MEDICINEINSIGHT

Vaccination coverage in the Australian general practice setting, based on MedicineInsight data

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Independent, not-for-profit and evidence-based, NPS MedicineWise enables better decisions about medicines, medical tests and other health technologies. We receive funding from the Australian Government Department of Health.

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EXECUTIVE SUMMARY

Background

This report estimates vaccination coverage for preventable diseases in Australia in 2018 and 2019 among adolescents and adults attending general practices sharing data with MedicineInsight, including vaccines for influenza, pneumococcal disease, meningococcal disease, pertussis and herpes zoster. It aims to estimate the overall vaccination coverage stratified by:

- patient characteristics: age, sex, socioeconomic status, rurality of patient's residence, health conditions/risk factors, eligibility to receive funded vaccines
- general practice/clinic characteristics: state, rurality and socioeconomic status.

Methods

This is a cross-sectional study using general practice data from MedicineInsight for 2018 and 2019. We included people aged 10 years or older regularly attending general practices, defined as at least three clinical encounters during the study time period). For herpes zoster, we included people aged 50 years or older. For all disease groups, we estimated cumulative vaccination coverage each year (ie, ever vaccinated) and the proportion of patients receiving their first vaccination in 2019. People were considered vaccinated if they were 10 years or older at the time their vaccination was recorded. Since influenza vaccines should be administered every year, we estimated influenza annual vaccination coverage irrespective of prior vaccination. Annual vaccination coverage was presented for each disease group and adjusted for clustering of patients within practices. We also estimated the associations between vaccination coverage in 2019 (the most recent year) and sociodemographic and clinical characteristics, funding eligibility status (either funded through the National Immunisation Program – NIP, by states or territories or via the Pharmaceutical Benefits Scheme – PBS) and practice characteristics using multivariable logistic regression adjusted for clustering. Sensitivity analyses were performed to evaluate the impact of study population selection, the inclusion of non-specific search terms for pneumococcal vaccination and health condition definitions on coverage estimates. Results of analyses are presented below by disease group.

Key findings

- Influenza
  - Vaccination coverage was 23.6% (95% CI 22.5 to 24.7) in 2018 and higher in 2019, at 26.3% (95% CI 25.1 to 27.5). People aged 65 years or older achieved the highest coverage in both years (~58%). Coverage among people with health conditions associated with an increased risk of influenza ranged between 39% and 42% and coverage among smokers was low (14%–17%). Coverage among people eligible for NIP-funded vaccines ranged from 39% to 42%.
  - In the multivariable model, older age, being female, living in the most advantaged socioeconomic status areas, being a non-smoker or ex-smoker, having prespecified health conditions and more frequently attending general practices increased the likelihood of influenza vaccination uptake. Eligibility to receive a NIP-funded vaccination increased influenza vaccination uptake by 40%. Differences in vaccination coverage were also observed according to practices' characteristics, with higher vaccination uptake among people attending practices in inner regional areas, most advantaged areas and in New South Wales compared to the Australian Capital Territory, Northern Territory, Queensland, and Western Australia.
  - Restricting the study population to regular patients who visited practices between March and August resulted in higher vaccination coverage estimates: 30.6% (95% CI 29.3 to 31.9) in 2018 and 33.8% (95% CI 32.5 to 35.2) in 2019. Again, people aged 65 years or older had the highest vaccination coverage (~67%–68%), and approximately half of the people with prespecified health conditions had an influenza vaccination recorded (46%–50%).

- Pneumococcal disease
  - Cumulative 23-valent pneumococcal vaccination (23vPPV) coverage (ie, ever vaccinated) was 12.4% (95% CI 11.5 to 13.3) in 2018 and 12.7% (95% CI 11.8 to 13.6) in 2019. In both years, the highest uptake of pneumococcal vaccination was recorded among people aged 65 years or older (~47%). Coverage among people with health conditions associated with an increased risk of pneumococcal disease ranged between 26% and 27% and coverage among smokers was only 6%–7%. Coverage among people eligible for NIP-funded vaccines was 43%–56% and 3%–4% among people eligible for state-funded or PBS-subsidised vaccination.
  - Cumulative 13-valent pneumococcal vaccination (13vPCV) coverage was 0.11% (95% CI 0.09 to 0.12) in 2018 and 0.13% (95% CI 0.11 to 0.15) in 2019.
  - In the multivariable model, older age, being female, being a non-smoker or ex-smoker, having prespecified health conditions and more frequently attending general practices increased the likelihood of 23vPPV vaccination uptake. In addition, the probability of 23vPPV vaccination uptake was 4.3-fold higher among people eligible for funded vaccination (through NIP, states/territories, or PBS). Differences in 23vPPV vaccination coverage were also observed according to practices' characteristics, with higher chances of vaccination among people attending practices in major cities, most advantaged areas and in New South Wales compared to the Northern Territory, Queensland, and Western Australia
  - When 23vPPV vaccination coverage was measured in terms of patients receiving their first vaccination in 2019, vaccination uptake was substantially lower, at 1.5% (95% CI 1.4 to 1.6).
  - Including broader terms (ie, non-specific search terms for pneumococcal vaccination) to define if patients were ever vaccinated for pneumococcal disease increased vaccination coverage to 13.9% (95% CI 12.9 to 14.9) in 2018 and 14.4% (95% CI 13.4 to 15.4) in 2019. Again, people aged 65 years and older had the highest vaccination coverage (~52%–54%), and approximately one-third of people with prespecified health conditions had a vaccination recorded (29%–30%).
- Meningococcal disease
  - Cumulative vaccination coverage was 2.4% (95% CI 2.1 to 2.7) in 2018 and 2.7% (95% CI 2.4 to 3.0) in 2019. In both years, coverage was significantly higher among people aged 10–13 years (~8%) and 14–19 years (~12%–14%) compared to the other age groups (0.9%–5.0%). Coverage among people eligible for NIP-funded vaccines was approximately 12%–14%, ranging from 5% to 15% among people eligible for state-funded vaccination.
  - In the multivariable model, younger age, being a non-smoker, having prespecified health conditions and more frequently attending general practices increased the likelihood of meningococcal vaccination uptake. In addition, the probability of vaccination uptake was 4.0-fold higher among people eligible for a funded vaccination. Differences in vaccination coverage were also observed according to practices' characteristics, with higher chances of vaccination among people attending practices from major cities, most advantaged areas and in South Australia, Tasmania and Victoria compared to New South Wales.
  - When coverage was measured in terms of patients receiving their first vaccination in 2019, meningococcal vaccination uptake was 0.4% (95% CI 0.4 to 0.5), with the highest rate among patients aged 14–19 years (3.4%).
- Pertussis
  - Cumulative vaccination coverage was 20.1% (95% CI 19.2 to 21.0) in 2018 and 21.6% (95% CI 20.6 to 22.5) in 2019. The lowest uptake of pertussis vaccination was recorded among people aged 10–13 years (5.6%) and 14–17 years (14%) in both 2018 and 2019. However, this is likely to be an artefact of the incomplete capture in primary health care data of vaccinations among school age children rather than a genuine pattern. Coverage was higher among females than males (22%–24% vs 18%–19%, respectively). Coverage among people eligible for NIP-funded vaccines was only 3%–6%, compared to 14% among people eligible for state-funded vaccination and 21%–22% among people ineligible for funded vaccines. Again, this is likely to be an artefact of the incomplete capture in primary health care data of

vaccinations among school age children, who are eligible for NIP-funded vaccines, rather than a genuine pattern.

  - In the multivariable model, older age, being female, being a non-smoker, living in areas in the second quintile of disadvantage and more frequently attending general practices increased the likelihood of pertussis vaccination uptake. Differences in vaccination coverage were also observed according to practices' characteristics, with higher chances of pertussis vaccination in practices in inner and outer regional areas compared to major cities, in the most advantaged areas and in New South Wales compared to most other states, except Tasmania and the Australian Capital Territory.
  - When coverage was measured in terms of patients receiving their first vaccination in 2019, vaccination coverage for pertussis in 2019 was 3.9% (95% CI 3.8 to 4.1) with the highest coverage among patients aged 18–39 years (5.3%).

- Herpes zoster
  - Cumulative vaccination coverage was 13.6% (95% CI 13.0 to 14.2) in 2018 and higher in 2019, at 15.1% (95% CI 14.4 to 15.8). The highest uptake of zoster vaccination was recorded among people aged 71–79 years (~50%–52%) and coverage among people eligible for NIP-funded vaccines ranged from 41% to 49%.
  - In the multivariable model, older age, being female, living in advantaged socioeconomic areas, being a non-smoker and more frequently attending general practices increased the likelihood of zoster vaccination. The probability of vaccination uptake was approximately 7.9-fold higher among people eligible for funded vaccination. Differences in vaccination uptake were also observed according to practices' characteristics, with higher chances of a recorded herpes zoster vaccination among patients attending practices from most advantaged areas (2nd, 3rd, and 5th quintiles compared to the 1st quintile) and in South Australia, Tasmania and Victoria compared to New South Wales.
  - When coverage was measured in terms of patients receiving their first vaccination in 2019, herpes zoster vaccination uptake was 2.5% (95% CI 2.4 to 2.6) with the highest uptake among patients aged 70 years (18.7%), followed by those aged 71–79 years (12.4%).

Implications of findings for vaccination policies and clinical practice

- Efforts are needed to increase vaccination coverage for all preventable diseases evaluated in this report
- People attending general practices frequently are more likely to be vaccinated. As general practitioners' recommendations can influence the decision to be vaccinated, each encounter represents an opportunity to offer immunisation and to increase the co-administration of vaccines.
- Uptake of pneumococcal vaccine was substantially lower than influenza among people aged 65 years, even though both vaccines are fully funded for this population. Co-vaccination of influenza and pneumococcal vaccines could be encouraged to increase pneumococcal vaccination uptake in this population.
- People with health conditions associated with increased probability of infectious diseases were more likely to be vaccinated even after adjusting for potentially confounding factors, suggesting knowledge of clinicians of which populations are at higher risk. However, current smokers are at increased susceptibility to infectious diseases and were consistently less likely to be vaccinated compared to non-smokers within all disease groups evaluated.
- Eligibility to receive a funded vaccination was consistently associated with vaccination uptake, increasing the probability of vaccination by 1.4 to 7.9-fold across the disease groups evaluated, except for pertussis. Therefore, the expansion of eligibility criteria for funded vaccination is a potentially modifiable factor to increase vaccination coverage.
- Practice level characteristics should be considered in strategies aiming to increase vaccination uptake, especially in most disadvantaged areas and remote/very remote areas. Differences in coverage observed between states should be interpreted carefully (see section Study strengths and limitations below).

Conclusion

MedicineInsight data revealed vaccination coverage among adolescents and adults regularly attending general practices in Australia is suboptimal. Encouragingly, people with health conditions associated with increased risk of influenza and pneumococcal disease were more likely to be vaccinated. However, current smokers had substantially lower vaccination rates compared to non-smokers across all disease groups evaluated. Our results also highlighted the impact of funding on increasing vaccination uptake. These results can support policy development, targeted strategies and further research to improve the quality use of vaccines and vaccination uptake in general practices across Australia.

Study strengths and limitations

MedicineInsight is regularly updated with anonymised electronic health record data from clinical information systems (CIS) in general practices that have consented at a practice level to provide data on a monthly basis. The main strength of the data includes its large size and representativeness of the Australian population attending general practices in terms of sex and age. However, like all large administrative health datasets, MedicineInsight has some limitations related to the purpose for which the data was originally collected. Findings presented in this report should be interpreted in light of the following limitations:

- Patients attending participating general practices may have been vaccinated elsewhere (eg, school, workplace, pharmacies, nursing homes), resulting in some underestimation of vaccination coverage. However, most elderly people receive vaccines in general practices. Thus, the underestimation is bigger for school-aged individuals and working-age people.
- Patients may attend a number of different general practices, and as MedicineInsight patient records are not linked across practices, or where practices are not part of MedicineInsight, this may lead to an underestimation of coverage and under-identification of the covariates. This was mitigated in part by only including patients who were regularly attending the MedicineInsight practice, hence were less likely to be temporary or visitor patients.
- Identification of conditions is dependent on the general practitioners recording these items in their clinical software systems and some conditions managed in specialist or hospital settings may not be fully captured in general practice datasets.
- Eligibility for funded-vaccines was defined based on a combination of patients' sociodemographic characteristics, health conditions and the state of the practice attended. Therefore, inaccuracies in the recording of these characteristics may have led to inaccurate categorisation of patients' eligibility for funding. In addition, some conditions which render a patient eligible for a funded vaccination (or eligible for a recommendation to receive a vaccination) were not feasible to identify in MedicineInsight data at this time, such as preterm birth and long-term use of specific medicines.

1. INTRODUCTION

1.1 About this report

Vaccination is a public health strategy to prevent a variety of infectious diseases that impose a burden on patients and health care systems. This report aims to estimate vaccination coverage in Australia for the adult and adolescent population, including vaccines for influenza, pneumococcal disease, herpes zoster, meningococcal disease, and pertussis.

The aim of this study was to examine overall vaccination coverage in recent years and produce coverage estimates, stratified by age groups, geographic regions, presence of medical conditions /risk factors and people's eligibility to receive funded vaccines.

The results of this study will be used to inform strategies for quality improvement in vaccination for adults and adolescents in primary health care. A greater understanding of vaccination uptake according to patient and practice characteristics will inform decisions about targeted interventions. The measurement of the association between funding eligibility criteria and vaccine uptake may be useful to inform funding policies in the future. Therefore, this research will inform health policy decisions and programs to improve the use of vaccines in Australia.

1.2 Vaccine availability and access

In Australia, information on the safest and most effective use of vaccines is published periodically by the Department of Health,[1] providing clinical advice for health professionals. People can access recommended vaccines through general practices, community pharmacies, public hospitals, school-based or workplace immunisation programs, other health clinics and aged care facilities.

The Australian National Immunisation Program (NIP) provides free vaccines for eligible people at the point of delivery. Vaccines not covered by the NIP can sometimes be obtained free of charge through specific immunisation programs funded by states and territories or through some workplaces. Some vaccines are also subsidised by the Pharmaceutical Benefits Scheme (PBS) under a capped co-payment, and individuals can privately purchase those not available in these programs. Table 1 summarises the vaccines for adolescents and adults recommended in the Australian Immunisation Handbook between 2018 and 2019 (our study period) for prevention of the infectious diseases of interest in this project, along with the indications covered by each funding scheme.

Influenza

- Influenza is a viral infectious disease that causes seasonal epidemics in Australia and can cause severe illness and death, with most of the deaths (80%) occurring among people aged 65 years and older.[2]
- Influenza vaccination is recommended every year for anyone aged 6 months and older, and vaccination is strongly recommended for people who have a greater risk of developing complications if they get influenza (see Appendix 1 for the list of medical conditions associated with increased risk of influenza complications).[1]
- Since viruses circulating each year can vary, strains used in seasonal influenza vaccines can change. Clinical advice on seasonal vaccines available each year in Australia is published by the Australian Technical Advisory Group on Immunisation (ATAGI).
- Funding for free seasonal influenza immunisation started in 1999 for people aged 65 years or over and for Aboriginal and Torres Strait Islander adults aged 50 years or older or medically at risk. In 2010, NIP-funded vaccination was expanded to include people with certain health conditions, pregnant women and all Aboriginal and Torres Strait Islander people aged 15 years or older. In 2019, funding was extended to all Aboriginal and Torres Strait Islander children and adolescents aged 5–14 years.[3]

Pneumococcal disease

- Pneumococcal disease is caused by the bacterium *Streptococcus pneumoniae*, commonly known as pneumococcus. It can cause severe invasive disease, including meningitis, pneumonia and bacteraemia, and non-invasive disease, including otitis media, sinusitis and bronchitis.[4]
- In Australia, two types of pneumococcal vaccines are available, pneumococcal conjugate vaccine (PCV) and pneumococcal polysaccharide vaccine (PPV). These vary in the number of pneumococcal serotypes they include.
- Recommendations for pneumococcal vaccination varies according to age, Aboriginal and Torres Strait Islander status, risk of developing invasive pneumococcal disease and previous doses of pneumococcal vaccine received. Adult vaccines include the 13-valent pneumococcal conjugate vaccine (13vPCV) and 23-valent pneumococcal polysaccharide vaccine (23vPPV). The 13vPCV is recommended, but unfunded, for people under category A risk, while the 23vPPV is recommended and funded for people under some category A and B risk (see Appendix 1). Pneumococcal 13vPCV vaccination is also recommended in childhood, with 23vPPV recommended for a small number of children.[4]
- Pneumococcal vaccine 23vPPV was subsidised through PBS in 1997 for adults aged 65 years or older and first included in the national schedule in 1999 for all Aboriginal and Torres Strait Islander people aged > 50 years and Indigenous adults with prespecified medical conditions. Further expansions in NIP-funded indications occurred in 2005 to include adults aged 65 years or older.[3]

Meningococcal disease

- Meningococcal disease is caused by the bacterium *Neisseria meningitidis*, commonly known as meningococcus. Of the 13 known meningococcal serogroups distinguished by differences in surface polysaccharides of the bacterium's outer membrane capsule, serogroups A, B, C, W and Y most commonly cause disease. Invasive meningococcal disease is a rare but serious disease, where up to 1 in 10 patients die. It most commonly presents as septicaemia and/or meningitis.[5]
- Several vaccines are available in Australia to prevent meningococcal disease in adolescents and adults, including two vaccines to protect against meningococcal serogroup B (Men B), and three vaccines to protect against meningococcal serogroups A, C, W and Y conjugate vaccines (MenACWY, quadrivalent). However, no single vaccine protects against all serogroups.
- Current recommendations for meningococcal vaccination are based on age and risk groups. Both vaccines (MenB and MenACWY) are recommended for adolescents aged 15–19 years and additionally for smokers, travellers, laboratory workers, young adults (aged 20–24 years) living in close quarters and people with medical conditions (see Appendix 1). Meningococcal vaccination is also recommended for all children under 2 years old and at older ages according to Indigenous status and health conditions.
- National funding for meningococcal serogroup C for children and adolescents (aged ≤ 19 years) started in 2003 and expanded to serogroups A, C, W and Y from April 2019.[3]

Pertussis

- Pertussis, commonly known as 'whooping cough', is a contagious infection of the respiratory tract caused by the bacterium *Bordetella pertussis*. Although infants are at higher risk of developing severe disease, adults represent half of the notified cases and are an important source of infection.[6]
- Pertussis vaccine is available in Australia in combination with diphtheria and tetanus, with or without inactivated poliomyelitis (IPV), hepatitis B (hepB) and *Haemophilus influenzae* type b (Hib). For adults, the pertussis vaccine is represented by the acronym dTpa, which contains lower amounts of diphtheria toxoid and pertussis antigens than the child (DTPa-containing) formulations.
- Pertussis vaccination is recommended for all infants < 6 months and boosters are recommended to adolescents and adults based on age, prior vaccination, and risk groups (see Table 1).
- State and territory funding for dTpa vaccines started in 2004 with different eligible groups across jurisdictions and was nationally funded for pregnant women in their third trimester of pregnancy in 2018.[3]

Herpes zoster

- Herpes zoster, commonly known as shingles, is a reactivation of the varicella zoster virus in a person who has previously had varicella (chickenpox). Herpes zoster occurs in about 20%–30% of people in their lifetime, mostly after the age of 50 years. It commonly presents as a painful, self-limiting vesicular rash in a dermatomal distribution, that can lead to post-herpetic neuralgia and other complications, with increased risk with age.[7]
- Herpes zoster vaccine contains attenuated varicella zoster virus and is recommended for adults aged 60 years or older, and adults aged 50 years or older who are household contacts of a person who is immunocompromised.
- National funding for herpes zoster vaccine was initiated in 2016 with a single dose for people aged 70 years and a 5-year catch-up program for people aged 71–79 years.[3]

TABLE 1: Vaccines available in Australia for adolescents and adults according to funding scheme (2018–2019)

Vaccine brand name	NIP funding criteria	PBS funding criteria	Additional state funding criteria (Not covered by NIP or PBS)	Other groups where vaccination is recommended (not funded)
Influenza				
Afluria Quad FluQuadri Fluarix Tetra Influvac Tetra	• Individuals aged ≥ 65 years • Pregnant women • All Aboriginal and Torres Strait Islander people aged ≥ 6 months • Aged ≥ 6 months with certain medical risk factors (see Appendix 1)	NA	NA	All people aged ≥ 6 months
Fluad Fluzone High dose	• Individuals aged 65 years and over	NA	NA	NA
Pneumococcal disease				
Pneumovax -23	• Aboriginal and Torres Strait Islander people aged ≥ 50 years • Aboriginal and Torres Strait Islander people aged ≥15-49 years and with a high risk of contracting pneumococcal infections (see Appendix 1) • Aged ≥ 65 years	• Individuals aged ≥ 2 years and must have undergone a splenectomy • Individuals with Hodgkin's disease • Individuals with a high risk of contracting pneumococcal infections (see Appendix 1)	**NT** • Aboriginal people aged ≥ 15 years • All people aged ≥ 6 months with chronic medical conditions or those who are immunocompromised **QLD** • Aboriginal and Torres Strait Islander people aged 15 to 50 years • All people aged ≥ 6 months with chronic medical conditions or those who are immunocompromised	People with conditions associated with an increased risk of invasive pneumococcal disease (see Appendix 1)
Prevenar 13	NA	NA	NA	People with conditions associated with a higher risk of invasive pneumococcal disease who have not previously received additional pneumococcal vaccines (see Appendix 1)

TABLE 1 (CONTINUATION)

Vaccine brand name	NIP funding criteria	PBS funding criteria	Additional state funding criteria (Not covered by NIP or PBS)	Other groups where vaccination is recommended (not funded
Meningococcal (MenACWY) disease				
Nimenrix Menveo Menactra	• Individuals aged 14–19 years	NA	NA	• Smokers • Travellers (MenACWY) • Laboratory workers • Young adults who live in close quarters • People with medical conditions (see Appendix 1)
Meningococcal (MenB) disease				
Bexsero Trumenba	NA	NA	**SA** • Students Year 10 (15 years old) • Individuals aged 17–21 years	
Pertussis				
Adacel Boostrix	Pregnant women (20–32 weeks) • Students Year 7 or age equivalent (10–19 years old) through school programs and catch-up programs		**NSW** • Individuals aged 17–19 years **QLD** • Individuals aged 10–19 years with partial or no documented history of previous vaccination	Routine booster vaccination: • Adults aged ≥ 50 years • Adults in special risk groups: Pregnant or breastfeeding women, travellers, healthcare workers and student health professionals, early childhood educators and carers, and people in close contact with infants • Adults aged ≥ 65 years if they have not been vaccinated in the past 10 years
Adacel Polio Boostrix-IPV	NA	NA	NA	NA
Herpes zoster				
Zostavax	• Individuals aged 70–79 years	NA	NA	• Adults aged ≥ 60 years (Funded 70–79 years) • Adults aged ≥ 50 years who are household contacts of a person who is immunocompromised
Shingrix	NA	NA	NA	NA

NA: not applicable; NIP: National Immunisation Program; NSW: New South Wales; NT: Northern Territory; PBS: Pharmaceutical Benefits Scheme; QLD: Queensland; SA: South Australia

Note: This table includes data relevant for the period between 2018-2019. Further expansions in funding occurred in 2020. The details of those changes can be assessed at the National Centre for Immunisation Research and Surveillance website[3] and the Australian Immunisation Handbook.[1]

1.3 Vaccination coverage estimates

The estimation of vaccination coverage among adolescents and adults in Australia is challenging due to the lack of a regular and nationally consistent source of data.[8] The Australian Immunisation Register (AIR) is a national register that contains records of vaccinations given to people of all ages in Australia, including NIP-funded vaccines administered in different settings and those privately purchased by individuals. Most general practices report vaccinations to this register automatically from their management software, with a smaller proportion entering data directly on the AIR website. Vaccinations administered in pharmacies are increasingly being reported using automated software. However, vaccination administered in workplaces and other non-GP settings are likely not captured, despite the fact health professionals can report vaccinations directly on the AIR website. Adult vaccination in AIR is associated with significant underreporting since the capture of AIR started in 2016 with vaccination in this population commonly performed in non-GP settings. The real uptake of vaccination in adults could be up to double that recorded on AIR, and potentially greater for non-NIP-funded vaccines.[9]

Previous research has identified suboptimal coverage of vaccines among adults in Australia, even among groups eligible for free vaccination. A systematic review reported rates from 1990 to 2015 for influenza vaccination ranging from 64% to 82% among people aged 65 years or older and between 30% and 49% for adults aged under 65 years.[10] Pneumococcal vaccination coverage was also low, ranging from 15% to 73% among people aged 65 years or older and between 5% and 34% for adults aged under 65 years. For both vaccines, coverage was higher after the introduction of free vaccination under the NIP.[10]

Recent studies describing influenza vaccination coverage in Australia reported rates between 27.3% and 83.6%, depending on the study population, setting and method used to measure vaccination uptake.[11-17] These studies highlighted low overall coverage among adults in the general population, with gaps especially among people belonging to higher risk groups (older Aboriginal and Torres Strait Islander people and those with chronic health conditions).[11,13] While not assessing the impact of funding, a study among aged care workers found immunisation programs in workplaces providing free vaccination to be one of the strongest predictors of vaccination uptake.[12]

Regarding pneumococcal vaccination, a time-series analysis from 2010 and 2016 showed a decreasing trend in the uptake over time, reducing from 63% to 52% during that period among older people regularly visiting general practices.[18] A longitudinal analysis of the same study evaluating when people between 60 and 65 years old received their first pneumococcal vaccination showed most people (~80%) had been vaccinated after turning 65, when they are eligible for free vaccination through NIP.[18] Figures for adults aged under 65 years were not estimated in this study and are likely to be substantially lower.

Estimates for herpes zoster vaccination among people aged 70 to 79 years range from 31% to 47%.[19,20] As with other vaccines, a peak in vaccination uptake occurs when people become eligible for free vaccination and in months where people are more likely to be immunised for influenza. Coverage is reported to be higher among women and people attending practices in the most socioeconomically advantaged areas, while attending practices in remote/very remote regions is associated with a lower probability of being vaccinated.[20]

Evidence about vaccination coverage in Australia for pertussis and meningococcal disease in adolescents and adults is limited, and mostly refers to specific subgroups. Pertussis vaccination coverage ranged between 64% and 79% among pregnant women,[15,16] 70% among hospitalised patients[21] and 75% among Australian early childhood education staff.[17] Meningococcal vaccination coverage among men who have sex with men was estimated to be 67%.[22]

Most commonly, these studies collected self-report data from interviews to estimate vaccination coverage,[10,12,13,17,21,23] which are susceptible to social desirability and recall bias. Other limitations included small sample sizes, with low statistical power to detect differences between subgroups,[21] unavailability of sociodemographic and clinical characteristics which may be associated with vaccination, and restricting the study population to certain subgroups. Therefore, studies using secondary data such as health insurance claims[24] and electronic health records from general

practices, such as MedicineInsight data,[11,18,20,25] have been increasingly used to estimate immunisation rates in the Australian population.

The use of real-world data adds to our understanding of true coverage in the general population and is a powerful source of information for planning. In this context, we report adolescent and adult vaccination coverage for influenza, pneumococcal, meningococcal disease, pertussis and herpes zoster, according to patient and practice characteristics using MedicineInsight data, a national dataset from general practices across Australia. We also examined differences in vaccination coverage according to eligibility to receive a funded vaccine and factors associated with the probability of vaccination uptake.

1.4 MedicineInsight program

MedicineInsight is a leading large-scale primary care data set of longitudinal de-identified general practice electronic health records extracted from clinical information systems (CIS) in Australia. MedicineInsight was initially established by NPS MedicineWise in 2011, with core funding from the Australian Government Department of Health, to collect general practice data to support quality improvement in Australian primary care and post-market surveillance of medicines. The monthly collation of collected data can be analysed to improve patient care, quality improvement and evaluation, performing population health analyses, research and developing health policy.

MedicineInsight utilises third-party data extraction tools which extract, de-identify, encrypt and securely transmit whole-of-practice data from the clinical information systems of over 700 general practices. Patient-level data are de-identified 'at source' meaning patients' personal identifiers such as name, date of birth and address are not extracted by the tool (although the year of birth and postcode are extracted, enabling the calculation of age and Socio-Economic Indexes for Areas [SEIFA]). The data held in the MedicineInsight database are non-identifiable. However, each patient in a practice site has a unique identifying number which allows all the records (clinical, prescription, referral etc) held in the database to be linked to the associated patient identifying number. The process of collecting patient data achieves a data collection that meets the definition of non-identified data in the NHMRC National Statement on Ethical Conduct in Human Research.

MedicineInsight data has been previously used to estimate vaccination coverage for pneumococcal vaccines among the elderly,[18] influenza vaccines for children[25] and influenza and herpes zoster vaccines among adults.[11,20,26] All the studies produced findings consistent with those from past surveys and, to some extent, with the AIR, demonstrating that MedicineInsight database is a low cost, feasible and reproducible source of information for immunisation monitoring purposes.

Further information is available online: https://www.nps.org.au/medicine-insight

1.5 Ethics approval for MedicineInsight

In December 2017, NPS MedicineWise was granted ethics approval for the standard operations and uses of the MedicineInsight database by NPS MedicineWise. This program approval was given by the RACGP NREEC (NREEC 17-017).

Ethics approval for this specific project was granted in May 2020 by the RACGP NREEC (NREEC 20-006) and approval by the Data Governance Committee in April 2020 (019–031).

2. AIMS AND METHODS

2.1 Study aims

The purpose of this study is to report on the following in relation to vaccines for influenza, pneumococcal, herpes zoster, meningococcal disease, and pertussis.

1. Describe the overall annual vaccination coverage among people aged 10 years or older from 1 January 2018 to 31 December 2019, and stratified by sociodemographic and clinical characteristics, and vaccine funding status.
2. Evaluate the independent association between patient sociodemographic and clinical characteristics, funding eligibility status and practice characteristics with vaccination uptake in the year 2019.

2.2 Study design and time period

This is a descriptive cross-sectional study, using Australian general practice data from MedicineInsight for 2018 and 2019. Data from 1 January 2017 to 31 December 2019, inclusive, were used to identify the general study population of patients regularly attending a MedicineInsight practice (3 visits in the past 2 years). Historical records outside of this study period were consulted when identifying patient demographics, health conditions and prior vaccinations.

2.3 Study population

General practice sites

De-identified patient data were obtained from Australian general practice sites which met the standard data quality criteria in the MedicineInsight May 2020 download. A general practice site is used to describe one or more practices that share the same general practice database, either because they are operating within a common administrative system (eg, the same corporate entity) or in the same geographical area.

The standard data quality criteria were applied:

- the site had been established for at least 2 years; and
- had no significant interruptions (of longer than 2 months in the 2 years previous) to their practice data; and
- met the minimum threshold of clinical activity (ie, at least 50 patients in the last 2 years).

Patient population

The **general study population** comprised patients of all ages who met the following inclusion criteria:

- they visited a practice site that contributed data to MedicineInsight and meets specific MedicineInsight data quality requirements
- they had valid information for age and sex
- they had at least three clinical encounters during the study time period (1 Jan 2017–31 Dec 2018 for inclusion in the 2018 analysis, and 1 Jan 2018–31 Dec 2019 for inclusion in the 2019 analysis).

The **study population** were patients in the general study population who met the following inclusion criteria:

- they were aged 10 years or older at the beginning of the year of interest (except for herpes zoster vaccination, in which the population was restricted to people aged 50 years or older).

Sample size

As MedicineInsight includes over a million regular patients, the whole dataset was utilised for this study. A random sample size of 2,688 patients would be necessary to estimate vaccination coverage, considering an anticipated vaccination coverage of 30% in the reference group;[9,11,18] at a significance level of 5%; 80% power to detect a 5% point difference between subgroups (exposed = 35%); and a ratio of sample sizes equal to 1. This estimation is a demonstration of how big the dataset is related to the minimum requirements to identify differences between groups. However, we included all patients who met the study inclusion criteria to be able to perform an exploratory analysis of factors associated with vaccination uptake. We calculated the sample size using the software OpenEpi (http://www.openepi.com) [accessed 9 March 2020].

2.4 Study outcomes

Vaccination identification

MedicineInsight data contain fields in which immunisations and the dates they were administered are recorded. These fields contain vaccinations that are administered at the practice or reported by the patient. Vaccinations may also be recorded in other fields, such as prescriptions issued, medicines used by the patient, diagnoses, and reasons for the encounter. As previous analyses evaluating pneumococcal and influenza vaccines [11,18] revealed that the immunisation field captured the vast majority of cases, we used information captured only from the immunisation field.

Since health professionals can record the immunisation using standard codes or using 'free text' descriptions, we adapted algorithms previously described[11,20,27] to extract the information from the immunisation field. This algorithm searched for brand names of the vaccines, their synonyms, and generic terms, retrieving any record containing potentially eligible terms as described in Table 2. In a second stage, we manually screened all terms recovered for each disease group to exclude records indicating the immunisation was likely not performed, such as 'decline', 'reject' or '?' (eg, a search for 'flu' that recovered 'rejected flu vaccine').

TABLE 2: Search list for identifying vaccines

Vaccine for	Brand names for 2018 and 2019 adult vaccines	Brand names for vaccines from previous years and non-adult vaccines	Generic terms for vaccinations entered as free text	Terms used in the search strategy to include records	Terms used to exclude records
Influenza	Afluria Quad, FluQuadri, Fluarix Tetra, Influvac Tetra, Fluad, Fluzone High dose	FluQuadri Junior, Fluarix, Fluvirin, Agrippal, Vaxigrip, Intanza	'flu', 'fluvax', 'flu high dose', 'influenza'	'Flu', 'Agrippal', 'Vaxigrip', 'Intanza'	'decline', 'reject', 'refuse', 'none', '?', 'can't tolerate', 'haemophilus and flu', 'fluid', 'no further fluvax allergic', 'fluanxol30mg'
Pneumococcal disease, 23vPPV	Pneumovax-23		'23vPPV ', 'PPV', 'Pneumovax'	'pneumovax', 'PPV'	'decline', 'reject', 'refuse', 'none', '?', 'does not' 'likely', 'reminders', 'advised'
Pneumococcal disease, 13vPCV	Prevenar 13		Prevenar 13 13 PCV	'PCV and 13', 'PREVENAR and 13'	'decline', 'reject', 'refuse', 'none', '?', 'does not' 'likely', 'reminders', 'advised'
Meningococcal disease	Nimenrix, Menveo, Menactra,	Menitorix, NeisVac-C, Menjugate,	'MenB', 'MenACWY',	'Men', 'Bexsero', 'NeisVac-C'	'decline', 'reject', 'refuse', 'none', '?', 'abdomen', 'cytamen', 'augmentin',

Vaccine for	Brand names for 2018 and 2019 adult vaccines	Brand names for vaccines from previous years and non-adult vaccines	Generic terms for vaccinations entered as free text	Terms used in the search strategy to include records	Terms used to exclude records
	Bexsero, Trumenba	Meningitec, Mencevax, Menomune	'MenC', 'meningococcal'		'complained of bloated feeling after mens', 'experimental', 'government', 'commenced', 'hymenoptera', 'immun' and 'doc', 'instrument', 'iutd' and 'meningo', 'jespect', 'not recommended', 'improvement ', 'cerumen', 'oitment', 'reminders', 'document', ' segment', 'unknown', 'comments', 'vitamen'
Pertussis	Adacel, Adacel Polio, Boostrix, Boostrix-IPV	Hexaxim, Infanrix, Infanrix penta, Infanrix hexa, Infanrix IPV, Quadracel, Tripacel, Pentaxim	'pertussis', 'pertusis', 'DTPa', 'dTpa', 'DTPa-IPV', 'DTPw', 'whooping cough', 'penta'	Adacel, Boostrix, Hexaxim, Infanrix, Quadracel, Tripacel, 'pertussis', 'pertusis', 'DTP', 'whooping cough'	'decline', 'reject', 'refuse', 'none', '?', 'did not have', 'missing'
Herpes zoster	Zostavax Shingrix	-	'shingles', 'zoster', 'zona', 'ZVL'	'zosta', 'zoster', 'Shingrix', 'shingles', 'zona', 'ZVL'	'decline', 'reject', 'refuse', 'none', '?', 'not for', 'contraindication', 'infection varicella zoster virus', 'not keen', 'defers', 'zig'

Vaccination coverage

We defined a vaccinated patient in the following three ways, with further detail provided in Table 3:

- 'ever vaccinated': patients who were vaccinated within each year of interest or any time prior as long as they were 10 years or older (eg, 2018 or any time prior in the dataset)
- 'first vaccinated that year': patients receiving a vaccination for the first time that year
- 'vaccinated that year': patients who were vaccinated within each year of interest (eg, 2018).

For patients with a record of vaccination on more than one date within each period evaluated, the first vaccination date was selected and used in the analyses.

For all disease groups, we estimated the annual vaccination coverage using the 'first vaccinated that year' and 'ever vaccinated' approaches. To exclude childhood vaccinations, we included only vaccinations recorded in MedicineInsight when people were aged 10 years or older. Since influenza vaccines should be taken every year, estimates were calculated using the 'vaccinated that year' approach only (see Table 3). Analyses were not conducted at the level of specific vaccines with vaccines within a disease group considered together.

We also estimated the associations between vaccination coverage in 2019 and sociodemographic, clinical characteristics, and funding eligibility status. These study outcomes are described in more detail in Table 3.

TABLE 3: Operational definitions of the study outcomes

Specific objectives	Disease group	Approach	Numerator	Denominator
Describe the annual vaccination coverage among individuals aged 10 years or older **in 2018** per disease group	Influenza	Vaccinated that year	Number of individuals receiving a vaccination in 2018 (ie, date of vaccination in 2018)	Total number of individuals who were considered regular patients in 2018 (irrespective of previous vaccination status)
	Pneumococcal Meningococcal Herpes zoster Pertussis	First vaccinated that year	Number of individuals receiving a vaccination for the first time in 2018 (ie, date of vaccination in 2018 and no prior vaccination)	Total number of individuals who were considered regular patients in 2018 **and not previously vaccinated** (ie, exclude patients vaccinated prior to 2018)
	Pneumococcal Meningococcal Herpes zoster Pertussis	Vaccinated ever	Number of individuals vaccinated in 2018 or prior (ie, date of vaccination in 2018 or any year prior)	Total number of individuals who were considered regular patients in 2018 (irrespective of prior vaccination status)
Describe the annual vaccination coverage among individuals aged 10 years or older **in 2019** per disease group	Influenza	Vaccinated that year	Number of individuals receiving a vaccination in 2019 (ie, date of vaccination in 2019)	Total number of individuals who were considered regular patients in 2019 (irrespective of prior vaccination status)
	Pneumococcal Meningococcal Herpes zoster Pertussis	First vaccinated that year	Number of individuals receiving a vaccination for the first time in 2019 (ie, date of vaccination in 2019 and no prior vaccination)	Total number of individuals who were considered regular patients in 2019 **and not previously vaccinated** (ie, exclude individuals vaccinated prior to 2019)
	Pneumococcal Meningococcal Herpes zoster Pertussis	Vaccinated ever	Number of individuals vaccinated in 2019 or prior (ie, date of vaccination in 2019 or any year prior)	Total number of individuals who were considered regular patients in 2019 (irrespective of prior vaccination status)
Describe the annual vaccination coverage stratified by sociodemographic, clinical characteristics, and funding eligibility status	Influenza Pneumococcal Meningococcal Herpes zoster Pertussis		Same as above to be estimated for each subgroup (by sociodemographic and clinical characteristics and funding eligibility status)	Same as above to be estimated for each subgroup (by sociodemographic and clinical characteristics and funding eligibility status)
Association between sociodemographic, clinical characteristics and funding eligibility status and vaccine coverage in the year **2019**	Pneumococcal Meningococcal Herpes zoster Pertussis	Vaccinated ever	Odds Ratio and marginally adjusted prediction of coverage in each subgroup of interest	Odds Ratio and marginally adjusted prediction of vaccination coverage in the reference group
	Influenza	Vaccinated that year		

Regular patients: Patients who had at least 3 clinical encounters within the consecutive 2-year period, according to the Royal Australian College of General Practitioners definition.

2.5 Definitions

Clinical encounters

A clinical encounter, or any professional exchange between a patient and a general practitioner or a nurse, was defined as all those encounters at the practice site that were:

a) not identified as administrator entries nor encounters that have been transferred/imported from another practice and

b) not identified by predefined administration-type terms found in the 'reason for encounter' or 'visit type' fields such as 'administrative reasons', 'forms', and 'recall'.

Sociodemographics

We measured sociodemographic characteristics as defined in Table 4.

TABLE 4: Sociodemographic definitions

Characteristic	Definition
Patient characteristics	
Age	Mean (SD), median (IQR) Age was calculated at the beginning of the year of interest based on the patient's date of birth (defined as 1 July in the patient's year of birth)
Age groups	Clinically relevant groups according to disease group: • Influenza: 10–19, 20–50, 51–64, 65+ years old • Pneumococcal disease: 10–19, 20–50, 51–64, 65+ years old • Meningococcal disease: 10–13, 14–19, 20–25, 26–50, 51–64, 65+ years old • Herpes Zoster: 50–59, 60–69, 70, 71–79, 80+ years old • Pertussis: 10–13, 14–17, 18–39, 40–64, 65+ years old
Sex	As recorded in the clinical information system (male, female, indeterminate)
Indigenous Status	As recorded in the clinical information system Aboriginal and/or Torres Strait Islander (Yes, No, missing). This variable was not used for testing associations. Rather, it was used to define patients' funding eligibility status (see Table 6)
Rurality (modified)	Rurality was assigned based on a mapping of each patient's postcode of residence using the Australian Bureau of Statistics (ABS) mapping of Postcode 2016 to ASGS Remoteness Areas 2016.[a] (Major city, Inner regional, Outer regional, Remote/Very remote)
Socioeconomic status (SEIFA) (quintiles)	SEIFA was assigned based on a mapping of each patient's postcode of residence using the Australian Bureau of Statistics (ABS) mapping of Postcode 2016 to the Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD). Quintiles: 1 (most disadvantaged) to 5 (most advantaged) [b]
Smoking status	Current smoking status as recorded in the clinical information system (Non-smoker, Smoker, Ex-smoker, Not recorded)
Health conditions	Patients were classified as having a morbidity if a condition was recorded in the clinical information system. Groups of conditions were dichotomised [eg, cardiac disease (Yes, No)] We also considered a broader category, including all relevant health conditions according to the Australian Immunisation Handbook together [Any relevant morbidity (Yes, No)] See the 'Condition definitions' section for more details
Clinical encounters	Mean (SD), median number of clinical encounters in the previous year
Funding eligibility status	Patients were classified as eligible for a funded vaccine if they comply with the eligibility criteria to receive funded vaccines thought the NIP, State or PBS. All other patients will be classified as non-eligible for a funded vaccine. Categories were dichotomised (NIP-eligible, PBS-eligible, State-eligible, not eligible)

[a] Australian Bureau of Statistics (ABS). Remoteness structure, Australia
https://www.abs.gov.au/websitedbs/D3310114.nsf/home/remoteness+structure
b Australian Bureau of Statistics (ABS). Census of population and housing: Socio-Economic Indexes for Areas (SEIFA), Australia.
http://www.abs.gov.au/ausstats/abs@.nsf/mf/2033.0.55.001.

Characteristic	Definition
	We also considered a broader category, including all funding schemes together (funded, unfunded).
Practice characteristics	
State in Australia	State/territory was assigned based on each practice's postcode
Rurality (modified)	Rurality was assigned based on a mapping of each practice's postcode of residence using the Australian Bureau of Statistics (ABS) mapping of postcode 2016 to ASGS Remoteness Areas 2016.[a] (Major city, Inner regional, Outer regional, Remote/Very remote)
Socioeconomic status (SEIFA) (quintiles)	SEIFA was assigned based on a mapping of each practice's postcode of residence using the Australian Bureau of Statistics (ABS) mapping of postcode 2016 to the Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD). Quintiles: 1 (most disadvantaged) to 5 (most advantaged) b

SD: Standard deviation

Conditions

MedicineInsight condition flags have been developed by a team of medical advisors (practising general practitioners) and clinical coders to indicate those records where the conditions of interest (or their relevant synonyms) are reported in MedicineInsight. The algorithms underlying these flags search for both coded conditions (entered by using a dropdown list in the clinical information system) and non-coded conditions (free text) in one or more of the 'Diagnosis', 'Reason for encounter' or 'Reason for prescription' fields. Records of medicines and tests can also be used to identify patients with a condition in MedicineInsight.

Records identified by a free text string alone are not automatically flagged but are individually reviewed by a clinical coder to determine whether the text string refers to the condition indicated or is present in another context (eg, a search for 'cancer' may identify 'partner died from cancer'). Each record was flagged accordingly. Records indicating 'suspected', 'query' or '?' records of the condition were not flagged as the condition unless otherwise specified.

For the purposes of this analysis, we included relevant clinical conditions according to the Australian Immunisation Handbook.[1] These conditions were identified using pre-existing MedicineInsight flags and terms used in previously published algorithms[11] or/and suggested by our medical advisors (See Table 5).

TABLE 5: Terms and combinations used to identify health conditions, according to disease group

Condition group	Disease group	Conditions list	Terms
Cardiac disease	Pneumococcal disease Influenza	Congestive heart failure Coronary artery disease	'cardiac failure', 'ccf', 'cor pulmonale', 'diastolic cardiac dysfunction', 'heart failure', 'hfmref', 'hfpef', 'hfref', 'high output cardiac failure', 'high output heart failure', 'left ventricular failure', 'pulmonary oedema', 'rhf (right heart failure)', 'right heart failure','systolic cardiac dysfunction', 'systolic heart failure', 'ventricular diastolic dysfunction', 'AF (atrial fibrillation)', 'arrhythmia', 'myocardial infarction','ischaemic heart disease', 'coronary artery disease', 'angina','bypass', 'stent' and other synonyms

a Australian Bureau of Statistics (ABS). Remoteness structure, Australia https://www.abs.gov.au/websitedbs/D3310114.nsf/home/remoteness+structure

b Australian Bureau of Statistics (ABS). Census of population and housing: Socio-Economic Indexes for Areas (SEIFA), Australia. http://www.abs.gov.au/ausstats/abs@.nsf/mf/2033.0.55.001.

Condition group	Disease group	Conditions list	Terms
Respiratory condition	Pneumococcal disease Influenza	Cystic fibrosis Bronchiectasis Asthma* Chronic obstructive pulmonary disease (COPD), emphysema, suppurative lung disease	'acute severe asthma', 'asthma', 'bronchial asthma', 'exercise induced asthma', 'exertional asthma', 'frequent episodic asthma', 'infective exacerbation of asthma', 'infrequent episodic asthma', 'occupational asthma', 'samter's triad', 'status asthmaticus', 'thunderstorm asthma', 'wheezy bronchitis', 'cystic fibrosis', 'chronic bronchi*', 'suppurative lung', 'COPD', 'bronchitis and chronic', 'cal (chronic airways limitation) ', 'chronic airways limitation', 'chronic bronchitis', 'chronic obstructive airways disease', 'chronic obstructive pulmonary disease', 'coad', 'emphysema', 'infective exacerbation of chronic bronchitis'
Neurological condition	Influenza	Seizure disorders Spinal cord injuries Neuromuscular disorders or hereditary and degenerative CNS diseases	'cerebral palsy', 'Charcot-Marie-Tooth disease', 'muscular dystrophy', 'myasthenia gravis', 'polymyositis', 'dermatomyositis', 'peripheral neuropathy', 'spinal muscular atrophy', 'amyotrophic sclerosis', 'multiple sclerosis', 'spinal cord injur', 'spinal cord damage', 'spinal cord lesion', 'epilepsy', 'absences', 'epileptic aphasia', 'dancing eyes syndrome', 'seizures', 'fits', 'convulsions', 'west syndrome' and other synonyms
Immuno-compromising condition	Pneumococcal disease Influenza	Malignancy Organ transplantation Asplenia or splenic dysfunction HIV infection Use of systemic corticosteroids	'cancer', 'leukaemia', 'adenocarcinoma', 'astrocytoma', 'carcinoma', 'glioma', 'hepatoma', 'histiocytoma', 'hypernephroma', 'tumor', 'lymphoma', 'mesothelioma', 'sarcoma', 'melanoma', 'blastoma',, 'liver transplant', 'renal transplant', 'lung transplant', 'card* transplant', 'asplenia', 'sickle cell disease', 'hyposplenia', 'splenectomy', 'acquired immuno deficiency syndrome', 'AIDS', 'hiv', 'human immunodeficiency virus', 'kaposi's sarcoma', 'tuberculosis – aids' and other synonims. People with two scripts of systemic corticosteroids in 2018 or 2019 (ATC codes 'H02AB01-02', 'H02AB04', 'H02AB06-10', 'H02AB15', 'H02AA02', 'H02BX01')
Chronic renal disease	Pneumococcal disease Influenza	Chronic renal failure	'chronic renal failure', 'chronic kidney disease', 'renal impairment', 'dialysis' and other synonims
Chronic liver disease	Pneumococcal disease	Chronic liver disease or Fibrosis or cirrhosis	'liver cirrhosis', 'liver coma', 'liver failure', 'copper storage disease', 'encephalopathy – hepatic liver fibrosis', 'Wilson's disease' and other synonyms
Diabetes	Pneumococcal disease Influenza	Type 1 diabetes Type 2 diabetes Diabetes, type not specified	'diabetes', 'diabetes mellitus', 'IDDM', 'diabetes mellitus - type I', 'insulin dependent diabetes mellitus', 'juvenile onset diabetes', 'NIDDM', 'non insulin dependent diabetes', 'T2DM', 'type 2 diabetes mellitus'
Other conditions possibly of interest **	Pneumococcal disease	Splenectomy Down syndrome Cochlear implants Intracranial shunts Hodgkin's disease	'Splenectomy', 'down syndrome', 'cochlear implants', 'intracranial shunts', 'Hodgkin's'
	Meningococcal disease	Deficiency of complement components	'Complement components deficiency', 'factor H deficiency', 'factor D deficiency', 'properdin deficiency'
	Influenza	Haemoglobino-pathies Chronic metabolic disorders	'haemophilia', 'thalassemia', 'metabolic disease', 'amino acid disorder', 'carbohydrate disorder', 'cholesterol biosynthesis disorder', 'fatty acid oxidation defect', 'lactic acidosis', 'mitochondrial disorder', 'organic acid disorder', 'urea cycle disorder', 'vitamin/cofactor disorder', 'porphyria'

ATC: Anatomical Therapeutical Classification system
Source: Adapted from De Oliveira Bernardo et al (2019),[11] Australian Immunisation handbook[1]

* This approach recognises that clinicians may not make a distinction between severe and non-severe asthma when recommending pneumococcal and influenza vaccines
** According to funding schemes

Funding eligibility status

The classification of patients according to funding eligibility status was conducted according to each disease group, as described in detail in Table 6.

TABLE 6: Criteria to define funding eligibility status according to disease group

Disease group	Funding category	Definition
Influenza		
Funding eligibility status	NIP-funded	If age ≥ 65 OR Indigenous status = "Yes" OR Influenza any relevant health condition = "Yes"
	Not eligible	People who do not fill the criteria for NIP-funded
Pneumococcal disease		
Funding eligibility status	NIP-funded	If age ≥ 65 OR Indigenous status = "Yes" AND age ≥50 OR Indigenous status = "Yes" AND age ≥15 AND (Pneumococcal any relevant health condition = "Yes" OR Smoking status = "Smoker")
	State-funded	If NIP-funded = "No" AND (State = NT AND Indigenous status = "Yes" AND age ≥15) OR (State = NT AND Pneumococcal any relevant health condition = "Yes" OR Smoking status = "Smoker") OR (State = QLD AND Indigenous status = "Yes" 15 ≤ age ≤50) OR (State = QLD AND Pneumococcal any relevant health condition = "Yes" OR Smoking status = "Smoker")
	PBS-funded	If NIP-funded = "No" AND State funded = "No" AND [(AGE ≥ 2 AND splenectomy = 1) OR (Hodgkin's disease = 1) OR (Pneumococcal any relevant health condition = "Yes" OR Smoking status = "Smoker")]
	Not eligible	People who do not fill the criteria for any of those types of funding
Meningococcal disease		
Funding eligibility status	NIP-funded	If 14 ≤ age ≤ 19
	State-funded	If NIP-funded = "No" AND (State = SA AND 17≤ age ≤ 21)
	Not eligible	People who do not fill the criteria for any of those types of funding
Pertussis		
Funding eligibility status	NIP-funded	If 10 ≤ age ≤ 13
	State-funded	If NIP-funded = "No" AND (State = NSW AND 17≤ age ≤ 19) OR (State = QLD AND 10≤ age ≤ 19)
	Not eligible	People who do not fill the criteria for any of those types of funding
Herpes zoster		
Funding eligibility status	NIP-funded	If 70 ≤ age ≤ 79
	Not eligible	People who do not fill the criteria for any of those types of funding

2.6 Data analysis and reporting

We analysed the overall characteristics of the study population and results for each disease group (influenza, pneumococcal, meningococcal disease, pertussis and herpes zoster), including:

- the crude vaccination coverage according to patients' and practices' characteristics in 2018 and 2019
- vaccination coverage stratified by funding eligibility status and factors associated with the annual vaccination coverage in the year 2019.

Study population characteristics were described as absolute numbers and percentages for categorical variables and means (SD) for continuous variables. The annual vaccination coverage was calculated, overall and stratified by sociodemographic, funding eligibility status and other relevant characteristics (percentage and 95% confidence intervals). Further details of the numerator and denominators for the study outcomes have been defined in Table 3 and are presented with descriptive statistics.

We also calculated the annual vaccination coverage estimates according to funding eligibility status in 2019 stratified by sociodemographic and other relevant characteristics (percentage and 95% confidence intervals).

If a particular result was only reported in 1–4 patients, this result has been reported as < 5 in order to preserve the privacy of individuals (except missing variables). If a particular result was not seen in any patient, the result has been reported using a dash (-).

The association between vaccination coverage in 2019 (the most recent year) and sociodemographic, clinical and practice characteristics was assessed via logistic regression using robust variance to account for clustering of patients within practices. For pneumococcal, meningococcal, herpes zoster and pertussis we used the 'vaccinated ever approach' to estimate vaccination coverage, while for influenza we used the 'vaccinated that year approach'. The crude associations were fully and mutually adjusted for patients' characteristics (age, sex, socioeconomic status, the median number of clinical encounters in the previous year and health conditions) and practices' characteristics (rurality, socioeconomic status and state) using odds ratios (OR) and 95% CI adjusted for clustering by practice site. Other confounders were added to the final model according to clinical relevance for each disease group (eg, health conditions for influenza, pneumococcal disease and meningococcal). We also tested the final model for multicollinearity by assessing the variance inflation factor (VIF) and tolerance and model goodness of fit by assessing the Hosmer–Lemeshow test.

Comparison of MedicineInsight data to other national data

We compared the sociodemographic profile of our study population to national data from the Medicare Benefits Schedule (MBS) and compared the prevalence of health conditions with data from the ABS National Health Survey (NHS) 2017–18.

The MBS claims data are an administrative by-product of the administration of the Medicare fee-for-service payment system. We compared our results to MBS data for patients who attended general practices in 2017–18 using data publicly available from a recent MedicineInsight report. However, publicly available estimates include people from all age groups (including those aged 9 years or less).[28]

The most recent ABS NHS, a general population survey, was conducted from July 2017 to June 2018 and collected data on a range of information about the health of Australians, including the prevalence of long-term health conditions which are defined as current medical conditions which have lasted, or are expected to last, for 6 months or more, unless otherwise stated. These health conditions are measured by self-report and collected by trained ABS interviewers and the data include people from all age groups (including those aged 9 years or less).[29]

Sensitivity analysis

To evaluate the impact of including patients with asthma irrespective of its severity on our estimate of vaccine coverage among patients with any relevant condition, we performed a sensitivity analysis excluding people with asthma from the "Any relevant health condition" covariable and provided a second estimate of vaccine coverage.

Since seasonal influenza vaccination is more likely to occur in specific periods of the year, we investigated the impact of restricting the study population to people attending general practices between March and August of each year in influenza coverage estimates.

We also investigated the impact of including the following non-adult vaccines and non-specific terms related to pneumococcal vaccination in 23vPPV pneumococcal coverage estimates: ‘pneumococcal’, ‘pneumo’, Synflorix, Prevenar 7, ‘PCV’, ‘7vPCV’, ‘10Vpcv’. However, terms related to vaccination with Prevenar 13 and its synonyms (‘PCV and 13’, ‘PREVENAR and 13’) were not included to estimate coverage. Instead, these terms were used to create a covariate representing 13-valent pneumococcal vaccination (13vPCV).

Analyses were performed in the statistical software SAS Enterprise Guide SAS version 9.4 (SAS Institute Inc., Cary, NC, USA), including the use of the ‘SURVEYFREQ’ and ‘SURVEYLOGISTIC’ procedures.

3. RESULTS

3.1 Characteristics of the study population

We identified 1,722,363 patients aged 10 years or older attending general practices in 2018 and 1,772,931 in 2019, with similar characteristics in both years (Table 7). This cohort of patients comprised the study population to estimate influenza, pneumococcal, meningococcal and pertussis vaccination coverage. The vaccination estimates for herpes zoster is presented in Section 3.5 where the study population only includes people aged 50 years or older.

The mean age of the study population was 47 (± 21) years, with 44% aged between 20 and 49 years and 57% female. Compared to the MBS national data, our study cohort was more likely to be female (57% vs 52%) and more likely to be between 20 and 39 years of age (29% vs 26%). Sex was indeterminate for 126 patients in 2018 and 167 in 2019 (< 0.1%) and the vaccination coverage among this sub-population is not shown due to low numbers, although they were not excluded from the study population.

A high proportion of patients resided in major cities (61%–62%) and attended practices in New South Wales (35%). The socioeconomic status of patients was evenly distributed, with 18% of patients from the most disadvantaged areas and 22% from the most advantaged areas. A similar pattern was observed for socioeconomic status of the area in which practices were located, with patients attending practices located in the most advantaged areas being the largest category (25%). The distribution of patients' rurality and socioeconomic status was similar to that in the MBS national data, except that patients in our study cohort were more likely to reside in inner regional areas (24% vs 12%) and in socioeconomically disadvantaged areas. Our study cohort included a higher proportion of practices from inner regional Australia (25% vs 19%), Tasmania (8% vs 3%) and a lower proportion of practices from South Australia (3% vs 8%).

TABLE 7: Sociodemographic characteristics of the study population

Characteristic	Sample distribution year 2018	Sample distribution year 2019	Australian national data (MBS)[a] 2017–18
	Number (%)	Number (%)	(%)
Total population (overall)	1,722,363 (100)	1,772,931 (100)	-
Patient characteristics			
Sex			
Female	988,696 (57.4)	1,015,291 (57.3)	52.4
Male	733,541 (42.6)	757,473 (42.7)	47.6
Indeterminate	126 (<0.1)	167 (<0.1)	-
Age group (years)			
10–19	179,795 (10.4)	186,549 (10.5)	11.0
20–29	234,581 (13.6)	239,260 (13.5)	12.2
30–39	265,756 (15.4)	275,594 (15.5)	14.0
40–49	255,506 (14.8)	259,864 (14.7)	13.3
50–59	253,531 (14.7)	258,753 (14.6)	13.0
60–69	237,885 (13.8)	244,415 (13.8)	11.5
70–79	179,088 (10.4)	188,902 (10.7)	8.1
80–89	90,128 (5.2)	92,865 (5.2)	3.9
90+	26,093 (1.5)	26,729 (1.5)	1.0
Rurality			
Major city	1,055,731 (61.3)	1,096,470 (61.9)	71.3
Inner regional	428,171 (24.9)	436,453 (24.6)	12.4
Outer regional	209,814 (12.2)	212,044 (12.0)	12.3
Remote/very remote	28,647 (1.7)	27,964 (1.6)	3.9
Socioeconomic status			
1 (most disadvantaged)	316,802 (18.4)	321,178 (18.1)	12.2
2	307,829 (17.9)	316,747 (17.9)	12.2
3	377,319 (21.9)	389,086 (22.0)	15.0
4	331,023 (19.2)	343,380 (19.4)	12.4
5 (most advantaged)	389,390 (22.6)	402,540 (22.7)	11.7
Median number of clinical encounters in the previous year (IQR)	4 (2; 8)	4 (2; 8)	-
Practice characteristics			
State			
Australian Capital Territory	38,047 (2.2)	41,116 (2.3)	1.5
New South Wales	593,583 (34.5)	619,507 (34.9)	30.2
Northern Territory	31,978 (1.9)	31,557 (1.8)	1.5
Queensland	284,321 (16.5)	296,137 (16.7)	21.7
South Australia	49,533 (2.9)	49,333 (2.8)	7.7
Tasmania	139,956 (8.1)	143,382 (8.1)	2.5
Victoria	392,774 (22.8)	393,094 (22.2)	24.4
Western Australia	192,171 (11.2)	198,805 (11.2)	10.5
Rurality			
Major city	1,071,376 (62.2)	1,110,992 (62.7)	68.6
Inner regional	423,550 (24.6)	433,630 (24.5)	18.8
Outer regional	201,918 (11.7)	203,604 (11.5)	8.9
Remote/very remote	25,519 (1.5)	24,705 (1.4)	3.7
Socioeconomic status			
1 (most disadvantaged)	306,992 (17.8)	309,151 (17.4)	-
2	298,342 (17.3)	306,487 (17.3)	-
3	380,925 (22.1)	399,251 (22.5)	-
4	300,575 (17.5)	308,687 (17.4)	-
5 (most advantaged)	435,529 (25.3)	449,355 (25.4)	-

IQR: Interquartile range; SD: Standard deviation; [a] As published by NPS MedicineInsight[28] Percentages are presented including people from 0 to 9 years old.

Health risk behaviours and health conditions (Table 8)

While 55% of patients were non-smokers at the time of the data collection, 20% were ex-smokers, 12% were smokers and 13% did not have their smoking status recorded. From a preselected list of health conditions evaluated, respiratory conditions were the most commonly recorded (17%–18%), of which asthma accounted for approximately 13% of cases. The next most commonly recorded conditions were immunocompromising conditions (15%), cardiac diseases (8%–9%) and diabetes (any type, 8%–9%). Overall, rates of smoking and health conditions identified in our study population were similar to the 2017–18 Australian Bureau of Statistics National Health Survey (ABS NHS), where available. However, we identified a higher rate of non-smokers (valid percentage approximately 64% vs 56%) and a higher prevalence of diabetes (8% vs 5%) compared to the ABS NHS data, a survey of the general population rather than a cohort of general practice patients.

Approximately 38% of patients in our study cohort had at least one morbidity associated with an increased risk of influenza, with this percentage reducing to 28% after the exclusion of asthma. There was a similar prevalence of conditions increasing the risk of pneumococcal disease (36%–37% with at least one morbidity and 27%–28% after the exclusion of asthma.

TABLE 8: Health risk behaviours and health conditions of the study population

Characteristic	Sample distribution year 2018	Sample distribution year 2019	ABS National Health Survey 2017–18 [a]
	Number (%) [valid %]	Number (%) [valid %]	(%)
Total population (overall)	1,722,363 (100)	1,772,931 (100)	-
Smoking status			
Smoker	214,242 (12.4) [14.2]	215,005 (12.1) [14.0]	15.2 [b]
Ex-smoker	343,646 (20.0) [22.8]	343,439 (19.4) [22.3]	29.1
Non-smoker	946,114 (54.9) [62.9]	979,327 (55.2) [63.7]	55.7
Not recorded	218,361 (12.7)	235,160 (13.3)	
Health conditions			
Asthma (Yes)	234,174 (13.6)	235,852 (13.3)	11.2
Cardiac disease (Yes)	149390 (8.7)	144,180 (8.1)	7.2[c]
Respiratory condition (Yes)	313,679 (18.2)	312,634 (17.6)	-
Respiratory condition (excluding asthma, Yes)	79,505 (4.6)	76,782 (4.3)	-
Neurological condition (Yes)	45,594 (2.7)	44,930 (2.5)	-
Immunocompromising condition (Yes)	262,458 (15.2)	261,886 (14.8)	-
Chronic renal disease (Yes)	16,980 (1.0)	16,440 (0.9)	1.0
Chronic liver disease (Yes)	5,286 (0.3)	5173 (0.3)	-
Diabetes (Yes)	146,851 (8.5)	145,401 (8.2)	4.9
Other health conditions relevant for:			
Influenza (Yes)	8,375 (0.5)	8,332 (0.5)	-
Pneumococcal (Yes)	7463 (0.4)	7395 (0.4)	-
Any relevant health condition associated with an increased risk of: [d]			
Influenza (Yes)	664,334 (38.6)	663,010 (37.4)	-
Influenza (excluding asthma, Yes)	497,225 (28.9)	494,464 (27.9)	-
Pneumococcal (Yes)	644,325 (37.4)	642,871 (36.3)	-
Pneumococcal (excluding asthma, Yes)	473,298 (27.5)	470,513 (26.5)	-
Meningococcal (Yes)	16 (0.0)	15 (0.0)	-

a Defined as a current medical condition which has lasted, or is expected to last, for 6 months or more, unless otherwise stated. Non-age standardised rate provided. Percentages are presented including people from 0 to 9 years old.
b Includes 13.8% of people who are daily smokers and 1.4% who smoke on less than daily basis.
c Includes coronary artery disease, peripheral vascular disease stroke, TIA, heart failure and atrial fibrillation
* In accordance with the Australian Immunisation Handbook [1]
Valid percentage: Calculated considering only people with reported data

Funding eligibility status (Table 9)

Eligibility to receive NIP-funded vaccines varied across disease groups, with the highest proportion for influenza vaccination (47%–48%). Approximately half of patients were eligible for funded pneumococcal vaccination, around 26% through NIP, 22% through PBS and 5% through state and territories. Lower proportions were observed for meningococcal (~6% through NIP and 0.1% through states and territories) and pertussis vaccination (3%–4% though NIP and 2% through states and territories).

TABLE 9: Eligibility to receive funded vaccination of the study population

Characteristic	Sample distribution year 2018	Sample distribution year 2019
	Number (%)	Number (%)
Total population (overall)	1,722,363 (100)	1,772,931 (100)
Eligible to receive NIP-funded vaccines for:		
Influenza (Yes)	829,009 (48.1)	830,471 (46.8)
Pneumococcal (Yes)	456,620 (26.5)	449,165 (25.3)
Meningococcal (Yes)	106,165 (6.2)	113,856 (6.4)
Pertussis (Yes)	52,594 (3.1)	72,693 (4.1)
Eligible to receive state-funded vaccines for:		
Pneumococcal (Yes)	83,908 (4.9)	85,587 (4.8)
Meningococcal (Yes)	1,181 (0.1)	1,180 (0.1)
Pertussis (Yes)	37,562 (2.2)	40,839 (2.3)
Eligible to receive PBS-funded vaccines for:		
Pneumococcal (Yes)	382,676 (22.2)	389,949 (22.0)

NIP: National Immunisation Program

3.2 Influenza

The vaccination coverage for influenza in 2018 and 2019, according to patient and practice characteristics is presented in Table 10. Vaccination coverage increased from 23.6% (95% CI 22.5 to 24.7) in 2018 to 26.3% (95% CI 25.1 to 27.5) in 2019. Considering age groups, the highest uptake of influenza vaccination was recorded among people aged 65 years or older in both years (~58%). However, a higher increase in vaccination uptake occurred among those aged 10–19 years: from 12% in 2018 to 19% in 2019. In general, patients from inner regional areas had higher vaccination uptake compared to those from major cities (28%–30% vs 22%–25%). Differences in vaccination coverage according to sex and socioeconomic status of the patients' residential areas were less pronounced.

Vaccination coverage increased to approximately 39%–42% among patients with any morbidity associated with an increased risk of influenza, further increasing to 45%–48% after excluding patients with asthma. These estimates ranged from 29% to 66% across different health conditions, with the highest level of coverage among those patients with chronic renal disease (66%). Influenza vaccination among smokers was low, with only 14%–17% of the study population defined as current smokers having a recorded vaccination compared to 24%–38% among ex-smokers or non-smokers.

There was variation in the recording of vaccination status across states/territories, with the lowest levels recorded in the Northern Territory (13%–16%) and the highest in South Australia (29%–33%). Patients attending practices from inner regional areas had the highest rates of vaccination coverage (28%–30%). Differences in vaccination coverage according to practices' socioeconomic status were less pronounced, although recording among patients in the fourth quintile (19%–22%) was slightly lower than for patients in the second quintile (26%–29%).

TABLE 10: Annual crude influenza vaccination coverage by patients and practices characteristics, 2018 and 2019

Characteristics	Vaccination coverage year 2018		Vaccination coverage year 2019	
	Number	% (95% CI)	Number	% (95% CI)
Total population (overall)	406,508	23.6 (22.5, 24.7)	465521	26.3 (25.1, 27.5)
Patient characteristics				
Sex				
Female	235,887	23.9 (22.7,25.0)	270,120	26.6 (25.4, 27.8)
Male	170,606	23.3 (22.1, 24.5)	195,373	25.8 (24.5, 27.1)
Age group (years)				
10–19	21,430	11.9 (11.3, 12.6)	35,862	19.2 (18.2, 20.2)
20–50	76,894	9.8 (2.3, 10.4)	99,870	12.5 (11.8, 13.1)
51–64	72,347	20.7 (19.9, 21.5)	79,647	22.2 (21.4, 23.1)
65+	235,837	57.3 (56.1, 58.5)	250,142	58.5 (57.4, 59.7)
Rurality				
Major city	230,807	21.9 (20.4, 23.3)	270,008	24.6 (23.1, 26.2)
Inner regional	118,913	27.8 (26.4, 29.2)	131,430	30.1 (28.7, 31.6)
Outer regional	51,771	24.7 (22.1, 27.3)	57,694	27.2 (24.5, 30.0)
Remote/very remote	5,017	17.5 (11.6, 23.5)	6,389	22.8 (16.6, 29.1)
Socioeconomic status				
1 (most disadvantaged)	82,079	25.9 (23.8, 28.0)	89,639	27.9 (25.8, 30.1)
2	80,354	26.1 (24.4, 27.8)	89,652	28.3 (26.5, 30.1)
3	87,494	23.2 (21.5, 24.9)	100,801	25.9 (24.0, 27.8)
4	65,463	19.8 (18.0, 21.6)	78,177	22.8 (20.9, 24.6)
5 (most advantaged)	91,118	23.4 (21.7, 25.1)	107,252	26.6 (24.8, 28.5)
Any relevant health condition (Yes) *	259,990	39.1 (38.0, 40.3)	278,205	42.0 (40.8, 43.1)
Any relevant health condition, excluding asthma (Yes) *	225,057	45.3 (44.1, 46.4)	235,012	47.5 (46.4, 48.7)
Cardiac disease (Yes)	85,067	56.9 (55.9, 58.0)	84,248	58.4 (57.4, 59.4)
Respiratory condition (Yes)	111,712	35.6 (34.5, 36.8)	121,753	38.9 (37.8, 40.1)
Respiratory condition, excluding asthma (Yes)	44,923	56.5 (55.3, 57.7)	44,739	58.3 (57.1, 59.4)
Neurological condition (Yes)	19,416	42.6 (41.4, 43.8)	20,098	44.7 (43.5, 45.9)
Immunocompromising condition (Yes)	121,925	48.3 (47.1, 49.4)	126,426	48.3 (47.1, 49.4)
Chronic renal disease (Yes)	11,179	65.8(64.4, 67.3)	10,823	65.8 (64.4, 67.2)
Diabetes (Yes)	72,796	49.6 (48.2, 51.0)	75,381	51.8 (50.4, 53.3)
Other (Yes)	2,457	29.3 (27.2, 31.5)	2,777	33.3 (31.3, 35.4)
Smoking status				
Smoker	30,857	14.4 (13.5, 15.3)	35,886	16.7 (15.8, 17.6)
Ex-smoker	120,941	35.2 (34.0, 36.4)	128,948	37.5 (36.4, 38.7)
Non-smoker	229,333	24.2 (23.1, 25.4)	264,421	27.0 (25.8, 28.2)
NIP-funding eligibility				
Eligible	326,179	39.3 (38.2, 40.5)	351,827	42.4 (41.2, 43.6)
Not eligible	80,329	9.0 (8.5, 9.5)	113,694	12.1 (11.4, 12.7)
Practice characteristics				
State				
Australian Capital Territory	9,048	23.8 (20.6, 27.0)	10,342	25.2 (21.7, 28.6)
New South Wales	153,422	25.8 (23.9, 27.8)	171,106	27.6 (25.5, 29.8)
Northern Territory	4,141	12.9 (10.7, 15.2)	4,953	15.7 (13.2, 18.2)
Queensland	62,384	21.9 (19.9, 24.0)	70,267	23.7 (21.7, 25.7)
South Australia	14,543	29.4 (25.1, 33.7)	16,429	33.3 (28.5, 38.1)
Tasmania	39,905	28.5 (26.6, 30.5)	42,607	29.7 (27.5, 31.9)
Victoria	89,737	22.8 (19.8, 25.9)	103,761	26.4 (22.9, 29.8)
Western Australia	33,328	17.3 (15.0, 19.7)	46,056	23.2 (20.6, 25.7)
Rurality				
Inner regional	119,594	28.2 (27.0, 29.5)	131,968	30.4 (29.0, 31.9))
Major city	232,493	21.7 (20.2, 23.2)	272,212	24.5 (22.9, 26.1)
Outer regional	49,916	24.7 (21.9, 27.5)	55,591	27.3 (24.4, 30.2)

Characteristics	Vaccination coverage year 2018		Vaccination coverage year 2019	
	Number	% (95% CI)	Number	% (95% CI)
Remote/very remote	4,505	17.7 (10.6, 24.8)	5,750	23.3 (15.8, 30.7)
Socioeconomic status				
1 (most disadvantaged)	78,898	25.7 (23.0, 28.4)	86,508	28.0 (25.2, 30.7)
2	78,268	26.2 (23.7, 28.8)	87,341	28.5 (25.9, 31.1)
3	89,438	23.4 (20.9, 26.1)	103,318	25.9 (22.9, 28.8)
4	56,175	18.7 (16.2, 21.2)	66,868	21.7 (19.1, 24.2)
5 (most advantaged)	103,729	23.8 (21.9, 25.7)	121,486	27.0 (25.0, 29.1)

NIP: National Immunisation Program
Estimated using the 'vaccinated that year' approach
* In accordance with the Australian Immunisation Handbook [1]

Influenza vaccination coverage per funding eligibility status (Table 11)

Overall, there was a strong association between influenza vaccination uptake and eligibility for receiving funded vaccines: unadjusted analyses indicate coverage is 5.4 times (95% CI 5.1 to 5.6) more likely to occur among those eligible for funding in 2019. Moreover, this association was observed within all strata evaluated, with odds ratios varying from 1.8 among people aged 10–19 years to 6.1 among people from most disadvantaged areas. The strength of this relationship between vaccination uptake and funding eligibility status differed according to patients' rurality (strongest in inner regional areas), socioeconomic status (strongest among patients residing in the most disadvantaged areas), and according to practices' state (strongest relationship in South Australia and Tasmania).

TABLE 11: Influenza vaccination coverage according to funding eligibility status and stratified by selected characteristics, 2019

Characteristics	Vaccination coverage	
	Number (%)	OR (95% CI)
Patient characteristics		
Sex		
Female		
Eligible	197,344 (42.51)	4.86 (4.66, 5.07)
Not eligible	72,776 (13.21)	1
Male		
Eligible	154,470 (42.18)	6.25 (5.95, 6.56)
Not eligible	40,903 (10.45)	1
Age group (years)		
10–19		
Eligible	13,255 (26.45)	1.81 (1.74, 1.89)
Not eligible	22,607 (16.57)	1
20–50		
Eligible	38,950 (19.52)	2.15 (2.07, 2.24)
Not eligible	60,920 (10.12)	1
51–64		
Eligible	49,480 (32.24)	2.75 (2.65, 2.85)
Not eligible	30,167 (14.77)	1
65+ (All eligible)	250,142 (58.54)	Not estimable
Rurality		
Major city		
Eligible	195,798 (41.61)	5.30 (5.02, 5.60)
Not eligible	74,210 (11.86)	1
Inner regional		
Eligible	105,341 (45.05)	5.55 (5.15, 5.98)
Not eligible	26,089 (12.88)	1
Outer regional		
Eligible	46,145 (40.82)	5.22 (4.69, 5.81)
Not eligible	11,549 (11.67)	1
Remote/very remote		
Eligible	4,543 (34.75)	3.76 (3.19, 4.45)
Not eligible	1,846 (12.40)	1
Socioeconomic status		
1 (most disadvantaged)		
Eligible	73,947 (42.34)	6.12 (5.66, 6.63)
Not eligible	15,692 (10.71)	1
2		
Eligible	71,600 (44.08)	5.95 (5.58, 6.34)
Not eligible	18,052 (11.70)	1
3		
Eligible	76,142 (41.64)	5.25 (4.91, 5.61)
Not eligible	24,659 (11.96)	1
4		
Eligible	55,345 (39.95)	5.30 (4.95, 5.68)
Not eligible	22,832 (11.15)	1
5 (most advantaged)		
Eligible	74,793 (43.49)	4.70 (4.35, 5.07)
Not eligible	32,459 (14.08)	1
Practice characteristics		
State		
Australian Capital Territory		
Eligible	7,837 (41.65)	5.64 (4.55, 6.99)
Not eligible	2,505 (11.23)	1
New South Wales		
Eligible	133,152 (43.68)	5.65 (5.28, 6.05)
Not eligible	37,954 (12.06)	1

Characteristics	Vaccination coverage	
	Number (%)	OR (95% CI)
Northern Territory		
Eligible	3,499 (28.47)	4.88 (4.13, 5.76)
Not eligible	1,454 (7.55)	1
Queensland		
Eligible	51,494 (38.76)	4.87 (4.38, 5.42)
Not eligible	18,773 (11.50)	1
South Australia		
Eligible	13,206 (49.43)	5.88 (4.70, 7.35)
Not eligible	3,223 (14.25)	1
Tasmania		
Eligible	35,024 (44.32)	5.96 (5.45, 6.52)
Not eligible	7,583 (11.78)	1
Victoria		
Eligible	74,467 (43.47)	5.05 (4.58, 5.58)
Not eligible	29,294 (13.21)	1
Western Australia		
Eligible	33,148 (39.18)	5.05 (4.48, 5.71)
Not eligible	12,908 (11.30)	1

Estimated using the 'vaccinated that year' approach

Factors associated with influenza vaccination coverage in 2019 (Table 12)

To evaluate factors independently associated with influenza vaccination in 2019, we performed a multivariate analysis adjusted for clustering. We observed a lower probability of receiving influenza vaccination among males (aOR 0.9, p<0.001), adults aged 20 to 50 years and 51 to 64 years as compared to people aged 10 to 19 years (aOR 0.5 and 0.8, respectively, p<0.001) and among smokers compared to non-smokers (aOR 0.7, p<0.001).

Factors associated with a higher probability of receiving influenza vaccination included being older (65+ compared to people aged 10 to 19 years, aOR 2.7, p<0.001), belonging to the most advantaged socioeconomic status group (aOR 1.1, p=0.003), having prespecified health conditions (aOR 1.5, p<0.001), being an ex-smoker (aOR 1.1, p<0.001) and eligible to receive NIP-funded vaccination (aOR 1.4, p<0.001). Patients attending general practices more than four times in the previous year were approximately two times more likely to have a recorded vaccination than those with four or fewer clinical encounters in the previous year (aOR 2.1, p<0.001).

Differences in the likelihood of vaccination were also observed according to practices' characteristics. Patients attending practices in the Northern Territory, Australian Capital Territory, Queensland, and Western Australia were 53% to 14% less likely to receive an influenza vaccination as compared to those attending practices in New South Wales (p<0.001). The probability of being vaccinated increased 12% among patients attending practices in inner regional areas as compared to those attending practices in major cities. This probability of being vaccinated for influenza was 23% higher among people attending practices in the most advantaged socioeconomic status areas compared to those in the most disadvantaged areas.

TABLE 12: Factors associated with influenza vaccination uptake, 2019

Characteristics	Vaccination coverage in 2019		
	Crude OR (95% CI)	Adjusted OR (95% CI) *	P-value
Patient characteristics			
Sex			
Male	0.96 (0.94, 0.98)	0.89 (0.88, 0.90)	<0.001
Female	1	1	
Age group (years)			<0.001
10–19	1	1	
20–50	0.60 (0.58, 0.62)	0.50 (0.47, 0.52)	
51–64	1.20 (1.14, 1.27)	0.79 (0.75, 0.84)	
65+	5.93 (5.61, 6.28)	2.73 (2.59, 2.87)	
Rurality			
Major city	1	-	-
Inner regional	1.32 (1.91, 1.46)	-	
Outer regional	1.14 (0.97, 1.34)	-	
Remote/very remote	0.91 (0.63, 1.30)	-	
Socioeconomic status			0.003
1 (most disadvantaged)	1	1	
2	1.02 (0.90, 1.16)	1.07 (1.00, 1.15)	
3	0.90 (0.79, 1.03)	1.07 (0.98, 1.17)	
4	0.76 (0.66, 0.87)	1.06 (0.97, 1.16)	
5 (most advantaged)	0.94 (0.82, 1.08)	1.17 (1.07, 1.28)	
Any relevant health condition*			
Yes	3.56 (3.45, 3.67)	1.49 (1.46, 1.53)	<0.001
No	1	1	
Smoking status			<0.001
Smoker	0.54 (0.52, 0.56)	0.66 (0.64, 0.68)	
Ex-smoker	1.63 (1.58, 1.67)	1.08 (1.06, 1.09)	
Non-smoker	1	1	
NIP -funding eligibility			
Eligible	5.36 (5.13, 5.60)	1.39 (1.34, 1.44)	<0.001
Not eligible	1	1	
Number of clinical encounters in the previous year			
> 4	3.36 (3.25, 3.46)	2.08 (2.03, 2.13)	<0.001
≤ 4	1	1	
Practice characteristics			
State			<0.001
New South Wales	1	1	
Australian Capital Territory	0.88 (0.71, 1.09)	0.82 (0.69, 0.96)	
Northern Territory	0.49 (0.39, 0.61)	0.47 (0.38, 0.58)	
Queensland	0.82 (0.70, 0.95)	0.86 (0.77, 0.96)	
South Australia	1.31 (1.03, 1.67)	1.19 (0.98, 1.43)	
Tasmania	1.11 (0.95, 1.29)	0.94 (0.81, 1.10)	
Victoria	0.94 (0.76, 1.16)	1.03 (0.89, 1.19)	
Western Australia	0.79 (0.66, 0.95)	0.87 (0.77, 0.98)	
Rurality			
Major city	1	1	0.130
Inner regional	1.35 (1.21, 1.50)	1.12 (1.02, 1.24)	
Outer regional	1.16 (0.98, 1.40)	1.14 (0.95, 1.36)	
Remote/very remote	0.94 (0.61, 1.43)	1.18 (0.83, 1.68)	
Socioeconomic status			0.040
1 (most disadvantaged)	1	1	
2	1.03 (0.85, 1.24)	1.09 (0.95, 1.27)	
3	0.90 (0.73, 1.10)	1.08 (0.91, 1.28)	
4	0.71 (0.58, 0.87)	1.03 (0.86, 1.22)	
5 (most advantaged)	0.95 (0.80, 1.13)	1.23 (1.03, 1.47)	

NIP: National Immunisation Program, * Estimated using logistic regression models and the 'vaccinated that year' approach, ** In accordance with the Australian Immunisation Handbook [1]

Results of the sensitivity analysis for influenza

Restricting the study population to people who were active patients and who visited practices between March and August increased influenza vaccination coverage to 30.6% (95% CI 29.3 to 31.9) in 2018 and 33.8% (95% CI 32.5 to 35.2) in 2019. Again, people aged 65 years and older had the highest vaccination coverage (~67%–68%), and approximately half of the people with relevant health conditions had a vaccination recorded (46%–50%) (see Appendix 2, supplementary table 1).

Factors associated with influenza vaccination coverage remained similar for active patients attending practices between March and August. Lower coverage was observed among males, people aged 20 to 64 years and smokers. Coverage remained higher among those residing in the most advantaged socioeconomic status areas, ex-smokers, those with relevant health conditions, eligible to receive NIP-funded vaccination, and attending practices more regularly in the previous year. People attending practices in inner regional areas, the most advantaged socioeconomic status areas and in South Australia also had a statistically higher chance of having a recorded influenza vaccination in 2019. People attending practices from the Northern Territory and Western Australia had lower chances of having a recorded influenza vaccination compared to those attending practices in New South Wales (see Appendix 2, supplementary table 2).

3.3 Pneumococcal disease

23-valent pneumococcal polysaccharide vaccine (23vPPV)

The cumulative vaccination coverage for 23vPPV pneumococcal per year and according to patient and practice characteristics is presented in Table 13. Cumulative vaccination coverage was similar in both years, 12.4% (95% CI 11.5 to 13.3) in 2018 and 12.7% (95% CI 11.8 to 13.6) in 2019. The highest uptake of pneumococcal vaccination was recorded among people aged 65 years or older in both 2018 and 2019 (~47%). In general, patients residing in inner regional areas (16%) had a higher vaccination uptake compared to those from major cities (11%) and from remote/very remote areas (7%–8%). People residing in the most disadvantaged socioeconomic status area had higher vaccination uptake compared to people from the most advantaged areas (quintiles 3 to 5).

Cumulative 23vPPV vaccination coverage increased to 26%–27% among patients with any morbidity, further increasing to 33%–34% after excluding patients with asthma. These estimates ranged from 22% to 58% across different health conditions, with the highest level of coverage among those patients with chronic renal disease (58%). Pneumococcal vaccination among smokers was low, with only 6%–7% of the study population defined as current smokers having a recorded vaccination. Among those previously vaccinated with the 13-valent pneumococcal conjugate vaccine (n = 2,782 in 2018 and 2,826 in 2019), coverage was 48%–52%.

There was variation in the recording of 23vPPV vaccination status across states and territories, with the lowest level recorded in the Northern Territory (8%) and the highest in South Australia and Tasmania (17%–18%). 23vPPV vaccination coverage was higher among patients from inner regional (16%) and outer regional (15%) areas compared to major cities (11%) and remote and very remote areas (8%). Differences in 23vPPV vaccination coverage according to practices' socioeconomic status were less pronounced, with lowest rates among patients from the fourth socioeconomic quintile (9%).

TABLE 13: Cumulative annual crude pneumococcal vaccination coverage (23vPVV) by patient and practice characteristics, 2018 and 2019

Characteristics	Vaccination coverage year 2018		Vaccination coverage year 2019	
	Number	% (95% CI)	Number	% (95% CI)
Total population (overall)	213,396	12.4 (11.5, 13.3)	225,548	12.7 (11.8, 13.6)
Patient characteristics				
Sex				
Female	117,102	11.8 (11.0, 12.7)	123,467	12.2 (11.3, 13.0)
Male	96,291	13.1 (12.2, 14.1)	102,078	13.5 (12.5, 14.4)
Age group (years)				
10–19	183	0.1 (0.1, 0.1)	195	0.1 (0.1, 0.1)
20–50	5,827	0.7 (0.7, 0.8)	5,930	0.7 (0.7, 0.8)
51–64	15,404	4.4 (4.1, 4.7)	15,901	4.4 (4.1, 4.8)
65+	191,982	46.7 (45.0, 48.3)	203,522	47.6 (46.0, 49.3)
Rurality				
Major city	114,309	10.8 (9.7, 11.9)	120,197	11.0 (9.8, 12.1)
Inner regional	66,235	15.5 (14.0, 16.9)	70,458	16.1 (14.7, 17.6)
Outer regional	30,793	14.7 (13.1, 16.3)	32,586	15.4 (13.8, 17.0)
Remote/very remote	2,059	7.2 (4.9, 9.5)	2,307	8.2 (5.9, 10.6)
Socioeconomic status				
1 (most disadvantaged)	47,482	15.0 (13.5, 16.5)	50,393	15.7 (14.1, 17.3)
2	45,721	14.9 (13.3, 16.4)	48,048	15.2 (13.6, 16.7)
3	44,258	11.7 (10.3, 13.1)	47,197	12.1 (10.6, 13.6)
4	31,185	9.4 (8.1, 10.8)	33,189	9.7 (8.3, 11.0)
5 (most advantaged)	44,750	11.5 (10.2, 12.8)	46,721	11.6 (10.3, 12.9)
Any relevant health condition (Yes) *	164,724	25.6 (24.4, 26.8)	170,628	26.5 (25.3, 27.8)
Any relevant health condition, excluding asthma (Yes) *	155,043	32.8 (31.4, 34.1)	160,047	34.0 (32.6, 35.4)
Cardiac disease (Yes)	69,920	46.8 (45.3, 48.3)	69,438	48.2 (46.7, 49.7)
Respiratory condition (Yes)	67,469	21.5 (20.4, 22.6)	69,334	22.2 (21.1, 23.3)
Respiratory condition, excluding asthma (Yes)	37,988	47.8 (46.3, 49.2)	38,165	49.7 (48.2, 51.2)
Immunocompromising condition (Yes)	86,474	32.9 (31.5, 34.4)	89,273	34.1 (32.6, 35.5)
Chronic liver disease (Yes)	1,579	29.9 (28.2, 31.6)	1,644	31.8 (30.0, 33.5)
Chronic renal disease (Yes)	9,500	55.9 (53.2, 58.7)	9,467	57.6 (55.0, 60.2)
Diabetes (Yes)	51,843	35.3 (33.7, 36.9)	53,278	36.6 (35.0, 38.3)
Other relevant health condition (Yes)	2,894	38.8 (37.2, 40.4)	2,951	39.9 (38.3, 41.5)
Smoking status				
Smoker	13,803	6.4 (5.9, 7.0)	15,134	7.0 (6.5, 7.6)
Ex-smoker	78,735	22.9 (21.8, 24.1)	82,237	23.9 (22.8, 25.1)
Non-smoker	113,836	12.0 (11.1, 12.9)	120,507	12.3 (11.4, 13.2)
13vPCV vaccination (Yes)	1,335	48.0 (43.8, 52.2)	1,467	51.9 (48.0, 55.8)
Funding eligibility				
NIP-eligible	195,548	42.8 (41.2, 44.4)	205,576	45.8 (44.1, 47.4)
State-eligible	2,575	3.1 (2.4, 3.7)	2,811	3.3 (2.6, 3.9)
PBS- eligible	12,420	3.2 (2.9, 3.6)	13,971	3.6 (3.2, 3.9)
Not eligible	2,853	0.4 (0.3, 0.4)	3,190	0.4 (0.3, 0.4)
Practice characteristics				
State				
Australian Capital Territory	4,052	10.7 (6.3, 15.0)	4,335	10.5 (6.4, 14.6)
New South Wales	81,311	13.7 (12.1, 15.3)	86,828	14.0 (12.2, 15.8)
Northern Territory	2,497	7.8 (5.9, 9.7)	2,618	8.3 (6.2, 10.4)
Queensland	27,896	9.8 (8.4, 11.3)	29,700	10.0 (8.6, 11.5)
South Australia	8,517	17.2 (13.0, 21.4)	8,785	17.8 (13.3, 22.3)
Tasmania	23,993	17.1 (15.2, 19.1)	25,137	17.5 (15.5, 19.6)
Victoria	47,079	12.0 (9.8, 14.1)	48,962	12.5 (10.3, 14.6)
Western Australia	18,051	9.4 (7.2, 11.6)	19,183	9.6 (7.5, 11.8)
Rurality				

Characteristics	Vaccination coverage year 2018		Vaccination coverage year 2019	
	Number	% (95% CI)	Number	% (95% CI)
Major city	115,176	10.8 (9.6, 11.9)	121,257	10.9 (9.8, 12.0)
Inner regional	66,835	15.8 (14.3, 17.3)	71,067	16.4 (14.9, 17.9)
Outer regional	29,611	14.7 (13.0, 16.3)	31,224	15.3 (13.6, 17.0)
Remote/very remote	1,774	7.0 (4.3, 9.6)	2,000	8.1 (5.3, 10.8)
Socioeconomic status				
1 (most disadvantaged)	44,845	14.6 (12.7, 16.5)	47,733	15.4 (13.5, 17.4)
2	44,605	15.0 (12.8, 17.1)	46,853	15.3 (13.1, 17.4)
3	46,242	12.1 (10.0, 14.3)	49,721	12.5 (10.2, 14.7)
4	25,569	8.5 (6.7, 10.3)	26,976	8.7 (6.9, 10.5)
5 (most advantaged)	52,135	12.0 (10.5, 13.4)	54,265	12.1 (10.6, 13.5)

Estimated using the 'ever vaccinated' approach

NIP: National Immunisation Program, PBS: Pharmaceutical Benefits Scheme

**In accordance with the Australian Immunisation Handbook[1]

Pneumococcal vaccination coverage per funding eligibility status (Table 14)

Overall, there was a strong association between 23vPPV vaccination uptake and eligibility for receiving funded vaccines: unadjusted analyses indicate coverage is 83.8% (95% CI 78.8 to 89.2) more likely to occur among those eligible for funding in 2019. This association was observed within all strata evaluated, with odds ratios varying from 6.5 among people aged 10–19 years to 104.4 among people from the Australian Capital Territory. The strength of the relationship between 23vPPV vaccination uptake and funding eligibility status differed according to patients' rurality (strongest in major cities), socioeconomic status (strongest among patients residing in the most advantaged areas), and according to practices' state (strongest relationship in Australian Capital Territory and South Australia).

TABLE 14: Cumulative pneumococcal vaccination (23vPPV) coverage according to funding eligibility status and stratified by selected characteristics, 2019

Characteristics	Vaccination coverage 2019	
	Number (%)	OR (IC95%)
Patient characteristics		
Sex		
Female		
Eligible	121,632 (24.08)	87.82 (82.03, 94.01)
Not eligible	1,835 (0.36)	1
Male		
Eligible	100,723 (24.01)	78.49 (72.23, 85.28)
Not eligible	1,355 (0.40)	1
Age group (years)		
10–19		
Eligible	133 (0.29)	6.46 (4.79, 8.72)
Not eligible	62 (0.04)	1
20–50		
Eligible	4,729 (1.73)	7.71 (7.05, 8.43)
Not eligible	1,201 (0.23)	1
51–64		
Eligible	13,974 (7.89)	7.94 (7.42, 8.50)
Not eligible	1,927 (1.07)	1
65+ (All eligible)	203,522 (47.63)	-
Rurality		
Major city		
Eligible	118,344 (22.40)	88.15 (81.30, 95.58)
Not eligible	1,853 (0.33)	1
Inner regional		
Eligible	69,592 (27.23)	77.76 (68.61, 88.13)
Not eligible	866 (0.48)	1
Outer regional		
Eligible	32,146 (25.53)	66.73 (59.13, 75.31)
Not eligible	440 (0.51)	1
Remote/very remote		
Eligible	2,276 (15.42)	77.44 (47.07, 127.40)
Not eligible	31 (0.23)	1
Socioeconomic status		
1 (most disadvantaged)		
Eligible	49,793 (25.43)	70.88 (61.92, 81.14)
Not eligible	600 (0.48)	1
2		
Eligible	47,437 (26.30)	79.26 (70.06, 89.68)
Not eligible	611 (0.45)	1
3		
Eligible	46,487 (22.75)	76.31 (68.69, 84.78)
Not eligible	710 (0.38)	1
4		
Eligible	32,661 (20.79)	92.35 (82.29, 103.62)
Not eligible	528 (0.28)	1
5 (most advantaged)		
Eligible	45,980 (24.58)	94.39 (83.85, 106.26)
Not eligible	741 (0.34)	1
Practice characteristics		
State		
Australian Capital Territory		
Eligible	4,280 (21.42)	104.36 (80.12, 135.93)
Not eligible	55 (0.26)	1
New South Wales		
Eligible	85,643 (25.66)	82.85 (74.10, 92.63)
Not eligible	1,185 (0.41)	1

Characteristics	Vaccination coverage 2019	
	Number (%)	**OR (IC95%)**
Northern Territory		
Eligible	2,564 (16.79)	60.66 (45.25, 81.32)
Not eligible	54 (0.33)	1
Queensland		
Eligible	29,236 (19.66)	77.53 (67.15, 89.52)
Not eligible	464 (0.31)	1
South Australia		
Eligible	8,700 (30.21)	104.04 (80.85, 133.89)
Not eligible	85 (0.41)	1
Tasmania		
Eligible	24,861 (28.67)	82.12 (65.15, 103.53)
Not eligible	276 (0.49)	1
Victoria		
Eligible	48,229 (24.57)	87.13 (77.70, 97.69)
Not eligible	733 (0.37)	1
Western Australia		
Eligible	18,845 (19.79)	75.36 (61.90, 91.75)
Not eligible	338 (0.33)	1

Estimated using the 'ever vaccinated' approach

Factors associated with cumulative 23vPPV vaccination coverage in 2019 (Table 15)

To evaluate factors independently associated with 23vPPV vaccination in 2019, we performed a multivariate analysis adjusted for clustering. We observed a lower probability of pneumococcal vaccination among males (aOR 0.9, p<0.001), and among smokers compared to non-smokers (aOR 0.7, p<0.001).

Factors associated with a higher probability of receiving 23vPPV vaccination included older age (all groups compared to people aged 10–19 years old, aOR 5.0 to 223.6, <0.001), having prespecified health conditions (aOR 1.8, p<0.001), being an ex-smoker compared to non-smokers (aOR 1.2, p<0.001) and eligible to receive funded vaccination (aOR 4.3, p<0.001). Patients attending general practices more than four times in the previous year were approximately three times more likely to have a recorded 23vPPV vaccination than those with four or less clinical encounters in the previous year (aOR 2.7, p<0.001).

Differences in the likelihood of 23vPPV vaccination were also observed according to practices' characteristics. Patients attending practices in Queensland and Western Australia were 30% to 20% less likely to receive 23vPPV vaccination as compared to those attending practices in New South Wales (p<0.001). People attending practices in remote and very remote areas were approximately 34% less likely to have a recorded 23vPPV vaccination compared to those attending practices in major cities (p=0.013). The probability of being vaccinated for pneumococcal disease increased 27% among patients attending practices in the most advantaged socioeconomic status areas compared to most disadvantaged areas (p=0.047).

TABLE 15: Factors associated with cumulative pneumococcal vaccination (23vPVV) uptake, 2019

Characteristics	Vaccination coverage in 2019		
	Crude OR (95% CI)	Adjusted OR (95% CI) *	P-value
Patient characteristics			
Sex			<0.001
Male	1.13 (1.10, 1.15)	0.96 (0.94, 0.98)	
Female	1	1	
Age group (years)			<0.001
10–19	1	1	
20–50	7.11 (6.05, 8.36)	4.96 (4.21, 5.84)	
51–64	44.39 (37.85, 52.05)	19.18 (16.34, 22.52)	
65+	867.82 (732.57, >999.99)	223.61 (188.27, 265.58)	
Rurality			-
Major city	1	-	
Inner regional	1.56 (1.35, 1.82)	-	
Outer regional	1.48 (1.25, 1.74)	-	
Remote/very remote	0.73 (0.52, 1.02)	-	
Socioeconomic status			0.146
1 (most disadvantaged)	1	1	
2	0.96 (0.83, 1.12)	1.01 (0.92, 1.11)	
3	0.74 (0.63, 0.88)	0.90 (0.81, 1.01)	
4	0.58 (0.48, 0.69)	0.93 (0.83, 1.05)	
5 (most advantaged)	0.71 (0.60, 0.83)	0.95 (0.85, 1.07)	
Any relevant health condition*			<0.001
Yes	7.07 (6.78, 7.38)	1.81 (1.76, 1.87)	
No	1		
Smoking status			<0.001
Smoker	0.54 (0.51, 0.57)	0.74 (0.71, 0.77)	
Ex-smoker	2.24 (2.16, 2.33)	1.16 (1.13, 1.18)	
Non-smoker	1	1	
Funding eligibility			<0.001
Eligible	83.84 (78.77, 89.24)	4.28 (4.03, 4.55)	
Not eligible	1	1	
Number of clinical encounters in the previous year			
> 4	6.42 (6.14, 6.72)	2.73 (2.63, 2.85)	<0.001
≤ 4	1	1	
Practice characteristics			
State			<0.001
New South Wales	1	1	
Australian Capital Territory	0.72 (0.46, 1.15)	0.71 (0.44, 1.15)	
Northern Territory	0.56 (0.41, 0.76)	0.74 (0.51, 1.07)	
Queensland	0.68 (0.55, 0.85)	0.70 (0.59, 0.83)	
South Australia	1.33 (0.94, 1.87)	1.07 (0.84, 1.36)	
Tasmania	1.30 (1.06, 1.60)	1.12 (0.92, 1.37)	
Victoria	0.87 (0.68, 1.12)	1.09 (0.92, 1.30)	
Western Australia	0.66 (0.49, 0.87)	0.80 (0.66, 0.96)	
Rurality			0.013
Major city	1	1	
Inner regional	1.60 (1.36, 1.88)	1.05 (0.90, 1.22)	
Outer regional	1.48 (1.24, 1.76)	1.12 (0.93, 1.35)	
Remote/very remote	0.72 (0.49, 1.06)	0.66 (0.48, 0.91)	
Socioeconomic status			0.047
1 (most disadvantaged)	1	1	
2	0.99 (0.79, 1.24)	1.15 (0.94, 1.40)	
3	0.78 (0.60, 1.01)	1.20 (0.97, 1.48)	
4	0.52 (0.40, 0.69)	1.01 (0.82, 1.25)	
5 (most advantaged)	0.75 (0.62, 0.92)	1.27 (1.02, 1.57)	

NIP: National Immunisation Program, * Estimated using logistic regression models and the 'ever vaccinated' approach, ** In accordance with the Australian Immunisation Handbook [1]

Pneumococcal vaccination (23vPPV) – first vaccinated in 2019

When the 'first vaccinated that year' approach was applied, the vaccination coverage for pneumococcal in 2019 was substantially lower, at 1.5% (95% CI 1.4 to 1.6) (see Appendix 2, Supplementary Table 3). This approach returned fewer between-group differences in coverage than the cumulative (ie, 'ever vaccinated') result. Coverage differed significantly between age groups, with coverage highest among patients aged 65 years and older, and lower among those aged 10–19 years. Coverage was higher among patients from inner regional areas compared to major cities and the most disadvantaged socioeconomic status areas compared to people from the most advantaged areas (quartiles 4 and 5).

Pneumococcal vaccination coverage in 2019 (first vaccination) was significantly higher among people with at least one chronic morbidity associated with an increased risk of pneumococcal disease (3.1%), with higher rates among people with chronic renal disease (6.8%). Coverage was also significantly lower among smokers compared to non-smokers (1.1% vs 1.4%), and higher among ex-smokers (3.0%).

Not surprisingly, vaccination coverage was significantly higher among patients eligible to receive a funded vaccine, through either the PBS (0.5%), states and territories (0.5%) or NIP (7.8%) compared to non-eligible people (<0.1%). People previously vaccinated with the 13-valent pneumococcal conjugate vaccine had coverage of 11%.

Differences in vaccination coverage according to practices' states/territories were less pronounced and significantly higher coverage was observed among people attending practices in inner regional areas (2.0%) compared to major cities. Lowest rates of vaccination uptake were observed among patients attending practices from the fourth and fifth socioeconomic quintiles (1.1%-1.3%) compared to the most disadvantaged areas (2.0%).

Results of the sensitivity analysis for pneumococcal

Including non-specific terms to define if patients were vaccinated for pneumococcal (eg, 'pneumococcal', 'PCV', 'PPV') increased cumulative vaccination coverage to 13.9% (95% CI 12.9 to 14.9) in 2018 and 14.4% (95% CI 13.4 to 15.4) in 2019. Again, people aged 65+ years had the highest vaccination coverage (~52%–54%), and approximately one-third of people with relevant health conditions had a vaccination recorded (29%–30%) (see Appendix 2, Supplementary Table 4).

Factors associated with pneumococcal vaccination coverage remained similar, with lower coverage among males and smokers. However, ex-smokers had lower coverage compared to non-smokers. Pneumococcal vaccination coverage remained higher among people aged 20 to 65+ years, those with relevant health conditions, people eligible to receive funded vaccination, and those who attended practices more regularly in the previous year. However, there was no difference in the likelihood of vaccination between people attending practices in remote/very remote areas and those attending practices in major cities. In addition to a lower probability of having a recorded vaccination if attending practices in Queensland and Western Australia, in the sensitivity analysis a lower chance of vaccination was also observed for people attending practices in the Northern Territory compared with practices in New South Wales. Finally, people attending practices in the most advantaged socioeconomic status areas again had a higher chance of having a recorded pneumococcal vaccination (see Appendix 2, Supplementary Table 5).

13-valent pneumococcal conjugate vaccine (13vPCV)

The cumulative 13vPCV vaccination coverage, per year and according to patient and practice characteristics, is presented in Table 16. Cumulative vaccination coverage was similar in both years, 0.11% (95% CI 0.09 to 0.12) in 2018 and 0.13% (95% CI 0.11 to 0.15) in 2019. Considering age groups, the highest uptake of 13vPCV was recorded among people aged 65 years or older in both years (0.21%–0.25%).

The cumulative pneumococcal 13vPCV vaccination coverage increased to approximately 0.23%–0.28% among patients with any morbidity, further increasing to 0.30%–0.37% after excluding patients with asthma. These estimates ranged from 0.18% to 7.58% across different health conditions, with the highest level of coverage among those patients with other health conditions, such as splenectomy, cochlear implants, and intracranial shunts (7.58%). Pneumococcal vaccination with 13vPCV among ex-smokers was higher than among smokers or non-smokers (0.18%–0.22% vs 0.08%–0.12%). Among those previously vaccinated with the 23-valent pneumococcal polysaccharide vaccine (n = 248,702 in 2018 and 241,607 in 2019), pneumococcal 13vPCV vaccination coverage was 0.44%–0.55%.

There was variation in the recording of 13vPCV vaccination status across states/territories, with the highest levels in Tasmania (0.15%–0.17%). There were no differences in 13vPCV vaccination uptake according to practices' rurality and socioeconomic status.

TABLE 16: Cumulative annual crude pneumococcal vaccination coverage (13vPCV) by patients and practices characteristics, 2018 and 2019

Characteristics	Vaccination coverage year 2018		Vaccination coverage year 2019	
	Number	% (95% CI)	Number	% (95% CI)
Total population (overall)	1,835	0.11 (0.09, 0.12)	2,264	0.13 (0.11, 0.15)
Patient characteristics				
Sex				
Female	1,001	0.10 (0.09, 0.12)	1,235	0.12 (0.11, 0.14)
Male	833	0.11 (0.09, 0.14)	1,028	0.14 (0.11, 0.16)
Age group (years)				
10–19	116	0.06 (0.05, 0.08)	127	0.07 (0.05, 0.08)
20–50	436	0.06 (0.05, 0.06)	528	0.07 (0.06, 0.08)
51–64	430	0.12 (0.10, 0.14)	539	0.15 (0.13, 0.17)
65+	853	0.21 (0.15, 0.26)	1,070	0.25 (0.20, 0.30)
Rurality				
Major city	1,009	0.10 (0.08, 0.11)	1,287	0.12 (0.10, 0.13)
Inner regional	556	0.13 (0.08, 0.18)	646	0.15 (0.10, 0.20)
Outer regional	87	0.09 (0.07, 0.11)	252	0.12 (0.10, 0.14)
Remote/very remote	83	0.29 (0.00, 0.75)	79	0.28 (0.00, 0.70)
Socioeconomic status				
1 (most disadvantaged)	399	0.13 (0.06, 0.19)	479	0.15 (0.08, 0.21)
2	331	0.11 (0.09, 0.13)	395	0.12 (0.10, 0.15)
3	428	0.11 (0.07, 0.15)	536	0.14 (0.10, 0.18)
4	270	0.08 (0.06, 0.10)	332	0.10 (0.07, 0.12)
5 (most advantaged)	407	0.10 (0.09, 0.12)	522	0.13 (0.11, 0.15)
Any health condition relevant to 23vPPV (Yes) *	1,484	0.23 (0.19, 0.27)	1,825	0.28 (0.24, 0.32)
Any health condition relevant to 23vPPV, excluding asthma (Yes) *	1,408	0.30 (0.25, 0.35)	1,731	0.37 (0.31, 0.42)
Cardiac disease (Yes)	351	0.24 (0.17, 0.30)	421	0.29 (0.22, 0.36)
Respiratory condition (Yes)	573	0.18 (0.15, 0.22)	687	0.22 (0.18, 0.26)
Respiratory condition, excluding asthma (Yes)	297	0.37 (0.28, 0.46)	351	0.46 (0.36, 0.56)
Immunocompromising condition (Yes)	1,096	0.42 (0.34, 0.49)	1,362	0.52 (0.44, 0.60)
Chronic liver disease (Yes)	23	0.44 (0.26, 0.61)	35	0.68 (0.44, 0.91)
Chronic renal disease (Yes)	98	0.58 (0.22, 0.93)	130	0.79 (0.33, 1.26)
Diabetes (Yes)	339	0.23 (0.18, 0.28)	412	0.28 (0.22, 0.34)
Other relevant health condition (Yes)	566	7.58 (6.72, 8.44)	671	9.07 (8.14, 10.01)
Smoking status				
Smoker	174	0.08 (0.07, 0.10)	213	0.10 (0.08, 0.12)
Ex-smoker	619	0.18 (0.14, 0.22)	741	0.22 (0.17, 0.26)
Non-smoker	925	0.10 (0.08, 0.11)	1,168	0.12 (0.10, 0.14)
23vPCV vaccination (Yes)	1,087	0.44 (0.34, 0.53)	1,337	0.55 (0.46, 0.65)
Practice characteristics				
State				
Australian Capital Territory	38	0.10 (0.07, 0.13)	46	0.11 (0.07, 0.15)
New South Wales	697	0.12 (0.08, 0.16)	899	0.15 (0.11, 0.18)
Northern Territory	15	0.05 (0.01, 0.08)	27	0.09 (0.02, 0.15)
Queensland	227	0.08 (0.06, 0.10)	265	0.09 (0.07, 0.11)
South Australia	41	0.08 (0.05, 0.12)	53	0.11 (0.06, 0.16)
Tasmania	209	0.15 (0.11, 0.19)	239	0.17 (0.12, 0.21)
Victoria	410	0.10 (0.08, 0.13)	499	0.13 (0.10, 0.16)
Western Australia	198	0.10 (0.03, 0.18)	236	0.12 (0.06, 0.18)
Rurality				
Major city	1,010	0.09 (0.08, 0.11)	1,287	0.12 (0.10, 0.13)
Inner regional	565	0.13 (0.08, 0.19)	666	0.15 (0.10, 0.21)
Outer regional	178	0.09 (0.07, 0.11)	235	0.12 (0.09, 0.14)
Remote/very remote	82	0.32 (0.00, 0.85)	76	0.31 (0.00, 0.78)

Characteristics	Vaccination coverage year 2018		Vaccination coverage year 2019	
	Number	% (95% CI)	Number	% (95% CI)
Socioeconomic status				
1 (most disadvantaged)	399	0.13 (0.06, 0.20)	475	0.15 (0.08, 0.22)
2	313	0.10 (0.08, 0.13)	375	0.12 (0.10, 0.15)
3	409	0.11 (0.06, 0.15)	534	0.13 (0.09, 0.18)
4	257	0.09 (0.06, 0.11)	298	0.10 (0.06, 0.13)
5 (most advantaged)	457	0.10 (0.09, 0.12)	582	0.13 (0.11, 0.15)

Estimated using the 'ever vaccinated' approach

**In accordance with the Australian Immunisation Handbook[1]

3.3 Meningococcal disease

The cumulative vaccination coverage for meningococcal in 2018 and 2019 according to patient and practice characteristics is presented in Table 17. Vaccination coverage remained stable across years, with 2.4% (95% CI 2.1 to 2.7) coverage in 2018 and 2.7% (95% CI 2.4 to 3.0) coverage in 2019. In both years, meningococcal vaccination coverage was significantly higher among people aged 10–13 years (~8%) and 14–19 years (~12%–14%) compared to the other age groups (0.9%–5.0%). There were no differences in vaccination uptake according to patients' sex or rurality. Patients from socioeconomic status quintiles 3 and 4 had lower vaccination coverage compared to those from the most disadvantaged areas.

Meningococcal vaccination coverage among non-smokers (5%–6%) was significantly higher than coverage among smokers or ex-smokers (1%–2%). As expected, significantly higher meningococcal vaccination coverage was observed among people eligible for funded vaccines, either from NIP (12%–14%) or states and territories (5%–15%) compared to people not eligible for funded vaccines (~2%).

There was variation in the recording of vaccination status across states/territories, with the highest levels recorded in Tasmania (9%). Differences in meningococcal vaccination uptake according to the rurality and socioeconomic status of the area in which the practice was based were less pronounced.

TABLE 17: Cumulative annual crude meningococcal vaccination coverage by patients and practices characteristics, 2018 and 2019

Characteristics	Vaccination coverage year 2018		Vaccination coverage year 2019	
	Number	% (95% CI)	Number	% (95% CI)
Total population (overall)	41,403	2.4 (2.1, 2.7)	47,087	2.7 (2.4, 3.0)
Patient characteristics				
Sex				
Female	23,906	2.4 (2.1, 2.7)	27,296	2.7 (2.4, 3.0)
Male	17,492	2.4 (2.1, 2.7)	19,782	2.6 (2.3, 2.9)
Age group (years)				
10–13	6,009	8.7 (6.4, 11.0)	5,592	7.7 (5.8, 9.6)
14–19	13,122	11.8 (10.5, 13.2)	15,452	13.6 (12.0, 15.2)
20–25	4,823	3.6 (3.1, 4.0)	6,563	4.8 (4.1, 5.4)
26–50	9,768	1.5 (1.3, 1.7)	10,754	1.6 (1.4, 1.8)
51–64	3,826	1.1 (1.0, 1.2)	4,284	1.2 (1.1, 1.3)
65+	3,855	0.9 (0.8, 1.0)	4,442	1.0 (0.9, 1.1)
Rurality				
Major city	21,571	2.0 (1.8, 2.3)	24,892	3.1 (2.3, 3.9)
Inner regional	12,141	2.8 (2.1, 3.6)	13,560	3.1 (2.3, 3.9)
Outer regional	7,137	3.4 (2.5, 4.3)	8,023	3.8 (2.8, 4.7)
Remote/very remote	554	1.9 (0.8, 3.1)	612	2.2 (1.0, 3.3)
Socioeconomic status				
1 (most disadvantaged)	8,960	2.8 (2.1, 3.5)	9,821	3.1 (2.3, 3.8)
2	8,965	2.9 (2.1, 3.7)	10,032	3.2 (2.4, 4.0)
3	6,564	1.7 (1.6, 1.9)	7,702	2.0 (1.8, 2.2)
4	6,601	2.0 (1.7, 2.2)	7,606	2.2 (1.9, 2.5)
5 (most advantaged)	10,313	2.6 (2.3, 2.9)	11,926	3.0 (2.6, 3.3)
Any relevant health condition (Yes) *	1	6.3 (0.0, 18.4)	1	6.6 (19.6, 0.0)
Smoking status				
Smoker	2,214	1.0 (0.9, 1.2)	2,439	1.1 (1.0, 1.3)
Ex-smoker	3,743	1.1 (1.0, 1.2)	4,101	1.2 (1.1, 1.3)
Non-smoker	27,553	2.9 (2.6, 3.3)	31,330	3.2 (2.8, 3.6)
Funding eligibility				
NIP-eligible	12,497	11.8 (10.2, 13.4)	15,452	13.6 (12.0, 15.2)
State-eligible	57	4.8 (2.2, 7.4)	176	14.9 (7.7, 22.1)
Not eligible	28,849	1.8 (1.6, 2.0)	31,459	1.9 (1.7, 2.1)
Practice characteristics				
State				
Australian Capital Territory	721	1.9 (1.3, 2.5)	872	2.1 (1.5, 2.7)
New South Wales	8,767	1.5 (1.3, 1.7)	10,305	1.7 (1.5, 1.9)
Northern Territory	397	1.2 (1.1, 1.4)	714	2.3 (1.8, 2.7)
Queensland	5,188	1.8 (1.6, 2.1)	6,296	2.1 (1.8, 2.4)
South Australia	719	1.5 (1.0, 1.9)	1,202	2.4 (1.7, 3.2)
Tasmania	12,072	8.6 (7.9, 9.3)	13,049	9.1 (8.4, 9.8)
Victoria	9,507	2.4 (2.0, 2.9)	10,266	2.6 (2.1, 3.1)
Western Australia	4,032	2.1 (1.8, 2.4)	4,383	2.2 (1.9, 2.5)
Rurality				
Major city	21,662	2.0 (1.8, 2.2)	24,995	2.2 (2.0, 2.5)
Inner regional	12,409	2.9 (2.1, 3.8)	13,901	3.2 (2.3, 4.1)
Outer regional	6,821	3.4 (2.4, 4.4)	7,637	3.8 (2.7, 4.8)
Remote/very remote	511	2.0 (0.6, 3.4)	554	2.2 (0.9, 3.6)
Socioeconomic status				
1 (most disadvantaged)	8,742	2.8 (2.0, 3.7)	9,503	3.1 (2.1, 4.0)
2	9,047	3.0 (2.0, 4.1)	10,189	3.3 (2.2, 4.4)
3	6,531	1.7 (1.4, 2.0)	7,907	2.0 (1.6, 2.4)
4	5,055	1.7 (1.5, 1.9)	5,818	1.9 (1.6, 2.1)
5 (most advantaged)	12,028	2.8 (2.4, 3.1)	13,670	3.0 (2.7, 3.4)

Estimated using the 'ever vaccinated' approach, NIP: National Immunisation Program, * In accordance with the Australian Immunisation Handbook

Meningococcal vaccination coverage according to funding eligibility status (Table 18)

Overall, there was a significant association between meningococcal vaccination uptake and eligibility for receiving funded vaccines: unadjusted analyses indicate in 2019, coverage was 8.1 (95% CI 7.5 to 8.8) times more likely to occur among those eligible for funding. This positive association was observed within all strata examined. The strength of the relationship between funding eligibility status and vaccination uptake varied the most between state and territories of the practice, with the strongest associations observed in Queensland, Tasmania, and South Australia.

TABLE 18: Cumulative meningococcal vaccination coverage according to funding eligibility status and stratified by selected characteristics,2019

Characteristics	Vaccination coverage 2019	
	Number (%)	OR (IC95%)
Patient characteristics		
Sex		
Female		
Eligible	8,688 (13.44)	7.78 (7.18, 8.43)
Not eligible	18,608 (1.96)	1
Male		
Eligible	6,937 (13.77)	8.63 (7.93, 9.39)
Not eligible	12,845 (1.82)	1
Age group (years)		
10–13 (All not eligible)	5,592 (7.69)	-
14–19 (All eligible)	15,452 (13.57)	-
20–25		
Eligible	176 (14.92)	3.58 (2.01, 6.37)
Not eligible	6,387 (4.67)	1
26–50 (All not eligible)	10,754 (1.62)	-
51–64 (All not eligible)	4,284 (1.20)	-
65+ (All not eligible)	4,442 (1.04)	-
Rurality		
Major city		
Eligible	7,868 (11.08)	7.38 (6.56, 8.30)
Not eligible	17,024 (1.66)	1
Inner regional		
Eligible	4,561 (15.74)	8.27 (7.48, 9.15)
Not eligible	8,999 (2.21)	1
Outer regional		
Eligible	2,984 (22.02)	10.84 (9.33, 12.60)
Not eligible	5,039 (2.54)	1
Remote/very remote		
Eligible	215 (14.46)	11.10 (8.82, 13.98)
Not eligible	397 (1.50)	1
Socioeconomic status		
1 (most disadvantaged)		
Eligible	3,545 (17.98)	10.31 (9.20, 11.56)
Not eligible	6,276 (2.08)	1
2		
Eligible	3,519 (18.23)	9.96 (9.00, 11.02)
Not eligible	6,513 (2.19)	1
3		
Eligible	2,861 (10.94)	9.09 (7.92, 10.42)
Not eligible	4,841 (1.33)	1
4		
Eligible	2,607 (10.98)	7.76 (6.80, 8.87)
Not eligible	4,999 (1.56)	1
5 (most advantaged)		
Eligible	3,096 (11.85)	5.60 (4.98, 6.29)
Not eligible	8,830 (2.35)	1

Characteristics	Vaccination coverage 2019	
	Number (%)	OR (IC95%)
Practice characteristics		
State		
Australian Capital Territory		
Eligible	272 (12.21)	8.88 (7.93, 9.94)
Not eligible	600 (1.54)	1
New South Wales		
Eligible	2,812 (7.36)	6.08 (5.36, 6.90)
Not eligible	7,493 (1.29)	1
Northern Territory		
Eligible	237 (12.28)	8.56 (6.94, 10.55)
Not eligible	477 (1.61)	1
Queensland		
Eligible	2,759 (13.64)	12.17 (10.64, 13.92)
Not eligible	3,537 (1.28)	1
South Australia		
Eligible	757 (17.86)	21.82 (13.13, 36.27)
Not eligible	445 (0.99)	1
Tasmania		
Eligible	4,636 (49.74)	14.78 (12.71, 17.19)
Not eligible	8,413 (6.28)	1
Victoria		
Eligible	2,500 (9.89)	5.09 (4.33, 5.98)
Not eligible	7,766 (2.11)	
Western Australia		
Eligible	1,655 (12.17)	9.27 (8.04, 10.68)
Not eligible	2,728 (1.47)	

Estimated using the 'ever vaccinated' approach

Factors associated with cumulative meningococcal vaccination coverage in 2019 (Table 19)

To evaluate factors independently associated with meningococcal vaccination in 2019, we performed a multivariate analysis adjusted for clustering. There was a higher probability of meningococcal vaccination among males (aOR 1.1), those eligible for funded vaccination (aOR 4.0) and those regularly visiting general practices in the previous year (aOR 1.7).

Lower probability of vaccination occurred with increased age, with all age groups having a lower chance of having a recorded vaccination compared to patients aged 10–13 years (aORs <0.1 to 0.3). Smokers and ex-smokers also had a significantly lower chance (aOR 0.5 to 0.7) of being vaccinated compared to non-smokers.

The likelihood of meningococcal vaccination also differed according to practice characteristics. Patients attending practices in the Australian Capital Territory, Northern Territory, and Western Australia were 26%–65% less likely to receive meningococcal vaccination compared to those attending practices in New South Wales ($p<0.001$). Patients attending practices in the most advantaged socioeconomic quintiles were significantly more likely to be vaccinated than patients attending practices in the most disadvantaged quintile (aOR 1.4).

TABLE 19: Factors associated with cumulative meningococcal vaccination uptake, 2019

Variable	Crude OR (95% CI)	Adjusted OR (95% CI)*	P-value
Patient characteristics			
Sex			
Male	0.97 (0.95, 1.00)	1.02 (1.00, 1.05)	0.284
Female	1	1	
Age group (years)			<0.001
10–13	1	1	
14–19	1.88 (1.62, 2.19)	0.49 (0.32, 0.75)	
20–25	0.60 (0.49, 0.74)	0.61 (0.49, 0.74)	
26–50	0.20 (0.16, 0.25)	0.20 (0.16, 0.26)	
51–64	0.15 (0.11, 0.19)	0.14 (0.10, 0.18)	
65+	0.13 (0.10, 0.16)	0.10 (0.07, 0.13)	
Rurality			
Major city	1	-	
Inner regional	1.38 (1.04, 1.83)	-	
Outer regional	1.69 (1.28, 2.25)	-	
Remote/very remote	0.96 (0.56, 1.67)	-	
Socioeconomic status			<0.001
1 (most disadvantaged)	1	1	
2	1.04 (0.77, 1.40)	1.09 (1.01, 1.19)	
3	0.64 (0.50, 0.82)	1.01 (0.84, 1.21)	
4	0.72 (0.56, 0.93)	1.07 (0.95, 1.21)	
5 (most advantaged)	0.97 (0.75, 1.26)	1.30 (1.12, 1.51)	
Any relevant health condition*			
Yes	2.63 (0.33, 20.84)	2.04 (0.17, 24.21)	0.572
No	1	1	
Smoking status			<0.001
Smoker	0.35 (0.32, 0.38)	0.46 (0.43, 0.49)	
Ex-smoker	0.37 (0.33, 0.40)	0.68 (0.63, 0.73)	
Non-smoker	1	1	
Funding eligibility			
Eligible	8.13 (7.51, 8.79)	4.02 (2.68, 6.02)	<0.001
Not eligible	1	1	
Number of clinical encounters in the previous year			
> 4	1.07 (1.02, 1.13)	1.70 (1.64, 1.76)	
≤ 4	1	1	
Practice characteristics			
Rurality			0.568
Major city	1	1	
Inner regional	1.44 (1.07, 1.94)	0.95 (0.79, 1.14)	
Outer regional	1.69 (1.24, 2.31)	0.91 (0.74, 1.12)	
Remote/very remote	1.00 (0.53, 1.86)	0.80 (0.58, 1.11)	
Socioeconomic status			0.001
1 (most disadvantaged)	1	1	
2	1.08 (0.68, 1.72)	0.92 (0.78, 1.08)	
3	0.64 (0.44, 0.92)	1.14 (0.83, 1.56)	
4	0.61 (0.43, 0.85)	0.95 (0.73, 1.25)	
5 (most advantaged)	0.99 (0.71, 1.39)	1.44 (1.11, 1.87)	
State			<0.001
New South Wales	1	1	
Australian Capital Territory	1.28 (0.95, 1.74)	0.88 (0.63, 1.23)	
Northern Territory	1.37 (1.07, 1.76)	1.24 (0.91, 1.69)	
Queensland	1.28 (1.06, 1.55)	1.20 (1.00, 1.45)	
South Australia	1.48 (1.04, 2.09)	1.49 (1.09, 2.04)	
Tasmania	5.92 (5.10, 6.88)	8.46 (6.98, 10.25)	
Victoria	1.59 (1.25, 2.00)	1.41 (1.11, 1.78)	
Western Australia	1.33 (1.11, 1.60)	1.16 (0.97, 1.39)	

NIP: National Immunisation Program * Estimated using logistic regression models and estimated using the 'ever vaccinated' approach

** In accordance with the Australian Immunisation Handbook [1]

Meningococcal vaccination – first vaccinated in 2019

When the 'first vaccinated that year' approach was applied, the vaccination coverage for meningococcal in 2019 was 0.4% (95% CI 0.4 to 0.5) (see Appendix 2, Supplementary Table 6). Meningococcal vaccination coverage again differed significantly between age groups, with the highest coverage among patients aged 14–19 years, and the lowest among those aged 65 years and older. Patients from remote and very remote areas had the lowest meningococcal vaccination rates (0.3%) and people from socioeconomic quintiles 1 to 4 were less likely to have a recorded vaccination compared to those from the 5th quintile (0.4% vs 0.6%).

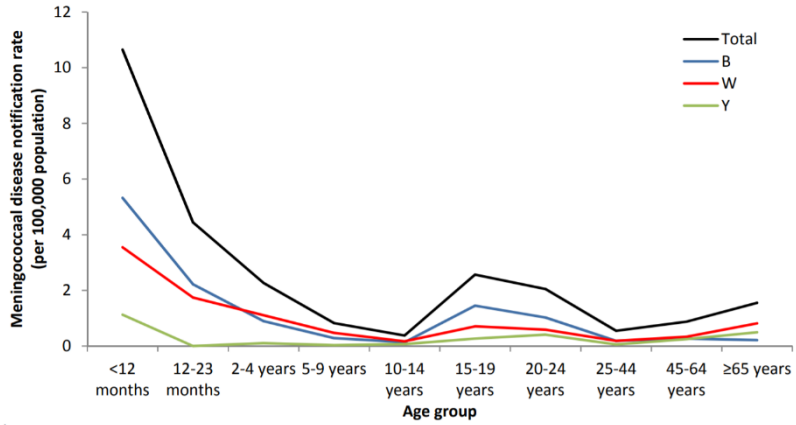
There were no differences in meningococcal vaccination uptake according to patients' sex and vaccination coverage remained significantly higher among non-smokers and people eligible for funded vaccines. Again, there was variation in the recording of meningococcal vaccination uptake across states/territories. The lowest levels of recording occurred in New South Wales and Victoria (~0.3%) and the highest in the Northern Territory (1.2%). Patients attending practices in remote and very remote areas again had the lowest rates of meningococcal vaccination uptake (0.3%). Differences in meningococcal vaccination uptake according to the socioeconomic status of the area in which the practice was based were less pronounced.

A closer look at meningococcal B vaccination

Invasive meningococcal disease (IMD) is an infectious disease caused by the bacterium *Neisseria meningitidis* that affects 0.5–1.2 million people worldwide, each year.[30] IMD affects mostly children under 5 years of age and adolescents (15–19 years of age).[5,30,31] In Australia, the annual IMD is low (1.1/100,000 people in 2018) but has increased between 2013–2018 and peaked in 2017 at 1.5/100,000 people.[32]

From 13 known meningococcal serogroups, serogroups A, B, C, W and Y cause > 95% of disease.[33] The serogroup B has been dominant over time and is the most common form of IMD in adolescents and young adults in Australia (See figure 1).[34,35]

Figure 1: Age-specific rates of meningococcal disease by subgroup and age group, Australia, 2016–2017*



*Data is for cases with a diagnosis date from 1 January 2016 onwards, as of 14 December 2017. Rates for 2017 have not been annualised. Unpublished data from analysis of National Notifiable Diseases Surveillance System core data by NCIRS.

Source: Australian Technical Advisory Group on Immunisation. Public consultation on changes to the recommended use of meningococcal and haemophilus influenzae type B vaccines. April 2018. Available at: https://consultations.health.gov.au/ohp-immunisation-branch/proposed-changes-to-meningococcal-and-hib/

Two multicomponent protein-based recombinant vaccines are available in Australia to prevent meningococcal B (MenB) disease in adolescents and adults: Bexsero® (4CMenB), introduced to the market in 2014 and Trumenba®, available since 2017. From 2014 to 2019, these vaccines were only available by private prescription in Australia, except for one state program funding these vaccines in South Australia, where free MenB vaccinations were available for children and adolescents from 2017.[36,37]

The Australian Immunisation Handbook recommends MenB for all infants under two years old, indigenous peoples aged 2–19 years, adolescents aged 15–19 years, young adults (aged 20–24 years) who smoke, live in close quarters or work in laboratories, or people with immunosuppressive conditions such as HIV, asplenia or treated with eculizumab.[1] However, estimates on vaccination coverage are lacking for these populations at higher risk of IMD.

MedicineInsight analysis

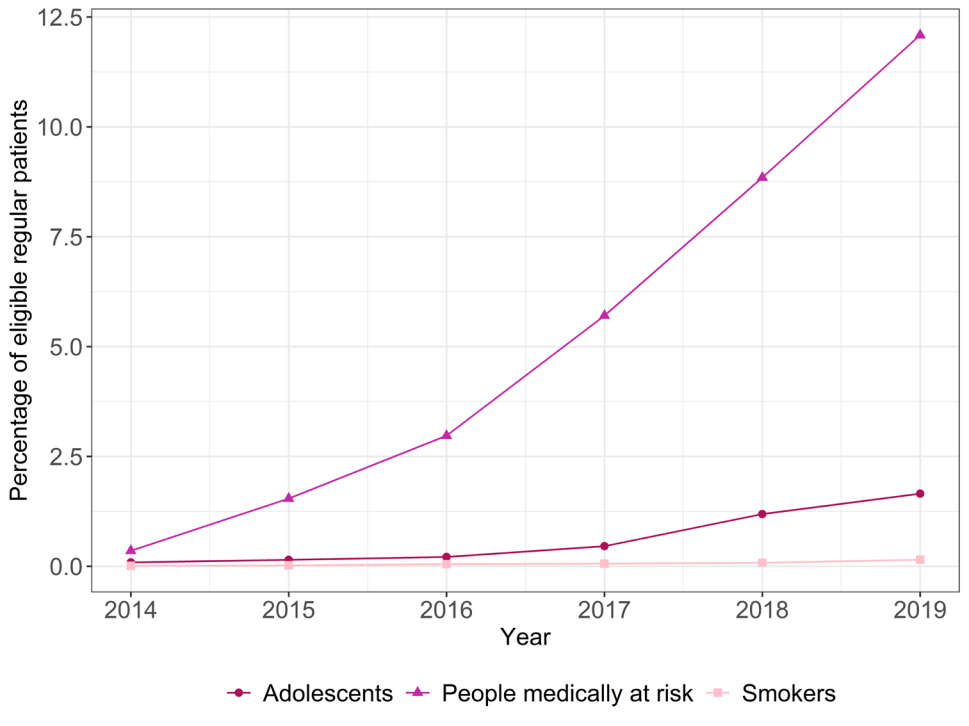
We used MedicineInsight data between 1 January 2014 and 31 December 2019 to estimate cumulative annual MenB vaccination rates among adolescents, young adults who smoke and people medically at risk since the introduction of MenB vaccine in Australia. The details of this analysis in published elsewhere.[38] We further examined the characteristics associated with vaccination coverage within each at-risk group in 2019 to inform targeting of future MenB vaccination programs.

We selected annual cohorts of people eligible for MenB vaccination within each of those three at-risk groups to determine cumulative vaccination rates each year for regular general practice patients. In

2019, our cohorts included 89,042 adolescents, 16,067 young adults who smoke, and 5,559 people medically at risk of meningococcal infection.

Cumulative vaccination coverage increased from 2014 to 2019 among all at-risk groups examined, with the highest growth observed for people medically at risk (See figure 2). For this group, cumulative coverage rose from 0.35% (95% CI 0.18%, 0.53%) to 12.09% (9.12%, 15.06%). Coverage increased from 0.09% (0.05%, 0.13%) to 1.65% (1.23%, 2.08%) for adolescents. Finally, while there was an increase in cumulative coverage among young adults who smoke, the absolute magnitude remained very low: from 0.01% (0.00%, 0.03%) to 0.15% (0.07%, 0.23%).[38]

Figure 2: Annual MenB vaccination coverage according to at-risk group



Source: de Oliveira Costa et al. (2021)[38]

We only evaluated factors associated with vaccination coverage among adolescents and people medically at risk due to sparse data for vaccinated young adults who smoke (n = 24). For these at-risk groups, we observed significant variation in the relative risk of being vaccinated according to patient and practice characteristics (See box 1). Despite these significant relative risks, crude vaccination coverage remained low, reaching a maximum of 31% among adolescents with relevant medical conditions and 36% people medically at-risk aged 10–14 years.[38]

Despite increased rates of MenB vaccination coverage in the years since the vaccine was introduced, coverage remains suboptimal for all at-risk groups examined. While we found variation in vaccination coverage according to sex, age, socioeconomic and clinical factors in adolescents and medically at-risk groups, the absolute magnitude of coverage was low among all subgroups examined. These results highlight the need of programs to increase MenB vaccination uptake among at-risk groups irrespective of patient and practice characteristics.[38]

General practices play a key role in reducing the burden of vaccine-preventable diseases, with GP recommendation being one of the strongest drivers of vaccination uptake.[39] Considering all participants in our study had visited the GP practices at least three times in the previous two years, all of them had missed opportunities to receive a MenB vaccine. Strategies that target people who frequent the practice less often and who show a lower probability of being vaccinated could be useful in increasing vaccination coverage.

Box 1: Meningococcal B coverage according to patient and practice characteristics and factors associated with being vaccinated for the 2019 annual cohorts.

Characteristics	Adolescents		People medically at risk	
	Coverage N (%)	aOR* (95% CI)	Coverage N (%)	aOR* (95% CI)
Patient characteristics				
Sex				
Male	696 (1.83)	1.21 (1.08, 1.34)	318 (9.14)	0.52 (0.40, 0.66)
Female	777 (1.53)	Ref	354 (17.02)	Ref
Age				
15	316 (1.97)	Ref	-	-
16	358 (2.13)	1.04 (0.90, 1.21)	-	-
17	294 (1.09)	0.81 (0.69, 0.95)	-	-
18	275 (1.48)	0.73 (0.61, 0.88)	-	-
19	230 (1.16)	0.58 (0.48, 0.70)	-	-
Age group				
10-14	-	-	12 (36.36)	Ref
15-19	-	-	15 (32.61)	1.05 (0.37 2.97)
20-24	-	-	8 (11.59)	0.25 (0.08 0.83)
25-50	-	-	146 (8.54)	0.17 (0.08 0.38)
51-64	-	-	219 (12.13)	0.25 (0.11 0.54)
65+	-	-	272 (14.35)	0.25 (0.11 0.54)
Socioeconomic status				
1 (most disadvantaged)	195 (1.38)	Ref	117 (12.35)	Ref
2	334 (2.00)	1.76 (1.34, 2.31)	131 (13.10)	1.23 (0.87, 1.74)
3	202 (0.97)	1.84 (1.28, 2.65)	148 (12.63)	1.22 (0.85, 1.75)
4	286 (1.61)	2.65 (2.01, 3.48)	106 (10.44)	1.08 (0.73, 1.60)
5 (most advantaged)	456 (2.31)	4.80 (3.33, 6.91)	170 (11.93)	1.59 (0.99, 2.58)
Median number of encounters in the previous year*				
Higher than the median	868 (2.41)	2.02 (1.74, 2.34)	393 (15.63)	1.99 (1.59, 2.49)
Lower or equal to the median	605 (1.14)	Ref	279 (9.16)	Ref
Any relevant medical condition				
Yes	14 (31.11)	30.92 (15.46, 61.84)	-	-
No	1,459 (0.02)	Ref	-	-
Practice characteristics				
State				
New South Wales	319 (1.01)	Ref	253 (13.49)	Ref
Australian Capital Territory	17 (1.62)	0.80 (0.48, 1.32)	7 (11.11)	0.76 (0.24, 2.41)
Northern Territory	22 (1.34)	1.00 (0.54, 1.87)	6 (7.32)	0.44 (0.14, 1.36)
Queensland	210 (1.18)	1.21 (0.74, 1.97)	93 (10.04)	0.71 (0.49, 1.02)
South Australia		-	19 (16.67)	1.18 (0.53, 2.61)
Tasmania	555 (9.65)	21.23 (13.53, 33.29)	78 (23.56)	2.11 (1.40, 3.19)
Victoria	229 (1.07)	1.00 (0.71, 1.43)	163 (9.41)	0.79 (0.45, 1.37)
Western Australia	121 (1.25)	1.01 (0.62, 1.67)	53 (12.21)	0.87 (0.54, 1.42)
Rurality				
Major city	693 (1.28)	Ref	392 (11.10)	Ref
Inner regional	549 (2.80)	1.14 (0.79, 1.65)	178 (13.86)	1.11 (0.79, 1.56)
Outer regional/ remote/ very remote	231 (1.50)	0.86 (0.54, 1.37)	112 (15.05)	1.19 (0.77, 1.83)
Socioeconomic status				
1 (most disadvantaged)	236 (1.35)	Ref	119 (13.37)	Ref
2	322 (2.22)	1.00 (0.61, 1.63)	112 (13.19)	0.90 (0.58, 1.40)
3	195 (0.94)	1.53 (0.84, 2.79)	160 (12.64)	1.08 (0.69, 1.69)
4	229 (1.59)	1.51 (0.67, 3.37)	92 (12.76)	1.18 (0.71, 1.94)
5 (most advantaged)	491 (2.24)	1.63 (0.85, 3.13)	189 (10.31)	0.86 (0.41, 1.81)

* All variables mutually adjusted. ** Median number of encounters is equal to 3 for adolescents and 7 for people medically at risk. Ref = reference group

Source: de Oliveira Costa et al. (2021)[38]

3.4 Pertussis

The cumulative vaccination coverage for pertussis in 2018 and 2019, according to patient and practice characteristics, is presented in Table 20. Pertussis vaccination coverage remained stable across years, with 20.1% (95% CI 19.2 to 21.0) coverage in 2018 and 21.6% (95% CI 20.6 to 22.5) coverage in 2019. In both years, pertussis vaccination coverage was significantly lower among males (18%–19%) than females (22%–24%). The lowest uptake of pertussis vaccination was recorded among people aged 10–13 years (5.6%) and 14–17 years (14%) in both 2018 and 2019. However, this is likely to be an artefact of the incomplete capture of vaccinations among school age children in primary health care data rather than a genuine pattern. Patients from remote and very remote areas had lower vaccination uptake compared to those from less remote areas (14%–16% vs 20%–24%). There were few differences in vaccination uptake according to the socioeconomic status of the patient's residential area, in 2018, vaccination coverage among patients in quintile 4 (18%–20%) was lower than among patients in quintiles 2 and 5 (21%–22%).

Pertussis vaccination coverage among smokers was significantly lower than coverage among other patients, with only 14%–15% of current smokers having a recorded vaccination compared with 23%–25% of non-smokers or ex-smokers.

There was variation in the recording of vaccination status across states and territories, with the lowest levels of recording in the Northern Territory (10%–11%) and the highest in Tasmania (28%–30%). Patients attending practices in remote and very remote areas had the lowest rates of pertussis vaccination (23%–25%). Differences in vaccination uptake according to the socioeconomic status of the area in which the practice was based were less pronounced.

TABLE 20: Cumulative annual crude pertussis vaccination coverage by patient and practice characteristics, 2018 and 2019

Characteristics	Vaccination coverage year 2018		Vaccination coverage year 2019	
	Number	% (95% CI)	Number	% (95% CI)
Total population (overall)	346,590	20.1 (19.2, 21.0)	382,478	21.6 (20.6, 22.5)
Patient characteristics				
Sex				
Female	218,055	22.1 (21.1, 23.0)	240,368	23.7 (22.7, 24.7)
Male	128,525	17.5 (16.7, 18.3)	142,096	18.8 (17.9, 19.6)
Age group (years)				
10–13	3,899	5.6 (5.3, 6.0)	4,105	5.6 (5.3, 6.0)
14–17	9,549	13.7 (12.7, 14.7)	10,015	13.8 (12.8, 14.8)
18–39	115,425	21.3 (20.3, 22.4)	125,584	22.6 (21.5, 23.6)
40–64	123,051	19.5 (18.5, 20.5)	134,646	20.9 (19.9, 21.9)
65+	94,666	23.0 (21.9, 24.1)	108,128	25.3 (24.2, 26.5)
Rurality				
Major city	206,653	19.6 (18.4, 20.7)	228,805	20.9 (19.7, 22.1)
Inner regional	94,350	22.0 (20.5, 23.5)	103,611	23.7 (22.3, 25.2)
Outer regional	41,535	19.8 (17.7, 21.9)	45,672	21.5 (19.3, 23.8)
Remote/very remote	4,052	14.1 (10.9, 17.4)	4,390	15.7 (12.4, 19.0)
Socioeconomic status				
1 (most disadvantaged)	64,414	20.3 (18.6, 22.1)	70,344	21.9 (20.0, 23.8)
2	66,583	21.6 (20.1, 23.2)	73,749	23.3 (21.7, 24.9)
3	73,538	19.5 (18.1, 20.9)	81,415	20.9 (19.5, 22.4)
4	60,033	18.1 (16.9, 19.4)	67,352	19.6 (18.3, 20.9)
5 (most advantaged)	82,022	21.1 (19.5, 22.6)	89,618	22.3 (20.7, 23.8)
Smoking status				
Smoker	29,387	13.7 (13.0, 14.4)	32,545	15.1 (14.4, 15.9)
Ex-smoker	79,639	23.2 (22.2, 24.1)	86,642	25.2 (24.2, 26.2)
Non-smoker	212,567	22.5 (21.4, 23.5)	235,061	24.0 (23.0, 25.0)
Funding eligibility				
NIP-eligible	1,582	3.0 (2.7, 3.3)	4,105	5.6 (5.3, 6.0)
State-eligible	5,163	13.7 (12.7, 14.8)	5,849	14.3 (13.2, 15.5)
Not eligible	339,845	20.8 (19.9, 21.8)	372,524	22.4 (21.5, 23.4)
Practice characteristics				
State				
Australian Capital Territory	7,982	21.0 (15.6, 26.4)	8,885	21.6 (16.7, 26.5)
New South Wales	137,930	23.2 (21.5, 24.9)	150,978	24.4 (22.6, 26.2)
Northern Territory	3,170	9.9 (8.0, 11.8)	3,441	10.9 (8.9, 12.9)
Queensland	53,505	18.8 (17.1, 20.6)	59,618	20.1 (18.4, 21.9)
South Australia	8,415	17.0 (14.9, 19.0)	9,276	18.8 (16.6, 21.0)
Tasmania	31,720	22.7 (20.6, 24.8)	35,790	25.0 (22.6, 27.3)
Victoria	74,382	18.9 (16.8, 21.1)	81,037	20.6 (18.4, 22.9)
Western Australia	29,486	15.3 (13.6, 17.1)	33,453	16.8 (15.0, 18.7)
Rurality				
Major city	208,725	19.5 (18.3, 20.7)	231,004	20.8 (19.6, 22.0)
Inner regional	94,548	22.3 (20.8, 23.8)	103,974	24.0 (22.5, 25.5)
Outer regional	39,767	19.7 (17.4, 22.0)	43,622	21.4 (19.0, 23.9)
Remote/very remote	3,550	13.9 (10.1, 17.7)	3,878	15.7 (11.8, 19.6)
Socioeconomic status				
1 (most disadvantaged)	63,479	20.7 (18.6, 22.7)	68,962	22.3 (20.2, 24.5)
2	64,515	21.6 (19.4, 23.9)	71,393	23.3 (21.0, 25.6)
3	72,459	19.0 (16.9, 21.1)	81,605	20.4 (18.3, 22.6)
4	53,294	17.7 (15.9, 19.6)	59,502	19.3 (17.4, 21.2)
5 (most advantaged)	92,843	21.3 (19.6, 23.1)	101,016	22.5 (20.7, 24.2)

Estimated using the 'ever vaccinated' approach

Pertussis vaccination coverage according to funding eligibility status (Table 21)

Overall, there was a negative association between pertussis vaccination uptake and eligibility for receiving funded vaccines: unadjusted analyses indicate in 2019, cumulative vaccination coverage was 0.33 (95% CI 0.31 to 0.36) times as likely to occur among those eligible for funding. Upon stratification by age category, this negative association was only observed among patients aged 18–39 years. Within this age category, only those based in New South Wales and Queensland and aged 18 or 19 years are eligible for funded vaccines. Vaccination may be lower among patients at the younger end of this age category because of previous vaccination in school-based programs (not captured in MedicineInsight data), while older individuals in this age category may be receiving vaccination due to increased contact with newborns and infants. The strength of the relationship between funding eligibility status and vaccination uptake varied the most between strata defined by state/territory of the practice, with the strongest associations observed in South Australia and the Australian Capital Territory.

TABLE 21: Cumulative pertussis vaccination coverage according to funding eligibility status and stratified by selected characteristics, 2019

Characteristics	Vaccination coverage 2019	
	Number (%)	OR (95% CI)
Patient characteristics		
Sex		
Female		
Eligible	5,479 (9.30)	0.32 (0.29, 0.34)
Not eligible	234,889 (24.56)	1
Male		
Eligible	4,474 (8.19)	0.37 (0.34, 0.40)
Not eligible	137,622 (19.58)	1
Age group (years)		
10–13 (All eligible)	4,105 (5.65)	-
14–17		
Eligible	2,725 (14.03)	1.02 (0.89, 1.18)
Not eligible	7,290 (13.75)	1
18–39		
Eligible	3,124 (14.59)	0.58 (0.52, 0.63)
Not eligible	122,460 (22.90)	1
40–64 (All not eligible)	134,646 (20.90)	-
65+ (All not eligible)	108,128 (25.31)	-
Rurality		
Major city		
Eligible	6,276 (8.65)	0.34 (0.31, 0.38)
Not eligible	222,529 (27.73)	
Inner regional		
Eligible	2,648 (9.35)	0.31 (0.26, 0.37)
Not eligible	100,963 (24.74)	
Outer regional		
Eligible	995 (8.64)	0.33 (0.27, 0.40)
Not eligible	44,677 (22.28)	
Remote/very remote		
Eligible	35 (3.06)	0.16 (0.09, 0.30)
Not eligible	4,355 (16.24)	
Socioeconomic status		
1 (most disadvantaged)		
Eligible	1,745 (9.54)	0.36 (0.31, 0.42)
Not eligible	68,599 (22.65)	1
2		
Eligible	72,104 (24.15)	0.31 (0.28, 0.35)
Not eligible	1,645 (9.04)	1
3		

Characteristics	Vaccination coverage 2019	
	Number (%)	OR (95% CI)
Eligible	2,488 (9.23)	0.37 (0.31, 0.43)
Not eligible	78,927 (21.80)	1
4		
Eligible	2,111 (8.39)	0.36 (0.31, 0.40)
Not eligible	65,241 (20.50)	1
5 (most advantaged)		
Eligible	1,965 (7.88)	0.28 (0.25, 0.32)
Not eligible	87,653 (23.21)	1
Practice characteristics		
State		
Australian Capital Territory		
Eligible	53 (3.59)	0.13 (0.08, 0.22)
Not eligible	8,832 (22.28)	1
New South Wales		
Eligible	3,895 (8.72)	0.28 (0.26, 0.30)
Not eligible	147,083 (25.59)	1
Northern Territory		
Eligible	71 (6.37)	0.55 (0.37, 0.80)
Not eligible	3,370 (11.07)	1
Queensland		
Eligible	4,111 (12.41)	0.53 (0.46, 0.61)
Not eligible	55,507 (21.10)	1
South Australia		
Eligible	40 (2.21)	0.09 (0.07, 0.13)
Not eligible	9,236 (19.44)	1
Tasmania		
Eligible	449 (7.40)	0.23 (0.18, 0.29)
Not eligible	35,341 (25.74)	1
Victoria		
Eligible	834 (5.02)	0.20 (0.16, 0.23)
Not eligible	80,203 (21.30)	1
Western Australia		
Eligible	501 (5.77)	0.29 (0.23, 0.37)
Not eligible	32,952 (17.33)	1

Estimated using the 'ever vaccinated' approach

Factors associated with cumulative pertussis vaccination coverage in 2019 (Table 22)

To evaluate factors independently associated with pertussis vaccination in 2019, we performed a multivariate analysis adjusted for clustering. There was a lower probability of pertussis vaccination among males (aOR 0.8), among smokers (aOR 0.6) and ex-smokers (aOR 0.9) compared to non-smokers and people eligible to receive a NIP-funded vaccination (aOR 0.7).

Factors associated with a higher probability of pertussis vaccination included older age groups (all age groups compared to patients aged 10–13 years, aORs 1.9 to 2.6) attending general practices more than four times in the previous year compared to those with four or less clinical encounters in the previous year (aOR 1.7).

The likelihood of pertussis vaccination also differed according to practice characteristics. Patients attending practices in all states/territories except Tasmania and the Australian Capital Territory were 68% to 21% less likely to receive a pertussis vaccination compared to those attending practices in New South Wales ($p<0.001$). Patients attending practices in inner regional and outer regional areas were significantly more likely to be vaccinated for pertussis than those attending practices in major cities (aORs 1.1 to 1.2). Patients attending practices in the most advantaged socioeconomic quintiles were significantly more likely to be vaccinated for pertussis than patients attending practices in all other socioeconomic quintiles (aOR 1.2).

TABLE 22: Factors associated with cumulative pertussis vaccination uptake, 2019

Characteristics	Vaccination coverage in 2019		
	Crude OR (95% CI)	Adjusted OR (95% CI) *	P-value
Patient characteristics			
Sex			<0.001
Male	0.74 (0.73, 0.76)	0.80 (0.79, 0.82)	
Female	1	1	
Age group (years)			<0.001
10–13	1	1	
14–17	2.68 (2.51, 2.87)	1.94 (1.76, 2.14)	
18–39	4.87 (4.50, 5.27)	2.93 (2.63, 3.25)	
40–64	4.42 (4.04, 4.82)	2.42 (2.14, 2.72)	
65+	5.66 (5.17, 6.20)	2.55 (2.25, 2.89)	
Rurality			
Major city	1	-	-
Inner regional	1.18 (1.06, 1.31)	-	
Outer regional	1.04 (0.90, 1.21)	-	
Remote/very remote	0.71 (0.54, 0.92)	-	
Socioeconomic status			0.110
1 (most disadvantaged)	1	1	
2	1.08 (0.95, 1.23)	1.08 (1.01, 1.17)	
3	0.94 (0.83, 1.07)	1.05 (0.96, 1.16)	
4	0.87 (0.77, 0.99)	1.02 (0.93, 1.11)	
5 (most advantaged)	1.02 (0.89, 1.17)	1.07 (0.98, 1.18)	
Smoking status			<0.001
Smoker	0.57 (0.54, 0.59)	0.55 (0.54, 0.57)	
Ex-smoker	1.07 (1.04, 1.10)	0.99 (0.97, 1.02)	
Non-smoker	1	1	
NIP -funding eligibility			<0.001
Eligible	0.33 (0.31, 0.36)	0.67 (0.61, 0.74)	
Not eligible	1	1	
Number of clinical encounters in the previous year			<0.001
> 4	1.85 (1.80, 1.90)	1.70 (1.66, 1.74)	
≤ 4	1	1	
Practice characteristics			
State			<0.001
New South Wales	1	1	
Australian Capital Territory	0.86 (0.63, 1.16)	0.74 (0.54, 1.01)	
Northern Territory	0.38 (0.30, 0.48)	0.32 (0.24, 0.43)	
Queensland	0.78 (0.68, 0.91)	0.80 (0.69, 0.92)	
South Australia	0.72 (0.60, 0.86)	0.71 (0.60, 0.84)	
Tasmania	1.03 (0.88, 1.21)	0.93 (0.78, 1.11)	
Victoria	0.81 (0.68, 0.95)	0.79 (0.68, 0.91)	
Western Australia	0.63 (0.53, 0.74)	0.61 (0.52, 0.72)	
Rurality			
Major city	1	1	0.072
Inner regional	1.20 (1.08, 1.34)	1.14 (1.01, 1.29)	
Outer regional	1.04 (0.88, 1.22)	1.23 (1.03, 1.47)	
Remote/very remote	0.71 (0.52, 0.96)	1.05 (0.79, 1.39)	
Socioeconomic status			
1 (most disadvantaged)	1	1	0.059
2	1.06 (0.88, 1.27)	1.09 (0.93, 1.27)	
3	0.90 (0.75, 1.07)	1.01 (0.84, 1.20)	
4	0.83 (0.70, 0.99)	1.03 (0.86, 1.23)	
5 (most advantaged)	1.01 (0.86, 1.18)	1.24 (1.05, 1.48)	

NIP: National Immunisation Program, * Estimated using logistic regression models and estimated using the 'ever vaccinated' approach

Pertussis vaccination – first vaccinated in 2019

When the 'first vaccinated that year' approach was applied, the vaccination coverage for pertussis in 2019 was 3.9% (95% CI 3.8 to 4.1) (see Appendix 2, Supplementary Table 7). This approach returned fewer between-group differences in coverage than the cumulative approach. Pertussis vaccination coverage was again lower among males (3.3% vs 4.4%), and differed significantly between age groups, with highest coverage among patients aged 18–39 years, and lower among those aged 14–17 years. Pertussis vaccination coverage did not differ significantly according to the rurality of the patient's residence nor the socioeconomic status of the patient's residential area.

Pertussis vaccination coverage among smokers (2.9%) was again significantly lower than coverage among non-smokers (4.4%), with coverage also significantly lower among ex-smokers (4.0%) compared to non-smokers (4.4%). Surprisingly, vaccination coverage was lower among patients eligible for receiving state-funded vaccine (3.0%) compared to those eligible for a NIP-funded vaccine (3.7%) or not eligible for funded vaccines (3.9%).

There was again lot of variation in the recording of pertussis vaccination status across states and territories in which the practice was based, with the lowest levels of recording in the Northern Territory (2.4%) and the highest in Tasmania (4.8%). There was no difference in pertussis vaccination coverage according to rurality of the practice attended or the socioeconomic status of the area in which the practice was based.

3.5 Herpes zoster

We identified 786,725 patients aged 50 years or older attending general practices in 2018, and 811,664 in 2019, and these patients comprised the study population to evaluate herpes zoster vaccination coverage (Table 23). The population characteristics were similar in both years, with approximately 55% of patients being female and 62% between 50 and 69 years old. Gender was indeterminate for a small number of patients, hence vaccination coverage among this sub-population is not shown.

Most commonly, patients were non-smokers (51%), with approximately 11% being current smokers. One-quarter of patients were eligible to receive NIP-funded vaccines. Patients were more often from major cities (56%) and attended practices from New South Wales (36%). Socioeconomic status was evenly distributed, with 21% of patients from the most disadvantaged areas and 22% from the most advantaged areas. However, a slightly higher proportion attended practices located in most advantaged areas (25%).

Cumulative herpes zoster vaccination coverage increased from 13.6% (95% CI 13.0 to 14.2) in 2018 to 15.1% (95% CI 14.4 to 15.8) in 2019 (Table 23). In both years, there were no differences in herpes zoster vaccination coverage associated with sex or socioeconomic status of patients' residential area. The highest uptake of herpes zoster vaccination was recorded among the catch-up cohort of people aged 71–79 years in both 2018 and 2019 (~50%–52%). Differences according to the rurality of the patients' residential areas were less pronounced, with a lower probability of being vaccinated among people from remote/very remote areas compared to those from inner regional areas in both years, and compared to people from major cities in 2018.

Cumulative herpes zoster vaccination coverage among smokers was significantly lower than coverage among other patients, with only 5%–6% of current smokers having a recorded vaccination compared with 14%–19% of non-smokers or ex-smokers. As expected, people eligible for NIP-funded vaccines had higher coverage estimates compared to those not eligible (41%–48% vs 5%) (Table 23).

There was variation in the recording of cumulative herpes zoster vaccination across states/territories, with the lowest levels recorded in the Northern Territory (6%–7%) and the highest in South Australia (18%–30%). Patients attending practices in remote and very remote areas had the lowest rates of vaccination uptake (9%–11%). Differences in herpes zoster vaccination uptake according to the socioeconomic status of the area in which the practice was based were less pronounced, although coverage among patients of practices in quintile 4 (11%) was lower than coverage among patients in quintile 5 (15%–16%) in both years, and coverage among patients of practices in quintile 4 (11%) was also lower than coverage among patients in quintile 2 (17%) in 2019 (Table 23).

TABLE 23: Cumulative annual crude herpes zoster vaccination coverage by patients and practices characteristics, 2018 and 2019

Characteristics	Sample distribution year 2018	Sample distribution year 2019	Vaccination coverage year 2018		Vaccination coverage year 2019	
	Number (%)	Number (%)	Number	% (95% CI)	Number	% (95% CI)
Total population (overall)	786,725 (100)	811,664 (100)	106,785	13.6 (12.9, 14.2)	122,434	15.1 (14.4, 15.8)
Patient characteristics						
Sex						
Male	355,195 (45.2)	366,633 (45.2)	47,129	13.27 (12.6, 13.9)	54,391	14.84 (14.1, 15.55)
Female	431,510 (54.8)	445,008 (54.8)	59,655	13.82 (13.2, 14.5)	68,042	15.29 (14.6, 15.97)
Indeterminate	20 (0.0)	23 (0.00)	-	-	-	-
Age group (years)						
50–59	253,531 (32.2)	258,753 (31.9)	998	0.4 (0.4, 0.4)	1,094	0.4 (0.4, 0.5)
60–69	237,885 (30.2)	244,415 (30.1)	4,685	2.0 (1.9, 2.2)	5,093	2.1 (1.9, 2.3)
70	22,585 (2.9)	23,111 (2.9)	5,280	23.4 (22.1, 24.7)	4,891	21.2 (20.0, 22.3)
71–79	156,503 (19.9)	165,791 (20.4)	78,173	50.0 (48.3, 51.6)	86,475	52.2 (50.5, 53.8)
80+	116,221 (14.8)	119,594 (14.7)	17,649	15.2 (14.5, 15.9)	24,881	20.8 (20.0, 21.6)
Rurality						
Major city	442,174 (56.2)	458,229 (56.5)	59,501	13.46 (12.6, 14.3)	67,157	14.7 (13.7, 15.6)
Inner regional	222,564 (28.3)	228,394 (28.1)	32,336	14.5 (13.5, 15.6)	38,006	16.6 (15.6, 17.7)
Outer regional	109,265 (13.9)	112,118 (13.8)	13,794	12.6 (11.5, 13.7)	15,923	14.2 (13.0, 15.5)
Remote/very remote	12,722 (1.6)	12,923 (1.6)	1,154	9.1 (6.1, 12.1)	1,348	10.4 (7.3, 13.6)
Socioeconomic status						
1 (most disadvantaged)	162,689 (20.7)	166,608 (20.5)	21,660	13.3 (12.4, 14.2)	25,107	15.1 (14.1, 16.1)
2	153,538 (19.5)	157,602 (19.4)	22,421	14.6 (13.6, 15.7)	25,805	16.4 (15.2, 17.6)
3	169,073 (21.5)	175,467 (21.6)	21,999	13.0 (11.9, 14.1)	25,511	14.5 (13.3, 15.7)
4	130,619 (16.6)	135,484 (16.7)	16,109	12.3 (11.4, 13.3)	18,349	13.5 (12.5, 14.6)
5 (most advantaged)	170,806 (21.7)	176,503 (21.7)	24,596	14.4 (13.1, 15.7)	27,662	15.7 (14.4, 17.0)
Smoking status						
Smoker	82,198 (10.5)	85,566 (10.5)	4,325	5.3 (4.9, 5.6)	5,177	6.1 (5.6, 6.5)
Ex-smoker	236,316 (30.0)	239,423 (29.5)	39,282	16.6 (15.9, 17.3)	44,752	18.7 (18.0 19.4)
Non-smoker	399,324 (50.8)	413,217 (50.9)	59,160	14.8 (14.1, 15.5)	67,794	16.41 (15.7, 17.1)
Not recorded	68,887 (8.8)	73,458 (9.1)				
Median number of clinical encounters (IQR)	6.0 (3.0, 11.0)	6.0 (3.0, 11.0)				
NIP-funding eligibility						
Eligible	188,814 (24.0)	188,902 (23.3)	76,977	40.8 (39.4, 42.2)	91,366	48.4 (46.8, 49.9)
Not eligible	597,911 (76.0)	622,762 (76.7)	29,808	5.0 (4.7, 5.3)	31,068	5.0 (4.7, 5.3)
Practice characteristics						

Characteristics	Sample distribution year 2018	Sample distribution year 2019	Vaccination coverage year 2018		Vaccination coverage year 2019	
	Number (%)	Number (%)	Number	% (95% CI)	Number	% (95% CI)
State						
Australian Capital Territory	17,558 (2.2)	18,411 (2.3)	2,506	14.27 (10.6, 17.9)	2,866	15.6 (11.6, 19.5)
New South Wales	283,014 (36.0)	293,352 (36.1)	37,792	13.35 (12.3, 14.4)	43,983	15.0 (13.8, 16.2)
Northern Territory	13,576 (1.7)	13,730 (1.7)	837	6.17 (5.0, 7.3)	1,021	7.4 (6.1, 8.8)
Queensland	126,132 (16.0)	131,796 (16.2)	16,474	13.06 (11.9, 14.3)	19,225	14.6 (13.2, 15.9)
South Australia	26,684 (3.4)	26,728 (3.3)	4,741	17.77 (13.8, 21.7)	5,232	19.6 (15.2, 23.9)
Tasmania	74,526 (9.5)	76,715 (9.5)	11,454	15.37 (14.1, 16.6)	13,235	17.3 (15.9, 18.6)
Victoria	165,682 (21.1)	167,929 (20.7)	23,278	14.05 (12.4, 15.7)	25,826	15.4 (13.7, 17.1)
Western Australia	795,53 (10.1)	83,003 (10.2)	9,703	12.20 (10.7, 13.7)	11,046	13.3 (11.6, 15.0)
Rurality						
Major city	449,827 (57.2)	465,419 (57.3)	59,985	13.34 (12.5, 14.2)	67,698	14.6 (13.57, 15.52)
Inner regional	220,746 (28.1)	227,404 (28.0)	32,382	14.67 (13.6, 15.7)	38,100	16.8 (15.69, 17.81)
Outer regional	104,792 (13.3)	107,457 (13.2)	13,385	12.77 (11.5, 14.1)	15,440	14.4 (12.98, 15.76)
Remote/very remote	11,360 (1.4)	11,384 (1.4)	1,033	9.09 (5.5, 12.7)	1,196	10.5 (6.74, 14.27)
Socioeconomic status						
1 (most disadvantaged)	156,722 (19.9)	159,972 (19.7)	20,322	13.0 (11.9, 14.1)	23,369	14.6 (13.38, 15.84)
2	148,468 (18.9)	152,607 (18.8)	21,981	14.8 (13.5, 16.2)	25,384	16.6 (15.18, 18.09)
3	171,427 (21.8)	180,471 (22.2)	22,993	13.4 (11.8, 15.0)	26,894	14.9 (13.15, 16.65)
4	115,947 (14.7)	118,234 (14.6)	13,258	11.4 (10.1, 12.8)	15,173	12.8 (11.38, 14.28)
5 (most advantaged)	194,161 (24.7)	200,380 (24.7)	28,231	14.5 (13.3, 15.8)	31,614	15.8 (14.41, 17.15)

Estimated using the 'ever vaccinated' approach, IQR: Interquartile range, NIP: National Immunisation Program

Herpes zoster vaccination coverage according to funding eligibility status (Table 24)

Overall, there was a strong association between herpes zoster vaccination uptake and eligibility for receiving funded vaccines: unadjusted analyses indicate in 2019, coverage was 17.84 (95% CI 16.99 to 18.73) times more likely to occur among those eligible for funding. This positive association was observed within all strata examined. The strength of the relationship between funding eligibility status and herpes zoster vaccination uptake varied the most between states and territories of the practice, with the strongest associations observed in South Australia and the Northern Territory.

TABLE 24: Cumulative herpes zoster vaccination coverage according to funding eligibility status and stratified by selected characteristics, 2019

Characteristic	Vaccination coverage 2019	
	Number (%)	OR (95% CI)
Patient characteristics		
Sex		
Female		
Eligible	49,935 (50.35)	18.36 (17.49, 19.26)
Not eligible	18,107 (5.24)	1
Male		
Eligible	41,431 (46.18)	17.47 (16.55, 18.44)
Not eligible	12,960 (4.68)	1
Age group (years)		
50–59 (All not eligible)	1094 (0.42)	-
60–69 (All not eligible)	5,093 (2.08)	-
70 (All eligible)	4,891 (21.16)	-
71–79 (All eligible)	86,475 (52.16)	-
80+ (All not eligible)	24,881 (20.80)	-
Rurality		
Major city		
Eligible	49,467 (49.14)	18.57 (17.37, 19.84)
Not eligible	17,690 (4.95)	1
Inner regional		
Eligible	28,773 (49.46)	17.07 (15.72, 18.53)
Not eligible	9,233 (5.42)	1
Outer regional		
Eligible	12,146 (44.31)	17.05 (15.41, 18.86)
Not eligible	3,777 (4.46)	1
Remote/very remote		
Eligible	980 (36.79)	15.64 (11.90, 20.57)
Not eligible	368 (3.59)	1
Socioeconomic status		
1 (most disadvantaged)		
Eligible	19,200 (45.29)	16.58 (15.33, 17.94)
Not eligible	5,907 (4.76)	1
2		
Eligible	19,647 (50.99)	19.08 (17.75, 20.50)
Not eligible	6,158 (5.17)	1
3		
Eligible	19,337 (47.48)	18.83 (17.17, 20.64)
Not eligible	6,174 (4.58)	1
4		
Eligible	13,659 (46.82)	19.07 (17.44, 20.87)
Not eligible	4,690 (4.41)	1
5 (most advantaged)		
Eligible	19,523 (51.26)	16.84 (15.28, 18.56)
Not eligible	8,139 (5.88)	1
Practice characteristics		
State		
Australian Capital Territory		
Eligible	2,125 (50.95)	18.92 (13.23, 27.05)
Not eligible	741 (5.20)	1

Characteristic	Vaccination coverage 2019	
	Number (%)	OR (95% CI)
New South Wales		
Eligible	32,657 (46.39)	16.17 (14.91, 17.54)
Not eligible	11,326 (5.08)	1
Northern Territory		
Eligible	822 (29.39)	22.45 (17.15, 29.38)
Not eligible	199 (1.82)	1
Queensland		
Eligible	14,831 (47.55)	19.85 (17.96, 21.94)
Not eligible	4,394 (4.37)	1
South Australia		
Eligible	4,028 (57.49)	20.80 (16.53, 26.16)
Not eligible	1,204 (6.11)	1
Tasmania		
Eligible	9,895 (51.30)	17.06 (15.02, 19.36)
Not eligible	3,340 (5.82)	1
Victoria		
Eligible	18,705 (51.81)	18.83 (16.88, 21.01)
Not eligible	7,121 (5.40)	1
Western Australia		
Eligible	8,303 (46.25)	19.54 (17.17, 22.24)
Not eligible	2,743 (4.22)	1

Estimated using the 'ever vaccinated' approach

Factors associated with cumulative herpes zoster vaccination coverage in 2019 (Table 25)

To evaluate factors independently associated with herpes zoster vaccination in 2019, we performed a multivariate analysis adjusted for clustering. There was a lower probability of zoster vaccination among males (aOR 0.9) and among smokers (aOR 0.6) compared to non-smokers.

Factors associated with a higher probability of herpes zoster vaccination included older age (all age groups compared to patients aged 50–59 years, aORs 4.6 to 229.5), attending general practices more than four times in the previous year compared to those with four or less clinical encounters in the previous year (aOR 2.0) and being eligible to receive a NIP-funded vaccination (aOR 7.9).

The likelihood of herpes zoster vaccination also differed according to practice characteristics. Patients attending practices in the Northern Territory were 49% less likely to have a herpes zoster vaccination recorded compared to those attending practices in New South Wales, while patients attending practices in South Australia, Tasmania and Victoria were more likely to have a recorded vaccination (aORs 1.2 to 1.4). Patients attending practices in the most advantaged socioeconomic quintiles were significantly more likely to be vaccinated than patients attending practices in all other socioeconomic quintiles (aOR 1.4).

TABLE 25: Factors associated with cumulative herpes zoster vaccination uptake, 2019

Characteristic	Vaccination coverage in 2019		
	Crude OR (95% CI)	Adjusted OR (95% CI)*	P-value
Patient characteristics			
Sex			
Male	0.97 (0.95, 0.99)	0.89 (0.87, 0.91)	<0.001
Female	1.00	1.00	
Age group (years)			0.001
50–59	1.00	1.00	
60–69	5.01 (4.58, 5.48)	4.59 (4.20, 5.01)	
70	63.20 (56.75, 70.38)	56.29 (50.69, 62.51)	
71–79	256.68 (230.72, 285.56)	229.51 (206.93, 254.56)	
80+	61.85 (55.75, 68.61)	46.12 (41.74, 50.95)	
Rurality			
Major city	1.00	-	
Inner regional	1.16 (1.05, 1.29)	-	
Outer regional	0.96 (0.85, 1.09)	-	
Remote/very remote	0.68 (0.48, 0.96)	-	

Characteristic	Vaccination coverage in 2019		
	Crude OR (95% CI)	Adjusted OR (95% CI)*	P-value
Socioeconomic status			0.017
1 (most disadvantaged)	1.00	1.00	
2	1.10 (0.99, 1.23)	1.05 (0.97, 1.14)	
3	0.96 (0.85, 1.08)	1.01 (0.92, 1.11)	
4	0.88 (0.79, 0.98)	1.03 (0.93, 1.14)	
5 (most advantaged)	1.05 (0.92, 1.19)	1.19 (1.05, 1.34)	
Smoking status			<0.001
Smoker	0.33 (0.31, 0.35)	0.57 (0.54, 0.60)	
Ex-smoker	1.17 (1.14, 1.20)	1.03 (1.00, 1.05)	
Non-smoker	1.00	1.00	
NIP -funding eligibility			
Eligible	17.84 (16.99, 18.73)	7.89 (7.40, 8.41)	<0.001
Not eligible	1.00	1.00	
Number of clinical encounters in the previous year			
> 4	3.21 (3.09, 3.34)	2.03 (1.95, 2.13)	<0.001
≤ 4	1.00	1.00	
Practice characteristics			
State			<0.001
New South Wales	1.00	1.00	
Australian Capital Territory	1.05 (0.76, 1.44)	1.02 (0.67, 1.57)	
Northern Territory	0.46 (0.37, 0.57)	0.51 (0.39, 0.67)	
Queensland	0.97 (0.84, 1.12)	1.11 (0.95, 1.29)	
South Australia	1.38 (1.03, 1.85)	1.42 (1.06, 1.90)	
Tasmania	1.18 (1.03, 1.35)	1.32 (1.12, 1.55)	
Victoria	1.03 (0.88, 1.21)	1.19 (1.03, 1.37)	
Western Australia	0.87 (0.73, 1.04)	1.00 (0.84, 1.18)	
Rurality			0.649
Major city	1.00	1.00	
Inner regional	1.18 (1.06, 1.32)	1.04 (0.91, 1.19)	
Outer regional	0.99 (0.86, 1.13)	0.96 (0.81, 1.14)	
Remote/very remote	0.69 (0.46, 1.04)	0.84 (0.53, 1.32)	
Socioeconomic status			<0.001
1 (most disadvantaged)	1.00	1.00	
2	1.17 (1.01, 1.35)	1.27 (1.08, 1.49)	
3	1.02 (0.86, 1.21)	1.21 (1.01, 1.45)	
4	0.86 (0.73, 1.01)	1.03 (0.84, 1.27)	
5 (most advantaged)	1.10 (0.95, 1.26)	1.35 (1.11, 1.65)	

NIP: National Immunisation Program, * Estimated using logistic regression models and estimated using the 'ever vaccinated' approach

Herpes zoster vaccination – first vaccinated in 2019

When the 'first vaccinated that year' approach was applied, the vaccination coverage for herpes zoster in 2019 was 2.5% (95% CI 2.4 to 2.6) (see Appendix 2, Supplementary Table 7). This approach returned fewer between-group differences in coverage than the 'ever vaccinated' approach. Herpes zoster vaccination coverage was again significantly different between age groups, with highest coverage among patients aged 70 years, and those aged 71–79 years. Patients from inner regional areas had higher coverage compared to those from major cities or remote and very remote areas. Patients from the 2nd socioeconomic status quintile had higher coverage compared to those from the 4th quintile.

Herpes zoster vaccination coverage among smokers (1.2%) was again significantly lower than coverage among non-smokers (2.7%). Herpes zoster vaccination coverage was again significantly higher among patients eligible to receive a NIP-funded vaccine (13.6%) compared to those not eligible (0.4%).

There was again variation in the recording of herpes zoster vaccination status across states and territories in which the practice was based, with the lowest levels recorded in the Northern Territory (1.8%) and the highest in Tasmania (2.9%). Patients attending practices in remote and very remote areas had the lowest rates of herpes zoster vaccination uptake (1.8%). Differences in herpes zoster

vaccination uptake according to the socioeconomic status of the area in which the practice was based were less pronounced, although coverage among patients of practices in quintile 4 (2.2%) was lower than coverage among patients in quintile 2.

4. DISCUSSION

The validity of MedicineInsight data for measuring vaccination coverage

The sociodemographic profile of people regularly attending general practices in Australia and included in our study is similar to national MBS data in terms of age and sex. We observed differences in the distribution of socioeconomic status and rurality of the area in which general practice patients are living. There was an overrepresentation of people from inner regional areas, from lower SEIFA IRSAD quintile, and attending practices in Tasmania, and an underrepresentation of people attending practices from South Australia. The impact of both over- and underrepresentation in vaccination coverage estimates is not possible to ascertain. Crude vaccination coverage could be higher than in the general population, especially for vaccines funded through states and territories which are overrepresented in MedicineInsight data. From our multivariable models, we observed a higher likelihood of vaccine uptake among patients attending practices from inner regional areas that could also contribute to inflating crude coverage estimates compared to the whole Australian population.

For the most part, the prevalence of health conditions in the study population was similar to prevalence estimates from the National Health Survey. Exceptions were the higher prevalence of diabetes and cardiac conditions among the population for the current study. Discrepancies between MedicineInsight and ABS NHS have been addressed in detail elsewhere.[28,40] MedicineInsight collects data from practices who joined the program voluntarily. To improve data quality, MedicineInsight study population is often restricted to patients attending general practices regularly, as in our study. More frequent clinical encounters possibly increases the likelihood of a patient having their diagnosis recorded and people having a chronic condition usually requires frequent GP consultations. In addition, MedicineInsight captures conditions recorded in the clinical information system over the lifetime of the patient (ie, cumulatively through the course of the patient's follow-up), while the ABS NHS captures self-report data on 'current conditions', defined as those occurring in the previous six months, and is a general population survey.[28] Therefore, the higher capture of health conditions in the MedicineInsight dataset is not surprising.

The higher prevalence of diabetes and cardiac conditions in the study population may imply a higher proportion of people with an indication for pneumococcal and influenza vaccination and a higher proportion may be eligible for a funded vaccine. Given that funding and morbidities are associated with an increased likelihood of vaccination, coverage estimates based on the MedicineInsight population may overestimate coverage in the whole Australian population.

Vaccination coverage results compared to existing evidence

Overall, influenza vaccination coverage was between 24% and 26%, with higher rates among people with health conditions (39%–42%) and the elderly (57%–59%). These results were similar to previous estimates in the general population (27%–53%)[11,13] and among elderly people (63%–82%).[10,11,13,41] However, they are well below the 75% of coverage target established by the World Health Organization for people aged 65 years and older or medically at higher risk of influenza.[42]

In line with previous studies, we found the uptake for the pneumococcal vaccine was substantially lower than for influenza vaccination in the same age groups, with only 47% of people aged 65 years or older vaccinated for pneumococcal in 2018 and 2019 compared to 57%–59% vaccinated for influenza.[18] Our pneumococcal vaccination estimates among the elderly were equal to those obtained in the NSW Population Health Survey conducted in 2016[43] and slightly lower than those previously estimated using MedicineInsight dataset, where about half of elderly people attending general practices in 2016 had a pneumococcal vaccination recorded in the clinical information system.[18] However, when comparing results from our sensitivity analysis using a broader definition of pneumococcal vaccination, results were similar to the previously reported (52%–54% in our study vs 52% in the previous one).[18]

There is little research to allow comparisons of our estimates on overall pneumococcal vaccination coverage. According to the BEACH survey, conducted in 2014, 27.6% of adults were vaccinated

against pneumococcal infection in the previous five years, with higher coverage among the elderly (49%–70%) and those with health conditions (51%).[44] These estimates are higher than the ones we found for people aged 10 years or older attending GP practices (12%) and among people with health conditions (~26%) even after including pneumococcal non-specific terms in our search strategy (~14% and 29%–30%, respectively). However, other studies have estimated that less than 10% of people at risk of pneumococcal disease under 65 years old are vaccinated.[45] The extent to which overall estimates reveal a poor use of pneumococcal vaccines is not possible to ascertain since the recommendations vary according to age, Indigenous status, risk factors, prior vaccination intervals and prior vaccination with the 13-valent pneumococcal conjugate vaccine. However, among the elderly and people at higher risk of pneumococcal infection, the results highlight a suboptimal coverage.

To our knowledge, population-based estimates on meningococcal vaccination coverage in adolescents and adults in Australia have not been published. However, our estimates were substantially lower than international estimates. In 2005, the United States recommended vaccination of adolescents aged 11–18 years. And one year later, approximately 11% of adolescents aged 13–17 years reported receiving one dose of MenACWY, increasing to 87% in 2018.[46] In England, coverage in the first year after the initiation of MenACWY vaccination program was 37%.[47] Meningococcal ACWY vaccination for adolescents in Australia was funded through most states and territories from July 2017 until it was introduced into the NIP schedule in April 2019. In the target population, aged 14–19 years, vaccination coverage ranged from 12%–14% in 2018 and 2019.

There is little research conducted on pertussis vaccination coverage at the national level. The 2009 Australian Adult vaccination survey reported pertussis vaccination coverage of 11.3% among adults aged 18 years and older.[23] However, changes in funding schemes and two pertussis epidemics have occurred since then, potentially impairing results comparison.[6] However, our estimates (20%–22%) were similar to those from a 2014 survey among adults aged 45 years or older in New South Wales, that found 22% pertussis vaccination coverage.[48] If we consider only people aged 40 years or older in our study population, these estimates would still be similar (~21%–23%, data not shown). We observed a progressively higher probability of having a recorded pertussis vaccination with increased age, suggesting people are immunised irrespective of eligibility for funded vaccination or/and a poor capture of pertussis vaccination among people at school age The identification of people at higher risk for pertussis infection was not possible in our dataset since pregnancy status, occupation and contact with infants are characteristics not consistently recorded in the CIS. However, other studies suggest vaccination coverage for pertussis is substantially higher among pregnant women, hospitalised patients, and childhood education staff, with estimates ranging from 64% to 75%.[15-17,21]

Our findings on herpes zoster vaccination coverage were similar or higher to previous national studies. We found approximately 14%–15% of people aged 50 years or older had a recorded vaccination, further increasing to 47%–48% among people aged 70 to 79 years old. The results in the latter subgroup are in accordance with a recent study using MedicineInsight data[20] and a survey conducted by the National Centre for Immunisation Research and Surveillance.[49] However, they are substantially higher than estimates from the AIR (~30%) which are acknowledged to substantially underestimate true uptake.[19] Our results also indicate new vaccinations occurred mostly among patients at age 70 and among those belonging to the catch-up cohort for zoster vaccination (71–79 years), probably because these groups are eligible for funded vaccination.[20]

Factors associated with vaccination and implications for vaccination policies and clinical practice

Being eligible to receive funded vaccination was consistently associated with vaccine uptake even after controlling for other confounding factors. The probability of vaccination uptake increased 1.4 to 7.9-fold across the disease groups evaluated, except for pertussis. The highest impact of funding was observed for herpes zoster vaccination. Previous studies using MedicineInsight data with a longitudinal cohort design have reported most people to be vaccinated after they become eligible to receive funded vaccines.[18,20] Other studies conducted to evaluate the impact of immunisation programmes have reported similar findings, with increased uptake after funded vaccination was

implemented.[25,48] While the impact of NIP-funded vaccination is evident, funded vaccination through states and territories, or the PBS, contributed to further increase of vaccination coverage. For instance, pneumococcal vaccination coverage among people eligible for funded vaccination through states and territories or through PBS, was eight times higher compared to people not eligible for any funded vaccine and, for meningococcal, offering state-funded vaccines increased the overall vaccination rates four to seven times compared to people not eligible for any funded vaccination. This impact is likely to be even higher since our algorithm could not distinguish the source of funding for people who were eligible to receive funded vaccines from multiple funders. Our results suggest the cost of the vaccines could be a barrier to increased access among people not eligible to receive funded vaccination, especially for pneumococcal, meningococcal and herpes zoster. Considering the low uptake of vaccines among adolescents and adults, the expansion of eligibility criteria for subsidised vaccination is a potentially modifiable factor to increase coverage, in conjunction with educational strategies to enhance vaccination awareness, especially among people at higher risk.

Smoking status was also consistently associated with lower vaccination uptake in the adjusted models, current smokers were 26% to 54% less likely to be vaccinated compared to non-smokers within all disease groups evaluated. On the other hand, ex-smokers had higher (for influenza and pneumococcal) or equal chances of being vaccinated for herpes zoster and pertussis, compared to non-smokers. These findings are in agreement with previous studies reporting people with unhealthy lifestyles, such as smoking, are less likely to be vaccinated.[50-53] However, smokers are at increased susceptibility to infectious diseases and greater severity of influenza and pneumococcal disease.[54] At the same time, the lack of perceived risk, the belief vaccines are ineffective and the lack of GP recommendation for vaccination are factors associated with under vaccination among smokers.[52] These results highlight the importance of enhancing vaccination counselling and improving smoking cessation strategies in this population.

Encouragingly, we found people with health conditions were more likely to be vaccinated even after adjusting for other factors. This result is not surprising since people with chronic health conditions may visit general practices more regularly, leading to increased interactions with health providers and opportunities for vaccination.[12,18] It also suggests people with chronic health conditions are knowledgeable that they are at risk of infections or complications.[18] In addition, higher number of visits to the GP was independently associated with higher vaccination rates across all disease groups evaluated. Targeting people that frequent the practice less often and may have chronic conditions could be useful in further interventions (eg, software that identifies these patients and provides reminders of these vaccines). Finally, these encounters also represent opportunities to increase the co-administration of vaccines to increase coverage.

Strengths and limitations of the study

The main strength of this study is the use of national data and a large sample size, with statistical power to enable the evaluation of vaccination coverage and factors associated with vaccination uptake. The data is collected regularly and includes the medical history of patients, increasing its quality. Moreover, the consistency of our findings with previous research estimating vaccination coverage using different methods is reassuring.

However, our study has several limitations.

First, it is likely it underestimates coverage because of vaccinations administered in workplaces, pharmacies and other non-GP immunisation settings. The impact of the underestimation can also vary according to the disease group. For example, meningococcal vaccination is targeted mostly to adolescents and young adults and is delivered primarily through school programs. In addition, adolescents and young adults are infrequent users of healthcare services, so they have fewer opportunities to either receive a vaccination or to have their vaccination received in non-GP settings recorded in the GPs clinical information system. Contrastingly, the target population for herpes zoster vaccination is more likely to frequent healthcare services, increasing the opportunities for vaccination and recording in the clinical information system even if administered in other settings. Yet, our results were consistent with the literature when there was evidence available.

Secondly, MedicineInsight data collects data generated for clinical purposes so that the quality and accuracy of records depend on each practice's and clinician's standards. For instance, we did not assess pregnancy status in our study since this characteristic is not consistently recorded in CISs. However, MedicineInsight data will be able to identify pregnancy status in the near future. Moreover, some conditions managed in specialist or hospital settings may not be fully captured in general practice datasets.

Thirdly, eligibility for funded vaccines was defined based on a combination of patient's age, health conditions, Indigenous status and the state of the practice patients attended. Therefore, inconsistency in recording in any of these characteristics can potentially lead to misclassification of the patient eligibility for funding. In addition, some conditions to which vaccines are recommended or funded were not feasible to identify in MedicineInsight data, such as preterm birth and long-term use of specific medicines. Thus, any association identified in this study could be even stronger.

Fourthly, patients may visit multiple general practices and we were not able to link information for the same patient across multiple practice sites. The impact of this in our vaccination estimates is not possible to ascertain. However, a previous analysis estimated this is the case for less than 5% of patients.

Finally, our study population includes only patients regularly attending general practices, who may have different patterns of health services utilisation than the general population. In particular, their regular attendance at general practices may increase their opportunity to receive a vaccination, overestimating coverage. However, we do not anticipate that this will have a substantial impact on the generalisability of the findings, as the average number of encounters per year among patients attending general practices (estimated from MBS data) is five, which is greater than the threshold we used to define and select regular patients.[28] It was important to use this criterion to minimise the probability of including temporary patients or visitors for whom details on lifetime vaccination, health conditions and other risk behaviours would be poorly captured in MedicineInsight.

5. CONCLUSION

Vaccination rates among adolescents and adults regularly attending general practices were suboptimal for all disease groups evaluated. While it is likely our results underestimate vaccination coverage, we generally observed similar results to estimates from studies conducted nationally or across Australian jurisdictions.

Encouragingly, we observed higher vaccination uptake among people at higher risk for influenza and pneumococcal infection. Using multivariable models adjusted for clustering, we were also able to identify sociodemographic and clinical characteristics associated with vaccination uptake, highlighting the role of funding in the vaccination coverage for all disease groups.

Our study reiterates the use of MedicineInsight dataset as a valuable source for vaccination monitoring purposes, to inform immunisation policies and target strategies aiming to improve vaccination uptake, especially among people at higher risk.

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APPENDIX 1 – Health conditions associated with increased risk of influenza, pneumococcal and meningococcal disease

Conditions associated with increased risk of influenza disease and severe outcomes

- Immunocompromising conditions including:
  - HIV infection
  - malignancy
  - chronic steroid use
  - solid organ transplant
  - haematopoietic stem cell transplant
- Functional or anatomical asplenia, including:
  - sickle cell disease or other haemoglobinopathies
  - congenital or acquired asplenia (for example, splenectomy) or hyposplenia
- Cardiac disease, including:
  - cyanotic congenital heart disease
  - congestive heart failure
  - coronary artery disease
- Chronic respiratory conditions, including:
  - suppurative lung disease
  - bronchiectasis
  - cystic fibrosis
  - chronic obstructive pulmonary disease
  - chronic emphysema
  - severe asthma (requiring frequent medical consultations or the use of multiple medicines)
- Chronic neurological conditions, including:
  - hereditary and degenerative CNS diseases
  - seizure disorders
  - spinal cord injuries
  - neuromuscular disorders
- Chronic metabolic disorders, including:
  - Type 1 or 2 diabetes
  - amino acid disorders
  - carbohydrate disorders
  - cholesterol biosynthesis disorders
  - fatty acid oxidation defects, lactic acidosis
  - mitochondrial disorders
  - organic acid disorders
  - urea cycle disorders vitamin/cofactor disorders
  - porphyrias
- Chronic renal failure
- Long-term aspirin therapy in children aged 6 months to 10 years
- Chronic liver disease [a]
- Down syndrome [a]
- Obesity (body mass index ≥30 kg per m^2) [a]
- Children born less than 37 weeks gestation [a]
- Harmful use of alcohol[a]

[a] Not funded under the National Immunisation Program Schedule

Conditions associated with increased risk of invasive pneumococcal disease

Category A: Conditions associated with the highest increased risk of invasive pneumococcal disease

- Functional or anatomical asplenia, including:
  - sickle cell disease or other haemoglobinopathies
  - congenital or acquired asplenia (for example, splenectomy), or splenic dysfunction
- Immunocompromising conditions, including:
  - congenital or acquired immune deficiency, including symptomatic IgG subclass or isolated IgA deficiency (note: children who need monthly immunoglobulin infusion are unlikely to benefit from vaccination)
  - immunosuppressive therapy (including corticosteroid therapy ≥2 mg per kg per day of prednisolone or equivalent for more than 1 week) or radiation therapy, where there is sufficient immune reconstitution for vaccine response to be expected
  - haematological and other malignancies
  - solid organ transplant
  - haematopoietic stem cell transplant
  - HIV infection (including AIDS)
  - chronic renal failure, or relapsing or persistent nephrotic syndrome
- Proven or presumptive cerebrospinal fluid leak
- Cochlear implants
- Intracranial shunts

Category B: Conditions associated with an increased risk of invasive pneumococcal disease

- Chronic cardiac disease: particularly cyanotic heart disease or cardiac failure in children excluding hypertension only (in adults)
- Chronic lung disease, including:
  - chronic lung disease in preterm infants
  - cystic fibrosis
  - severe asthma in adults (requiring frequent medical consultations or the use of multiple medications)
- Diabetes
- Down syndrome
- Alcoholism
- Chronic liver disease
- Preterm birth at <28 weeks gestation
- Tobacco smoking (associated with an increased risk of pneumococcal disease)
- History of previous invasive pneumococcal disease in children.

Conditions associated with increased risk of invasive meningococcal disease

- Defects in, or deficiency of, complement components, including factor H, factor D or properdin deficiency
- Current or future treatment with eculizumab (a monoclonal antibody directed against complement component C5)
- Functional or anatomical asplenia, including sickle cell disease or other haemoglobinopathies, and congenital or acquired asplenia
- HIV, regardless of disease stage or CD4+ cell count
- Haematopoietic stem cell transplant

APPENDIX 2 – Additional analysis according to disease group

Influenza

Supplementary Table 1: Annual crude influenza vaccination coverage among patients regularly attending general practices between March and August each year, by patients and practices characteristics, 2018 and 2019

Characteristics	Sample distribution year 2018	Sample distribution year 2019	Vaccination coverage year 2018		Vaccination coverage year 2019	
	Number (%)	Number (%)	Number	% (95% CI)	Number	% (95% CI)
Total population (overall)	1,314,868 (100)	1,361,601 (100)	402,381	30.6 (29.3, 31.9)	460,680	33.8 (32.5, 35.2)
Patient characteristics						
Sex						
Female	763,542 (58.1)	788,021 (57.9)	233,468	30.6 (29.3, 31.8)	267,324	33.9 (32.6, 35.2)
Male	551,232 (41.9)	573,445 (42.1)	168,899	30.6 (29.3, 32.0)	193,329	33.7 (32.3, 35.2)
Indeterminate	94 (0.0)	135 (0.0)	-			
Age group (years)						
10–19	128,501 (9.8)	137,802 (10.1)	21,127	16.4 (15.6, 17.3)	35,450	25.7 (24.5, 27.0)
20–50	559,920 (42.6)	576,650 (42.4)	75,545	13.5 (12.8, 14.2)	98,266	17.0 (16.1, 17.9)
51–64	277,375 (21.1)	284,003 (20.9)	71,565	25.8 (24.9, 26.7)	78,753	27.7 (26.8, 28.6)
65+	349,072 (26.6)	363,146 (26.7)	234,144	67.1 (66.1, 68.1)	248,211	68.4 (67.3, 69.4)
Rurality						
Major city	797,524 (60.7)	838,261 (61.6)	228,598	28.7 (27.0, 30.4)	267,567	31.9 (30.1, 33.7)
Inner regional	335,797 (25.5)	341,239 (25.6)	117,744	35.1 (33.5, 36.6)	130,003	38.1 (36.6, 39.6)
Outer regional	160,748 (12.2)	161,659 (11.9)	51,127	31.8 (29.0, 34.6)	56,897	35.2 (32.2, 38.2)
Remote/very remote	20,799 (1.6)	20,442 (1.5)	4,912	23.6 (16.4, 30.8)	6,213	30.4 (22.7, 38.1)
Socioeconomic status						
1 (most disadvantaged)	244,581 (18.6)	247,714 (18.2)	81,253	33.2 (30.9, 35.5)	88,642	35.8 (33.5, 38.1)
2	239,435 (18.2)	246,931 (18.1)	79,580	33.2 (31.4, 35.1)	88,605	35.9 (33.9, 37.9)
3	288,412 (21.9)	298,319 (21.9)	86,633	30.1 (28.1, 32.0)	99,739	33.4 (31.3, 35.6)
4	248,751 (18.9)	259,830 (19.1)	64,819	26.1 (23.9, 28.2)	77,431	29.8 (27.6, 32.0)
5 (most advantaged)	293,689 (22.3)	308,807 (22.7)	90,096	30.7 (28.7, 32.6)	106,263	34.4 (32.3, 36.5)
Any relevant health condition (Yes) *	555,531 (42.3)	555,467 (40.8)	257,930	46.4 (45.2, 47.6)	275,975	49.7 (48.5, 50.9)
Any relevant health condition, excluding asthma (Yes) *	425,750 (32.4)	422,651 (31.0)	223,396	52.5 (51.3, 53.6)	233,248	55.2 (54.0, 56.4))
Cardiac disease (Yes)	129,080 (9.8)	124,468 (9.1)	84,522	65.5 (64.5, 66.4)	83,648	67.2 (66.3, 68.1)
Respiratory condition (Yes)	257,836 (19.6)	258,376 (19.0)	110,772	43.0 (41.7, 44.2)	120,714	46.7 (45.5, 48.0)
Respiratory condition, excluding asthma	68,429 (5.2)	66,028 (4.9)	44,597	65.2 (64.1, 66.3)	44,409	67.3 (66.2, 68.3)

Neurological condition (Yes)	38,953 (3.0)	38,242 (2.8)	19,263	49.5 (48.2, 50.7)	19,960	52.2 (51.0, 53.4)
Immunocompromising condition (Yes)	227,859 (17.3)	225,998 (16.6)	121,089	53.1 (51.9, 54.4)	125,588	55.6 (54.4, 56.8)
Chronic renal disease (Yes)	15,088 (1.15)	14,457 (1.1)	11,090	73.5 (72.3, 74.7)	10,740	74.3 (73.0, 75.5)
Diabetes (Yes)	126,090 (9.6)	124,900 (9.17)	72,259	57.3 (55.9, 58.7)	74,838	59.9 (58.6, 61.3)
Other relevant health condition (Yes)	7,111 (0.5)	7,048 (0.52)	2,433	34.2 (31.8, 36.6)	2,757	39.1 (36.9, 41.4)
Smoking status						
Smoker	158,164 (12.0)	159,099 (11.68)	30,527	19.3 (18.3, 20.4)	35,482	22.3 (21.2, 23.4)
Ex-smoker	282,337 (21.5)	282,517 (20.75)	119,923	42.5 (41.2, 43.7)	127,941	45.3 (44.1, 46.5)
Non-smoker	733,148 (55.8)	762,271 (55.98)	226,961	31.0 (29.7, 32.3)	261,555	34.3 (33.0, 35.7)
Not recorded	141,219 (10.7)	157,714 (11.58)				
Median number of clinical encounters in the previous year (IQR)	4 (2, 9)	5 (2, 9)				
NIP-funding eligibility						
Eligible	685,357 (52.1)	688,669 (50.6)	323,491	47.2 (46.0, 48.4)	348,855	50.7 (49.4, 51.9)
Not eligible	629,511 (47.9)	672,932 (49.4)	78,890	12.5 (11.9, 13.2)	111,825	16.6 (15.8, 17.5)
Practice characteristics						
State						
Australian Capital Territory	29,522 (2.3)	32,130 (2.4)	8,935	30.3 (26.7, 33.9)	10,263	31.9 (28.1, 35.8)
New South Wales	459,621 (35.0)	482,344 (35.4)	151,797	33.0 (30.9, 35.2)	169,174	35.1 (32.6, 37.6)
Northern Territory	22,459 (1.7)	21,398 (1.6)	4,056	18.1 (14.8, 21.3)	4,875	22.8 (19.3, 26.3)
Queensland	210,611 (16.0)	220,003 (16.2)	61,742	29.3 (27.0, 31.7)	69,373	31.5 (29.2, 33.9)
South Australia	39,697 (3.0)	39,079 (2.9)	14,442	36.4 (31.8, 40.9)	16,348	41.8 (37.2, 46.4)
Tasmania	112,394 (8.6)	113,678 (8.4)	39,467	35.1 (33.1, 37.2)	42,104	37.0 (34.8, 39.3)
Victoria	296,765 (22.6)	300,185 (22.1)	88,906	30.0 (26.4, 33.6)	102,791	34.2 (30.5, 38.0)
Western Australia	143,799 (10.9)	152,784 (11.2)	33,036	23.0 (20.2, 25.8)	45,752	30.0 (27.0, 32.9)
Rurality						
Major city	808,329 (61.5)	848,359 (62.3)	230,271	28.5 (26.7, 30.2)	269,738	31.8 (30.0, 33.6)
Inner regional	333,552 (25.4)	339,879 (25.0)	118,455	35.5 (34.1, 36.9)	130,543	38.4 (36.9, 39.9)
Outer regional	154,481 (11.8)	155,166 (11.4)	49,247	31.9 (28.9, 34.9)	54,814	35.3 (32.2, 38.5)
Remote/very remote	18,506 (1.4)	18,197 (1.3)	4,408	23.8 (15.4, 32.3)	5,585	30.7 (21.7, 39.7)
Socioeconomic status						
1 (most disadvantaged)	237,174 (18.0)	240,092 (17.6)	78,087	32.9 (27.0, 35.9)	85,524	35.6 (32.64, 38.6)
2	234,039 (17.8)	239,933 (17.6)	77,562	33.1 (30.2, 36.1)	86,399	36.0 (33.1, 38.9)
3	291,633 (22.2)	304,030 (22.3)	88,462	30.3 (27.4, 33.3)	102,173	33.6 (30.3, 36.9)
4	220,949 (16.8)	231,426 (17.0)	55,649	25.2 (22.2, 28.2)	66,188	28.6 (25.6, 31.6)
5 (most advantaged)	331,073 (25.2)	346,120 (25.4)	102,621	31.0 (28.8, 33.2)	120,396	34.8 (32.4, 37.1)

IQR: Interquartile range, NIP: National Immunisation Program, * In accordance with the Australian Immunisation Handbook [1]

Supplementary Table 2: Factors associated with influenza vaccination uptake among patients regularly attending general practices between March and August, 2019

Characteristics	Vaccination coverage in 2019		
	Crude OR (95% CI)	Adjusted OR (95% CI) *	P-value
Patient characteristics			
Sex			<0.001
Male	0.99 (0.97, 1.01)	0.91 (0.90, 0.92)	
Female	1	1	
Age group (years)			<0.001
10–19	1	1	
20–50	0.59 (0.57, 0.62)	0.50 (0.48, 0.52)	
51–64	1.11 (1.05, 1.17)	0.76 (0.72, 0.80)	
65+	6.24 (5.89, 6.60)	3.07 (2.92, 3.23)	
Rurality			
Major city	1	-	
Inner regional	1.31 (1.19, 1.45)	-	
Outer regional	1.158 (0.994, 1.35)	-	
Remote/very remote	0.93 (0.64, 1.35)	-	
Socioeconomic status			0.001
1 (most disadvantaged)	1	1	
2	1.00 (0.89, 1.13)	1.06 (0.99, 1.12)	
3	0.90 (0.80, 1.02)	1.05 (0.97, 1.14)	
4	0.76 (0.67, 0.87)	1.04 (0.95, 1.14)	
5 (most advantaged)	0.94 (0.83, 1.07)	1.15 (1.06, 1.26)	
Any relevant health condition **			<0.001
Yes	3.23 (3.23, 3.42)	1.47 (1.43, 1.51)	
No	1	1	
Smoking status			<0.001
Smoker	0.55 (0.53, 0.57)	0.67 (0.65, 0.69)	
Ex-smoker	1.59 (1.54, 1.63)	1.06 (1.05, 1.08)	
Non-smoker	1	1	
NIP -funding eligibility			<0.001
Eligible	4.94 (4.94, 5.38)	1.32 (1.26, 1.37)	
Not eligible	1	1	
Number of clinical encounters in the previous year			<0.001
> 4	3.22 (3.12, 3.32)	1.97 (1.93, 2.01)	
≤ 4	1	1	
Practice characteristics			
State			<0.001
New South Wales	1	1	
Australian Capital Territory	0.87 (0.71, 1.07)	0.81 (0.69, 0.94)	
Northern Territory	0.55 (0.44, 0.69)	0.50 (0.41, 0.62)	
Queensland	0.85 (0.73, 0.99)	0.90 (0.81, 1.01)	
South Australia	1.33 (1.07, 1.67)	1.22 (1.03, 1.44)	
Tasmania	1.09 (0.94, 1.26)	0.92 (0.80, 1.06)	
Victoria	0.96 (0.79, 1.18)	1.05 (0.91, 1.21)	
Western Australia	0.79 (0.66, 0.95)	0.86 (0.76, 0.98)	
Rurality			
Major city	1	1	0.090
Inner regional	1.34 (1.20, 1.48)	1.13 (1.02, 1.25)	
Outer regional	1.17 (0.99, 1.38)	1.15 (0.97, 1.37)	
Remote/very remote	0.95 (0.62, 1.46)	1.21 (0.83, 1.77)	
Socioeconomic status			0.038
1 (most disadvantaged)	1	1	
2	1.02 (0.85, 1.22)	1.10 (0.94, 1.28)	
3	0.92 (0.75, 1.11)	1.10 (0.93, 1.30)	
4	0.72 (0.59, 0.88)	1.05 (0.87, 1.25)	
5 (most advantaged)	0.96 (0.82, 1.14)	1.25 (1.04, 1.50)	

NIP: National Immunisation Program, * Estimated using logistic regression models and estimated using the 'vaccinated that year' approach **In accordance with the Australian Immunisation Handbook [1]

Pneumococcal disease

Supplementary Table 3: Annual crude pneumococcal vaccination (23vPPV) coverage by patients and practices characteristics (first vaccinated)

Characteristics	Sample characteristics	Vaccination Coverage Year 2019	
	Number (%)	Number	% (95% CI)
Total population (overall)	1,571,013 (100)	23,630	1.5 (1.4, 1.6)
Patient characteristics			
Sex			
Female	904,247 (57.6)	12,423	1.4 (1.3, 1.5)
Male	666,602 (42.4)	11,207	1.7 (1.5, 1.8)
Age group (years)			
10–19	186,409 (11.9)	55	0.0 (0.0, 0.0)
20–50	796,317 (50.7)	897	0.1 (0.1, 0.1)
51–64	344,156 (21.9)	2,323	0.7 (0.6, 0.7)
65+	244,131 (15.5)	20,355	8.3 (7.8, 8.8)
Rurality			
Major city	988,783 (62.9)	12,510	1.3 (1.1, 1.4)
Inner regional	373,299 (23.8)	7,304	2.0 (1.7, 2.2)
Outer regional	182,896 (11.6)	3,438	1.9 (1.6, 2.2)
Remote/very remote	26,035 (1.7)	378	1.5 (0.9, 2.0)
Socioeconomic status			
1 (most disadvantaged)	276,247 (17.6)	5,462	2.0 (1.7, 2.3)
2	273,345 (17.4)	4,646	1.7 (1.5, 1.9)
3	347,086 (22.1)	5,197	1.5 (1.3, 1.7)
4	313,945 (20.0)	3,754	1.2 (1.1, 1.3)
5 (most advantaged)	360,390 (22.9)	4,571	1.3 (1.1, 1.4)
Any relevant health condition (Yes) *	487,398 (31.0)	15,155	3.1 (2.9, 3.3)
Any relevant health condition, excluding asthma (Yes) *	324,270 (20.6)	13,804	4.3 (4.0, 4.5)
Cardiac disease (Yes)	79,341 (5.1)	4,599	5.8 (5.4, 6.2)
Respiratory condition (Yes)	249,149 (15.9)	5,849	2.3 (2.2, 2.5)
Respiratory condition, excluding asthma (Yes)	41,437 (2.6)	2,820	6.8 (6.4, 7.2)
Immunocompromising condition (Yes)	179,752 (11.4)	7,139	4.0 (3.7, 4.2)
Chronic liver disease (Yes)	3,701 (0.2)	172	4.6 (3.9, 5.4)
Chronic renal disease (Yes)	7,482 (0.5)	509	6.8 (6.1, 7.5)
Diabetes (Yes)	96,664 (6.2)	4,541	4.7 (4.4, 5.0)
Other pneumococcal (Yes)	4,656 (0.3)	212	4.6 (3.9, 5.2)
Smoking status			
Smoker	202,083 (12.9)	2,212	1.1 (1.0, 1.2)
Ex-smoker	269,228 (17.1)	8,026	3.0 (2.8, 3.2)
Non-smoker	871,060 (55.5)	12,240	1.4 (1.3, 1.5)
Funding eligibility			
NIP-eligible	264,338 (16.8)	20,749	7.8 (7.4, 8.3)
State-eligible	83,178 (5.3)	402	0.5 (0.4, 0.6)
PBS- eligible	377,949 (24.1)	1,971	0.5 (0.5, 0.6)
Not eligible	845,548 (53.8)	508	0.1 (0.1, 0.1)
Previous 13vPCV vaccination	1,534 (0.1)	175	11.4 (9.0, 13.9)
Practice characteristics			
State			
Australian Capital Territory	37,209 (2.4)	428	1.2 (0.8, 1.5)
New South Wales	542,318 (34.5)	9,639	1.8 (1.5, 2.0)
Northern Territory	29,334 (1.9)	395	1.3 (0.9, 1.8)
Queensland	269,881 (17.2)	3,444	1.3 (1.1, 1.5)
South Australia	41,299 (2.6)	751	1.8 (1.2, 2.4)
Tasmania	120,514 (7.7)	2,269	1.9 (1.5, 2.3)
Victoria	348,660 (22.2)	4,528	1.3 (1.1, 1.5)
Western Australia	181,798 (11.6)	2,176	1.2 (1.0, 1.4)
Rurality			
Major city	1,002,486 (63.8)	12,751	1.3 (1.2, 1.4)
Inner regional	369,870 (23.5)	7,307	2.0 (1.7, 2.2)
Outer regional	175,613 (11.2)	3,233	1.8 (1.5, 2.2)

Remote/very remote	23,044 (1.5)	339	1.5 (0.9, 2.1)
Socioeconomic status			
1 (most disadvantaged)	266,770 (17.0)	5,352	2.0 (1.6, 2.4)
2	264,166 (16.8)	4,532	1.7 (1.5, 2.0)
3	354,866 (22.6)	5,336	1.5 (1.3, 1.7)
4	284,898 (18.1)	3,187	1.1 (0.9, 1.3)
5 (most advantaged)	400,313 (25.5)	5,223	1.3 (1.2, 1.4)

Estimated using the estimated using the 'first vaccinated that year' approach
NIP: National Immunisation Program, PBS: Pharmaceutical Benefits Scheme

Supplementary Table 4: Cumulative annual crude pneumococcal vaccination (23vPPV) coverage using broader vaccination terms by patients and practices characteristics, 2018 and 2019

Characteristic	Vaccination coverage year 2018		Vaccination coverage year 2019	
	Number	% (95% CI)	Number	% (95% CI)
Total population (overall)	239,457	13.9 (12.9, 14.9)	255,800	14.4 (13.4, 15.4)
Patient characteristics				
Sex				
Female	131,246	13.3 (12.4, 14.2)	139,828	13.8 (12.8, 14.7)
Male	108,206	14.8 (13.7, 15.8)	115,967	15.3 (14.2, 16.4)
Age group (years)				
10–19	328	0.2 (0.2, 0.2)	347	0.2 (0.2, 0.2)
20–50	7,056	0.9 (0.8, 1.0)	7,247	0.9 (0.8, 1.0)
51–64	17,663	5.0 (4.7, 5.4)	18,433	5.2 (4.8, 5.5)
65+	214,410	52.1 (50.5, 53.7)	229,773	53.8 (52.2, 55.4)
Rurality				
Major city	127,896	12.1 (11.0, 13.3)	135,730	12.4 (11.2, 13.6)
Inner regional	75,031	17.5 (16.0, 19.1)	80,841	18.5 (17.0, 20.1)
Outer regional	33,724	16.1 (14.3, 17.9)	36,152	17.0 (15.2, 18.9)
Remote/very remote	2,806	9.8 (6.3, 13.3)	3,077	11.0 (7.4, 14.6)
Socioeconomic status				
1 (most disadvantaged)	53,196	16.8 (15.1, 18.5)	56,899	17.7 (16.0, 19.4)
2	51,824	16.8 (15.2, 18.4)	55,093	17.4 (15.7, 19.1)
3	49,073	13.0 (11.5, 14.5)	52,876	13.6 (12.0, 15.2)
4	35,014	10.6 (9.1, 12.0)	37,634	11.0 (9.5, 12.4)
5 (most advantaged)	50,350	12.9 (11.5, 14.4)	53,298	13.2 (11.8, 14.7)
Any relevant health condition (Yes) *	183,669	28.5 (27.3, 29.8)	192,024	29.9 (28.6, 31.2)
Any relevant health condition, excluding asthma (Yes) *	172,667	36.5 (35.1, 37.8)	179,912	38.2 (36.8, 39.6)
Cardiac disease (Yes)	76,800	51.4 (50.0, 52.8)	76,963	53.4 (52.0, 54.8)
Respiratory condition (Yes)	74,942	23.9 (22.8, 25.0)	77,616	24.8 (23.7, 26.0)
Respiratory condition, excluding asthma (Yes)	42,053	52.9 (51.5, 54.3)	42,576	55.5 (54.0, 56.9)
Neurological condition (Yes)	14,272	31.3 (30.0, 32.6)	14,583	32.5 (31.1, 33.8)
Immunocompromising condition (Yes)	96,374	36.7 (35.3, 38.1)	100,400	38.3 (36.9, 39.8)
Chronic liver disease (Yes)	1,809	34.2 (32.5, 35.9)	1,907	36.9 (35.1, 38.6)
Chronic renal disease (Yes)	10,644	62.7 (60.4, 65.0)	10,668	64.9 (62.8, 67.0)
Diabetes (Yes)	57,371	39.1 (37.4, 40.7)	59,369	40.8 (39.1, 42.5)
Other relevant health condition (Yes)	3,326	44.6 (43.0, 46.1)	3,406	46.1 (44.5, 47.7)
Smoking status				
Smoker	15,803	7.4 (6.8, 7.9)	17,481	8.1 (7.5, 8.8)
Ex-smoker	88,085	25.6 (24.4, 26.9)	92,895	27.0 (25.8, 28.3)
Non-smoker	127,441	13.5 (12.5, 14.4)	136,334	13.9 (12.9, 14.9)
Funding eligibility criteria				
NIP	218,602	47.9 (46.3, 49.5)	232,229	51.7 (50.1, 53.3)
State	2,930	3.5 (2.8, 4.1)	3,241	3.8 (3.1, 4.4)
PBS	14,458	3.8 (3.4, 4.1)	16,379	4.2 (3.8, 4.6)
Not eligible	3,467	0.4 (0.4, 0.5)	3,951	0.5 (0.4, 0.5)
Practice characteristics				
State				
Australian Capital Territory	4,911	12.9 (8.8, 17.0)	5,414	13.2 (9.2, 17.2)
New South Wales	91,525	15.4 (13.7, 17.2)	98,424	15.9 (14.0, 17.8)
Northern Territory	2,549	8.0 (6.1, 9.9)	2,672	8.5 (6.4, 10.5)
Queensland	32,138	11.3 (9.7, 12.9)	34,822	11.8 (10.1, 13.4)
South Australia	9,693	19.6 (15.2, 24.0)	10,053	20.4 (15.5, 25.2)
Tasmania	26,813	19.2 (17.3, 21.0)	28,435	19.8 (17.9, 21.8)
Victoria	51,396	13.1 (10.8, 15.4)	53,929	13.7 (11.4, 16.0)
Western Australia	20,432	10.6 (8.3, 13.0)	22,051	11.1 (8.7, 13.5)
Rurality				
Major city	128,773	12.0 (10.8, 13.2)	136,785	12.3 (11.1, 13.5)
Inner regional	75,578	17.8 (16.3, 19.4)	81,424	18.8 (17.2, 20.4)
Outer regional	32,595	16.1 (14.2, 18.1)	34,834	17.1 (15.1, 19.1)

Characteristic	Vaccination coverage year 2018		Vaccination coverage year 2019	
	Number	% (95% CI)	Number	% (95% CI)
Remote/very remote	2,511	9.8 (5.7, 14.0)	2,757	11.2 (6.9, 15.4)
Socioeconomic status				
1 (most disadvantaged)	50,350	16.4 (14.4, 18.4)	53,985	17.5 (15.3, 19.6)
2	50,672	17.0 (14.6, 19.3)	53,822	17.6 (15.2, 19.9)
3	50,851	13.3 (11.1, 15.6)	55,318	13.9 (11.4, 16.3)
4	29,087	9.7 (7.8, 11.6)	30,994	10.0 (8.1, 12.0)
5 (most advantaged)	58,497	13.4 (11.8, 15.0)	61,681	13.7 (12.1, 15.3)

NIP: National Immunisation Program, * In accordance with the Australian Immunisation Handbook [1]

Supplementary Table 5: Factors associated with cumulative pneumococcal vaccination (23vPPV) uptake using broader vaccination terms, 2019

Characteristics	Vaccination coverage in 2019		
	Crude OR (95% CI)	Adjusted OR (95% CI)*	P-value
Patient characteristics			
Sex			
Male	1.13 (1.11, 1.16)	0.96 (0.94, 0.98)	0.001
Female	1	1	
Age group (years)			<0.001
10–19	1	1	
20–50	4.90 (4.24, 5.66)	3.39 (2.93, 3.93)	
51–64	29.15 (25.16, 33.77)	12.45 (10.72, 14.46)	
65+	624.15 (533.12, 730.72)	165.43 (141.27, 193.73)	
Rurality			
Major city	1	-	-
Inner regional	1.61 (1.39, 1.86)	-	
Outer regional	1.46 (1.23, 1.72)	-	
Remote/very remote	0.88 (0.60, 1.28)	-	
Socioeconomic status			0.026
1 (most disadvantaged)	1	1	
2	0.98 (0.84, 1.13)	1.04 (0.96, 1.13)	
3	0.73 (0.62, 0.86)	0.90 (0.81, 1.01)	
4	0.57 (0.48, 0.68)	0.94 (0.84, 1.05)	
5 (most advantaged)	0.71 (0.60, 0.84)	0.99 (0.87, 1.11)	
Any relevant health condition*			
Yes	7.12 (6.84, 7.42)	1.87 (1.81, 1.92)	<0.001
No	1	1	
Smoking status			<0.001
Smoker	0.55 (0.52, 0.58)	0.80 (0.76, 0.84)	
Ex-smoker	2.29 (2.21, 2.38)	0.75 (0.72, 0.78)	
Non-smoker	1	1	
Any funding eligibility			
Eligible	79.97 (75.13, 85.12)	4.00 (3.77, 4.24)	<0.001
Not eligible	1	1	
Number of clinical encounters in the previous year			
> 4	4.48 (4.30, 4.67)	2.82 (2.72, 2.92)	<0.001
≤ 4	1	1	
Practice characteristics			
State			<0.001
New South Wales	1	1	
Australian Capital Territory	0.80 (0.55, 1.17)	0.82 (0.57, 1.18)	
Northern Territory	0.49 (0.36, 0.66)	0.55 (0.38, 0.79)	
Queensland	0.71 (0.57, 0.88)	0.72 (0.61, 0.86)	
South Australia	1.36 (0.97, 1.89)	1.12 (0.86, 1.45)	
Tasmania	1.31 (1.08, 1.58)	1.08 (0.92, 1.28)	
Victoria	0.84 (0.66, 1.07)	1.03 (0.87, 1.22)	
Western Australia	0.66 (0.50, 0.88)	0.79 (0.65, 0.95)	
Rurality			
Major city	1	1	0.207
Inner regional	1.65 (1.41, 1.92)	1.14 (0.99, 1.32)	
Outer regional	1.47 (1.23, 1.76)	1.17 (0.99, 1.39)	
Remote/very remote	0.90 (0.58, 1.39)	0.99 (0.67, 1.46)	
Socioeconomic status			0.024
1 (most disadvantaged)	1	1	
2	1.01 (0.81, 1.25)	1.19 (0.99, 1.44)	
3	0.76 (0.59, 0.98)	1.15 (0.94, 1.42)	
4	0.53 (0.41, 0.69)	1.04 (0.84, 1.29)	
5 (most advantaged)	0.75 (0.62, 0.92)	1.32 (1.06, 1.63)	

NIP: National Immunisation Program, * Estimated using logistic regression models and using the 'ever vaccinated' approach ** In accordance with the Australian Immunisation Handbook [1]

Meningococcal disease

Supplementary Table 6: Annual crude meningococcal vaccination coverage by patients and practices characteristics, 2019 (first vaccinated)

Characteristics	Sample characteristics 2019	Vaccination coverage year 2019	
	Number (%)	Number	% (95% CI)
Total population (overall)	1,733,369 (100)	7,525	0.4 (0.4, 0.5)
Patient characteristics			
Sex			
Female	992,269 (57.3)	4,274	0.4 (0.4, 0.5)
Male	740,938 (42.8)	3,247	0.4 (0.4, 0.5)
Age group (years)			
10–13	68,338 (3.9)	1,237	1.8 (1.6, 2.1)
14–19	101,831 (5.9)	3,427	3.4 (3.1, 3.6)
20–25	132,075 (7.6)	759	0.6 (0.5, 0.7)
26–50	653,832 (37.7)	1,115	0.2 (0.1, 0.2)
51–64	354,013 (20.4)	563	0.2 (0.1, 0.2)
65+	423,280 (24.4)	424	0.1 (0.1, 0.1)
Rurality			
Major city	1,076,228 (62.1)	4,650	0.4 (0.4, 0.5)
Inner regional	424,652 (24.5)	1,759	0.4 (0.4, 0.5)
Outer regional	205,059 (11.8)	1,038	0.5 (0.4, 0.6)
Remote/very remote	27,430 (1.6)	78	0.3 (0.2, 0.4)
Socioeconomic status			
1 (most disadvantaged)	312,474 (18.0)	1,117	0.4 (0.3, 0.4)
2	308,012 (17.8)	1,297	0.4 (0.4, 0.5)
3	382,877 (22.1)	1,493	0.4 (0.3, 0.4)
4	337,191 (19.5)	1,417	0.4 (0.4, 0.5)
5 (most advantaged)	392,815 (22.7)	2,201	0.6 (0.5, 0.6)
Any relevant health condition (Yes) *	14 (0.0)	0	0
Smoking status			
Smoker	212,861 (12.3)	295	0.1 (0.1, 0.2)
Ex-smoker	339,774 (19.6)	436	0.1 (0.1, 0.1)
Non-smoker	952,869 (55.0)	4,872	0.5 (0.5, 0.6)
Funding eligibility			
NIP-eligible	101,831 (5.9)	3,427	3.4 (3.1, 3.6)
State-eligible	1,125 (0.1)	121	10.8 (5.2, 16.3)
Not eligible	1,630,413 (94.1)	3,977	0.2 (0.2, 0.3)
Practice characteristics			
State			
Australian Capital Territory	40,414 (2.3)	170	0.4 (0.4, 0.5)
New South Wales	611,227 (35.3)	2,025	0.3 (0.3, 0.4)
Northern Territory	31,207 (1.8)	364	1.2 (0.8, 1.6)
Queensland	291,375 (16.8)	1,534	0.5 (0.4, 0.6)
South Australia	48,633 (2.8)	502	1.0 (0.7, 1.4)
Tasmania	131,222 (7.6)	889	0.7 (0.6, 0.8)
Victoria	384,138 (22.2)	1,310	0.3 (0.3, 0.4)
Western Australia	195,153 (11.3)	731	0.4 (0.3, 0.4)
Rurality			
Major city	1,090,666 (62.9)	4,669	0.4 (0.4, 0.5)
Inner regional	421,529 (24.3)	1,800	0.4 (0.4, 0.5)
Outer regional	196,958 (11.4)	991	0.5 (0.4, 0.6)
Remote/very remote	24,216 (1.4)	65	0.3 (0.1, 0.4)
Socioeconomic status			
1 (most disadvantaged)	300,627 (17.3)	979	0.3 (0.3, 0.4)
2	297,632 (17.2)	1,334	0.4 (0.4, 0.5)
3	393,003 (22.7)	1,659	0.4 (0.3, 0.5)
4	304,081 (17.5)	1,212	0.4 (0.3, 0.5)
5 (most advantaged)	438,026 (25.3)	2,341	0.5 (0.5, 0.6)

Pertussis

Supplementary Table 7: Annual crude pertussis vaccination coverage by patients and practices characteristics, 2019 (first vaccinated)

Characteristics	Sample characteristics 2019	Vaccination coverage year 2019	
	Number (%)	Number	% (95% CI)
Total population (overall)	1,446,961 (100)	56,508	3.9 (3.8, 4.1)
Patient characteristics			
Sex			
Female	810,545 (56.0)	35,622	4.4 (4.2, 4.6)
Male	636,259 (44.0)	20,882	3.3 (3.2, 3.4)
Age group (years)			
10–13	71,230 (4.9)	2,642	3.7 (3.5, 4.0)
14–17	63,733 (4.4)	1,309	2.1 (1.9, 2.2)
18–39	454,950 (31.4)	24,263	5.3 (5.1, 5.6)
40–64	527,412 (36.5)	17,828	3.4 (3.2, 3.5)
65+	329,636 (22.8)	10,466	3.2 (3.0, 3.4)
Rurality			
Major city	902,899 (62.4)	35,234	3.9 (3.7, 4.1)
Inner regional	346,936 (24.0)	14,094	4.1 (3.8, 4.3)
Outer regional	172,738 (11.9)	6,366	3.7 (3.2, 4.1)
Remote/very remote	24,388 (1.7)	814	3.3 (2.7, 3.9)
Socioeconomic status			
1 (most disadvantaged)	260,649 (18.0)	9,815	3.8 (3.5, 4.1)
2	253,467 (17.5)	10,469	4.1 (3.8, 4.4)
3	319,950 (22.1)	12,279	3.8 (3.6, 4.1)
4	287,387 (19.9)	11,359	4.0 (3.7, 4.2)
5 (most advantaged)	325,508 (22.5)	12,586	3.9 (3.6, 4.1)
Smoking status			
Smoker	187,825 (13.0)	5,365	2.9 (2.7, 3.0)
Ex-smoker	267,445 (18.5)	10,648	4.0 (3.8, 4.2)
Non-smoker	778,630 (53.8)	34,364	4.4 (4.2, 4.6)
Funding eligibility			
NIP-eligible	71,230 (4.9)	2,642	3.7 (3.5, 4.0)
State-eligible	36,074 (2.5)	1,084	3.0 (2.7, 3.3)
Not eligible	1,339,657 (92.6)	52,782	3.9 (3.8, 4.1)
Practice characteristics			
State			
Australian Capital Territory	33,523 (2.3)	1,292	3.9 (3.3, 4.4)
New South Wales	488,569 (33.8)	20,040	4.1 (3.9, 4.3)
Northern Territory	28,813 (2.0)	697	2.4 (2.1, 2.8)
Queensland	246,691 (17.1)	10,172	4.1 (3.8, 4.5)
South Australia	41,309 (2.9)	1,252	3.0 (2.6, 3.5)
Tasmania	113,005 (7.8)	5,413	4.8 (4.3, 5.3)
Victoria	323,483 (22.4)	11,426	3.5 (3.2, 3.9)
Western Australia	171,568 (11.9)	6,216	3.6 (3.3, 4.0)
Rurality			
Major city	915,580 (63.3)	35,592	3.9 (3.7, 4.1)
Inner regional	343,833 (23.8)	14,177	4.1 (3.8, 4.4)
Outer regional	165,980 (11.5)	5,998	3.6 (3.1, 4.1)
Remote/very remote	21,568 (1.5)	741	3.4 (2.7, 4.1)
Socioeconomic status			
1 (most disadvantaged)	249,606 (17.3)	9,417	3.8 (3.4, 4.1)
2	245,307 (17.0)	10,213	4.2 (3.7, 4.6)
3	330,101 (22.8)	12,455	3.8 (3.5, 4.1)
4	259,738 (18.0)	10,553	4.1 (3.7, 4.4)
5 (most advantaged)	362,209 (25.0)	13,870	3.8 (3.6, 4.1)

Herpes zoster

Supplementary Table 8: Annual crude herpes zoster vaccination coverage by patients and practices characteristics, 2019 (first vaccinated)

Characteristic	Sample characteristics 2019	Vaccination coverage year 2019	
	Number (%)	Number	% (95% CI)
Total population (overall)	706,787 (100)	17,557	2.5 (2.4, 2.6)
Patient characteristics			
Sex			
Female	386,352 (54.7)	9386	2.4 (2.3, 2.6)
Male	320,413 (45.3)	8,171	2.6 (2.4, 2.7)
Indeterminate	22 (0)	0	-
Age group (years)			
50-59	257,907 (36.5)	248	0.1 (0.1, 0.1)
60-69	240,305 (34.0)	983	0.4 (0.4, 0.5)
70	22,412 (3.2)	4,192	18.7 (17.6, 19.8)
71-79	90,538 (12.8)	11,222	12.4 (11.7, 13.1)
80+	95,625 (13.5)	912	1.0 (0.9, 1.1)
Rurality			
Major city	400,050 (56.6)	8,978	2.2 (2.1, 2.4)
Inner regional	196,351 (27. 8)	5,963	3.0 (2.7, 3.3)
Outer regional	98,586 (14.0)	2,391	2.4 (2.1, 2.8)
Remote/very remote	11,800 (1.7)	225	1.9 (1.4, 2.5)
Socioeconomic status			
1 (most disadvantaged)	145,268 (20.6)	3,767	2.6 (2.3, 2.9)
2	135,538 (19.2)	3,741	2.7 (2.5, 3.0)
3	153,845 (21.8)	3,889	2.5 (2.3, 2.8)
4	119,716 (16.9)	2,581	2.2 (2.0, 2.3)
5 (most advantaged)	152,420 (21.6)	3,579	2.4 (2.2, 2.6)
Smoking status			
Smoker	81,392 (11.5)	1,003	1.2 (1.1, 1.4)
Ex-smoker	200,829 (28.4)	6,158	3.1 (2.9, 3.2)
Non-smoker	355,022 (50.2)	9,599	2.7 (2.6, 2.9)
Not recorded	69,544 (9.8)	-	-
Funding eligibility			
NIP-eligible	112,950 (16.0)	15,414	13.6 (12.9, 14.4)
Not eligible	593,837 (84.0)	2,143	0.4 (0.3, 0.4)
Practice characteristics			
State			
Australian Capital Territory	15,911 (2.3)	366	2.3 (1.6, 3.1)
New South Wales	256,089 (36.2)	6,720	2.6 (2.4, 2.9)
Northern Territory	12,935 (1.8)	226	1.8 (1.2, 2.3)
Queensland	115,662 (16.4)	3,091	2.7 (2.4, 3.0)
South Australia	22,076 (3.1)	580	2.6 (1.9, 3.4)
Tasmania	65,382 (9.3)	1,902	2.9 (2.5, 3.4)
Victoria	145,175 (20.5)	3,072	2.1 (1.9, 2.4)
Western Australia	73,557 (10.4)	1,600	2.2 (1.9, 2.5)
Rurality			
Major city	406,815 (57.6)	9,094	2.2 (2.09, 2.4)
Inner regional	195,265 (27.6)	5,961	3.1 (2.78, 3.3)
Outer regional	94,336 (13.4)	2,319	2.5 (2.09, 2.8)
Remote/very remote	10,371 (1.5)	183	1.8 (1.16, 2.4)
Socioeconomic status			
1 (most disadvantaged)	140,068 (19.8)	3,465	2.5 (2.12, 2.8)
2	130,958 (18.5)	3,735	2.9 (2.55, 3.2)
3	157,606 (22.3)	4,029	2.6 (2.23, 2.9)
4	105,371 (14.9)	2,310	2.2 (1.95, 2.4)
5 (most advantaged)	172,784 (24.5)	4,018	2.3 (2.12, 2.5)