Influenza surveillance within hospitals: what is the world doing?

Kylie S Carville, Heath A Kelly

Abstract

Influenza within hospitals is receiving increasing attention as a result of planning for an influenza pandemic and the magnitude and severity of the 2007 influenza season in Australia. This article reviews current approaches to influenza surveillance of admitted patients, as opposed to surveillance of emergency departments, in hospitals internationally. Most examples came from the United States of America and Canada, although systems have been described in the United Kingdom and Japan. In-hospital surveillance of influenza occurs within broader surveillance systems established by national governments, and through other systems established by sub-national governments and individual hospitals. Systems vary in focus, i.e. laboratory confirmed influenza or influenza-like illness, and some are labour intensive while others incorporate differing degrees of automation. The approach to influenza surveillance within hospitals will depend on objectives and available resources, although an automated approach is likely to have greater longevity as labour requirements are reduced. *Commun Dis Intell* 2007;31:413–418.

Keywords: Influenza, surveillance, hospital, admission, pandemic

Introduction

The avian influenza epidemic and preparedness for pandemic influenza, along with a number of publicised influenza-associated deaths in the 2007 influenza season,[1] have focused considerable attention on surveillance of influenza. In all Australian jurisdictions except South Australia laboratory-confirmed influenza is a notifiable disease, and surveillance for influenza-like illness (ILI) in the community, using general practitioner (GP) sentinel surveillance, is established in many Australian states and territories.[2] Syndromic surveillance of Emergency Departments (ED) has also been established in a number of Australian jurisdictions. In New South Wales, the well established ED surveillance system is utilised in the place of a sentinel GP system.[3] ED syndromic surveillance has often been established as part of bioterrorism preparedness, and a wealth of literature is available, predominantly from the United States of America (USA).[4] Syndromic surveillance can provide timely alerts of increased incidence of influenza in the population through identification and counts of triage text indicative of ILI, and counts of diagnosis codes related to influenza.[5] However, data collection does not generally extend into the hospital for admitted patients. Currently, assessment of discharge diagnosis codes for ILI occurs retrospectively as data are not available in a timely fashion.[2,6]

Thus our understanding of influenza admission rates and burden on hospitals is limited. International studies have analysed retrospective hospitalisation data to document the burden of influenza, however many focus on laboratory-confirmed influenza in children, which will underestimate the burden of disease.[7–9] Some studies, including one from New South Wales,[10] have sought to estimate the true burden of paediatric influenza related hospitalisation, however different methods provide different results. Routine sentinel surveillance in hospitals not only has the potential to increase our understanding of the burden of influenza and/or ILI-related hospitalisations, but to provide timely data for action for infection control practitioners (ICP) and to provide surveillance experience and systems that may be of use during a pandemic. We sought to review inpatient surveillance for influenza or ILI in comparable countries in order to inform approaches to this surveillance in Victoria.

Methodology

Searches of MEDLINE were last conducted in September 2007 utilising the terms 'surveillance AND (hospital OR hospitalisation) AND influenza'. Articles were excluded if it was clear that the focus of the title or abstract was not influenza surveillance (or syndromic surveillance including influenza-like illness) or hospital-based. Articles under the 'Related Links' heading were examined where the title and abstract suggested the article could be relevant. Searches were carried out with Google using the same terms to identify any surveillance measures detailed on the Internet but not yet published in peer-reviewed literature.

Approaches to in-hospital surveillance for influenza

Twenty-three articles describing surveillance of influenza, or influenza-like illness, in hospitalised patients were found. Importantly, most articles do not evaluate attributes of system operation such as timeliness, completeness of reporting, or actual costs.

Active influenza surveillance systems with specific study personnel

In Canada, surveillance of laboratory-confirmed influenza among both paediatric and adult admissions has utilised two systems, Immunization Monitoring Program ACTive (IMPACT) and the Toronto Invasive Bacterial Diseases Network (TIBDN). IMPACT is a national paediatric hospital-based active surveillance network for adverse events following immunisation, vaccine failures and selected vaccine preventable diseases in children aged less than 16 years.[11] The network involves 12 Canadian centres, representing about 90% of all tertiary care paediatric beds in Canada. These hospitals routinely perform viral diagnostic tests on children admitted with acute respiratory symptoms. Each IMPACT centre has a designated part time nurse who reviews medical records of children with laboratory-confirmed influenza to determine whether influenza was the cause of admission and, if so, to collect specific data.

TIBDN is a collaboration of all hospitals, microbiology laboratories, infection control practitioners, physicians and public health units serving the population of metropolitan Toronto and Peel Regions (population 3.7 million).[12] Surveillance for hospital admissions associated with laboratory-confirmed influenza, or positive rapid test, was conducted from 1 July 2004 to 30 June 2007. It was felt increased influenza testing may occur over the period under study, due to the advent of routine rapid testing for influenza and the attention focused on viral respiratory illnesses post SARS. Microbiology laboratories contacted TIBDN when an isolate of influenza was identified from an in-patient unit or the ED (where the patient was admitted), consent was sought by a study nurse and data collected by interview and chart review.

Data from TIBDN on adults indicated that a majority of patients (79%) had at least one underlying illness. Testing for influenza among adults was rare and a variety of laboratory approaches were used (some laboratories were using culture only, which is not a timely measure), ultimately impacting on clinical care, surveillance and costs.[13] IMPACT data can be assessed by season, region and age. Data indicate that half of the children admitted with influenza were otherwise healthy. Nearly half required supplemental oxygen, around 12% of admissions were to the ICU, and half of these required ventilation.[14–17] The need to evaluate impacts of changes to paediatric influenza immunisation recommendations in Canada (vaccination of all children aged 6–24 months) were used to promote surveillance.[15] Data from IMPACT are incorporated into FluWatch, the Canadian national influenza surveillance network, and are reported alongside viral detection and strain identification data and sentinel practitioner ILI consultations.[18,19]

In the USA two Centers for Disease Control and Prevention associated systems, the New Vaccine Surveillance Network (NVSN) and, to a lesser extent, the Emerging Infections Program (EIP) Network, have been used to conduct influenza surveillance. The NVSN, established in 1999, evaluates the impact of new vaccines and vaccine policies through a network of sites that conduct population-based surveillance, among other research.[20] Active surveillance of hospitalisation with acute respiratory illness is conducted in children aged under five years in three urban counties. Study nurses identify children admitted over 4 days of the week (96 hours) (increased to 7 days in 2004–2005) with a diagnosis (by admitting physician) that fits the broad case definition of acute respiratory infection. When informed consent is obtained, swabs are taken for respiratory virus polymerase chain reaction (PCR) testing, and medical record review and parent interview are conducted.

The EIP is designed to assess the public health impact of emerging infections and evaluate methods for surveillance, prevention and control.[21] Some EIP sites began identifying cases of laboratory-confirmed influenza-associated hospitalisations in patients aged under 18 years in 2003, chiefly through review of hospital laboratory lists of influenza positive results. EIP surveillance is thus cheaper and logistically simpler to implement than NVSN, although EIP depends on whether practitioners order influenza tests and can be affected by the lower sensitivities of rapid diagnostic tests.

NVSN data have shown that older children are more likely to require oxygen than younger children, and that 72% of children whose hospitalisation for acute respiratory infection or fever in 2000–2004 was attributable to laboratory confirmed influenza, were not assigned a discharge diagnosis of influenza.[22] Admission rates have been seen to vary across seasons, institutions and ages. In 2000–2001 one third of children had one or more underlying medical conditions, 80% of influenza associated paediatric hospitalisations were in children under two years, and 3% of children enrolled had a positive influenza test.[23,24]

EIP data from 2003-2004 showed that 25% of children hospitalised with laboratory-confirmed influenza received antiviral therapy and that 35% of children aged over 6 months had received at least one influenza vaccination, although these figures vary across hospitals.[25] Surveillance data from EIP were compared with a retrospective audit of discharge data for a range of ICD codes previously shown to reflect influenza in children. This showed that the incidence of hospitalisations for influenza based on these codes was around 10 times higher than those with laboratory evidence.[25]

Data from NVSN and EIP were used to perform a capture-recapture analysis to better estimate the number of children hospitalised with influenza.[26,27] The NVSN identified a greater proportion of children with influenza than did the EIP (69% and 39%, respectively, using capture-recapture estimates as a reference), however, it did not achieve complete ascertainment despite the resources invested in the program. This was largely due to atypical presentations that did not meet enrolment criteria. The authors state that capture-recapture can be used to obtain better estimates about the total number of influenza cases from these two imperfect systems, and that the more expensive, sensitive system (NVSN) would thus not need to operate full time.

A pilot was conducted in the West Midlands region of the United Kingdom over two winter seasons (2001–2002 and 2002–2003) to determine the burden of influenza and other respiratory infections among respiratory patients and to assess the feasibility of their approach as a surveillance tool.[28] Nurses were employed to conduct a daily review of admissions, enrol patients, and take samples for PCR testing. There was little influenza activity in the seasons studied, limiting assessment of the burden of influenza and other respiratory viruses on winter bed pressures. The authors did not comment on the potential of the overall system to function beyond suggesting (potentially expensive) routine diagnostic assessment of respiratory patients using PCR.

Active influenza/ILI surveillance systems that utilise existing hospital staff

The International Medical Centre of Japan conducted syndromic surveillance for acute respiratory infections for three winters, as preparation for any future re-emergence of SARS or a novel influenza pandemic.[29,30] The system encompassed patients and staff. A case was defined as a patient who had a fever and one or more symptoms of respiratory tract infection. The system was labour intensive, requiring surveillance forms to be completed by section heads with daily follow up by ICP. Rapid tests for influenza were recommended for cases; use of rapid tests increased over subsequent seasons. Results were documented weekly on the hospital intranet. The authors state that the system clearly documented sudden outbreaks of influenza in the hospital, but did not specify whether this system assisted with outbreak identification. They did state that staff with influenza were instructed to undergo treatment at home, which they believe assisted in control of nosocomial infection. As no additional study staff were utilised (unlike IMPACT or NVSN), cooperation of general hospital personnel and effective functioning of the infection control team was essential. The authors reported a decrease in the number of reports after the seasonal peak compared with before, which they attributed to a sense of 'impending crisis' in physicians and nurses prior to peak, which then decreased.

Some USA states have developed their own influenza surveillance systems. Colorado has established a laboratory-confirmed surveillance system for influenza hospitalisations, as influenza-associated hospitalisation was made notifiable in the state in 2004.[31] ICP review laboratory and admission information and report over the Internet or via facsimile. While underestimating the burden of influenza as it is based on positive tests (including less sensitive rapid diagnostic tests), it does provide data on all ages (NVSN is children only). Reported cases peaked in the same week as reports from sentinel health-care providers in the state.

In California, where influenza is not a notifiable disease, the Department of Health Services initiated enhanced surveillance of paediatric intensive care units (ICU) in December 2003 following reports of severe impacts from the new Influenza A/H3N2 strain.[32] ICP collected data on children aged under 18 years with a clinical syndrome consistent with influenza; laboratory confirmation; and paediatric ICU admission; or death anywhere in the hospital. A report on the first two seasons of the program indicated no incentive was offered for collection of data, but did not provide information on completeness or timeliness of reporting. Data produced by the system included age profile (more than 80% under 5 years), underlying medical conditions (suffered by 53%), and vaccination (only 16% of patients were vaccinated).

The Connecticut Department of Public Health established hospital admissions syndromic surveillance (HASS) in 2001. In this partially automated system, hospital staff conduct a daily review of the previous day's admissions, categorise admissions into 11 syndrome categories and submit aggregate data via a secure website. The report states that this requires only 10–15 minutes per day. The use of case counts simplifies the system but without case-based demographic data further analyses are not possible. Excess pneumonia admissions (over annual weekly average) paralleled laboratory confirmation of influenza and sentinel GP reporting, however there was a slight lag.[33, 34]

Automated influenza-like illness surveillance systems

In California, in addition to the data generated by the paediatric ICU surveillance system described above, hospitalisation data from the main health maintenance organisation in the state (providing care to over one sixth of Californian residents) on 'flu admits' ('pneumonia', 'influenza' or 'flu' in hospital

admission diagnosis field) are also collected. Data are electronically extracted and transmitted daily to the California Department of Health Services; data are compiled weekly as the proportion of hospitalisations that were 'flu admits'.[35] Data from both paediatric ICU surveillance and automated hospitalisation surveillance are compiled into a comprehensive Californian influenza surveillance system, which includes outpatient ILI visits, school-based ILI surveillance, antiviral prescription data, sentinel laboratories and the state reference laboratory. Louie et al, state that these strategies are simple, flexible, stable and acceptable, and cover a range of unique populations in order to contribute to a more complete picture of influenza activity in the state.[35]

An attempt to automate surveillance of pneumonia in two neonatal ICUs in New York used a natural language processor, which created coded clinical information from computerised laboratory and radiology reports.[36] This system was evaluated by comparison with prospective identification of cases by ICP. The system had a positive predictive value of 8% but a negative predictive value of 99%, leading the authors to suggest it could be used to screen out negatives and enable ICP to focus on the highest risk cases.

The University of Utah Hospital in Salt Lake City established an automated surveillance system within the University Hospital, based on electronic medical records, for the Winter Olympics in 2002.[37] Project staff aimed to develop a system with access to real-time medical record information, as it was felt that ED surveillance systems were limited by the lack of immediate access to detailed patient level data. The approach was intended to make it easier for ICP to assist public health agencies with timely surveillance by decreasing the number of false positive alerts sent to public health authorities, without using substantial ICP time. ICP led a team that developed a rule-based system used to identify patients who fit within certain infection syndromes, including 'hospitalised influenza'. The electronic system considered items such as patient contact data (including ICU admission and death), test ordering and results, and used a statistical technique called CUSUM to determine an upper limit for the number of cases expected. Alerts were generated when this upper limit was exceeded. ICP had intranet access to the system to view both aggregated and individual patient data, enabling review of the detailed electronic medical records. Increased influenza activity (largely resulting from a separate project for influenza surveillance in the athletes' village) was the only confirmed public health event of significance reported to local public health authorities. While the use of such a system would depend on the type of data entered into patient management, laboratory and other electronic data systems within a given hospital, this approach could be applied in other institutions.

Conducting in-hospital surveillance in Australia

Beyond pilot programs in two hospitals in Victoria, we are unaware of routine influenza or ILI surveillance of admitted patients in Australia. The needs and resources of hospitals and health departments will shape routine influenza/ILI surveillance objectives and thus the type of system, if any, to be developed. Surveillance systems such as IMPACT and NVSN require ongoing investment in labour and resources. In contrast, while the initial establishment of an automated system may require substantial resources, ongoing requirements would be less. The utility of automated systems will depend on the existence and quality of data that can be obtained electronically. Laboratory requests, results and burden information (such as length of stay, admission to ICU, ventilation, and death) should be accessible electronically in many hospitals. Manual record review may be needed for some data unless hospitals have extensive medical records. Other factors, such as the case definition of ILI (influenza presentations to the ED have been shown to exhibit confusing symptoms[38]) and use of diagnostic testing for at least some cases, would need to be addressed in the development of an ILI surveillance system. An effective routine system could rely in part on automation of case identification and data extraction from ED, patient management and laboratory data systems. Individual hospitals could value-add by manual collection of any additional information required for their own purposes, with a substantially reduced workload compared to a completely manual system. Both labour intensive and automated systems can provide timely data to enable ICP to enact infection prevention measures however, electronic systems may be more likely to function during a pandemic when high workforce absenteeism is likely. Within hospital response may be the responsibility of ICP, who then need to be resourced appropriately.

Retrospective reviews of influenza-associated hospitalisations can provide influenza burden data with which to inform policy and practice, but are estimates limited by lack of routine testing and discrepancies between discharge coding and test results, and data may not be reviewed at individual hospital level. Real time measures of the burden on hospitals may assist in timely reallocation of resources during years of high seasonal activity. Beyond alerting ICP and providing information on the burden in hospitals, data from routine sentinel influenza/ILI surveillance in hospitals could contribute to existing influenza surveillance systems, as use of more than one surveillance system improves the age range of

patients captured by surveillance and allows validation of findings.[6] A pilot program modelled on the IMPACT system, Paediatric Active Enhanced Disease Surveillance (PAEDS) commenced in Australia in August 2007.[39] This program focuses on acute flaccid paralysis, intussusception, severe varicella and seizures in children aged one month to less than 8 months. It may be worth considering whether there is scope for PAEDS to expand to influenza in children if the pilot is successful. Indeed, during the 2007 influenza season, following reports of child deaths attributed to influenza, the Department of Health and Ageing engaged the Australian Paediatric Surveillance Unit to conduct weekly active surveillance for the month of September on cases of severe complicated influenza in children aged under five years.[40] Development and refinement of ED syndromic surveillance systems around the country could consider extending the work to alert ICP and other relevant hospital staff of the admission of infectious patients, and collection of useful electronic data for admitted patients. Depending on resources, hospitals may be able to conduct stand alone influenza surveillance to some extent, but a commitment to the establishment of electronic systems that would serve routinely and in a pandemic may represent a better use of resources.

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Author details

Kylie S Carville, Epidemiologist

Heath A Kelly, Head of Epidemiology

Victorian Infectious Diseases Reference Laboratory, Carlton South, Victoria

Corresponding author: Ms Kylie S Carville, Victorian Infectious Diseases Reference Laboratory, Locked Bag 815, Carlton South VIC 3053. Telephone: +61 3 9342 2606. Facsimile: +61 3 9342 3930. Email: kylie.carville@mh.org.au

References

1. Top medical officer warns of deadly flu. *The Age.* 15 August 2007. Available from: http://www.theage.com.au/news/National/Top-medical-officer-warns-of-deadly-flu/2007/08/15/1186857588715.html Accessed October 2007.
2. O'Brien K, Barr IG. Annual report of the National Influenza Surveillance Scheme, 2006. *Commun Dis Intell* 2007;31(2):167–179.
3. Communicable diseases report, New South Wales, for November and December 2006. *N S W Public Health Bull* 2007;18:28–35.
4. Centers for Disease Control and Prevention, Epidemiology Program Office, Division of Public Health Surveillance and Informatics. Annotated Bibliography for Syndromic Surveillance. 30 November 2006. Available from: http://www.cdc.gov/epo/dphsi/syndromic/index.htm Accessed October 2007.
5. Zheng W, Aitken R, Muscatello DJ, Churches T. Potential for early warning of viral influenza activity in the community by monitoring clinical diagnoses of influenza in hospital emergency departments. *BMC Public Health* 2007;7:250.
6. Clothier HJ, Atkin L, Turner J, Sundararajan V, Kelly HA. A comparison of data sources for the surveillance of seasonal and pandemic influenza in Victoria. *Commun Dis Intell* 2006;30:345–349.
7. Ampofo K, Gesteland PH, Bender J, Mills M, Daly J, Samore M, et al. Epidemiology, complications, and cost of hospitalization in children with laboratory-confirmed influenza infection. *Pediatrics* 2006;118:2409–2417.
8. Keren R, Zaoutis TE, Saddlemire S, Luan XQ, Coffin SE. Direct medical cost of influenza-related hospitalizations in children. *Pediatrics* 2006;118:e1321–1327.
9. Schanzer DL, Langley JM, Tam TW. Hospitalization attributable to influenza and other viral respiratory illnesses in Canadian children. *Pediatr Infect Dis J* 2006;25:795–800.
10. Beard F, McIntyre P, Gidding H, Watson M. Influenza related hospitalisations in Sydney, New South Wales, Australia. *Arch Dis Child* 2006;91:20–25.
11. Immunization Monitoring Program ACTive. September 2007. Available from: http://www.cps.ca/English/surveillance/IMPACT/IMPACT.htm Accessed October 2007.
12. Toronto Invasive Bacterial Diseases Network. 2007. Available from: http://microbiology.mtsinai.on.ca/tibdn/studies/influenza.asp Accessed October 2007.
13. Surveillance for laboratory-confirmed influenza requiring hospital admission in adults, metropolitan Toronto and Peel region, 2004–2005 influenza season. *Can Commun Dis Rep* 2005;31:249–255.
14. The epidemiology of influenza in children hospitalized in Canada, 2004–2005, in Immunization Monitoring Program Active (IMPACT) centres. *Can Commun Dis Rep* 2006;32:77–86.
15. Moore DL, Vaudry W, Scheifele DW, Halperin SA, Dery P, Ford-Jones E, et al. Surveillance for influenza admissions among children hospitalized in Canadian immunization monitoring program active centers, 2003–2004. *Pediatrics* 2006;118:e610–619.
16. Roberts A, Bitnun A, McGeer A, Tran D, Yau Y, Simpson K, et al. Laboratory-confirmed influenza-associated hospitalizations among children in the metropolitan Toronto and Peel region by active surveillance, 2004–2005. *Can Commun Dis Rep* 2006;32:203–207.
17. Vaudry W, Roth A, Lee B, Spady D. Active surveillance for influenza infection in children; Stollery Children's Hospital, 2003–2004 season. *Can Commun Dis Rep* 2004;30:157–164.
18. Reyes F, Aziz S, Macey JF, Winchester B, Zabchuk P, Wootton S, et al. Influenza in Canada: 2006–2007 season update. *Can Commun Dis Rep* 2007;33:85–92.
19. Reyes F, Macey JF, Aziz S, Li Y, Watkins K, Winchester B, et al. Influenza in Canada: 2005–2006 season. *Can Commun Dis Rep* 2007;33:21–41.
20. Centers for Disease Control and Prevention. New Vaccine Surveillance Network. 20 December 2006. Available from: http://www.cdc.gov/vaccines/stats-surv/nvsn/default.htm Accessed October 2007.
21. Centers for Disease Control and Prevention. Emerging Infections Programs. Available from: http://www.cdc.gov/ncidod/osr/site/eip/index.htm Accessed October 2007.

22. Poehling KA, Edwards KM, Weinberg GA, Szilagyi P, Staat MA, Iwane MK, et al. The underrecognized burden of influenza in young children. *N Engl J Med* 2006;355:31–40.

23. Griffin MR, Walker FJ, Iwane MK, Weinberg GA, Staat MA, Erdman DD. Epidemiology of respiratory infections in young children: insights from the new vaccine surveillance network. *Pediatr Infect Dis J* 2004;23 Suppl: S188–S192.

24. Iwane MK, Edwards KM, Szilagyi PG, Walker FJ, Griffin MR, Weinberg GA, et al. Population-based surveillance for hospitalizations associated with respiratory syncytial virus, influenza virus, and parainfluenza viruses among young children. *Pediatrics* 2004;113:1758–1764.

25. Schrag SJ, Shay DK, Gershman K, Thomas A, Craig AS, Schaffner W, et al. Multistate surveillance for laboratory-confirmed, influenza-associated hospitalizations in children: 2003–2004. *Pediatr Infect Dis J* 2006;25:395–400.

26. Grijalva CG, Weinberg GA, Bennett NM, Staat MA, Craig AS, Dupont WD, et al. Estimating the undetected burden of influenza hospitalizations in children. *Epidemiol Infect* 2007;135:951–958.

27. Grijalva CG, Craig AS, Dupont WD, Bridges CB, Schrag SJ, Iwane MK, et al. Estimating influenza hospitalizations among children. *Emerg Infect Dis* 2006;12:103–109.

28. Kaye M, Skidmore S, Osman H, Weinbren M, Warren R. Surveillance of respiratory virus infections in adult hospital admissions using rapid methods. *Epidemiol Infect* 2006;134:792–798.

29. Kawana A, Teruya K, Hama T, Kuroda E, Sekiguchi J, Kirikae T, et al. Trial surveillance of cases with acute respiratory symptoms at IMCJ Hospital. *Jpn J Infect Dis* 2005;58:241–243.

30. Kawana A, Teruya K, Kirikae T, Sekiguchi J, Kato Y, Kuroda E, et al. 'Syndromic surveillance within a hospital' for the early detection of a nosocomial outbreak of acute respiratory infection. *Jpn J Infect Dis* 2006;59:377–379.

31. Centers for Disease Control and Prevention. Surveillance for laboratory-confirmed, influenza-associated hospitalizations—Colorado, 2004–05 influenza season. *MMWR Morb Mortal Wkly Rep* 2005;54:535–537.

32. Louie JK, Schechter R, Honarmand S, Guevara HF, Shoemaker TR, Madrigal NY, et al. Severe pediatric influenza in California, 2003–2005: implications for immunization recommendations. *Pediatrics* 2006;117: e610–618.

33. Dembek ZF, Carley K, Siniscalchi A, Hadler J. Hospital admissions syndromic surveillance—Connecticut, September 200–November 2003. *MMWR Morb Mortal Wkly Rep* 2004;53 Suppl:50–52.

34. Hadler JL, Siniscalchi A, Dembek Z. Hospital admissions syndromic surveillance—Connecticut, October 2001–June 2004. *MMWR Morb Mortal Wkly Rep* 2005;54 Suppl:169–173.

35. Louie JK, Schnurr DP, Guevara HF, Honarmand S, Cheung M, Cottam D, et al. Creating a model program for influenza surveillance in california results from the 2005–2006 influenza season. *Am J Prev Med* 2007;33:353–357.

36. Haas JP, Mendonca EA, Ross B, Friedman C, Larson E. Use of computerized surveillance to detect nosocomial pneumonia in neonatal intensive care unit patients. *Am J Infect Control* 2005;33:439–443.

37. Gundlapalli AV, Olson J, Smith SP, Baza M, Hausam RR, Eutropius LJ, et al. Hospital electronic medical record-based public health surveillance system deployed during the 2002 Winter Olympic Games. *Am J Infect Control* 2007;35:163–171.

38. Monmany J, Rabella N, Margall N, Domingo P, Gich I, Vazquez G. Unmasking influenza virus infection in patients attended to in the emergency department. *Infection* 2004;32:89–97.

39. National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases. Paediatric Active Enhanced Disease Surveillance (PAEDS). NCIRS newsletter 16, 2007. Available from: http://www.ncirs.usyd.edu.au/newsltrs/newsletter_16.pdf Accessed October 2007.

40. Australian Paediatric Surveillance Unit. Severe Influenza Surveillance (Urgent request for September 2007). Available from: http://www.apsu.org.au/ Accessed October 2007.