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# Using general practice data to monitor influenza vaccination coverage in the medically at risk: a data linkage study

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## ABSTRACT

**Objective** To examine the possibility of using data from a network of Australian General Practices (GPs) to estimate influenza vaccination coverage in Australians medically at risk.

**Design** Data electronically extracted from a large national network of Australian GP clinics (MedicineInsight) was analysed for annual influenza vaccination coverage from 2008 to 2014. We compared the results with the 2009 and 2014 Adult Vaccination Survey. We adjusted for differences in the distribution of age, risk groups and provider types.

**Setting** All states in Australia.

**Participants** GPs participating in MedicineInsight programme.

**Interventions** Not applicable.

**Main outcome measures** Annual vaccination coverage across risk groups as recorded in Adult Vaccination Survey in 2009 and 2014 were compared with vaccination coverage in MedicineInsight. The impact of National Immunisation Programme expansion of free vaccine in 2010 to cover patients aged <65 years with medical risk factors.

**Results** The proportion of MedicineInsight patients aged ≥18 years and diagnosed with medical risk factors was higher in 2014 (33.2%), compared with the AVS in 2009 (25%). In 2009, influenza vaccination coverage estimates for those aged 18–64 years with medical risk factors was lower for MedicineInsight patients compared with the AVS (26% vs 36%). There was no evidence of any change in coverage between 2008 and 2014, despite the vaccine being available free of charge to this group from 2010.

**Conclusion** General practice databases have the potential to help fill the gap in vaccination coverage data in patients with medical risk factors.

## Strengths and limitations of this study

- Used 7 years of patient records from a national network of Australian General Practices (GP)s, making it an extensive study of vaccination coverage in Australia.
- Data from vaccination surveys based on self-report were used for comparison; many studies have reported similar surveys to be highly sensitive and specific.
- This is the first national study in Australia to explore GP databases for estimating national influenza vaccination coverage in a difficult-to-vaccinate population.
- Patients attending participating clinics may have been vaccinated elsewhere, resulting in some underestimation of vaccination coverage.

## INTRODUCTION

Vaccination is among the most successful human interventions in health, and vaccination programmes account for around 10% of government spending on prevention activities in Organisation for Economic Co-operation and Development (OECD) countries.[1] The foundation stone of an effective programme is regular, reliable coverage data to allow tracking of performance and identify areas of underperformance.[2] The optimal way to do this is a well-functioning vaccination register which includes all of the target population, allowing the follow-up of unvaccinated individuals in addition to providing coverage data.[3] Failing that, rolling population surveys are used successfully,[4 5] while the least reliable, so-called 'administrative method' simply divides the number of vaccines distributed by the target population. Coverage monitoring and programme delivery have appropriately focused mainly on children, and well-performing systems for programme monitoring and delivery are in place in most developed countries, with ≥90% of children vaccinated in 38 of 44 countries reported by OECD.[6] Contrastingly, coverage monitoring for adult vaccines tends to be less sophisticated and coverage is substantially lower, with only 4 out of 28 European Union countries achieving the target of 75% coverage in the elderly.[7]

Programmes targeting subpopulations are even more difficult to implement and monitor compared with simple age-based groups. Influenza vaccine is recommended and funded for individuals aged 6 months to 64 years with high-risk medical conditions in many countries as part of their influenza immunisation programme. These conditions vary somewhat between countries but generally include chronic respiratory, cardiac,

hepatic, renal and neurological diseases, diabetes, immunocompromise and pregnancy. People with one or more of these conditions are at high risk of serious outcomes following influenza infection, including hospitalisation and death.[8] This eligible population is large, with prevalence estimates for one or more of these conditions ranging from 10% to 20% among people aged 6 months to 64 years.[9] Of 16 European countries which funded the vaccine in this group, only seven could provide coverage data when requested.[7] In countries which provided data, coverage was typically around 20% points lower for this group than for the elderly, and in Australia 45% lower.[5] Low vaccination coverage in this large population resulted in this group constituting an estimated 44% of all eligible but undervaccinated Australians.[10]

Individuals with medical risk factors, and the elderly, are more likely to visit primary care than younger healthy adults, and a large proportion of vaccinations are conducted in this setting in Australia. Therefore, this study examines the potential of GP clinic data as a novel alternative for monitoring national influenza vaccination coverage in Australian adults, focusing on the medically at risk and elderly Australians.

## METHODS

### Electronic GP clinic data

MedicineInsight is an ongoing collection of patients' deidentified records from participating GP clinics in Australia.[11] Recruitment of GP practices began in 2011 and continued throughout the period covered in this study. Data entered prior to practice recruitment ('retrospective') were extracted along with data entered post-recruitment. Practice recruitment was designed to be geographically and demographically representative of the national patient population. This study was one of several experimental analyses in preparation for its expanded use in health research. Data components used for this study include age, immunisations, diagnosed medical conditions, reason for encounter and a unique deidentified identification number issued to individual patients at each clinic.

### Data processing

Data on patients that attended participating GPs between 1 January 2006 and 31 December 2014 and aged 18 years and above were extracted from the MedicineInsight database. Prior to data analysis, the extracted data set was examined for duplicates, and all exact duplicate records were removed. The patients were grouped into the age categories of 18 to 49 years, 50 to 64 years and ≥65 years.

### 'Active' patients

Australian patients are not restricted to a single primary healthcare provider and it is currently not possible to link records on a single patient from more than one clinic. Therefore, patients attending multiple participating clinics appear in the data as multiple patients, and data on patients from consultations at non-participating clinics are not available. It is therefore common practice to use the concept of an 'active' patient as a surrogate for a patient that regularly attends a single clinic. We used the definition of the Royal Australian College of General Practitioners, that is, a minimum of three consultations at the same practice in the previous 2 years.[12] Patients not satisfying this criterion or recorded as 'inactive' or 'died' were excluded. 'Active' status was determined for each patient each year.

### Influenza vaccination status

Influenza vaccination status for each active patient, for each year, was determined by retrieving free text entries in the 'Immunisation', 'Reason for encounter' or 'Diagnosis' fields. Text entries such as 'Influenza vaccination', 'Flu shot' or 'Seasonal influenza vaccination' were coded as seasonal influenza vaccination. The coding was developed through an extensive two-stage visual review of the data, first, to capture all entries that may refer to influenza vaccination, then second, excluding records that were detected but on review found to be not referring to influenza vaccination.

For some periods during 2009 and 2010, a monovalent 2009 pandemic H1N1 vaccine was available, while seasonal trivalent vaccines were available at other times during those years. Entries such as 'H1N1', 'Swine Flu' or 'Pandemic vaccine' were excluded. The SAS code used to determine influenza vaccination status is available from the authors on request.

### Determination of risk for influenza

The medical conditions which put people at risk of serious outcomes from influenza infection and eligible for free vaccine in Australia are: pregnancy, cardiac disease, chronic neurological disease, immunocompromise, chronic respiratory disease (including severe asthma, COPD and chronic bronchitis), as well as other chronic diseases including diabetes and renal failure.[13] We reviewed text entries in 'medical diagnoses' and 'reason for encounter' fields, and recoded them according to their influenza vaccine risk factor status. Due to the large number of different text entries, entries with less than 1000 occurrences were excluded.

For a patient to be categorised as at risk, he or she must have been diagnosed with one or more of the eligible medical conditions, either in the active year or any prior year (pregnancy must be in the active year). Patients were categorised as whether or not they were at risk in each active year.

The Indigenous status of patients can be recorded in this data set and the measurement of vaccine coverage in this high-risk group would be useful. However, this was not examined in our study, as this field is regarded as underestimating the actual number of Indigenous patients and consequently restrictions have been placed on its use by the data custodians.

As 2 years of data on patient attendance was required to determine 'active' status before they could be included, the first 2 years of data (2006 and 2007) were used only to determine a patient's active status in 2008, and other results were determined for each year from 2008 to 2014.

### Other data sources

The 2009 adult vaccination survey[5] was used as a comparator with MedicineInsight for vaccination coverage and risk factor prevalence. This is the latest in a series of national surveys which have been the primary source of data for vaccination of Australian adults. The survey was conducted by random digit dialling and telephone interview. Information was collected by self-report, from 10 231 respondents, without referring to written records. In addition to the usual trivalent seasonal influenza vaccine available from March each year, in 2009 a monovalent pandemic H1N1 influenza vaccine was promoted and free for all Australians aged ≥10 years from September 2009. Respondents were asked separate questions about receipt of the 'seasonal' and 'pandemic' vaccine that calendar year. They were also asked about diagnoses of any of the medical risk conditions providing eligibility for free influenza vaccine. A smaller telephone survey of 1200 adults in 2014[14] was used as the source of data on vaccination coverage for 2014. It was also the only national source of data on the provider types reported to have given influenza vaccine to adults.

A study by Li-Kim-Moy *et al*[9] of data from the National Health Survey (NHS) 2011–2012 was used as another comparator on risk factor prevalence. This was a face-to-face survey of 15 600 private dwellings. Influenza risk factor status was derived from a wide range of health-related questions and did not correspond exactly to recommendations of the Australian Immunisation Handbook.

### Statistical analysis

Influenza vaccination rates vary substantially by age and risk factor status. For the purpose of comparing vaccination coverage in broad age groups with other data sources, two separate statistical adjustments were applied to MedicineInsight data. Firstly, they were age standardised to the national Australian population estimates for comparison years (2009 and 2014),[15] using the direct method. Secondly, crude estimates were standardised to risk factor prevalence estimates by age group from the National Health Survey, using the direct method.[14] Approximately 6% of vaccinations in MedicineInsight were recorded as given by another provider, with little difference by age group. However, this was much lower than a survey estimate of 30% overall, ranging from 46% in younger adults to 11% in the elderly.[14] Therefore an additional adjustment was carried out using estimates from 2014 telephone survey,[14] for under-recording of vaccinations given elsewhere, which excluded vaccinations in MedicineInsight that were recorded as given elsewhere, and applied direct adjustments from the proportions in the 2014 survey. Statistical analysis was carried out in SAS V.9.4.[16]

### Patient and public involvement

Patients or the public were not involved in the design and conception of this study.

## RESULTS

The annual total numbers of participating practices, patients, consultations, influenza vaccinations and active patients in the MedicineInsight data set are summarised in table 1. While the number of participating practices remained relatively stable between 2008 and 2014, there were increases in the number of patients that attended those practices (by 37%), total annual consultations (50%), annual influenza vaccinations (51%) and the number of patients classified as actively attending a single practice (50%). The number of provider unique identification numbers also increased over the period, by 22% (data not shown).

The age distribution of the patients actively attending MedicineInsight clinics in 2014 was slightly older than the general population (table 2).

The prevalence of medical conditions putting people at increased risk of serious outcomes following influenza infection are summarised in table 3, by age group, from three different sources. Prevalence was highest in the

**Table 1** Annual number of participating practices, patients and associated consultations and seasonal influenza vaccinations

| Year | Total practices | Total patients | Total consults | Total vaccinations | Active* patients |
|---|---|---|---|---|---|
| 2008 | 353 | 1 841 039 | 10 318 070 | 206 122 | 1 346 315 |
| 2009 | 356 | 2 015 869 | 11 501 564 | 258 633 | 1 468 122 |
| 2010 | 357 | 2 096 902 | 12 326 717 | 263 049 | 1 609 844 |
| 2011 | 360 | 2 209 854 | 13 227 084 | 269 132 | 1 732 793 |
| 2012 | 363 | 2 337 066 | 14 056 683 | 282 573 | 1 823 364 |
| 2013 | 365 | 2 447 503 | 14 828 160 | 342 368 | 1 922 363 |
| 2014 | 365 | 2 514 684 | 15 471 571 | 311 896 | 2 012 427 |

*An active patient is one who has attended the same practice 3 or more times in the previous 2 years, and has not been previously recorded as 'inactive' or 'died'.

Table 2 Age distribution of the Australian and MedicineInsight populations, 2014

| Age (years) | ABS* | MedicineInsight |
|---|---|---|
| 18–34 | 31% | 28% |
| 35–49 | 26% | 26% |
| 50–64 | 23% | 24% |
| 65–74 | 11% | 12% |
| 75+ | 8% | 10% |

*Australian Demographic Statistics 2014, Australian Bureau of Statistics.[15]

MedicineInsight patient population, and lowest in the National Health Survey. Prevalence increased with age in both populations, but the increase was much greater in the survey population, with much lower prevalence in younger adults. In the MedicineInsight population prevalence increased more than 1.5-fold between 2008 and 2014 (data not shown).

Figure 1 shows influenza vaccination coverage by year and age group among the groups eligible for free influenza vaccine, with the medically at risk and <65 years split into two age groups. Coverage was higher in older age groups, in all years. Coverage in the ≥65 year age group was highest in 2009 and lowest in 2014, while in younger medically at-risk adults coverage was highest in 2013 and lowest in 2008, with no evident increase following the introduction of national funding for this group in 2010.

Crude coverage estimates from MedicineInsight data were lower than those from the telephone surveys, the extent of the difference between sources differed by age group (table 4), reflecting the larger proportion of younger adults vaccinated at work, and therefore not captured in the GP data. Age standardisation slightly reduced MedicineInsight estimates, reflecting the slightly older GP-attending population. Adjusting for the age distribution of risk factors resulted in higher MedicineInsight estimates, as more weight was given to older age groups with higher coverage. After adjustment for the proportion of doses given outside General Practice,

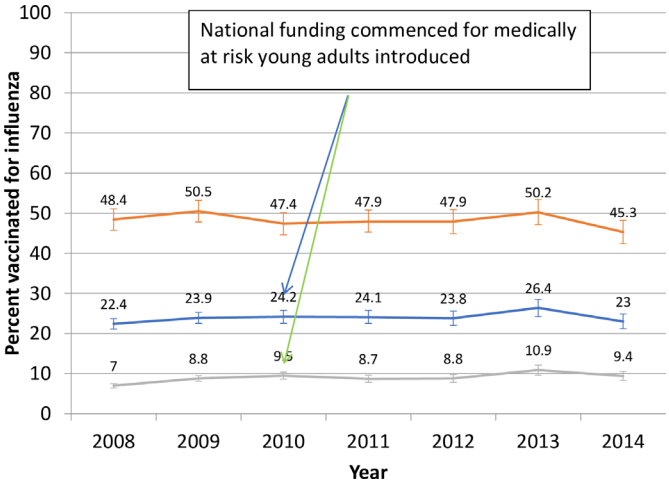


Figure 1 Seasonal influenza vaccination status, MedicineInsight data. Orange, ≥65 Years (ie, patients aged 65 years or older); blue, 50 – 64 Years at risk (ie, patients aged 50 to 64 years with risk factors); grey, 18 – 49 Years at risk (ie, patients aged 18 to 49 years with risk factors).

MedicineInsight coverage increased further, to 73% and 71% of survey estimates for the ≥65 years and 18–64 years at risk respectively in 2009, and ranged from 30% in 2014 to 53% in 2009 for all younger adults.

## DISCUSSION

Our population of patients actively attending GP practices were slightly older, with a higher prevalence of medical conditions making them eligible for free influenza vaccine, compared with self-report data from surveys of individuals selected randomly from the community. Influenza vaccination coverage estimates for this population recorded in GP clinic data were lower than surveys of the general population. After adjustment for the distributions of age, risk factor prevalence and provider type, coverage estimates for younger adults with medical risk conditions and adults aged ≥65 years were around 70% of those from population surveys, and for all younger adults, 30%–53% of those from population surveys.

Table 3 Prevalence of medical risk factors entitling free influenza vaccine*

| Age group (years) | NHS† 2011–12 % (95% CI) | AVS‡ 2009 % (95% CI) | MedicineInsight 2014 % (95% CI) |
|---|---|---|---|
| 18–34 | 4.2 (3.5 to 4.9) | N/A | 19.5 (18.7 to 20.4) |
| 35–49 | 8.8 (7.8 to 9.9) | N/A | 26.4 (25.5 to 27.3) |
| 50–64 | 19.8 (18.1 to 21.6) | N/A | 39.5 (38.5 to 40.6) |
| 65–74 | 35.2 (32.2 to 38.2) | N/A | 56.0 (54.8 to 57.1) |
| ≥75 | 42.0 (38.4 to 45.6) | N/A | 66.5 (65.1 to 67.8) |
| ≥18 | 15.0 | 25.0 | 33.2§ |

*Heart disease, lung disease, another chronic illness including diabetes and renal failure, chronic neurological condition including multiple sclerosis and seizure disorders, immune compromising condition including HIV infection, or pregnancy.
†National Health Survey 2011–2012.[9]
‡Adult Vaccination Survey.[5]
§Age standardised to 2009 Australian population.

Table 4 Comparison of influenza vaccination coverage estimates from national telephone surveys and NPS MedicineInsight

| Vaccine / age / risk factor status | AVS (95% CI) | MI, crude (95% CI) | MI, Age std | MI, RF prev std.* | MI, provider adj.† | MI adj.† / AVS (%) |
|---|---|---|---|---|---|---|
| Trivalent seasonal 2009 | | | | | | |
| ≥18 years | | | | | | |
| At risk | 53.4 (N/A)‡ | 36.2 (34.1 to 38.4) | | 39.5 | 41.5* | 77.7 |
| 18–64 years | | | | | | |
| At risk | 36.2 (N/A)‡ | 15.5 (14.5 to 16.5) | | 17.3 | 25.8* | 71.3 |
| All | 22.8 (21.3 to 24.4)‡ | 7.9 (7.3 to 8.4) | 7.4‡ | | 12.1‡ | 53.1 |
| ≥65 years | | | | | | |
| All | 74.6 (73.1 to 76.0)‡ | 50.5% (47.8 to 53.2) | 50.3‡ | | 54.2‡ | 72.7 |
| Trivalent seasonal 2014 | | | | | | |
| 18–34 years, all | 23 (23 to 34) | 3.8 (3.3 to 4.2) | | | 6.8 | 29.6 |
| 35–49 years, all | 29 (19 to 39) | 6.0 (5.4 to 6.6) | | | 13.6 | 46.9 |
| 50–64 years, all | 46 (37 to 55) | 15.0 (13.7 to 16.2) | | | 19.7 | 42.8 |
| ≥65 years, all | 73 (70 to 79) | 45.3 (42.4 to 48.2) | 45.1§ | | 49.8§ | 68.2 |
| ≥18 years, at risk | 63 (57 to 69)§ | 30.5 (27.9 to 33.2) | | 36.0 | 41.5* | 65.9 |

*Standardised for risk factor prevalence by age group to the 2011–2012 National Health Survey.
†Adjusted for the proportion of influenza doses administered outside of general practice, by age group.
‡Age standardised to 2009 Australian population.
§Age standardised to 2014 Australian population.
AVS, adult vaccination survey; M, MedicineInsight; RF, risk factor.

We found increasing numbers of patients, providers and encounters, as well as an increase in risk factor prevalence over the study period. These are likely attributable to a combination of the increasing size of practices, increasing numbers of encounters per provider by means such as more use of nurse practitioners, and improved completeness of electronic data.

Coverage of the seasonal vaccine was slightly higher in 2009 than nearly all other years, which may be indicative of some misclassification of pandemic as seasonal influenza vaccine, or of a real increase due to concern generated by the pandemic strain in that year. The decrease in coverage in 2014 in the GP practice data is consistent with a non-significant decrease in coverage in the ≥65 year age group found in the population surveys between 2009 and 2014, with limited power to detect a change due to wide confidence intervals (table 4). Most notably from this study however, there is no evidence of an increase in vaccination coverage in those medically at risk when the vaccine became freely available in 2010.[17] While the funding of childhood vaccines in Australia is usually closely followed by rapid uptake, the impact of funding adult vaccines for entire age groups such as ≥65 years has been less marked[5] but still evident. A disappointing outcome from funding a targeted campaign is not unusual,[7] and the lack of coverage data to provide feedback on programme performance, for the first 7 years, has not been helpful.

There are several limitations to this study, in particular the lack of external validation of the coding algorithms used, and the absence of data from patients that were actively attending a participating practice but were vaccinated elsewhere. The definition of 'active' patient is imperfect, studies have shown that vaccination coverage calculated from practice databases increases with the specificity of the definition of an active patient,[18] but an improved definition would have required individual patient follow-up, which was beyond the scope of this study. The accuracy of self-reported influenza vaccination within the previous 12 months, as was used in the surveys used for comparison in this study, has been assessed in several studies and found to have high sensitivity and specificity.[19 20] The most likely explanation for the disparity between results from MedicineInsight and the surveys is the under-recording of vaccinations in MedicineInsight clinic data. A comparison of influenza vaccination status in another electronic GP data collection with self-reported vaccination status of the same patients found that electronic data provided lower coverage estimates (37% vs 51%),[21] which is in consistent with our findings. A recently published study of MedicineInsight data found influenza coverage estimates for 2015 to 2017 (aged ≥65 years 61%–65%[22]) to be slightly higher than those found in our study (51% in 2009, 45% in 2014) using a different definition of 'active' patient. They also concluded that this data set was a potentially important source of coverage data. The prevalence of medical risk factors was substantially greater in our study compared with the National Health Survey. This is not unexpected, as active clinic attendees are likely to be sicker than the general population. Regan *et al*[21] found the presence of medical risk conditions in electronic

GP data was slightly lower than self-report by the same patients (30% vs 39%).

In conclusion, we have shown that electronic primary care data appear to be a very good source of data on medical risk conditions, while vaccination data are less complete. This source therefore has much potential to assist in monitoring vaccination coverage in this large but difficult population to target. Possible mechanisms include direct use of this data source following validation audits to more rigorously quantify its reliability, or through two-way transfer of these data items between practice databases and other electronic health records including vaccination registers. While GP data are used to directly measure coverage in the UK,[23] which is well suited to this approach due to its capitation (single provider) method of healthcare delivery, we are not aware of its use elsewhere, or the two-way data transfer approach being used in any setting.

**Contributors** Both DB and RM designed the project, carried out data management, linkage, analysis and interpretation of the results. Both authors drafted and critically revised the manuscript; and approved the final version to be published.

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**Patient consent for publication** Not required.

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**Data availability statement** The data used in this study are available from NPS Medicinewise subject to approval of their Data Governance Committee and payment of a fee. Data are however available from the authors upon reasonable request and with permission of NPS Medicinewise.



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