A Summary of Influenza Surveillance Systems in Australia, 2015

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Executive Summary

The World Health Organization (WHO) estimates that worldwide 5-15% of the population are affected by influenza each year, with between three to five million cases of severe illness and about 250,000 to 500,000 deaths.[1] In Australia, it has been estimated that influenza is associated with 366 respiratory and 1,400 all-cause deaths,[2] 18,000 hospitalisations and over 300,000 general practice consultations[3] each year.

The morbidity, mortality and subsequent economic costs of influenza vary from year to year, in large part due to changes in the predominant circulating type and subtypes. Ongoing surveillance of influenza is important due to the variations in the severity, timing, circulating strains and vaccine composition each season. Surveillance of these factors contributes to a better understanding of the potential impact of an influenza season or outbreak and guides public health prevention and control activities.

Coordinated national or regional influenza surveillance and reporting schemes exist in a number of countries, including Australia. In Australia, the National Influenza Surveillance Scheme[4] began in 1994, with the objectives to:

- ensure the early detection of influenza epidemics;
- trigger public health prevention and control activities;
- characterise the epidemic, especially identification of risk groups and disease severity;
- estimate the impact of the epidemic;
- characterise the circulating viruses to inform vaccine virus selection and assess the effectiveness of influenza vaccines and antiviral medications; and
- ensure flexibility to enable adaptability for responding to additional surveillance requirements during a pandemic or particularly severe season.

The National Influenza Surveillance Scheme is supported by a number of surveillance systems that aim to be nationally representative and monitor important aspects of severity, incidence and virology. These systems capture influenza activity in the community, GP clinics, emergency departments and hospitals, as well as influenza-associated mortality.

Over time, the systems used in reporting for the National Influenza Surveillance Scheme have changed to enable a better understanding of influenza activity and severity in the community, and

to inform public health action. To ensure the continued effectiveness and informative value of the National Influenza Surveillance Scheme, this paper provides a comprehensive summary of the influenza surveillance systems operating in Australia as at 2015. The paper also describes the strengths and limitations of these systems in terms of the aspect of influenza activity that they inform and their contribution to the overall monitoring of influenza activity in Australia.

1 Introduction

Influenza is an acute viral illness that mainly affects the respiratory system. Influenza epidemics can cause substantial mortality and can take an economic toll through lost workforce productivity and strained health services. The World Health Organization (WHO) estimates that worldwide 5-15% of the population are affected by influenza each year, with between three and five million cases of severe illness and about 250,000 to 500,000 deaths.[1] In Australia, it has been estimated that influenza is associated with 366 respiratory and 1,400 all-cause deaths,[2] 18,000 hospitalisations and over 300,000 general practice consultations per annum.[3] Respiratory complications arising as a result of influenza infection include bronchitis, pneumonitis, secondary bacterial pneumonia and exacerbations of existing chronic respiratory conditions.[5, 6] Non-respiratory complications include: cardiovascular complications, including myocarditis and pericarditis; renal complications; Reye's syndrome; neurological sequelae, including Guillain-Barre syndrome and post infectious encephalitis; febrile convulsions; otitis media; myositis and myoglobinuria; and various haematological abnormalities.[5, 6, 7]

The age groups at greatest risk of developing severe complications are children aged less than 5 years and adults aged 65 years and over. These groups experience the highest mortality and hospitalisation rates.[8, 9, 10, 11] Other groups at high risk are Aboriginal and Torres Strait Islander peoples, and people with specific medical conditions,[12, 13] including cardiac disease, chronic respiratory conditions, chronic neurological conditions, immunocompromising conditions, diabetes and other metabolic disorders, chronic renal disease, haemoglobinopathies, Down syndrome, significant obesity, pregnant women and children (aged 6 months to 10 years) on long-term aspirin therapy.

Economically, influenza costs society directly through health care costs and indirectly though productivity losses due to absenteeism arising from increased illness and increased mortality rates [14]. Children may disproportionately contribute to the economic costs of influenza illness as they

have the highest rates of infection and complications arising from infection and are therefore more likely to be hospitalised,[11] resulting in significant costs to the health care system.[15, 16, 17, 18, 19] These costs may nearly double if the child has a high risk condition.[20] In addition, illness in children contributes to indirect costs through parental absenteeism.[21, 22, 23]

The morbidity, mortality and subsequent economic costs of influenza vary from year to year, in large part due to changes in the predominant circulating type and subtypes. Two main influenza types result in clinical disease in humans, namely influenza A and B. Influenza A is further subtyped based on the surface proteins, haemagglutinin (H) and neuraminidase (N), and currently two subtypes circulate in humans: A(H1N1) and A(H3N2). In general, seasons during which A(H3N2) circulates result in higher numbers of influenza notifications, hospitalisations and deaths compared with other years. This was the case in Australia in 2007 and 2012. Conversely, seasons during which influenza B circulates tend to result in lower reported morbidity.

Although the immune system generates antibodies to influenza after infection, and this provides some protection against reinfection by the same or a similar strain, people can be reinfected with influenza many times. Frequent mutations in the surface antigens – *antigenic drift* – mean that antibodies are eventually unable to recognise and neutralise the virus, resulting in infection. In general, the population is comprised of a mix of susceptible and immune people. Very occasionally, the virus undergoes a major *antigenic shift*, where changes in the virus are so great that most people have no immunity to the virus and these major changes result in a pandemic. This was the case in 2009, when a new A(H1N1) virus emerged which contained a new combination of genes from American pigs, Eurasian pigs, birds and humans.

Influenza vaccines have been available since the 1940s. In 2015, the majority of vaccines used in Australia contained three strains of virus, two influenza A subtypes and one influenza B lineage (i.e. trivalent influenza vaccine), representing currently circulating viruses. Additionally, in 2015 quadrivalent influenza vaccines (QIV) containing four influenza virus strains (including an additional influenza B virus strain from the other circulating B lineage) became registered for use in Australia and were available on the private market.[6] As the vaccine induces antibodies directed mainly against the viral haemagglutinin, its strain composition needs to be updated frequently to keep up with antigenic drift. The recommendation of suitable strains is made annually for each hemisphere by the WHO and in Australia this is considered in October by the Australian Influenza Vaccine Committee (AIVC) of the Australian Government's Therapeutic Goods Administration.

Vaccination is one of the most important and practical measures for preventing and attenuating the burden of influenza,[24, 25] despite the need for repeated administration. Many countries have established publicly-funded influenza vaccination programs that target high risk groups. As part of the Immunise Australia Program, the Australian Government recommends that routine influenza vaccination is considered for anyone aged ≥ 6 months who wishes to reduce the likelihood of becoming ill with influenza.[12] The vaccine is actively promoted, and fully-funded under the National Immunisation Program, for selected groups at increased risk of severe complications as a result of influenza infection.[12]

1.1 Coordinated influenza surveillance systems

Ongoing surveillance of influenza is important due to the variations in the severity, timing, circulating strains and vaccine composition each season. Surveillance of these factors contributes to a better understanding of the potential impact of an influenza season or outbreak and guides public health prevention and control activities.

Co-ordinated national or regional influenza surveillance schemes exist in a number of countries. For example, in the United States, the Centers for Diseases Control and Prevention[26] co-ordinates a collaborative surveillance system including health departments, public health and clinical laboratories, vital statistics offices, health care providers, clinics and emergency departments. Surveillance is conducted year round and includes influenza-associated paediatric mortality and human infection with novel influenza A viruses. Aggregate data on influenza cases are also reported through an extensive laboratory network. A variety of data summaries and reports are available online, including *FluView*[27] which is produced weekly from October to May. In the United Kingdom, the Influenza Surveillance Section of Public Health England co-ordinates influenza surveillance using data from a variety of sources in collaboration with similar agencies in Scotland, Wales and Northern Ireland. Influenza is not a notifiable condition in the United Kingdom.[28] Several data sources are used to understand influenza activity including clinical, microbiological, disease severity and mortality data. Various reports are available online. Similarly, the European Centre for Disease Control (ECDC) coordinates influenza surveillance for Europe. Data are obtained from clinicians, epidemiologists and virologists in 53 member countries covering a population of 896 million people. Comprehensive interactive reports are published weekly online.[29] These systems provide valuable information for public health action during influenza seasons and pandemics.

1.2 Purpose of this document

Australia has a coordinated National Influenza Surveillance Scheme, but at the time of writing, a comprehensive summary of the components of this scheme did not exist. To that end, the objectives of this paper are to:

- describe the range of surveillance systems that monitor influenza in Australia, as of 2015;
- describe strengths and limitations of these systems that contribute to the National Influenza Surveillance Scheme; and
- assess the overall surveillance picture and identify existing gaps.

2 National Influenza Surveillance Scheme

The National Influenza Surveillance Scheme began in 1994, when the previous influenza activity reporting from the Laboratory Virology and Serology Reporting Scheme was expanded to include information from several other already established national and jurisdictional surveillance systems to measure influenza activity.[4] The objectives of the scheme are to:

- ensure the early detection of influenza epidemics;
- trigger public health prevention and control activities;
- characterise the epidemic, especially identification of risk groups and disease severity;
- estimate the impact of the epidemic;
- characterise the circulating viruses to inform vaccine virus selection and assess the effectiveness of antiviral medications; and
- ensure flexibility to enable adaptability for responding to additional surveillance requirements during a pandemic or particularly severe season.

Over time, the datasets used in reporting for the National Influenza Surveillance Scheme have changed to enable a better understanding of influenza activity and severity in the community.

The 2007 and 2009 influenza seasons tested Australia's influenza surveillance systems, especially in terms of the types of data collected and the sustainability of data collection. These seasons demonstrated not only the value of existing systems, but also the challenges and complexities involved in ensuring that accurate and meaningful information is able to be provided in a timely manner. Following the 2007 influenza season, the *Enhanced Influenza Surveillance Framework for Australia* was developed by the Communicable Diseases Network Australia (CDNA).[30] In order to

oversee the process of 'enhancing' influenza surveillance for Australia, CDNA created the Seasonal Influenza Surveillance Strategy Working Group, which in 2014 became an ongoing subcommittee of CDNA known as the National Influenza Surveillance Committee (NISC). Outcomes of the 2009 pandemic further supported the need for enhancements to routine surveillance activities and for ensuring scalability during a pandemic. One recommendation from the 2009 pandemic response review was to develop surveillance systems that have the capacity to be up scaled rapidly in response to unexpectedly high influenza activity. This also ensures that there are pre-established links to other existing influenza surveillance systems and that there are established reporting protocols and procedures in place.

Membership of NISC comprises representatives from the Commonwealth and state and territory government surveillance departments, laboratories and other non-government entities such as sentinel hospital and GP surveillance networks. The overall aim of the NISC is to improve national and regional influenza surveillance systems in order to provide high-quality and timely information on influenza activity, and to better prepare and support Australian health systems for influenza epidemics and pandemics. NISC's work encompasses surveillance related to syndromes, virology, laboratory testing practices, healthcare utilisation, morbidity and mortality; and includes the evaluation and improvement of the performance, integration and reporting of diverse influenza surveillance activities. Its aims are achieved through the activities of its members working within their own organisations and through the provision of recommendations to CDNA. Specifically, the objectives of the surveillance committee are to:

- develop and maintain effective, responsive and scalable national influenza surveillance systems;
- promote consistency in influenza surveillance across jurisdictions and systems;
- characterise the severity and burden of seasonal influenza epidemics and pandemics; and
- develop and maintain a system that informs the understanding of the early clinical, epidemiological, transmission and virological parameters in an influenza pandemic.

The *Enhanced Influenza Surveillance Framework for Australia*[30] and the subsequent work of NISC has focussed on providing:

- baseline and timely death data;
- vaccination status of cases and estimates of vaccine effectiveness;
- detailed typing data on influenza viruses;
- protocols for laboratory testing to ensure results are representative of the national picture;

- virological surveillance data; and
- timely clinical information on unusual influenza or severe influenza illness.

This intelligence is used to guide the appropriate public health response, including the development of guidelines on vaccination and antiviral treatment and a needs assessment of clinical and health service resources.

In Australia, influenza activity and severity are monitored using a number of indicators collected by a series of complementary surveillance schemes. These are summarised in Table 1 and described in this report.

During the influenza season, which generally extends from May to October each year, the Australian Government Department of Health (AGDH) compiles data from each of these surveillance systems and publishes the *Australian Influenza Surveillance Report* on the AGDH website each fortnight. These reports also include international surveillance data. An annual surveillance report, which includes influenza surveillance system summary data is published in the *Communicable Diseases Intelligence* journal.[31]

Table 1. Sources of ILI and influenza surveillance data in 2015

Aspect of influenza surveillance	Influenza-like illness (ILI)	Laboratory-confirmed Influenza
Notifications		National Notifiable Disease Surveillance System (NNDSS)
Community (non-medically attended)	National Health Call Centre Network (NHCCN)* FluTracking Absenteeism†	
General practitioner (GP)	Australian Sentinel Practices Research Network (ASPREN) Sentinel Practitioners Network of WA (SPN(WA)) Victorian Sentinel Practice Influenza Network (VicSPIN) National Home Doctor Service (Vic data) Electronic General Practice Surveillance (eGPS) (NSW)	ASPREN SPN(WA) VicSPIN
Emergency department (ED) presentations	ED presentations (NSW, NT, Qld, SA, WA)	ED presentations (WA) Children's WA Influenza Vaccine Effectiveness (WAIVE) Study
Hospitalisation General admission	ED admissions (NSW, WA)	Influenza Complications Alert Network (FluCAN) Qld EpiLog WA hospitalisation data Australian Paediatric Surveillance Unit (APSU) Paediatric Enhanced Disease Surveillance (PAEDS)‡ Children's WA Influenza Vaccine Effectiveness (WAIVE) Study
Admissions to critical care	ED admissions (NSW)	FluCAN Australian and New Zealand Intensive Care Society (ANZICS)‡
Mortality	State and territory Births, Deaths and Marriages (BDM) Registries (ACT,NSW,NT,SA,WA) National death data (incorporating data from state and territory BDM Registries)	NNDSS - nationally notified influenza-associated deaths Autopsy surveillance (WA) Linkage of influenza notification data to state and territory BDM Registries (SA, NT, ACT)
Laboratory/Virology		WHO Collaborating Centre for Reference and Research on Influenza (WHO CC) Percent positive laboratory test reporting (National Influenza Centres (NICs) in NSW, Vic, WA; and laboratories in Qld, Tas)

Notes: *not available from mid-2015; †not active in 2015; ‡not routinely available; ACT: Australian Capital Territory, NSW: New South Wales, NT: Northern Territory, Qld: Queensland, SA: South Australia, Tas: Tasmania, Vic: Victoria, WA: Western Australia

3 National Notifiable Diseases Surveillance System (NNDSS)

The primary system for surveillance of communicable diseases in Australia is the National Notifiable Diseases Surveillance System (NNDSS). It was established in 1990 and is a passive surveillance system. In 2001, laboratory confirmed influenza became nationally notifiable in all jurisdictions, except in the Australian Capital Territory and South Australia where it became notifiable in 2004 and 2008 respectively.

Notifications are initially made to the state or territory health authority by treating clinicians, diagnostic laboratories or hospitals under the provisions of jurisdictional public health legislation. A summary of the source of jurisdictional notification data is provided in Table 2. Electronic, de-identified unit records (case-level data) of notifications in each jurisdiction are supplied to the NNDSS on a daily basis. There are nationally agreed case definitions and national core data specifications for reporting these notifications to ensure consistency in the definition of an influenza case and also, high quality and interpretable information on cases for analysis.

Table 2. Sources of notification data by jurisdiction, 2015

Jurisdiction	Laboratory notification	Medical Practitioner notification
ACT	Yes	Yes
NSW	Yes	No
NT	Yes	No
Qld	Yes	No
SA	Yes	Yes
Tas	Yes	No
Vic	Yes	Yes
WA	Yes	Yes

ACT: Australian Capital Territory, NSW: New South Wales, NT: Northern Territory, Qld: Queensland, SA: South Australia, Tas: Tasmania, Vic: Victoria, WA: Western Australia

Notifications data provided to the NNDSS require completion of the following mandatory fields for each disease record: a unique record reference number, state or territory identifier, disease code and date of notification to the relevant health authority.[32] The following fields are also provided where available: date of onset, specimen date, laboratory diagnosis method, influenza type and subtype, sex, date of birth, age, Indigenous status, and postcode of residence. Additionally the national core data specifications enable the capture of other fields, where relevant or the information is available (for example through case follow-up), which include how the case was identified, the date and type of vaccines given, place of acquisition, outbreak reference,

hospitalisation status, and, if the patient died, whether their death was attributable to influenza. The collection, provision and completeness of these additional fields in the NNDSS are highly dependent on the level of case follow-up or data linkage within each jurisdiction.

NNDSS data are publicly available online and contain basic aggregated epidemiological information. These data can be downloaded from the AGDH website, broken down by state and territory, age group, sex, month and year of diagnosis, number of cases and a rate per 100,000 population.[i] Additionally, a line-listed public dataset of influenza notifications, which includes week of diagnosis, state, 5-year age group, sex, Indigenous status and influenza type/subtype, is available from 2009 onwards and is refreshed annually in July.[ii] Access to further disaggregated data for research and policy purposes can be requested from the AGDH. Individual jurisdictions also report notifiable disease surveillance data on their departmental websites – links to these jurisdictions are available on the AGDH website.[iii]

3.1 Strengths and limitations

Notifications data are the primary source of influenza activity data across Australia. However, these data represent only the proportion of cases who seek medical care, have a test performed, have a diagnosis made, and where notification is made to health authorities. The quality and completeness of data compiled in the NNDSS are strongly influenced by the healthcare seeking behaviours of patients, testing and notification practices and follow-up by jurisdictional health departments.

The proportion of infected individuals tested is unknown and likely varies by season and jurisdiction. Changes to testing policies, preferential testing of high risk populations, the use of less invasive and more sensitive diagnostic tests, periodic awareness campaigns and media may all influence the number of notifications received at a particular point in time. To the extent possible, these factors must be considered when interpreting the data.[33]

A further vulnerability of the system is its reliance on notifications from treating clinicians, diagnostic laboratories or hospitals. Laboratory notification is the minimum requirement across all jurisdictions. Legislation in some jurisdictions requires dual laboratory and medical notification. However nationally medical notification data for influenza are incomplete.

[i] NNDSS Summary data: http://www.health.gov.au/nndssdata
[ii] NNDSS Influenza (laboratory confirmed) Public dataset: http://www9.health.gov.au/cda/source/pub_influ.cfm
[iii] NNDSS Influenza webpage: http://www.health.gov.au/flureport

To overcome these problems, notification data within the National Influenza Surveillance Scheme are complemented by a number of other sentinel surveillance systems that provide more detailed information on the severity of influenza activity as well as the virological characteristics. These systems describe the spectrum of influenza disease by age group, geographic area, or high-risk status.

4 Community surveillance (non-medical): Influenza-like illness

Influenza-like illness (ILI) is generally characterised by fever, cough, fatigue, sore throat or some other combination of these symptoms.[34, 35] ILI has generally been used as a proxy measure for influenza activity in the community although these symptoms are common to many respiratory infections and were commonly used as an outcome of interest in the earliest vaccine trials.[36, 37] Several community-based ILI reporting systems are used to capture non-medically attended ILI.

4.1 FluTracking

FluTracking[iv] is an online health surveillance system established to detect epidemics of influenza[38, 39] and monitor the transmission and severity of ILI across Australia. Participants respond to a brief weekly email survey regarding ILI that they, or their household members, experienced during the previous week. Figure 1 provides a screenshot of a typical FluTracking survey for a participant with cough and fever, time absent from normal duties and receipt of medical care.

Established in 2006, the Australia-wide system has grown to over 27,000 participants, with over 23,000 completing the survey each week during the 2015 season. At the beginning of each influenza season, the FluTracking organisers promote participation through a number of mechanisms including emails to previous season participants encouraging them to invite their friends to join the survey; and, health department and other large company promotion of the survey through staff email distribution lists, intranet sites and their social media profiles. In addition, the FluTracking website and associated social media profiles (eg. Twitter and Facebook) are also used to encourage community participation.

FluTracking asks participants about their vaccination status, permitting estimation of vaccine effectiveness against ILI (but not influenza).[40] Where a participant reports compatible ILI symptoms, FluTracking also collects information on health seeking behaviour. This enables a burden of illness pyramid to be constructed that describes the relative proportion of FluTracking

[iv] FluTracking (www.flutracking.net)

participants who report cough and fever that seek health care, are hospitalised, or receive a (self-reported) clinical or laboratory confirmed diagnosis of influenza.

Summary FluTracking data are reported in the *Communicable Diseases Intelligence* journal annually and have been the subject of several peer-reviewed papers in the international literature.

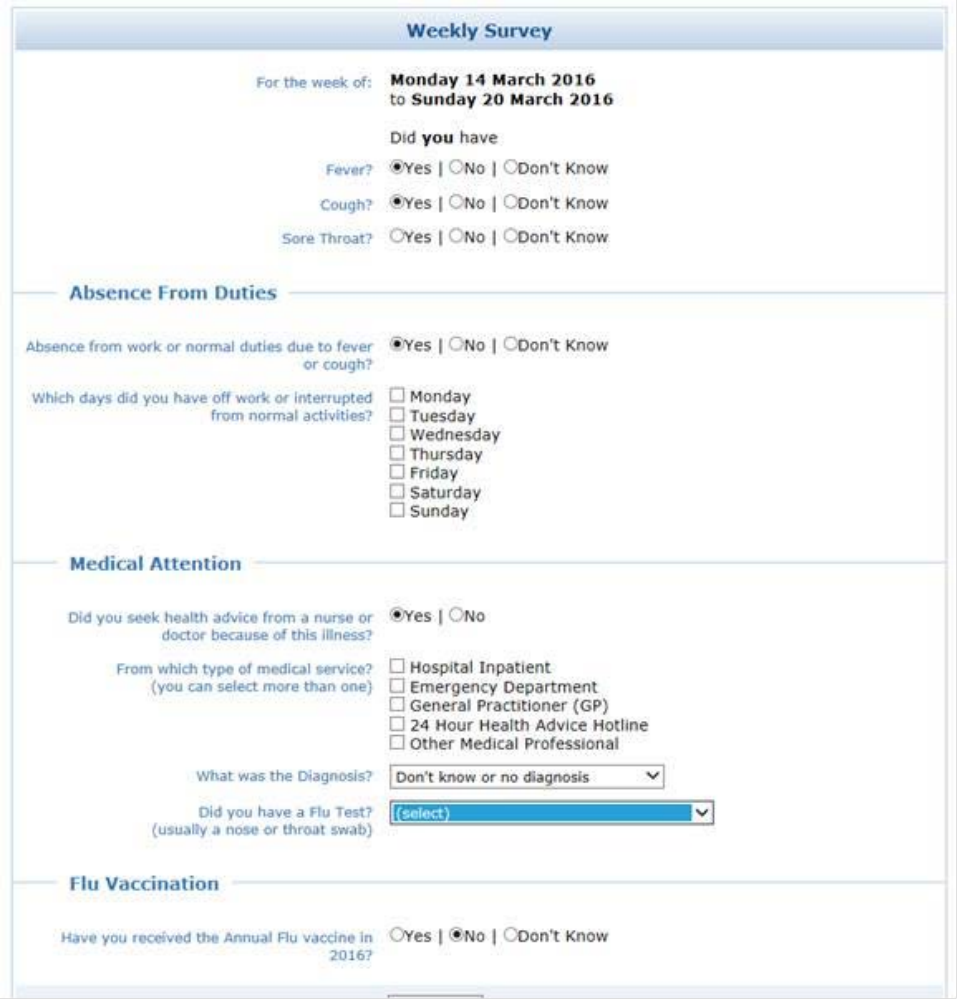

Figure 1. Screenshot of typical FluTracking survey

4.2 National Health Call Centre Network (NHCCN)

The National Health Call Centre Network (NHCCN) commenced national service delivery in July 2007 under the name *healthdirect Australia* and is an initiative of the Council of Australian Governments. The NHCCN provides free health triage advice and information services by telephone, and is available to the general public 24 hours a day, 7 days a week. Since 2012, over 640,000 calls per annum have been received and managed by the network. Registered nurses are supported by electronic decision support software and algorithms to provide advice and to triage callers. The network also has the capacity to support add-on services to assist in health threats and emergency situations. In 2015, the network was operational in all jurisdictions except Victoria and Queensland where locally-operated health call centres operated.

The NHCCN is able to provide de-identified data to the AGDH, including information about the caller's state of residence, age, Indigenous status, presenting issue, patient guideline (or diagnosis) and final triage disposition (e.g. 'go to the emergency department' etc.). More than 400 patient guidelines are available, of which the following subset have been used to define an ILI 'syndrome' for analysis in the Australian Influenza Surveillance Report:

- Colds (paediatric)
- Cough (paediatric)
- Cough (adult)
- Flu-like symptoms
- Flu-like symptoms, Pregnant
- Influenza A (H1N1) Swine Flu
- Influenza [Swine]
- Upper Respiratory Tract Infections / Colds
- Upper Respiratory Tract Infections / Colds: Pregnant

Up until mid-2015, call centre network data were provided to AGDH on a daily basis. Following a system change to the network's database, data have not been able to be received by AGDH due to system incompatibilities. Whilst data transfer incompatibilities have affected the continuity of reporting in the national Scheme, once these are resolved it is anticipated that there will be no impact on the continuity of the dataset as they continue to be collected by the NHCCN.

These data are a useful tool for monitoring community level ILI syndromic trends and have the potential to inform ILI severity analyses using the final triage disposition field.

4.2.1 Victoria 'Nurse-on-Call' service

Victoria has its own nurse-based phone triage system known as Nurse-on-Call. In 2013, an agreement was set in place to obtain weekly exports of influenza-like illness data from the Nurse-on-Call system on an ongoing basis. These data will be reviewed for usefulness and representativeness with a view to using it as a regular source of information on community-based influenza.

4.2.2 Queensland '13 Health' service

Queensland has a locally operated call centre ('13 Health'), which is available 24 hours a day. It is a state-wide service staffed by registered nurses, providing access to health advice, information, triage and referral.

The data collected by '13 Health' have not yet been reviewed for their usefulness as an adjunct to other ILI surveillance data sources.

4.3 Absenteeism Data

Up to 2010, a major nationwide government employer, representing around 33,000 employees; provided weekly line-listed absenteeism data to the AGDH. These data were used to calculate absenteeism, defined as an absence recorded as 'sick-leave' for three or more consecutive days, and were reported as a rate per 100 employees per week. In mid-2010 changes to the employer's human resources system meant they were no longer able to extract the data.

4.4 Strengths and limitations in community ILI surveillance

ILI surveillance was used during the 2009 H1N1 influenza pandemic to demonstrate that community attack rates for ILI were no higher than most other years. This provided a situational awareness suggesting that much of the increase in laboratory confirmed influenza tests was due to an increase in the fraction of community ILI cases presenting to medical practitioners coupled with increased testing of those patients.[41]

ILI is a non-specific indicator for influenza, and the illness reported may be due to a variety of pathogens, making it difficult to interpret. Thus, it is important to develop thresholds for signalling and scaling epidemic activity using historical data. FluTracking has operated for ten years and NHCCN for nine, so it may be possible to set baselines and thresholds for these data, since common methods for developing thresholds use at least five years of data.[35]

There are some differences between the data collected by FluTracking and NHCCN that hinder direct comparison and interpretation. Neither may be entirely representative of influenza activity, geographically or demographically. A large proportion of those reporting to FluTracking are healthcare workers, while NHCCN data may over represent calls regarding children and people with limited access to healthcare. Furthermore, participants from New South Wales were initially overrepresented in FluTracking and while this bias has reduced, representation from each jurisdiction is not uniform. Additionally, the NHCCN does not include data for Victoria and Queensland. While data are collected by locally operated services in these jurisdictions they have not been evaluated to determine their usefulness as an indicator of ILI activity either locally or at the national level. The case definitions used to define ILI differ between FluTracking and the NHCCN. FluTracking is based on self-reports of cough and fever, while NHCCN cases are evaluated by a nurse via a telephone conversation and different symptoms are used to define ILI. The NHCCN

guidelines for diagnosis have not been updated in recent years and may need to be reviewed in light of current information to ensure the ILI subset used is still relevant.

Despite these limitations, the two systems provide complementary data for understanding and interpreting trends in influenza. Importantly, FluTracking has very high participant retention, which may be due to the simplicity and timing (Monday morning) of the questionnaire distribution.

Although NHCCN data are currently not able to be received by AGDH, the data continue to be collected and once data transfer incompatibilities are resolved, retrospective comparisons of activity should be possible.

Workplace absenteeism is a significant component of the economic costs of influenza. The inherent uncertainty in the proportion of absenteeism which can be attributed to influenza also contributes to the uncertainty of estimates of the economic burden of influenza. Although absenteeism data are no longer available for analysis, they provided a valuable tool for informing the potential workplace-level impacts associated with ILI, capturing both absences due to illness as well as carer absences. The level of absenteeism correlated well with laboratory-confirmed influenza notifications and the data were able to provide alerts of increased activity up to two weeks prior to other data sources.[42]

5 General practitioner sentinel surveillance: ILI and laboratory-confirmed influenza

Sentinel General Practitioner (GP) surveillance systems are a valuable source of data that enumerates incidents of medically-attended ILI and also includes laboratory-confirmed influenza. These data are used by health departments to establish baselines and thresholds that indicate the start and end of an influenza season, and signal elevated activity. In addition, when coupled with the collection of data about patients' vaccination status, these systems are used to estimate influenza vaccine effectiveness against medically-attended ILI. Multiple GP-based systems operate throughout Australia, as described below.

5.1 Australian Sentinel Practices Research Network (ASPREN)

The Australian Sentinel Practices Research Network (ASPREN) is a network of sentinel general practitioners run through the Royal Australian College of General Practitioners and the University of Adelaide. The system has collected de-identified information on ILI and other conditions seen in

general practice since 1991. ASPREN aims to provide an indicator of the burden of disease in the primary health care setting and to act as an early warning indicator in the event of an influenza pandemic.[31] In 2015, 211 GPs were enrolled Australia-wide and contributed data to the ASPREN sentinel surveillance system for influenza-like illness on a weekly basis. The system has limited coverage in Victoria (see 5.3) while Western Australia manages its surveillance autonomously (see 5.1.1).

The ILI case definition for inclusion in ASPREN includes history of fever, cough and fatigue. ASPREN GPs submit de-identified patient data on ILI throughout the year. Patient data can be submitted via one of three ways: the Canning Flu Tool, which allows for automated data extraction from patient records; a web-based form; or by paper-based return. The majority of GPs submit their data electronically, with almost two-thirds utilising the Canning Flu Tool and 30% utilising the web-based form; only a small proportion (2%) of GPs report using the paper based form. Participating GPs are eligible to receive continuing medical education points for their involvement and receive up to date, first-hand information about infectious disease trends around Australia on a fortnightly basis.

Laboratory testing of ILI cases was implemented in 2010, allowing for viral testing of around 20% of ILI patients. GPs, at their discretion, collect nasal samples using flocked swabs (Copan Diagnostics) and send them by express post to South Australia Pathology in Adelaide where the specimens are tested using a real-time reverse transcription polymerase chain reaction (RT-PCR)-based test for a panel of respiratory pathogens which include influenza A (unsubtyped), influenza A(H1N1)pdm09, influenza A(H3N2), influenza A(H5N1) and influenza B as well as adenoviruses, *Bordetella pertussis*, metapneumoviruses, *Mycoplasma pneumoniae*, para-influenza virus types 1, 2 and 3, respiratory syncytial virus, and rhinoviruses. All viable ASPREN influenza-positive samples are sent on to the WHO CC in Melbourne for more detailed analysis (see 9.2). Since 2010, data on the vaccination status of patients have also been collected permitting estimation of vaccine effectiveness.

5.1.1 Sentinel Practitioners Network of Western Australia SPN(WA)

Western Australia has conducted year-round surveillance of ILI at general practice sites since 2007 through the Sentinel Practitioners Network of Western Australia (SPN(WA)). SPN(WA) comprises 86 GPs who report weekly consultations for ILI, gastroenteritis, shingles, and chickenpox. GPs are paid for their participation in the network. Data on ILI consultations are collected using a modified

version of the ASPREN Canning Flu Tool (93% of GPs), and a small proportion report using the ASPREN web-based form (5% of GPs) and paper form (1% of GPs).

Around 85% of ILI patients have two nasal and one throat swabs collected for laboratory testing; and data on vaccination status, demographics and the existence of comorbidities that would increase a patient's risk of complications due to influenza are also collected by the GPs using a stamp on the pathology request form (Figure 2). The samples and pathology request form are forwarded to PathWest Laboratory Medicine, Western Australia (PathWest), where all laboratory testing is performed. Influenza positive samples are forwarded to the WHO CC for strain identification and molecular analysis (see 9.2). Vaccination and risk factor data can potentially be used to estimate vaccine effectiveness.

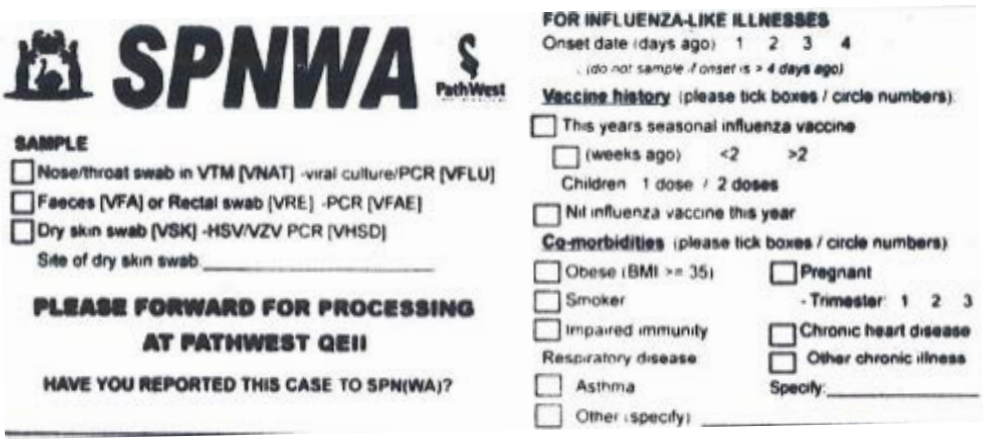

Figure 2. Data collection stamp for the Sentinel Practices Network of Western Australia (SPN(WA))

SPN(WA) data are forwarded regularly to ASPREN for inclusion in their reports and are included in the Australian Influenza Surveillance Report with ASPREN data. However, they are frequently reported separately noting that SPN(WA) data are heavily overrepresented in ASPREN data. SPN(WA) data are also reported in the newsletter Virus WAtch[v] along with emergency department data, laboratory results and notification data. Virus WAtch is distributed weekly to over 1,000 email addresses, including GPs, infectious disease physicians, public health officers, and media, with subscriptions open to the public[vi]. Vaccine effectiveness has also been estimated using data from this system.[43]

[v] Western Australia Virus WAtch (http://www.public.health.wa.gov.au/3/487/2/virus_watch_homepage.pm)
[vi] Western Australia Virus WAtch subscription email: virus.watch@health.wa.gov.au

5.2 Victorian Sentinel Practice Influenza Network (VicSPIN)

The Victorian Sentinel Practice Influenza Network (VicSPIN), is a sentinel general practice program for the surveillance of ILI in Victoria and has been coordinated by the Victorian Infectious Diseases Reference Laboratory (VIDRL) in partnership with the Victorian Government Department of Health and Human Services since 1993. GPs report the number of patients presenting with ILI and the total number of patients seen, and receive continuing medical education points for participating in the scheme. Ninety-five GPs contributed to the VicSPIN scheme in 2015.

Laboratory testing of a sample of ILI cases from the surveillance program commenced in 1998. Currently, GPs collect nasal or throat samples using flocked swabs in 3ml virus transport media and forward these to VIDRL by pre-paid express post packs for testing. Samples are tested by real-time RT-PCR for influenza A and B. If positive for influenza A, they are subsequently subtyped for A(H1N1)pdm09 or A(H3N2). All polymerase chain reaction (PCR) positive samples are then forwarded to the WHO CC for strain identification and molecular analysis (see 9.2). The proportion of ILI cases swabbed was initially around 40% prior to the 2009 pandemic, but since has remained steady at around 70%. Since 2007, the VicSPIN has collected information on the vaccination status of patients, permitting calculation of vaccine effectiveness estimates. This capacity was enhanced in 2011 when GPs were asked to supply additional information on clients considered high risk for severe complications of influenza—an important confounder of vaccine effectiveness.

During the surveillance period (weeks 18-44), VIDRL[vii] publishes a weekly report on laboratory-confirmed influenza data, as well as sentinel surveillance data from the VicSPIN and the Victorian component of the National Home Doctor Service (see 5.3). At the end of the surveillance period, all surveillance data (including notifications data) from Victoria are compiled into an annual report. Vaccine effectiveness estimates are published separately in an international journal.

5.3 Locum service data in Victoria: National Home Doctor Service (NHDS)

The Victorian component of the National Home Doctor Service (Vic NHDS), formally the Melbourne Medical Deputising Service, is an after-hours medical locum service which provides medical services to patients in their own home or aged care facility. Data from the locum medical service has contributed to Victorian influenza surveillance since 2003, through VIDRL. VIDRL monitors weekly rates of influenza-related diagnoses by over 159 Vic NHDS clinicians. ILI consultation data per 1,000 consultations are calculated from records returned from the Vic NHDS clinical database using the search terms ‘influenza’ and ‘flu’. To avoid inclusion of those who

[vii] Victorian VicSPIN report (http://www.vidrl.org.au/surveillance/influenza-surveillance)

present for influenza immunisation, records containing terms such as 'flu vax', 'at risk', 'vacc' and 'immunisation' are excluded from the rate calculation.

VIDRL provides a weekly line-list of these data to the Victorian Government Department of Health and publishes the ILI activity, as indicated by this system, in their weekly influenza surveillance reports. Whilst ILI data from this surveillance system are not formally reported as part of the national Scheme, these data are used to inform local influenza activity trends.

5.4 New South Wales Electronic General Practice Surveillance (eGPS)

GP-based ILI surveillance is conducted in New South Wales in three local health districts in the greater Sydney region: Northern Sydney, South Eastern Sydney and Illawarra Shoalhaven. During 2015 weekly reports were received from on average 11 sentinel practices. GP recruitment is limited to those GPs who use 'Best Practice' software to store patient information. The Canning tool developed by ASPREN (section 5.1) is used to perform a free-text search and extract information about ILI surveillance. The extracted data are sent to the local public health unit where a report is automatically generated using purpose-built software. Data are reported in the state's weekly influenza report. Whilst this report is forwarded to AGDH, surveillance data from this system are not routinely reported as part of the national Scheme, however information from this system is used to inform local influenza activity trend interpretations.

5.5 Strengths and limitations of GP surveillance

GP based surveillance systems are a valuable source of medically-attended ILI and influenza activity in the community. In particular, they can signal the start and severity of a season, particularly when combined with laboratory data. However these systems provide limited coverage of the population as they are generally biased towards working aged adults.[44] Moreover, while GP-based ILI and laboratory-confirmed influenza surveillance is present in all states and territories, there are three separate networks that collect these data. While some integration of these data occurs at the national level to inform the Australian Influenza Surveillance Report, data pooling is currently limited by several factors:

- SPN(WA) and VicSPIN are currently overrepresented in national reporting;
- Some Victorian GPs report ILI data to both ASPREN and VicSPIN, resulting in some double reporting;
- Information collected about patients differs slightly among the systems: e.g. VicSPIN and SPN(WA) collect information on the presence of any conditions predisposing the patient to severe influenza;

- VicSPIN does not test for non-influenza pathogens, while ASPREN and SPN(WA) do; however, the pathogens tested differ;
- The method of data collection differs between systems and may affect the quality of date collected, with ASPREN using a combination of web-based forms or data extraction methods, SPN(WA) using data extraction and a data collection stamp, and the VicSPIN using a data collection form; and
- ASPREN and SPN(WA) collect data year-round, while VicSPIN collects data during the period when influenza is most likely to be circulating (weeks 18-44).

The systems have begun to harmonise their data collection processes to aid data pooling and interpretation. Since 2014, these systems have used the same ILI case definition; collected the same types of information about vaccination status; and collected the same information about confounding factors to enable pooled estimates of influenza vaccine effectiveness. System harmonisation concerning data collection methods is ongoing.

6 Emergency Department Surveillance

Emergency Department (ED) surveillance systems are also useful for understanding the ILI burden in the community. Time series analyses show a correlation between ED ILI presentations and laboratory-confirmed influenza infections.[45] ED presentations can also provide a picture of ILI activity amongst the very old and very young, groups which may be underrepresented in GP surveillance.[44] Surveillance systems for ED ILI presentations are in place in New South Wales, the Northern Territory, Queensland, South Australia and Western Australia. A study in Western Australia additionally monitors influenza vaccine effectiveness in children based on ED ILI presentation. Data from the New South Wales, Northern Territory and Western Australian ED ILI presentation systems are formally included in the national Scheme, whilst data from the other ED surveillance systems are monitored to inform local influenza activity trends.

6.1 ED Surveillance in New South Wales

In 2003, a database of information on ILI presentations to 12 New South Wales hospital emergency departments (EDs) was established and has since grown to include 59 public hospitals capturing approximately 85% of metropolitan and 60% of rural ED presentations in New South Wales. Data are collected through the NSW Health Public Health Rapid Emergency Disease and Syndromic Surveillance System (PHREDSS) and reporting is by hospital, Local Health District and metropolitan/regional/rural aggregations across all of the 59 hospitals.

The database is updated by real-time data messages (Health Level 7 or HL7 protocol) or frequent batch files (file transfer protocol or FTP) generated and transferred by hospital patient management information systems. A daily reporting system interrogates the rapid surveillance database and is supplemented by historical data from the more slowly reported New South Wales ED administrative data collection. The reporting system produces daily and weekly presentation counts and statistical signals when those counts exceed certain thresholds compared with historical counts. System reports indicating unusual activity are manually reviewed every day, including weekends and public holidays, and signals assessed to be of potential public health concern are reported to health protection personnel at the state or regional level.

Influenza activity is monitored by the system using several methods. The most specific method is by monitoring the incidence of ED presentations that were assigned a primary provisional ED diagnosis of influenza or influenza-like illness. Depending on the type of information system used at the hospital, the diagnosis is reported as an International Classification of Diseases 9th or 10th revision (ICD-9 or ICD-10) code or a Systematized Nomenclature of Medicine – Clinical Terminology (SNOMED-CT) concept identifier. While few of these presentations would have had a laboratory confirmation for influenza, and many patients presenting to hospital with complications of influenza will be assigned other diagnoses, time series analysis shows a correlation between the incidence of these presentations and of laboratory-reported confirmed influenza infections,[46] as well as discrimination between the incidence of influenza and respiratory syncytial virus.[47]

The system also includes monitoring of broader ED diagnosis groupings relevant to influenza, including pneumonia; all respiratory illness; fever or unspecified infections (including 'unspecified viral infection'). For these, the impact of influenza epidemics is usually evident by comparing observed counts with usual background counts observed at the same time in other years. The system also includes analyses according to apparent severity. For example, an important grouping included in the system is influenza-like and pneumonia ED diagnoses that are admitted to a critical care ward. The system has a broad range of additional diagnosis groupings, ranging from gastroenteritis, through meningitis/encephalitis to drug and alcohol indicators.

ED presentations that involve influenza are automatically reported to the New South Wales Health Communicable Diseases Branch and included in their weekly, and monthly out of season, influenza report.[viii]

[viii] New South Wales Influenza Epidemiology Report
(http://www.health.nsw.gov.au/Infectious/Influenza/Pages/reports.aspx)

6.2 ED Surveillance in the Northern Territory

The ED surveillance system in the Northern Territory started in 2007 and covers the Royal Darwin, Gove District, Katherine District, Tennant Creek and Alice Springs hospitals. Several features make it very simple and cost-efficient:

- all hospitals in the Northern Territory have the same information system which includes a separate ED module;
- the ED module has fields for presenting complaint and discharge diagnoses;
- the presenting complaint field is not free text – it comprises a set list of values allowing the user to select only one per presentation;
- all data in the Northern Territory health department are stored in a central data warehouse; and
- there is one standard generic business intelligence tool to analyse the warehouse data.

Retrospective analysis comparing presenting complaints or discharge diagnoses to laboratory confirmed notifications revealed that the best correlations were from four presenting complaints: febrile illness, cough, respiratory infection and viral illness. These were grouped together to define 'influenza-like illness'.

Data from the ED module are abstracted once a day (overnight). An automated report of daily ILI presentations for each hospital is generated and communicated with each of the regional disease control units. This report is then linked to an Excel spreadsheet which updates a graph and creates a CuSum statistic for each hospital each day. The CuSum is the cumulative sum of the difference between the number of ILI presentations that day and the 'expected' number (which is the mean of the previous 28 days). This graph is examined daily for unusual activity; whilst there is no defined threshold, if a substantial increase in ILI activity is detected, public health units alert their local EDs and encourage testing of ILI cases for influenza. Additionally, combined NT ED ILI presentation data, including cases per 1,000 presentations are provided to the AGDH for analysis and inclusion in the Australian Influenza Surveillance Report.

6.3 ED Surveillance in Queensland

The Emergency Department Information System (EDIS) captures Queensland Health Emergency Department (ED) attendance data. In 2013 access to EDIS summary data, for public hospital presentations assigned ICD codes J11 – J18, was established by the Communicable Diseases Branch (CDB) within Queensland Health. Data are extracted weekly and a summary report including hospital name, diagnosis code, date of presentation, age, sex and departure status is

provided to the CDB. A detailed review of these data is yet to be undertaken, including the potential for future linkage of EDIS data with admitted patient data.

6.4 ED Surveillance in South Australia

Since 2001, the Communicable Disease Control Branch (CDCB) of South Australia Health has undertaken sentinel surveillance of influenza-like illness using data generated from ED presentations. During 2015 three hospital emergency departments participated - two tertiary metropolitan adult hospitals and one tertiary paediatric hospital. The health event under surveillance is clinically diagnosed influenza or ILI in patients presenting to the selected hospitals' ED, based on the ICD codes J11.0 (influenza with pneumonia) or J11.1 (influenza or influenza-like syndrome). ED database administrators extract clinical presentation data from hospital specific software (predominantly Hospital Administration Software Solutions-Emergency Department (HASS-ED)) on a weekly basis and provide data to the CDCB. Data are reported on the South Australia Health website on a weekly basis but are not included in the Australian Influenza Surveillance Report.[ix,x]

6.5 ED Surveillance in Western Australia

In July 2007 the Communicable Disease Control Directorate (CDCD) commenced Emergency Department Sentinel Surveillance (EDSS) using the Emergency Department Information System (EDIS). Presenting complaint codes are entered by triage nurses on first patient presentation whereas diagnosis codes are given to a patient once a diagnosis has been made by an attending medical officer. Nine public Perth metropolitan EDs and one regional hospital ED provide EDIS data to CDCD on a weekly basis. These hospitals include the major paediatric hospital (Princess Margaret Hospital) and adult teaching hospitals (Royal Perth Hospital, Fremantle Hospital and Sir Charles Gairdner Hospital) in Perth.

Records from EDIS are automatically downloaded each Monday morning at 5am for the previous week, ending midnight Sunday. Data collected from each EDIS entry include the patient's age and whether the patient was admitted for further treatment. This allows the analysis of non-admitted and admitted patient data. EDSS reports on three conditions: 1) respiratory viral presentations (upper respiratory tract infection [J06.9] and viraemia [B34.9]); 2) gastroenteritis (gastroenteritis

[ix] South Australian Health Weekly Epidemiological Summary (http://www.sahealth.sa.gov.au/wps/wcm/connect/public+content/sa+health+internet/resources/weekly+epidemiological+summary)

[x] South Australian Health Influenza Activity chart (http://www.sahealth.sa.gov.au/wps/wcm/connect/public+content/sa+health+internet/resources/influenza+in+south+australia)

presumed infectious [A09] and gastroenteritis viral [A08.5]); and 3) varicella (chicken pox [B01.9] and shingles [B02.9]). Analysis of previous years' data highlighted that some EDIS code usage was not consistent across hospitals or for particular age groups. The particular combination of codes chosen reduces the risk of hospital or age bias and has been found to have the highest correlations with notification and laboratory data for the viruses of interest: influenza, rotavirus and varicella, respectively.

EDSS results are reported weekly to the CDCD, and printed in Virus WAtch[xi], with graphical display throughout the year of the number and rate of hospital admissions among ILI patients; and during winter, of the proportion of ILI patients admitted to sentinel hospitals who are subsequently confirmed to have influenza infection during that admission. Additionally these data, including cases per 1,000 presentations are provided to the AGDH for analysis and inclusion in the Australian Influenza Surveillance Report.

6.6 Western Australian Influenza Vaccine Effectiveness (WAIVE) study

In 2008, the Western Australia Government commenced providing free influenza vaccination to all children aged 6-59 months in response to three influenza-related deaths among children in the previous season.[48, 49] Two vaccine manufacturers, CSL Biotherapies and Sanofi-Pasteur Ltd, donated vaccines for children in the metropolitan area and the Western Australian Department of Health provided vaccine for children in regional parts of the state. The Western Australia Influenza Vaccine Effectiveness (WAIVE) study was established in 2008 to monitor the impact of this program. As part of the initial study protocol, children aged 7 months to 5 years were recruited from the Emergency Department of Princess Margaret Hospital for Children and from GPs in both the Perth metropolitan area and Kalgoorlie (a rural area of Western Australia). Children presenting within 72 hours of the onset of ILI symptoms were swabbed and samples forwarded to PathWest for testing. Collection of demographic and comorbidity data permitted calculation of vaccine effectiveness against medically-attended influenza and hospitalisation. Due to poor recruitment, from 2009 onwards the WAIVE study was restricted to children presenting to the Princess Margaret Hospital for Children, and the period between onset of ILI symptoms and presentation was extended to within 96 hours of the onset of ILI symptoms. The study was active up until the end of 2015. Vaccine effectiveness monitoring and influenza associated paediatric hospitalisations continue to be monitored through the Influenza Complications Alert Network (FluCAN) surveillance system (see Section 7.2).

[xi] Western Australia Virus WAtch (http://www.public.health.wa.gov.au/3/487/2/virus_watch_homepage.pm)

Whilst data from this study were not routinely reported, positive cases were reported to the Western Australia Department of Health, as required by public health legislation, and their findings have also been reported in peer-reviewed papers.[48, 49, 50]

6.7 Strengths and limitations of emergency department surveillance

Current ED surveillance is limited by a number of issues. First, states vary in their choice of diagnosis codes and definitions used to enumerate the number of influenza or influenza-related emergency department presentations. Comparisons across jurisdictions are also limited due to the use of different data collection methods (Table 3). The recording of diagnosis information can vary between hospitals or hospital districts. Secondly, many patients with influenza may not be tested for influenza or test results may not be available until after the patient is discharged. Other codes that are used when the diagnosis is uncertain can be very vague, such as fever or unspecified viral infections. Thus, ED data may underestimate the true burden of influenza on ED presentations. Thirdly, ED surveillance (and hospital surveillance, described in Section 7) can be hindered by changes to hospital administrative information systems. For example, in South Australia with the progressive rollout to a new patient administration system, two of the original five hospitals included in ED ILI surveillance have moved to the new system and are no longer contributing data.

Table 3. ICD-10 diagnosis codes and other identifiers used in ED surveillance

State	ICD-10 codes used	Other coding systems used
NSW	J09-J11	ICD-9 and SNOMED CT*
NT		Diagnosis codes not used. Instead uses a list of presenting complaints from patient triage information.
Qld	J11-J18	
SA	J11.0, J11.1	
WA	J06.9, B34.9	

*Systematized Nomenclature of Medicine Clinical Terminology; NSW: New South Wales, NT: Northern Territory, Qld: Queensland, SA: South Australia, WA: Western Australia

Not all jurisdictions collect ED surveillance data, and in 2015 only three regularly reported their data for inclusion into the national Scheme: New South Wales, the Northern Territory and Western Australia. Guidance may be needed to harmonise the presentation codes abstracted to aid comparisons. EDIS software is used by many hospitals around the country, so in principle, it could be feasible to support ED surveillance across a wider group of hospitals. However, NSW

began the transition to a new information system, Cerner FirstNet, in 2007 and now only two of that state's hospitals use EDIS.[51]

7 Hospital admission surveillance

Surveillance for hospitalised cases of influenza is useful for gauging the severity of a season. Analysis of admitted patient data can provide an indication of expected bed occupancy, and hence impact on the health-care sector during an influenza season. This may be used to inform the establishment of baselines and thresholds to assist in assessing severity as a new season evolves. This type of surveillance is currently conducted throughout the country through either sentinel based networks nationally or at the jurisdictional level. Data from the Influenza Complications Alert Network (FluCAN), Queensland's EpiLog system and the Australian Paediatric Surveillance Unit are formally included and reported on in the national Scheme, whilst data from other hospital admission surveillance systems are monitored to inform local influenza activity trends.

7.1 Nationally Notified Influenza Associated Hospitalisations

Within the national notifications data on laboratory confirmed influenza that are reported to the NNDSS from states and territories, a field is available to record information on the hospitalisation status of the case. Whilst the field has been available since 2014, these data are currently not easily captured or of sufficient completeness for routine analysis.

7.2 Influenza Complications Alert Network (FluCAN)

The Influenza Complications Alert Network (FluCAN) provides hospital-based sentinel surveillance for severe influenza at 17 hospitals around Australia, representing approximately 12% of national hospital bed capacity. The system was first implemented in 2009 to fill the gap in reliable, comprehensive, consistent and rapidly available data on adult acute respiratory hospitalisations, including ICU admissions.[52, 53] There is at least one FluCAN site in each Australian state and territory. Since 2014 the system has included two paediatric hospital sites, with data on cases from these sites available from 2011. Additionally, since 2014 four community based hospitals, located in Victoria, Queensland, the Australian Capital Territory and the Northern Territory, have collected data on paediatric patients (Table 4).

Data are collected on patients with laboratory-confirmed influenza admitted to hospital, and the next test-negative control patient with an acute respiratory infection. These data are obtained from record review or patient interview. Information collected includes demographic details (age,

sex, Indigenous status), admission date, test date, influenza type and subtype, chronic medical comorbidities, ICU admission, vaccination status and mortality.

Standard case definitions are used for community-acquired pneumonia, influenza and comorbidities. Community-acquired pneumonia is based on onset prior to admission or within 48 hours of admission, confirmed by demonstration of consolidation on chest x-ray. Comorbidities are collected based on medical documentation and/or patient self-report and include diabetes, heart disease, chronic liver disease, and chronic respiratory disease. Influenza testing is initiated by the attending clinician and not paid for by FluCAN. Testing is by real-time RT-PCR for influenza A, B and A(H1N1)pdm09.

The collection of vaccination status for patients with laboratory-confirmed influenza admitted to hospital, and the next test-negative control patient with an acute respiratory infection permit the calculation of influenza vaccine effectiveness estimates against hospitalisation. Additionally the information collected can provide information on nosocomial influenza infections.[54]

During the influenza season, data are made available to national and jurisdictional health authorities in real time through a web-based line-listed database, with reports also issued weekly. Additionally, the overall epidemiology of influenza associated hospitalisations, as well as vaccine effectiveness in adults and children are reported separately and published annually in the *Communicable Diseases Intelligence* journal and international journals.

Table 4. Hospitals participating in FluCAN, 2015*

State	Hospital
ACT	Canberra Hospital†
	Calvary Hospital
NSW	John Hunter Hospital
	Westmead Hospital
	The Children's Hospital at Westmead*
NT	Alice Springs Hospital†
Qld	Cairns Base Hospital†
	Mater Hospital
	Princess Alexandra Hospital
SA	Royal Adelaide Hospital
Tas	Royal Hobart Hospital
Vic	The Alfred Hospital

State	Hospital
	University Hospital Geelong†
	Monash Medical Centre
	Royal Melbourne Hospital
WA	Royal Perth Hospital
	Princess Margaret Hospital for Children*

* Paediatric hospital site; †Community based hospital site also collecting data on paediatric patients.

ACT: Australian Capital Territory, NSW: New South Wales, NT: Northern Territory, Qld: Queensland, SA: South Australia, Tas: Tasmania, Vic: Victoria, WA: Western Australia.

7.3 New South Wales Hospitalisations Data

ILI ED presentations that result in hospital admission and admissions to intensive care through the ED are part of the NSW Health PHREDSS (see section 6.1). ILI admissions are identified using the disposition (discharge status) from the ED and the provisional diagnosis given on admission as an inpatient.

Additionally, admitted patient data collections can be analysed for influenza and pneumonia admissions but there can be some months' delay in coding of admission diagnoses, so these data are only useful for retrospective analyses and to inform public health responses. They are reported in the annual Chief Health Officer's Report, but are not included in the Australian Influenza Surveillance Report.

7.4 Queensland Public Hospital Admissions (EpiLog)

EpiLog is a web-based application that is used to register patients, presenting with ILI, that have been admitted to Queensland public hospitals. It was originally developed in-house during the 2009 influenza pandemic and has since undergone important enhancements.

Once a record has been created in the system, the EpiLog application is populated with demographic data (names, sex, date of birth, permanent address, temporary address, contact numbers, indigenous status) and hospital stay data (admission date and admission source, discharge date, discharge destination, transfer into and out of intensive care units). Most of these data items are obtained through an interface with the Hospital Based Corporate Information System (HBCIS) in Queensland public hospitals. EpiLog also has an interface with AUSLAB™, the information system used by the public laboratories in Queensland. This interface automatically registers an admitted patient, not already in EpiLog, if a test for influenza is ordered or a result received. Currently the number of laboratory confirmed influenza admissions are reported per 1,000 notifications.

When a HBCIS screen is filed, the HBCIS system generates and sends a message, containing patient and hospital stay related data, to a central system called e*GATE. HBCIS generates a range of different message types including patient registration, demographic updates, admissions, discharges and transfers. e*GATE forwards these messages to a central database (called ePADT), which maintains the patient demographics and a full history of the episodes and transfers during an inpatient stay. In this way, ePADT is kept up to date in near real-time with all changes made for patients in all HBCIS systems across the state.

When a patient's unit record number and hospital are entered into EpiLog, the application is able to automatically match these to the patient and hospital stay data in ePADT. The patient details in EpiLog come from ePADT and are updated within seconds of any changes in HBCIS. The AUSLAB™ interface automatically registers and/or updates patients' disease status based on electronic monitoring of influenza test requests and results.

The data in EpiLog can be searched using various combinations of data filters to edit records and produce data extracts for further analysis. In addition, a range of 'snap shot' reports with a date and time stamp can be produced. Summary data providing a profile of admission and occupancy by week are also available.

Data are reported weekly in the Queensland Health weekly influenza surveillance report[xii] during the season and an aggregated dataset are also provided to the AGDH.

7.5 Western Australia Hospitalisations Data

7.5.1 Emergency Department ILI admission data

As described in section 6.5, Western Australian hospitalisations are monitored for persons presenting with ILI to sentinel Emergency Departments. Data are provided weekly to the CDCD, and reported in the weekly Virus WAtch publication[xiii], with graphical display throughout the year of the number and rate of hospital admission among ILI patients; and during winter, of the proportion of ILI patients admitted to sentinel hospitals who are subsequently confirmed to have influenza infection during that admission.

[xii] Queensland Statewide Weekly Influenza Surveillance Report (http://www.health.qld.gov.au/ph/cdb/sru_influenza.asp)
[xiii] Western Australia Virus WAtch (http://www.public.health.wa.gov.au/3/487/3/virus_watch_homepage.pm)

7.5.2 State-wide influenza hospitalisation data

Since 2009, hospital admission data from all Western Australian public hospitals have been linked on a weekly basis to influenza notification data from the Western Australian Notifiable Infectious Diseases Database (WANIDD). This linkage allows identification of laboratory confirmed influenza cases that are hospitalised within one week preceding or following the date of collection of their positive influenza specimen. It is assumed that the influenza infection was responsible for, or at least contributed to, the need for hospitalisation. The linkage also allows identification of admissions to intensive care units and deaths among these hospitalised influenza cases. Information on hospitalisation and mortality is added to notification records for influenza cases in WANIDD. Additional information on admissions to private hospitals may be provided on the notification form when medical practitioners notify influenza cases, and these data are also added to WANIDD. However, hospitalisation data for the private sector is likely to be incomplete.

Summary hospitalisation data are published weekly during winter in Virus WAtch[xiii], with graphical displays of the number and percentage of confirmed influenza cases admitted, with comparison to average levels in previous seasons, as well as the percentage of all admitted patients with a confirmed influenza infection.

7.6 Australian Paediatric Surveillance Unit (APSU)

The Australian Paediatric Surveillance Unit (APSU) is an active surveillance mechanism for prospective, national identification and study of children aged <15 years, newly diagnosed with uncommon conditions including rare infectious and vaccine preventable diseases, genetic disorders, child mental health problems, and rare injuries.[55] APSU relies on monthly reporting by around 1,400 paediatricians and other child health clinicians. Clinicians reporting cases are asked to provide details about demographics, diagnosis, treatments and short-term outcomes. Over 80% of clinicians respond via e-mail and all negative and positive reports are logged into a database. The report card return rate has been maintained at over 90% over the last 20 years.

In response to several childhood deaths in 2007 and after establishing feasibility, severe complications of influenza was added to the APSU data collection.[56] This proved useful during the 2009 pandemic as APSU was able to provide AGDH with information on children hospitalised with severe complications of influenza.[57]

APSU reports cases of children hospitalised with severe complications of influenza to AGDH on a weekly basis between July and September each year. Key findings related to influenza are

reported in APSU's bi-annual reports and have been the subject of scholarly articles. There is, however, a time lag in reporting with the most recent available report being for 2009-2010.[xiv]

7.7 Paediatric Active Enhanced Disease Surveillance (PAEDS)

The Paediatric Active Enhanced Disease Surveillance (PAEDS) system was initiated in 2007 and is coordinated by APSU and the National Centre for Immunisation Research and Surveillance (NCIRS). The purpose of the system is to enhance existing public health surveillance for vaccine-preventable diseases in the paediatric population. The PAEDS system operates across five paediatric hospital sites nationally and currently conducts surveillance for: acute flaccid paralysis, intussusception, varicella and herpes zoster, pertussis, febrile seizures, acute childhood encephalitis. During the 2009 pandemic, active, prospective hospital-based surveillance for cases of laboratory confirmed influenza was performed at six tertiary and quaternary paediatric hospital sites national under the PAEDS model between 1 June and 30 September 2009. Data were collected using standardised protocols and included demographic characteristics, past medical history, influenza vaccination status, clinical course, complications, treatment and outcome.[58]

From 2014 an influenza component of the system has been operational in two sites, the Children's Hospital at Westmead in Sydney and the Princess Margaret Hospital for Children in Perth, as an integrated component within the FluCAN project (see 7.2). Data collected from these two PAEDS sites are made available to national and jurisdictional health authorities in real time through a web-based line-listed database, with reports also issued weekly. The overall epidemiology of influenza, as well as vaccine effectiveness in adults and children are reported separately and published annually in the *Communicable Diseases Intelligence* journal as well as international journals.

7.8 Australian and New Zealand Intensive Care Society (ANZICS)

Whilst not routine, data are also available in emergencies (such as pandemics) from research databases such as that maintained by the Australian and New Zealand Intensive Care Society (ANZICS). ANZICS is a specialist society of the Royal Australasian College of Physicians and the leading advocate on all intensive care related matters. ANZICS is active in research through its Clinical Trials Group and patient databases, including the Adult Patient Database, the Paediatric Intensive Care Registry and Critical Care Resources.

[xiv] Australian Paediatric Surveillance Unit Biannual Reports: http://www.apsu.org.au/annual-reports/annual-reports/

During 2009 and 2010, ANZICS maintained a database of influenza admissions that was updated daily within their network of all ICUs across Australia and New Zealand.[59] Data describing 88 variables were collected for each case, including demographic information (e.g. age in years, age in months, sex, ethnicity, state/territory where admission occurred), body mass index, height, weight, pregnancy, comorbidities (e.g. chronic medical condition, immunosuppression), influenza subtype, antiviral use, treatment interventions, discharge date, and outcome of hospitalisation (including death). Laboratory testing, generally by real-time RT-PCR, was performed by reference and local laboratories.[11] The data generated by ANZICS were primarily for research and are not routinely reported to AGDH. This system still exists and, as demonstrated during 2009, could be activated during a pandemic. A minimal dataset of all ICU admissions (AORTIC software) is also maintained by ANZICS and is used for quality improvement and resource planning.

7.9 Strengths and limitations of hospital surveillance

Surveillance data for influenza and pneumonia-related hospitalisations are available from every jurisdiction. While some states, such as New South Wales and Queensland, have additional sources for this information, the introduction of FluCAN, with its use of standard case definitions, provides uniform national reporting of hospital data, with influenza status confirmed by PCR. Although many patients may no longer shed virus by the time they are hospitalised, confirmation of influenza status means that the specificity of case ascertainment is high.

Within the national notifications data on laboratory confirmed influenza that are reported to the NNDSS from states and territories, a field is available to record information on the hospitalisation status of the case. However, completeness of this field is low since ascertainment of hospitalisation requires follow-up for which influenza is not a high priority disease. However, as data linkages between systems continue to evolve, completeness and utility of this field may improve.

FluCAN has recently been expanded to include two paediatric hospitals, and several community based hospitals collecting data on paediatric patients, thus increasing its representation of the paediatric population.

Hospital admissions for influenza and pneumonia through EDs provide some information on community cases. While Queensland and Western Australia have the capacity to track patients through the public hospital system, it is currently not easy to track a patient's journey from community care (e.g. GP consultations) into the hospital system. This information would facilitate routine estimation of the risk of hospitalisation among patients with confirmed clinical disease.

The lack of denominator (i.e. source population) data is a major limitation of hospital-based surveillance in Australia. This precludes the calculation of incidence rates.

As part of the 2009 pandemic response, access to additional hospitalisation data sources, such as ANZICS, became available to inform specific aspects of the pandemic impact. There is a need to ensure awareness of these routinely collected or adaptable additional data sources, including an understanding of the benefits of the information they can provide and identification of the mechanisms to enable access during a pandemic or particularly severe influenza season.

8 Mortality surveillance

As with hospital surveillance, influenza-related mortality surveillance provides an indication of the severity of a season. However, unlike hospital surveillance, mortality data coded by the Australian Bureau of Statistics for vital statistics reporting is not available in real-time and is therefore most useful for retrospective analyses of a season. In New South Wales, death registrations from the NSW Registry of Births, Deaths and Marriages are used for rapid statistical estimation of excess deaths during seasonal and pandemic influenza periods using time series analysis.[60] Similar methods are used in the United States[61] and Europe[62].

8.1 Nationally Notified Influenza Associated Deaths

Within the national notifications data on laboratory confirmed influenza that are reported to the NNDSS from states and territories, a field is available to record information on the mortality status of the case. Completeness of this field is low since ascertainment of mortality requires follow-up for which influenza is not a high priority disease. To improve the completeness of the died status field of notified cases, a range of variably applied methods have been employed by jurisdictional health departments. These methods include: cross-matching of notifications with local death registration data; reporting by doctors; linkage to hospitalisation records; and reporting of deaths detected by sentinel hospital surveillance systems to jurisdictional health departments. Current limitations to these methods include, the variability in the methods used to improve the completeness of the died status field; the timeliness to which the information is available; and the potential discrepancies in the methods applied to determine the relatedness of a death to an influenza notification.

8.2 National death registration data

Levels of influenza-related mortality can be estimated from national death registration data, compiled by the Australian Bureau of Statistics (ABS) from information provided by the state and territory Registrars of Births, Deaths and Marriages (BDM) and the National Coronial Information System. These data are coded using the ICD-10. An "underlying cause" of influenza and pneumonia (J10–J18) is utilised since mortality from a primary influenza infection is rare and most of the deaths attributed to influenza occur from complications including pneumonia, obstructive airway disease and sudden cardiac death. These data are published annually and are usually released within 12 to 18 months of collection.

8.2.1 National Death Index

The Australian Institute of Health and Welfare collects monthly death registration information from state and territory vital statistics registers. A pilot project in 2014 demonstrated the feasibility of applying the same time series methods used in New South Wales[60] (see Section 8.5) to estimate national all-cause excess mortality associated with influenza.

8.3 Australian Capital Territory Births, Deaths and Marriages (BDM)

Data regarding persons from the Australian Capital Territory (ACT) who died from any respiratory cause, as indicated by ICD codes on death certificates, are supplied by the Register of BDM fortnightly to ACT Health. Since 2013, mortality records have been cross-checked against influenza notification data to identify deaths associated with influenza. Records are checked by the ACT Health fortnightly during the influenza season and on an *ad hoc* basis outside this period.

8.4 New South Wales Influenza and Pneumonia BDM

Under New South Wales public health legislation, the Registrar of BDM is required to make death registry information available to the New South Wales Ministry of Health.[60] Data are transmitted daily and include an electronic copy of the death certificate for each death certified in New South Wales. The certificate includes a section describing the disease or condition directly leading to death, and any antecedent causes, co-morbid conditions, or other significant contributing conditions. Deaths are required to be certified within 7 days and registered within 75 days. In recent years, the median interval between the date of death and being available for analysis at the New South Wales Ministry of Health has been 17 days. Nearly all registrations are reported electronically by funeral directors. Deaths referred to a Coroner are registered but the text of the cause of death is not recorded until there has been a coronial determination, which can take some months or years.

The submitted data are scanned for the keywords 'pneumonia' and 'influenza' (and various misspellings) to generate a weekly count and population rate of deaths that mention pneumonia or influenza on the death certificate. All-cause death rates are produced as well because influenza epidemics can influence death rates from other underlying conditions. Weekly data for the current and five previous years (excluding epidemic years) are then fitted using a time-series regression model, based on the methods of Serfling.[63] The model is used to forecast expected seasonal behaviour for the current year. An empirically determined epidemic threshold is used to indicate above-seasonal death rates.[64] An example figure produced using this method appears in Figure 3. The red line indicates expected activity, while the smooth black line represents the threshold of variation of usual activity (1.2 standard errors of prediction) from the time series model. Deaths in excess of this upper limit indicate unusually high activity.

These data are reported weekly for inclusion in the New South Wales weekly and monthly influenza epidemiology reports[xv] and have been used in publications in peer-reviewed journals.

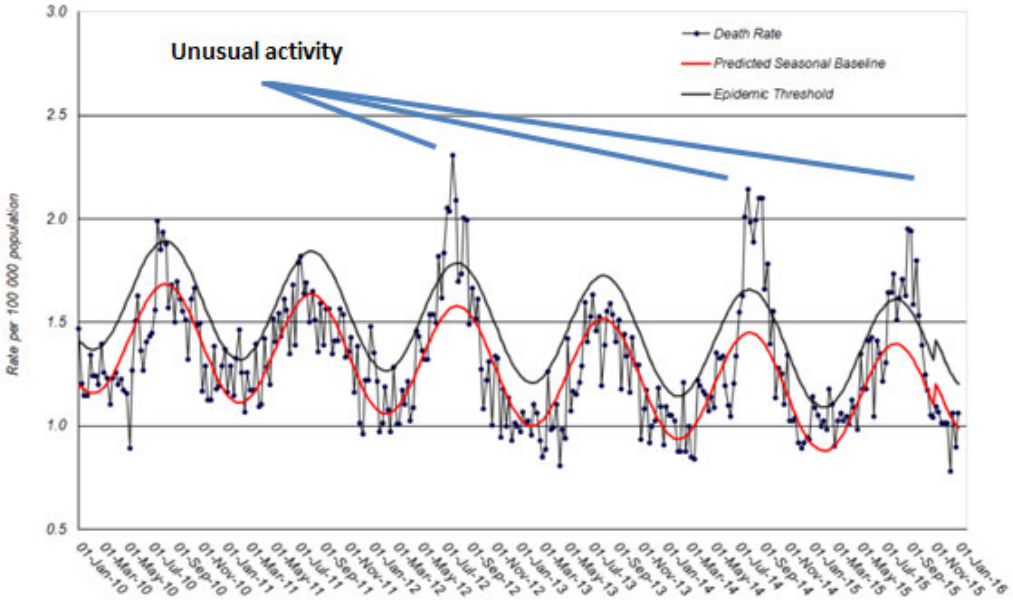

Figure 3. Rate of deaths classified as influenza and pneumonia per 100,000 New South Wales population from New South Wales Registered Death Certificates, 2010 to 2015.

[xv] New South Wales Influenza Epidemiology Report
(http://www.health.nsw.gov.au/Infectious/Influenza/Pages/reports.aspx)

8.5 Northern Territory BDM

Since December 2012, the Northern Territory has received monthly de-identified line listings of all pneumonia-related deaths. The data are provided by the registry custodians Promadis with the consent of Northern Territory BDM. The data are not identifiable and so are not linked to the laboratory confirmed cases of influenza. The extraction method is similar to that used by New South Wales but the data are still being tested and regular analysis has not commenced. Additionally, all Northern Territory laboratory confirmed cases are followed up to ascertain died status.

8.6 South Australia BDM

The South Australia Communicable Disease Control Branch (CDCB) of the South Australia Department for Health and Ageing routinely reviews records for death due to notifiable diseases, including influenza. The South Australian BDM Registration Office provides an electronic record of recent deaths to CDCB monthly. These data are reviewed for specific search terms within cause of death fields to identify death due to notifiable conditions. Mortality records have been cross-checked against influenza notification data to identify deaths associated with influenza.

8.7 Western Australia mortality surveillance

Deaths due to influenza are captured by two mechanisms in Western Australia, with information from both sources added to notification records in WANIDD, and subsequently transmitted to the NNDSS. Firstly, weekly linkage of influenza notification data with hospitalisation data allows identification of individuals who have died during an admission associated with an influenza infection, as described in section 7.5.2. Secondly, PathWest notifies CDCD of any cases detected through routine influenza testing of specimens collected during post mortem examinations, as described below (see Section 8.8.1). Whilst not reported routinely, these data allow timely monitoring of deaths directly associated with influenza infection, including comparison with previous seasons and association with features such as age and influenza virus type.

8.7.1 Coronial death surveillance

Following the detection of influenza A in three paediatric sudden deaths within several weeks in 2007, an enhanced microbiological surveillance of autopsy cases was commenced. Deaths referred to the state coroner, where the cause of death is unknown or an infectious aetiology is suspected, have respiratory tract samples collected for microbiological examination. PathWest performs all the microbiological investigations for the Western Australian State Mortuary and specimens are received by the microbiology laboratory without delay as the mortuary and microbiology services

are co-located. Virus PCR and culture are performed to detect the common respiratory viruses in children and adults, using standardised microbiological testing of autopsy cases. [65]

PathWest conducted a review of post-mortem samples collected between July 2007 and June 2011 from 1,611 patients who died from an undetermined infectious disease or a suspected respiratory tract infection.[65] Of 50 influenza virus infections detected post-mortem, only six had been identified prior to death. Whilst undertaken initially as a prospective study, PathWest has continued the routine PCR testing of selected coronial autopsies. Influenza-positive post-mortem samples are notified to Western Australian Department of Health and NNDSS in the usual way, and tissue samples are forwarded to the WHO CC for antigenic characterisation and antiviral resistance testing.

8.8 Strengths and limitations of mortality surveillance

Mortality surveillance for influenza can operate in several ways: notified laboratory confirmed influenza deaths, official coding of influenza deaths from national vital statistics reporting, or estimates of excess mortality associated with influenza epidemics using time series analysis. Many persons dying with an influenza-associated illness will not have been tested for influenza and will not appear in notified influenza deaths. Thus deaths coded as due to influenza in national statistics underestimate deaths with a prior or coincident influenza infection.[64] The statistical time series approach may provide more realistic estimates of the impact of influenza but the approach does not allow for the attribution of any particular death to influenza.

As the majority of confirmed influenza reports are laboratory based, public health follow up of cases is required in order to determine the outcome of their infection. Therefore the mortality data available in NNDSS are unlikely to represent the true mortality impact associated with this disease. The work being undertaken by the Western Australia Department of Health as part of their autopsy surveillance system has improved the representation of mortality for Western Australia (see Section 8.8.1).

Timeliness is another challenge due to administrative processing intervals for registering deaths, recording causes of death and for official coding of causes of death. This is especially true for deaths which are the subject of review by the State or Territory Coroner as these cases may take several months. Timeliness is a critical objective in influenza surveillance especially during influenza epidemics where deaths can rise rapidly and peak early.[66] If surveillance is to inform the epidemic response then it must be rapid.

There can be challenges for some jurisdictional health departments in accessing death data. While some jurisdictions currently access BDM data directly from their local registries, other jurisdictions (for example Victoria) do not have access to BDM data. BDM registries provide death data to the ABS. State and territory health departments can request coded data from the ABS. Although this information has limited utility in real-time surveillance given the typical two-year delay, it nevertheless provides a means for validation of mortality estimates that had been generated throughout the year (e.g. rapid estimates in New South Wales).

Whilst there is an opportunity for the public health follow-up of notifications of influenza to provide more timely indications of case mortality status, the resources involved in seeking this information severely outweigh the utility. In some jurisdictions, such as in the Northern Territory, interpretation of these data may be limited by small numbers.

Coroner's case surveillance may also represent an opportunity for more complete and timely information on the mortality status of cases. Testing of autopsy tissues could potentially improve the measurement of the impact of specific respiratory pathogens on mortality, particularly among younger and more often previously healthy populations compared to a hospital cohort. Testing of autopsy tissues could also help detect novel outbreaks and new serious disease threats.

9 Laboratory surveillance

Laboratory surveillance provides ever increasing levels of detail about influenza; and encompasses virological, antigenic, genetic and antiviral drug resistance testing. Some types of laboratory surveillance are useful for developing baselines and thresholds to indicate the start, end and severity of the influenza season, while others are used to monitor antigenic drift and antiviral drug susceptibility.

9.1 Laboratory Surveillance – per cent positive and subtyping

9.1.1 National Influenza Centres (NICs)

National Influenza Centres (NICs) are part of the World Health Organization Global Influenza Surveillance and Response System (WHO GISRS). This network was established in 1952 to monitor the frequent changes in influenza viruses with the aim of reducing the impact of influenza through the use of vaccines containing currently circulating strains. NICs collect virus specimens, perform preliminary analysis and ship representative and unusual clinical specimens and isolated viruses to

WHO Collaborating Centres for advanced antigenic and genetic analysis (see 9.2). These Centres are national institutions designated by Ministries of Health and recognised by the WHO.

The NICs receive samples for respiratory virus testing from sites across their respective jurisdictions, and in some cases neighbouring jurisdictions. Testing for influenza is generally performed by RT-PCR using in-house primers which may be part of a panel of primers for several respiratory viruses. NICs are able to isolate viruses from clinical samples with original clinical samples and/or isolates forwarded to the WHO CC for further analysis (see 9.2). Each of the NICs report the proportion of specimens positive for influenza among all samples received for respiratory virus testing, as well as providing influenza A subtyping data to inform interpretations of the broader unsubtyped influenza A virus fraction in the notifications dataset. The NICs and other public laboratories are part of the Public Health Laboratory Network (PHLN), an AGDH committee that monitors laboratory issues related to influenza and other diseases.

Australia has three NICs: PathWest; the Institute of Clinical Pathology and Medical Research (ICPMR); and Victorian Infectious Diseases Reference Laboratory (VIDRL).

PathWest conducts around 80% of respiratory virus testing and all respiratory serological testing in Western Australia, including SPN(WA) and WAIVE surveillance samples, and considers that data provided is reasonably representative of the viruses circulating in Western Australia. Prior to 2009, nucleic acid detection tests for influenza were performed exclusively by PathWest after which limited testing has been performed in private sector laboratories. Influenza gene positive samples are routinely referred to PathWest for subtyping, so that nearly all influenza positive patients are recorded by PathWest. Nucleic acid detection tests for respiratory viruses other than influenza are only performed at PathWest while antigen detection by immunofluorescence is performed more widely. Samples positive for influenza A are routinely referred to PathWest for subtyping, but samples positive for influenza B and other respiratory viruses may not be.[65]

ICPMR is the main public health microbiology laboratory for New South Wales. As a reference laboratory, it performs follow-up testing for other labs and undertakes primary testing for the Westmead Hospital, as well as for other hospitals in the Pathology West network (which covers about 70% of the land area of New South Wales). Samples received are likely to disproportionately represent cases among children and the elderly presenting to EDs.

VIDRL receives samples from some hospitals and local GPs and performs all testing for the VicSPIN in Victoria. Viruses tested at VIDRL are considered to be fairly representative of circulating viruses,

though this has not been empirically measured. Although VIDRL used to be responsible for a majority of influenza testing for the state, since Medicare billing for influenza testing was introduced in 2009, the volume of influenza testing performed by VIDRL has reduced substantially and the proportion of testing performed there of all testing in Victoria is uncertain.

9.1.2 Tasmania

In Tasmania, PCR test counts are collected state-wide from public and private laboratories. There are only two laboratories performing influenza tests: one private laboratory and the Royal Hobart Hospital (RHH). For the private tests, an automatic extract of the total number of PCR influenza tests performed in each 7-day period is emailed to the Tasmanian Department of Health and Human Services; this provides the denominator for proportion positive calculations. Positive samples are notified within 5 days and form the numerator. This laboratory provides the influenza type only.

RHH also provide a weekly line list of all influenza PCR tests done, and notifications are made daily. The laboratory performs subtype testing of influenza A samples. The population seen at RHH includes its own patients as well as patients seen at other public hospitals. All testing is by multiplex PCR, which permits evaluation of the circulation of a number of respiratory viruses. Samples from the north and north-west of the state are transported in virus transport medium, making them suitable for shipping to the WHO CC for further testing.

9.1.3 Queensland

Queensland Health receives timely electronic notifications of influenza from public sector laboratories and the two major private pathology services, which together represent around 95% of all influenza notifications for the state. The remaining 5% are provided by other means such as fax, email or regular post.

PCR testing is widely used and routinely provides data on virus type only. Some diagnostic serological testing also occurs in some laboratories. A sample of PCR positive influenza specimens is forwarded for subtyping (influenza A) or lineage determination (influenza B), to the public health virology laboratory located within the Queensland Health Forensic and Scientific Services. Some subtyping may also be done at the Pathology Queensland laboratory located at the Royal Brisbane and Women's Hospital. Subtyping may be undertaken on 20 – 40% of influenza A notifications in a given season. The results are transferred electronically to the relevant notifications which already exist in the notifiable conditions register. Virus isolates, along with some of the original clinical specimen, are sent to WHO CC for further testing.

Line listed influenza test data are extracted weekly from the public laboratory system database, AUSLAB™, year round. The data include a unique specimen number, basic demographic elements and results for influenza tests as well as the non-notifiable pathogens respiratory syncytial virus, human metapneumovirus, adenovirus and parainfluenza viruses. These data are used to estimate the percentage of influenza tests that are positive and are published in a weekly report during the season.[xvi] Summary percentage positive data are also available from two private laboratories.

9.1.4 New South Wales

In 2015, sentinel laboratory surveillance for influenza and other respiratory viruses was conducted at twelve public and private sentinel laboratory sites, including 2 reference laboratories. Laboratories report on the number of positive influenza results, including subtyping information, and respiratory tests undertaken. These data have included point-of-care test results since 2012, but exclude serological diagnoses. Data are submitted weekly throughout the year to the Communicable Disease Branch of NSW Health via email, fax or an online database.

These data are reported weekly for inclusion in the New South Wales weekly and monthly influenza epidemiology reports[xvii].

9.2 WHO Collaborating Centre for Reference and Research on Influenza

The WHO Collaborating Centre for Reference and Research on Influenza (WHO CC) at VIDRL in Melbourne is part of GISRS. Together with WHO Collaborating Centres in Atlanta, Beijing, London and Tokyo, the WHO CC is responsible for analysing influenza viruses currently circulating in the human population globally. Twice a year (once each for the northern and southern hemispheres) the WHO makes recommendations on suitable influenza strains to be included in the next seasonal vaccine based on data and advice from the five Collaborating Centres and other experts.

Throughout the year, the WHO CC receives influenza virus samples from NICs, public health laboratories and private laboratories in Australia and abroad. Samples are received as original clinical samples or isolates that have been grown in cell culture. Every submitted sample that arrives at the Centre is first inoculated into cell culture to obtain or expand a virus isolate. Isolates are then analysed by haemagglutination inhibition assay to determine their antigenic similarity to the strain included in the vaccine and other circulating strains. A selection of viruses also undergoes gene sequencing of the HA and NA to assess the genetic diversity of submitted viruses

[xvi] Queensland Health Statewide Weekly Influenza Surveillance Report (https://www.health.qld.gov.au/clinical-practice/guidelines-procedures/diseases-infection/surveillance/reports/flu/default.asp)
[xvii] New South Wales Influenza Epidemiology Report (http://www.health.nsw.gov.au/Infectious/Influenza/Pages/reports.aspx)

and to determine the genetic basis of antigenic changes. Finally, all viruses are tested for sensitivity to neuraminidase inhibitors in vitro, a proxy measure of clinical antiviral resistance. The WHO CC is also the only primary reference laboratory in the country for the identification of new strains of the virus, derivation of virus isolates suitable for vaccine production and for routine determination of the subtype of the neuraminidase of influenza A viruses and the lineage of influenza B viruses.

The virological surveillance data generated by the WHO CC are primarily used to inform vaccine recommendations by WHO and the Australian Influenza Vaccine Committee (AIVC) and to help health departments understand whether the viruses circulating are well matched to the vaccine. Analysis of Australian samples is reported to AGDH weekly during the influenza season and fortnightly at other times. Data are also reported in an annual report to the Commonwealth. The WHO CC has an active research program and provides antigenic and genetic information that aids interpretation of other systems, such as vaccine effectiveness estimates.

9.3 Strengths and limitations of laboratory surveillance

The number of influenza PCR tests performed provides a further indicator of respiratory illness. This measure depends on the rate of presentation with respiratory disease, and the testing behaviour of doctors. Most jurisdictions receive regular reports from laboratories in their respective state or territory on the per cent positive, while others may access this information on an *ad hoc* basis.

Since 2009 when influenza testing was assigned a billable Medicare number, the number of laboratories able to perform influenza testing has increased remarkably and a range of commercial kits for influenza typing by RT-PCR have become available. As required by law and described in section 3, these laboratories report influenza-positive cases to state and territory health departments, who then forward the notification data to the NNDSS. In general, reports include the influenza type and may include a subtype if type A. Testing performed using a commercial antigen detection kit typically tests for influenza A but cannot identify subtypes. Only those laboratories using in-house PCR assays (e.g. NICs, reference laboratories and some other larger public and private laboratories) and/or tissue culture can provide subtype data. In some cases, such as in Queensland, a sample of unsubtyped influenza A viruses are sent by private laboratories to the public health laboratory for subtyping. Serological testing is also undertaken by public reference laboratories and some other large public and private laboratories. Certain serological testing methods (e.g. the complement fixation test) only identify the virus type while others (e.g.

haemagglutination inhibition and microneutralisation assays) can identify subtypes. Thus, there is variable reporting of subtypes across jurisdictions. Samples sent to the WHO CC will generally lead to a subtype and a lineage, for influenza A and B respectively. This information is communicated back to the originating laboratory where it can be used to update subtype information in health department records. However, this is not possible in some jurisdictions. Moreover, there are delays in this process, meaning the reporting of subtypes to AGDH is not timely.

Another limitation is the representativeness of the samples tested. The sample of patients from which swabs are taken is certainly biased and virological data generated from such samples may be a biased representation of the viruses circulating. Thus, in a year with a mixed representation of strains that cause severe and mild disease, laboratory data are likely to over-report the strains that cause severe disease or were isolated from patients with atypical presentation. This might happen, for example, if both A(H3N2) and B viruses are circulating; laboratory data might show that A(H3N2) is predominant, when in fact it is only predominant in severe cases. This may not be a problem in practice, however, if health system preparedness is primarily geared towards treating severe disease.

10 Conclusion

Australia's National Influenza Surveillance Scheme provides timely and accurate syndromic and laboratory surveillance of influenza from the community through to hospitalisation and death. Limitations of its surveillance systems must be taken into consideration when interpreting their outputs (Table 5). Components of the scheme combine to inform control measures to lessen the burden of influenza in the Australian community and ensure that decision makers have access to the best available and timely information on which to base their decisions.

Table 5. Summary of the National Influenza Surveillance Scheme goals and gaps, 2015

Core objectives:	Aspect of influenza activity surveillance							Gaps
	Notifications	Community	GP	ED	Hospital	Mortality	Laboratory	
Ensure the early detection of influenza epidemics	X	X	X	X	X		X	Incomplete coverage of surveillance system data for all aspects of influenza activity across jurisdictions. Variation of case definitions within and among some aspects of influenza activity surveillance.
Trigger public health prevention and control activities	X			X	X	X	X	Limited sustainability of some current influenza surveillance activities. Current systems do not provide or utilise common baseline and threshold definitions.
- Thresholds for interventions	X		X	X	X	X		Current systems do not provide or utilise common baseline and thresholds. Surveillance data are vulnerable to various biases.
- Understand healthcare system response capacity				X	X		X	Healthcare system resource capacity is not currently monitored in relation to influenza surges in a systematic manner.
Characterise the epidemic	X	X	X	X	X	X	X	Lack of denominator data limits comparisons across seasons and jurisdictions. Unknown biases in the influenza surveillance data. Variation among case definitions within and among aspects of influenza activity surveillance.
- Identification of risk groups			X	X	X	X		Different data collected among surveillance systems.
- Identification of disease severity			X	X	X	X		Severity measured by type of presentation. Incomplete coverage of surveillance system data for all aspects of influenza activity across jurisdictions.
Estimate the impact of the epidemic	X	X	X	X	X	X	X	Opportunities exist within existing systems to measure public health intervention effectiveness; however there are inconsistencies in their approach.
Characterise the circulating viruses to inform vaccine virus selection and effectives of antiviral medications							X	Limited understanding of the representativeness of viruses and whether samples received at the WHOCCRRI are truly representative of circulating viruses.
Ensure surveillance system capability and capacity to meet pandemic requirements	X	X	X	X	X	X	X	Surveillance protocols, in addition to seasonal approaches, are required to support pandemic preparedness.

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