admission; ICU admission; deaths.

Mak (2010)	WA	Cross sectional	Primary	1,724 (NA)	NA (15.1%)	Estimated uptake of influenza A(H1N1) 2009 pandemic vaccination.
Moberley et. al. (2016)(24)	NT – Darwin, Alice Springs and 4 other remote locations	Cross sectional study (nested within a randomised controlled trial)	Primary and secondary	214 pregnant women (100%)	214 (100%)	Vaccination status; socio-demographic factors associated with vaccination (age; parity; medical conditions, education; smoking; over-crowding).
New South Wales Public Health Network (2009) (32)	NSW	Cohort	Secondary	1,214 hospital admissions (NR), 225 ICU admissions (NR), 48 deaths (NR)	96 hospital admissions (NR), 14 ICU admissions (NR), 5 deaths (NR)	Number, rate and relative risk for hospital admission, ICU admission and death.
Pennington (2017) (26)	Australia	Cohort	Primary and secondary	37,754 (61.8%) notifications; 5,085 hospital admissions (72.5%); 686 ICU admission (NR); 188 (NR)	3,966 notifications (17.0%); 807 hospital admissions (21.9%); 99 ICU admissions (NR); 23 deaths (NR)	Number, age, sex ratio, rate (age-standardised) and relative risk for notification; age; hospital admission; ICU admission; and death. Duration of hospital admission and ICU admission.
Phung et. al. (2011)(28)	QLD	Cross sectional	Secondary	1,236 hospital admissions (90.2%)	191 (15.4%)	ICU/SCU admission
Rudge & Massey (2010)(29)	NSW	Cohort	Secondary	1,214 hospital admissions (93.2%); 225 ICU admissions (90.2%); NR deaths (93.8%)	96 (8.5%) for hospital admissions; 14 (6.9%) for ICU admissions; and 5 (11.1%) for deaths	Median age; sex ratio. Number, rate and relative risk of hospital admission, ICU admission and death.
Schaffer et. al. (2012)(30)	NSW	Time series	Secondary	75,154 unplanned ICU admissions (NR)	NR (NR)	Estimated differences in observed and predicted rates and counts of intensive care admissions ICU admission.

NR = Not reported
NA = Not available – Proportions of the population First Nations/non-Indigenous applied from one dataset to another to estimate vaccine uptake.
ICU: Intensive Care Unit; SCU: Special Care Unit:

Table 2. Main clinical and epidemiological outcomes[1] reported for influenza A(H1N1) pandemic cases that were stratified by First Nations status

Variable	Result
Demographics	
Age	• Median age for notification was lower for First Nations cases (23 years) compared to non-Indigenous cases (25 years) (25) • Median age for notification was lower for First Nations cases (18 years) compared to non-Indigenous cases (21 years) (26) • Median age for notification was the same for First Nations cases (26 years) compared to non-Indigenous cases (26 years) (8) • Median age of First Nations cases hospitalised was lower (39 years) compared to non-Indigenous cases (46 years) (25) • Median age of First Nations cases hospitalised was lower (25 years) compared to non-Indigenous cases (32 years) (29) • Median age of First Nations cases hospitalised was higher (32 years) compared to non-Indigenous cases (30 years) (26) • Median age of First Nations cases hospitalised was higher (39 years) compared to non-hospitalised First Nations cases (21 years) (8) • Median age of First Nations cases admitted to ICU was lower (41 years) compared to non-Indigenous cases (44 years) (26) • Median age for death was lower for First Nations cases (48 years) compared to non-Indigenous cases (54 years) (26)
Sex	• Ratio of males to females was similar for First Nations and non-Indigenous cases admitted to hospital (no ratio provided) (29) • No difference between proportion of male First Nations and non-Indigenous cases (8) • No difference between proportion of male hospitalised and non-hospitalised First Nations cases (8) • No difference in proportion of females for hospitalised cases for First Nations and non-Indigenous patients (25) • Ratio of males to females lower for First Nations for notifications (0.90:1) compared to non-Indigenous notifications (0.97:1). Similarly, ratio of males to females lower for First Nations for hospital admissions (0.89:1) compared to non-Indigenous hospital admission (1:1) (26)
Location	• A higher proportion of First Nations hospitalised cases were living in remote areas compared to non-Indigenous hospitalised cases (49% versus 6%) (25) • For the First Nations population, the RR of hospital admission for remote compared with urban dwelling was 0.63 (25)
Transmission	
Notification rate	• First Nations age-standardised notification rate was 1,116 per 100,000 population compared to 315 per 100,000 population for the non-Indigenous population (25) • First Nations age-standardised notification rate was 596 per 100,000 population versus 168 per 100,000 population for the non-Indigenous population. Standardised morbidity ratio was 3.5 (26)
Comorbidities and risk factors	
Pregnancy	• No difference in the proportion of First Nations cases that were pregnant compared to non-Indigenous cases (8) • No difference in the proportion of First Nations hospitalised cases that were pregnant compared to non-hospitalised First Nations cases (8) • No difference in the proportion of First Nations hospitalised cases that were pregnant compared to non-hospitalised First Nations cases (25) • RR of ICU admission for First Nations pregnant women 6.2 versus non-Indigenous women (31)
Smoking	• No difference in the proportion of First Nations hospitalised cases that were smokers compared to non-hospitalised First Nations cases (8) • A higher proportion of First Nations hospitalised cases reported being a current smoker compared to non-Indigenous hospitalised cases (41% versus 13%) (25)
Alcohol use	• A higher proportion of First Nations hospitalised cases reported hazardous alcohol use compared to non-Indigenous hospitalised cases (26% versus 8%) (25)
Co-morbidities	• A higher proportion of First Nations cases had ≥1 comorbidity compared to non-Indigenous cases (74% vs. 54%; OR 2.5) (23) • A higher proportion of First Nations cases had diabetes compared non-Indigenous cases (12% versus 3% OR 4.2) (23)

	• A higher proportion of First Nations hospitalised cases had chronic kidney disease compared to non-Indigenous hospitalised cases (20% versus 5%) but no difference for asthma, COPD, bronchiectasis, obesity, cardiac disease, diabetes, chronic liver disease, neurological disease, immunosuppression or ≥1 comorbidity (25) • Among First Nations cases, there was a higher proportion of cases hospitalised with diabetes (44% versus 7%), heart disease (25% versus 5%, p=0.03), a respiratory condition (44% versus 15%), and obesity (25% versus 5%), but not with other medical conditions (neurological disease, blood disorders, metabolic disorders and immune disorders) or renal diseases (8) • A higher proportion of First Nations hospitalised cases reported having any medical condition (comorbidities, pregnancy and smoking) than non-hospitalised First Nations cases (81% versus 45%) and ≥2 medical conditions/risk factors (63% versus 7%) (8) • In a multivariate model, First Nations status was not an independent predictor for hospitalisation, but ≥2 medical conditions or risk factors (OR 4.9) and age (OR 1.02) was associated with hospitalised (8)
Severity of disease	
Clinical course	• A higher proportion of First Nations cases reported cough (97% vs 85%) and a lower proportion reported myalgia (49% versus 66%), headache (49% versus 66%), diarrhoea (8% versus 20%) and vomiting (19% versus 34%) compared to non-Indigenous cases. There were no differences for other symptoms (influenza-like illness, pyrexia, sore throat, dyspnoea, coryza, fatigue, rigors) (8) • No difference in median days of symptoms between First Nations and non-Indigenous cases (25) • No difference in median days hospitalised between First Nations and non-Indigenous cases (8) • No significant difference in the initial vital signs (heart rate, respiratory rate, temperature, systolic blood pressure, hypoxia) between First Nations hospitalised cases and non-hospitalised First Nations cases. First Nations hospitalised cases were more likely to have adverse initial investigations (lower haemoglobin, higher white cell count, lower serum albumin, higher C-reactive protein) but not infiltrates on chest x-ray compared to non-Indigenous hospitalised cases (25) • Median days of hospitalisation and ICU admission was similar for First Nations and non-Indigenous cases (26)
Hospitalisations	• Hospitalisation rate for First Nations population was 269 per 100,000 compared to 29 per 100 000 population for the non-Indigenous population. RR 12 (adjusted for age and remoteness) (25) • Hospitalisation rate for First Nations population was 63 per 100,000 population compared to 15 per 100,000 population for the non-Indigenous population. RR 4.2, standardised morbidity ratio 3.2 (29) • Hospitalisation rate for First Nations population was 126 per 100,000 population compared to 20 per 100,000 population for the non-Indigenous population. RR 6.2, standardised morbidity ratio was 7.0 (26) • Hospitalisation rate for First Nations population was 63 per 100,000 population, RR 3.6 compared to non-Indigenous population (32) • RR for hospital admission for First Nations population was 7.9 compared to the non-Indigenous population (23) • RR for hospital admission for First Nations population was 6.6 compared to the non-Indigenous population (27) • RR for hospital admission for First Nations cases was 0.3 compared to the non-Indigenous cases (23) • A higher proportion of First Nations cases were hospitalised compared to non-Indigenous cases (27% versus 10%) (8)
ICU admission	• RR for ICU admission was 5.2 for First Nations population compared to non-Indigenous population (25) • RR for ICU admission was 3.7 for First Nations population compared to non-Indigenous population (23) • RR for ICU admission was 6.2 for First Nations population compared to non-Indigenous population (27) • ICU admission rate for First Nations population was 9.1 per 100,000 population compared to 2.3 population for the non-Indigenous population. RR 3.9, standardised morbidity ratio 4.0 (29) • ICU admission rate for First Nations population was 15 per 100,000 population compared to 3 per 100,000 population for the non-Indigenous population. RR 5.5, standardised morbidity ratio was 7.3 (26) • ICU admission rate for First Nations population was 9 per 100,000 population, RR 3.1 compared to non-Indigenous population (32) • No difference in proportion of hospitalised patients admitted to ICU/SCU who were First Nations versus non-Indigenous (28)

	• First Nations status was not significantly associated with ICU admission among hospitalised cases (25) • Difference between observed and predicted rates of ICU admission for the First Nations population of 10.9 per 100,000 for Influenza only, 17.2 for influenza/pneumonia and 17.0 for all respiratory (30)
Death	• First Nations death rate was 3 per 100,000 population compared to 0.6 per 100,000 population for the non-Indigenous population. RR 5.6, standardised mortality ratio 4.5 (29) • First Nations death rate was 4 per 100,000 population compared to 0.8 per 100,000 population for the non-Indigenous population. RR 4.6 standardised mortality ratio 7.6 (26) • First Nations death rate was 3 per 100,000 population, RR 4.7 compared to non-Indigenous population (32) • RR for death for First Nations population was 3.2 compared to the non-Indigenous population (23) • RR of death for First Nations Australians was 5.2 compared to the non-Indigenous population (27)
Interventions	
Antiviral use	• A higher proportion of First Nations cases were treated with antivirals versus non-Indigenous cases (73% vs 41%) (8) • A higher proportion of First Nations patients were treated with Oseltamivir versus non-Indigenous patients (94% vs 79%) (23) • There was no difference in antiviral administration for First Nations hospitalised cases and non-hospitalised First Nations cases (8)
Vaccination	• Estimated First Nations population pandemic A(H1N1) 2009 influenza vaccination uptake 19.5% versus 21.0% for the non-Indigenous population (34) • Estimated First Nations population pandemic A(H1N1) 2009 influenza vaccination uptake 20.0% versus 12.1% for the non-Indigenous population (35). • Influenza vaccination coverage (vaccine type not specified) amongst a cross section of pregnant First Nations women increased from 2.2% in the pre-pandemic period to 41% intra-pandemic period. No socio-demographics characteristics were associated with the likelihood of vaccination (maternal age, parity, medical condition, education, tobacco use or overcrowded living conditions) (24) • Non-hospitalised and hospitalised First Nations cases had similar levels of seasonal influenza vaccination (8)

1. Outcomes where a comparison group was provided

RR: relative risk; OR: Odds Ratio; ICU: Intensive Care Unit; SCU: Special Care Unit.

Interventions

Two studies reported on the use of antivirals (8, 23), with one study specifying Oseltamivir (23). Both studies compared antiviral use between First Nations and non-Indigenous cases and found that First Nations people were more likely to be treated with antivirals (8, 23). One study compared antiviral use between hospitalised and non-hospitalised First Nations cases and found no difference (8). Four studies reported on influenza vaccination status (8, 24, 34, 35). Two studies reported on the uptake of influenza A(H1N1) 2009 pandemic vaccine with one national study reporting similar levels of vaccination coverage and a WA based study indicating that the First Nations population had higher uptake compared to non-Indigenous population (34, 35). One study reported that there was no difference in vaccination coverage between First Nations hospitalised and non-hospitalised cases (8). One study reported no sociodemographic variables were associated with vaccination uptake amongst First Nations pregnant women (24).

Engagement

None of the included studies documented processes for engagement or consultation with First Nations individuals, communities or health services regarding the study design, data collection, analysis, interpretation and reporting before the pandemic commenced. One study, Rudge and Massey (2010), reported on the collaboration between NSW Health and the Aboriginal Community-Controlled Health Sector, that preceded pandemic and was further strengthened through the urgency of the situation (29). The study highlights the value of the existing collaboration in enabling speedy access to six different First Nations communities to gain insights into what these communities needed on the ground at that time. While this consultation was not done prior to the 2009 pandemic, it provided invaluable recommendations from First Nations communities during the pandemic. None of the other 12 studies that met the inclusion criteria included any further information on community engagement, consultation or cultural governance.

Discussion

We found a small number of studies that reported outcomes for First Nations populations, a key risk group, during the influenza A(H1N1) 2009 pandemic. Largely these studies used secondary data and reported on outcomes relating to severity (hospital and/or ICU admission), and comorbidities and other risk factors (e.g. pregnancy). Most of the studies had a small number of First Nations participants, which may have reduced the ability to statistically identify differences in outcomes, particularly when stratified by sub-groups (e.g. by hospital/ICU admission status). Further, the study with the largest number of First Nations participants (n=3,966) also had the lowest completeness for First Nations status which may have resulted in conservative estimates of the impact for First Nations peoples (26).

The majority of the studies undertook univariable analyses of outcomes by First Nations status. There would be benefits to more complex analyses that sought to understand the contributing factors to the higher frequency and severity of disease observed amongst First Nations populations. While First Nations status was a risk factor in the severity of disease in univariable analysis in the studies in this review, multivariable analysis in two studies identified that being First Nations was not a risk factor for hospitalisation when chronic conditions were considered nor were they at higher risk of ICU admission when initial signs and investigations at hospital admission were considered (8, 25). Further, it is difficult to understand the causes for the higher rates of notification among First Nations peoples as testing rates were not included in any of the studies. Such understanding during infectious disease emergencies may help inform more nuanced clinical and public health responses, for example, special considerations for First Nations with chronic diseases.

No study reported on transmission outcomes for First Nations populations. There are multiple factors that may contribute to differences in transmission of infectious diseases within First Nations populations, compared to non-Indigenous populations, such as frequent travel and inadequate housing infrastructure, which results in crowded housing (36-38). Household transmission studies where data are collected on cases and their household contacts can allow description of transmission and severity across the spectrum of clinical presentation (39). Such studies could be considered for future infectious disease events for First Nations populations. Acknowledging the differences in household structures for First Nations peoples, visual tools such as a magnetic boards have been developed to assist with defining the household structures for studies (40).

There was limited reporting on interventions by First Nations status. The clinical interventions reported on were antiviral use and vaccination status. Goggin (2011) reported on both antiviral use and vaccination status in a state-wide study (WA) (8). The other studies on antiviral use and vaccination status were small, sub-state studies. Use of clinical and public health interventions may vary by both First Nations status as well as by location. This is evident with higher uptake of seasonal influenza immunisation amongst First Nations populations compared to non-Indigenous populations, although coverage is still sub-optimal (41, 42). No study reported on use of non-pharmaceutical interventions, such as isolation. While participatory action research had been conducted to identify public health interventions to reduce transmission, the implementation and evaluation of these interventions has not been documented (43). Ideally, public health responders around Australia will need to know the uptake and effectiveness of interventions during an

infectious disease emergency specifically for the populations which they serve.

Only one study referred to any level of engagement with First Nations populations, specifically Aboriginal Community Controlled Health Service Organisations. Further, this was for the response rather than the study design, analysis and interpretation of the data presented (29). Rudge (2010) cited the need for meaningful and extensive consultation with First Nations communities and community-controlled health services across Australia as not only important, but paramount to ensuring the same over-representation of disease during a pandemic does not happen again (29). Preferably this engagement builds upon existing relationships, rather than study specific relationships, and involves active participation of First Nations communities and health services (43-45). While engagement may have occurred in other studies, but was not documented, we argue that the description of the engagement with First Nations individuals, health services and communities in studies of infectious disease emergencies is an integral part of the methodology and should be documented to encourage best practice.

There are several limitations with our study. Firstly, we only reviewed publicly available studies. Online situation reports produced by the Commonwealth Department of Health may have provided additional information but were no longer available at the time of this study. Further, additional studies may have been available to responders that was not made publicly available. Secondly, while the focus of the review was on data collected related to influenza A(H1N1) pandemic cases, the publication of some studies occurred well after the pandemic. If the results of these studies were not available to responders at the time of the pandemic, it would indicate that the information for responders was even more limited.

Conclusion

A decade on from the 2009 influenza pandemic, and in the midst of the COVID-19 pandemic, a protocol for enhanced data collection, a FFX study, for the general population has been developed by the World Health Organization and is to be implemented in Australia (prospective study of confirmed COVID-19 cases and their close contacts, aiming to collect real-time data on clinical, virological, and epidemiological characteristics of cases) (46). This protocol may only include a small number of First Nation COVID-19 cases, making analyses of outcomes by First Nations status difficult. Such studies for First Nations peoples are required for participatory development of responses that are evidence-based. As our study has demonstrated, we cannot rely on routine data collection on COVID-19 or ad-hoc research studies to ensure adequate data are collected on all outcomes to inform the response for COVID-19 within First Nations populations. To ensure that appropriate responses to COVID-19, or any other an infectious disease emergency within the First Nations populations in Australia, adequate engagement and participation, as defined by First Nations peoples, in all steps of enhanced surveillance studies (design, implementation, analysis, interpretation and reporting) is required.

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How to cite this article: Gall A, Law C, Massey P, Crooks K, Andrews R & Field E. Outcomes Reported for Australian First Nation Populations for the Influenza A(H1N1) 2009 Pandemic and Lessons for Future Infectious Disease Emergencies: a Systematic Review. *Global Biosecurity, 2020; 1(4).*

Published: July 2020

Global Biosecurity is a peer-reviewed open access journal published by University of New South Wales.