Optimising adolescent and adult coverage rate methodologies

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Review of vaccination coverage analysis and reporting methodologies globally

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Key stakeholder interviews

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Comparison of current coverage calculation methodologies routinely used in Australia

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Executive summary

Background

The whole-of-life Australian Immunisation Register (AIR) was established in 2016, expanded from the Australian Childhood Immunisation Register, which only collected data for children aged <7 years. Analysis and reporting of vaccination coverage in adolescents and adults have been more limited than that in children. Under funding agreements with the Australian Government Department of Health and Aged Care (the Department), the National Centre for Immunisation Research and Surveillance (NCIRS) has expanded analysis in recent years in its annual immunisation coverage reports to include adolescent and adult data. However, such analysis has several challenges including less well-established methodological approaches, lack of retrospective data on vaccinations given to adults and older children pre-2016, as well as past and ongoing underreporting to the AIR. Although some vaccines are funded on the National Immunisation Program (NIP) for individuals with specified medical conditions, coverage in these risk groups is not routinely reported due to lack of data on these conditions in the AIR. We aimed to review methodologies currently used in Australia and overseas to assess adolescent and adult vaccination coverage (excluding COVID-19) and recommend evidence-based approaches to optimise coverage assessment and reporting from a clinical, immunisation program and public health perspective.

Methods

We reviewed published and grey literature on adolescent and adult vaccination coverage analysis and reporting methodologies in Australia and overseas, particularly in comparable countries with similar immunisation information systems and schedules; conducted semi-structured interviews with key stakeholders and experts; compared assessment methodologies used in Australia; and analysed relevant AIR data. We also assessed feasibility of using linked data resources for regular reporting of coverage of vaccines specific to medically at-risk adolescents and adults.

Results/Discussion

Literature review

We found limited evidence on assessment and reporting of adolescent and adult vaccination coverage overseas, with most reporting related to human papillomavirus (HPV) vaccination coverage in adolescents and influenza vaccination coverage in adults. Based on our findings, Australia has some of the most comprehensive public reporting on adult/adolescent vaccines globally, predominantly via the NCIRS annual coverage reports, although this reporting is much

less extensive than for children and has been in place for a much shorter time. Of particular note, in the United States, composite measures are used to assess coverage for vaccinations recommended in adolescents and adults, an approach not used in public reporting to date in Australia, although 'fully vaccinated' coverage has been reported in children for decades. Focusing composite measures on vaccinations recommended in the relevant age group would be more straightforward than attempting to include all vaccinations that should have been received at earlier ages, from both a programmatic monitoring perspective (e.g. can focus on adolescent uptake, primarily delivered through jurisdictional school-based programs, rather than catch-up of childhood vaccinations) and a data quality/logistic perspective (the cohort born in 2009 is the first where all-age vaccination could be contemporaneously captured, without interruption, following expansion of the register in 2016, which creates challenges for accurately estimating coverage in older adolescents and adults).

Key stakeholder interviews

Stakeholders perceived the whole-of-life AIR to be a key asset allowing comparison of coverage data across Australian jurisdictions and internationally. They considered current reporting of adolescent and adult vaccination coverage in Australia to be useful, particularly the comprehensive reporting of adolescent HPV vaccination coverage. However, more regular and timely reporting of coverage (particularly in adolescents), and with more geographical granularity, was recommended. Stakeholders strongly supported regular assessment and reporting of coverage both in Aboriginal and Torres Strait Islander adolescents and adults and in those medically at-risk, for whom additional vaccinations are funded under the NIP, and considered that it would be useful to assess and report coverage in other key groups, such as aged/disability care residents and culturally and linguistically diverse (CALD) populations. While coverage in Aboriginal and Torres Strait Islander adolescents and adults is already reported to some extent using the AIR, stakeholders observed that coverage in the medically at-risk and other key population groups cannot be assessed using the AIR alone, with AIR data linked to other datasets the most obvious route.

Feasibility of using linked data for reporting of vaccination coverage in medically at-risk groups

There are some medical conditions that could be ascertained through proxy measures (such as Pharmaceutical Benefit Scheme and Medicare Benefits Schedule codes) using currently available linked data in the Multi-Agency Data Integration Project (MADIP), and used for reporting of vaccination coverage. However, linkage to hospitalisation (ICD-coded discharge data) and

perinatal data collections would provide substantially more comprehensive and reliable information on which to base assessment of coverage.

Optimal ages for assessment and reporting of coverage

Adolescent – individual vaccines

Our analysis of AIR data found substantial variation in age of vaccination by jurisdiction for all individual vaccines, though much of this was due to jurisdictions having offered HPV and adolescent diphtheria-tetanus-pertussis (dTpa) vaccination in different school years and meningococcal ACWY more broadly in response to previous outbreaks. With all jurisdictions offering HPV and dTpa vaccination in Year 7 from 2023, this should be less of an issue, so more regular and timely assessment and reporting of coverage could be undertaken at both jurisdictional and national levels – for example, annually for HPV and dTpa in cohorts turning 13–19 years in the year of interest, and for meningococcal ACWY in cohorts turning 15–19 years. Calculations of dTpa coverage should include doses of paediatric diphtheria-tetanus-pertussis (DTPa) vaccines recorded as given at ≥10 years of age, due to data entry/transfer issues in the earlier years of the expanded register, particularly relevant to older cohorts. While we found that vaccination coverage did not change much overall in older cohorts, it did increase in Aboriginal and Torres Strait Islander adolescents, highlighting the importance of monitoring (and promoting) catch-up in older cohorts particularly in disadvantaged populations.

Adolescent – potential composite measures

A composite measure comprising receipt of both the now recommended single HPV vaccine dose and an adolescent dose of dTpa vaccine could be assessed and reported at both jurisdictional and national levels, annually for each 1-year wide age cohort turning 13 through to 19 years in the year of interest (and quarterly using rolling annualised methodology). If a single assessment age milestone needs to be prioritised – for example, for performance monitoring purposes – coverage in adolescents turning 15 years of age may be most appropriate, given the small changes in coverage after this age and that 15 years is the World Health Organization (WHO)-recommended standard age for HPV vaccination coverage assessment, including under cervical cancer elimination planning. Coverage for adolescents turning 15 years in 2022 using this HPV-dTpa composite measure (with doses of DTPa given at ≥10 years included) was 83.7% overall and 80.0% for Aboriginal and Torres Strait Islander adolescents.

A second composite measure comprising receipt of one dose of HPV vaccine, and adolescent doses of dTpa vaccine and meningococcal ACWY vaccine, could be assessed and reported at both jurisdictional and national levels, annually or quarterly (using rolling annualised methodology)

for each 1-year wide age cohort turning 16–19 years in the year of interest. If a single assessment age milestone needs to be prioritised, coverage in adolescents turning 18 years of age could be most appropriate, as it would capture most vaccinations given to adolescents before leaving school. Coverage for adolescents turning 18 years in 2022 using this 3 vaccine-based composite measure (with doses of DTPa given at ≥10 years included) was 73.5% overall and 65.6% for Aboriginal and Torres Strait Islander adolescents.

Adult – individual vaccines

The majority of zoster-vaccinated adults turning 70–75 years of age in 2022 (and hence eligible for vaccination with the live attenuated herpes zoster vaccine at 70 years under the NIP, following introduction of the program in late 2016) were vaccinated at age 70. However, a substantial proportion were vaccinated through the catch-up program, with coverage highest (54.5%) by annual aged-based cohort in those turning 75 years in 2022. It will be important to monitor coverage by 1-year age cohorts, particularly given the live attenuated zoster vaccination catch-up program finishes in late 2023. In contrast, the highest coverage of 13-valent pneumococcal conjugate vaccine (13vPCV), funded as a single dose for all adults aged ≥70 years, was in adults turning 71 years of age, at 33.8% (as compared with 22.1% for those turning 70 years). In contrast, annual seasonal influenza vaccination coverage in 2022 was greater with each year of age from 70 to 79 years.

Adult – potential composite measures

Composite measures comprising any combination of the three NIP-funded vaccines could be assessed and reported at both jurisdictional and national levels annually for 1-year-wide age cohorts turning 70–79 years in the year of interest (and quarterly using rolling annualised methodology if indicated). Two vaccines, 13vPCV + influenza, may be the most appropriate measure for initial use, pending resolution of the uncertainty around future zoster vaccination scheduling (a decision on potential for NIP-funding of the two-dose recombinant zoster vaccine, Shingrix, is awaited). If a single assessment age milestone needs to be prioritised, coverage in adults turning 71 years of age could be most appropriate on a timeliness basis, given that 13vPCV is funded from 70 years. Coverage for adults turning 71 years of age in 2022 using this two-vaccine composite measure was 29.7% overall and 30.6% for Aboriginal and Torres Strait Islander adults.

Other methodological considerations

Consistency of coverage assessment and reporting in Australia

AIR data on adolescent and adult vaccination coverage in Australia are primarily analysed and reported by Services Australia, the Department and NCIRS. We identified several differences in the methodologies used by these organisations, which could contribute to small differences in reported coverage estimates. Ongoing discussions between the three organisations are recommended to ensure consistent methods are used where possible, and to facilitate transparency and clarity around any differences and their impact on reported coverage. The agencies should also consider strategies, such as the use of standardised protocols/templates, to promote consistency of analytic methods among other organisations which analyse and report coverage data (e.g. state/territory health departments) and researchers.

Geographical granularity of reporting

Given the expressed need of stakeholders for greater geographical granularity of reporting, further consultation to delineate appropriate and feasible levels of sub-jurisdictional reporting, aligned to specific local needs and the capacity of relevant analytic/reporting organisations to generate this, are recommended. A publicly accessible data visualisation interface could also be considered to allow more interactive and timely data at appropriate geographical levels.

Lag periods

We found minimal differences in vaccination coverage at adolescent and adult milestones using a 1-month lag period (between the end of the relevant assessment period and the date of AIR data used), compared to the current standard 3-month lag period. This likely reflects improved timeliness of reporting to the AIR, due to increased electronic reporting and the introduction of mandatory reporting. Using a 1-month data extraction lag would improve timeliness of reporting of coverage data without loss of accuracy, and is recommended.

Conclusions

Australia's assessment and reporting of adolescent and adult vaccination coverage are some of the most comprehensive measures undertaken globally, although there is scope for expansion and refinement, requiring relatively modest additional work. Such expansion should support efforts to improve efficiency and effectiveness of programs, and in turn, disease prevention, and should include assessment in groups with risk factors, who are targeted under the NIP. Composite measures should be considered to monitor overall NIP performance across the lifespan, similar to the longstanding use of 'fully vaccinated' coverage measures in young children. The increasing

use of new vaccines in adults, including COVID-19 (which may also warrant inclusion in composite coverage measures as vaccination recommendations become more stable), underpins the need to also evaluate and improve reporting of vaccines to the AIR in this age group, noting new mandatory reporting requirements.

Recommendations

Adolescent coverage

1. Organisations involved in vaccination coverage analysis should consider regular (e.g. annual/quarterly) and timely assessment and reporting of coverage, by Aboriginal and Torres Strait Islander status (and gender where indicated) at relevant (national, jurisdictional, subjurisdictional) levels for:
    a. HPV and dTpa vaccine coverage in 1-year wide age cohorts turning 13–19 years in the year of interest and for meningococcal ACWY in cohorts turning 15–19 years
    b. composite measures comprising receipt of:
        i. an HPV vaccine dose + adolescent dTpa booster vaccine dose, assessed for 1-year-wide age cohorts turning 13–19 years in the year of interest (or at 15 years if a single age milestone needs to be prioritised)
        ii. an HPV vaccine dose + adolescent dTpa booster vaccine dose + dose of meningococcal ACWY vaccine, assessed for 1-year-wide age cohorts turning 15–19 years in the year of interest (or at 18 years if a single age milestone needs to be prioritised).
2. Adolescent coverage estimates of dTpa vaccination should be calculated with inclusion of any doses of DTPa (paediatric formulation) recorded as given at ≥10 years of age, to account for data entry/transfer errors.

Adult coverage

3. Organisations involved in vaccination coverage analysis should consider regular reporting (annual), by Aboriginal and Torres Strait Islander status (and gender where indicated) at relevant (national, jurisdictional, subjurisdictional) levels, for:
    a. 13vPCV and zoster vaccination coverage assessed for 1-year-wide age cohorts turning 70–79 years in the year of interest
    b. a composite measure comprising receipt of a dose of 13vPCV + a dose of influenza vaccine given in the relevant calendar year, assessed for 1-year-wide age cohorts turning 70+ years in the year of interest (or at 71 years if a single age milestone needs to be prioritised).
4. Composite measures including zoster vaccine should be assessed for potential use once uncertainties around zoster vaccination scheduling on the NIP are resolved.
5. Evaluation of the impact of mandatory reporting to the AIR (introduced in 2021) on completeness of AIR data, and levels of any ongoing underreporting, should be undertaken to inform interpretation of adult coverage data.

Use of linked data to report vaccination coverage in medically at-risk and other key population groups

6. Organisations involved in vaccination coverage analysis should consider use of relevant data fields in currently available linked datasets (i.e. MADIP) to report vaccination coverage in relevant adolescent and adult medically at-risk groups, and other key groups such as aged/disability care residents and CALD populations.
7. Organisations involved in vaccination coverage analysis should collaborate to further progress linkage of MADIP and/or the AIR to hospitalisation, perinatal data collections or other relevant disease registers in order to facilitate regular reporting of comprehensive and reliable vaccination coverage data in medically at-risk and other key population groups.

Consistency and utility of analysis and reporting of coverage data

8. The Department, Services Australia and NCIRS should meet regularly to facilitate consistent analysis and reporting methods where possible, and timeliness, transparency and clarity in reporting, including on the impact of any methodological differences.
9. The Department, Services Australia and NCIRS should engage with other organisations which analyse and report coverage data (e.g. state/territory health departments) and researchers, to promote consistency of analysis and reporting.
10. The Department should consider establishment of an advisory group or oversight committee to enhance strategic approaches to coverage assessment using AIR or AIR-linked data assets.
11. Organisations/individuals involved in vaccination coverage analysis should use a 1-month lag period (between end of relevant assessment period and date of AIR data extraction) for all analyses (rather than the current standard 3-month lag period).
12. Following implementation of any new coverage assessment/reporting methodologies (e.g. use of composite measures), these should be monitored and evaluated to inform any future changes required – for example, inclusion of new vaccines such as COVID-19 or respiratory syncytial virus (RSV) in the measures.

Background

The Australian Immunisation Register (AIR) was established on 1 October 2016, incorporating demographic data from Medicare on people of all ages in Australia. The AIR was expanded from the Australian Childhood Immunisation Register (ACIR), which was created in 1996 and collected data only for children aged <7 years. Participation in the AIR is 'opt out', with the result that the AIR constitutes a nearly complete population register for Australian residents. Vaccinations given to both Medicare and non-Medicare holders can be reported to the AIR. Data are transferred to the AIR when a recognised immunisation provider supplies details of an eligible vaccination. All people registered with Medicare are automatically added to the AIR and assigned a Personal Identification Number (PIN) that then travels with that person for life, across all relevant Medicare card numbers (e.g. where multiple due to family circumstances or maturity). Individuals who are not Medicare-registered, but for whom a vaccination encounter is reported to the AIR, are assigned a Supplementary Identification Number (SIN),[1] with subsequent assignment of a PIN where the individual is identified to be Medicare-registered. The AIR contains limited information for each individual (PIN/SIN, date of birth, gender, Aboriginal and Torres Strait Islander status and postcode) and vaccinations received (brand/type, dose number, date, immunisation provider).

The 'whole-of-life' AIR has created potential for comprehensive analysis and reporting on vaccination coverage in adolescents and adults, along the lines of the reporting long undertaken in children.[2] However, apart from detailed coronavirus 2019 (COVID-19) vaccination coverage data (all ages)[3] and historical human papillomavirus (HPV) vaccination coverage data[4] (adolescents and young adults) from the now discontinued National HPV Vaccination Program Register (NHPVPR), the Australian Government Department of Health and Aged Care (the Department) does not currently publish any other adolescent or adult coverage data, though it does publish weekly dose counts of influenza vaccinations with limited age breakdown (<5, 5–64 and ≥65 years) during the influenza season.[5,6] Services Australia also provides quarterly adolescent coverage reports to Jurisdictional Immunisation Coordinators (JICs). Under funding agreements with the Department, the National Centre for Immunisation Research and Surveillance (NCIRS) has undertaken regular analysis and reporting of vaccination coverage data since the late 1990s from the ACIR and then the AIR, and published 14 national annual immunisation coverage reports.[7,8] These have predominantly focused on coverage in young children. However, the 2010–2017 reports[8] included HPV vaccination coverage data in adolescents, derived from the National HPV Vaccination Program Register.[8] In the 2020 report,[9] limited adolescent (HPV, diphtheria-tetanus-pertussis [dTpa], meningococcal ACWY) and adult (zoster) vaccination coverage data from the AIR were included for the first time, along with influenza vaccination coverage data

across all ages,[9] and in the 2021 report coverage of 13-valent pneumococcal conjugate vaccine (13vPCV) in adults was also included.[10,11]

Analysis of adolescent and adult coverage data has several challenges including limited well-established methods, lack of retrospective data on adult vaccinations given prior to the Register's expansion, and previously documented underreporting of adult vaccinations.[10] While mandatory reporting of all COVID-19, influenza and National Immunisation Program (NIP) vaccinations to the AIR was implemented in 2021, the impact of this on completeness of reporting has not been formally evaluated. Despite several vaccines included on the NIP being targeted to individuals with specified medical conditions, including pregnant women, coverage in these risk groups is not routinely reported due to the limited data fields in the AIR, in particular the lack of data on comorbidities and pregnancy. Similarly, despite some evidence of lower vaccination uptake in some culturally and linguistically diverse (CALD) groups, ethnicity and country of birth are not available in the AIR. Linkage of AIR to other datasets – for example, via the Multi-Agency Data Integration Project (MADIP)[12] – has the potential to facilitate more granular analyses and reporting of vaccination uptake in medically at-risk and other key population groups, in order to monitor vaccination program impact and inform targeted interventions to increase uptake and optimise program impact and equity.

Evaluation of optimal coverage assessment and reporting methodologies should also take into consideration recent and anticipated changes in the adolescent and adult vaccination schedules. Issues of particular relevance in the current Australian context include the change to a single dose HPV vaccination schedule from February 2023,[13] and the uncertainty around zoster vaccination scheduling given discontinuation of Zostavax sale and use in the United States in 2020[14] and planned discontinuation in Australia by October 2023, as well as outcomes awaited from a recent resubmission to the Pharmaceutical Benefits Advisory Committee seeking NIP inclusion of the currently recommended[15] but unfunded recombinant inactivated zoster vaccine Shingrix in older adults.[16]

Aims

With respect to AIR coverage data for adolescents and adults (excluding COVID-19), we aimed to:

- assess appropriateness and consistency of current coverage assessment methodologies
- explore alternative coverage assessment methodologies, including consideration of potential for assessment of 'fully vaccinated' coverage
- recommend evidence-based approaches to optimise coverage assessment and reporting from a clinical, immunisation program and public health perspective.

Methods

Literature review

Bibliographic searches were undertaken by an experienced information specialist to locate published literature on adult or adolescent immunisation coverage methodologies. Databases searched included Ovid Medline ALL including Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Daily and Versions (1946-27 October 2022) and Ovid Embase (1974-26 October 2022). Controlled vocabulary terms used included 'Immunization', 'Immunization Programs', 'Vaccines', 'Vaccination Coverage', 'Registries', 'Information Systems', 'Methods', 'Algorithms', 'Adolescent', 'Young Adult', 'Adult', 'Middle Aged' and 'Aged'. Equivalent textword/keyword terms were utilised where appropriate. Searches were limited to items in English and with a publication date of 2007 onwards. Additional papers were identified through searches of reference lists of papers found through the formal bibliographic searches, as well as through independent content experts.

Grey literature searches were also undertaken in key websites, including searching country level department of health websites and immunisation registry websites either at a country/national level or a state/jurisdictional/province level, where immunisation systems and/or schedules were similar to Australia. Grey literature searches were also undertaken in key international health body websites such as the World Health Organization (WHO) and UNICEF.

Key stakeholder interviews

Semi-structured interviews were held with key stakeholders including senior NCIRS staff, relevant Department staff, JIC/Australian Technical Advisory Group on Immunisation (ATAGI) members, and other identified individuals with experience/expertise in coverage assessment, to identify and delineate information needs, and what the objectives and optimal analyses should be for reporting adolescent and adult coverage, from a clinical and public health perspective. Implied and/or verbal consent was obtained from all participants for interviews, and verbal consent for recording of interviews. Virtual interviews were conducted via videoconferencing platforms (e.g. Teams and Webex), professionally transcribed and thematically analysed, with all information included in this report deidentified.

Comparison of coverage calculation methodologies used in Australia

We obtained a copy of the general coverage information and AIR rules used by Services Australia to calculate adolescent and adult immunisation coverage and compared with methodologies used

by NCIRS. We also obtained information from the Department regarding the methodologies used for calculating influenza vaccination coverage.

Burden of disease assessment

The burden of each of the diseases covered by vaccines in the adolescent and adult immunisation schedules was assessed, based on expert opinion informed by review of the Australian Institute of Health and Welfare's *The Burden of Vaccine Preventable Diseases in Australia* report.[17]

Analysis of AIR data

We analysed AIR data to assess utility and impact of potential new or modified immunisation coverage assessment methodologies, and impact on calculated coverage where methodologies of Services Australia/the Department and NCIRS differ. Methods are described briefly as required in relevant sections of the results below, with some additional detail provided in Appendix 1.

Analysis of AIR-MADIP linked data

We worked with the Health Economics and Research Division (HERD) of the Department to advise on exploratory analyses of linked AIR-MADIP data to assess the feasibility of using this resource for regular reporting of coverage of NIP vaccines specifically recommended for adolescents and adults with certain medical conditions or during pregnancy. For pregnancy, this included identifying potential Medicare Benefits Schedule (MBS) items numbers for pregnancy-related ultrasound, comparing estimates of the number of pregnant women from this proxy methodology to reported data on estimated births from birth registrations and advising on methods to estimate timing of vaccination in relation to gestational age. For medical conditions this included reviewing estimates of the prevalence of some medical conditions generated using different analytical methods proposed by HERD and validation studies.

Ethical considerations

Ethical approval for this study was sought and granted by the Sydney Children's Hospitals Network Human Research Ethics Committee, protocol 2022/ETH02177.

Results

Review of immunisation coverage analysis and reporting methodologies globally

From the bibliographic searches, there were 471 search results across both databases. Titles and abstracts of all results were screened and assessed for relevance by two independent content experts. To be included, items needed to discuss any of the following:

- immunisation/vaccination registries/registers
- immunisation information systems
- adolescent vaccination coverage/uptake
- adult vaccination coverage/uptake
- immunisation/vaccination coverage methodology.

There were 38 results across both databases meeting the inclusion criteria. These 38 research papers were then reviewed by the two independent content experts to assess their relevance to adolescent/adult vaccination coverage methodologies. Another 11 papers were identified via reference lists of papers and content experts. From the 49 research papers reviewed, information from 17 papers was considered relevant.[18–34] One paper of particular interest evaluated coverage in adolescents aged 17 years in the United States, using a composite measure that included all recommended adolescent doses of HPV, meningococcal ACWY and diphtheria-tetanus-pertussis vaccines.[33] Another paper of particular interest from the United States outlined the comprehensive pathway taken by a coalition of federal government and other partners to develop and test a composite measure (tetanus toxoid-containing, pneumococcal, herpes zoster and influenza vaccines) to assess vaccination coverage in adults aged ≥19 years (vaccines with narrower age indication were excluded from the measure for ineligible age groups) for quality performance monitoring purposes.[24] This composite measure was then utilised in a surveillance summary of vaccination coverage in adults in 2018, published by the United States Centers for Disease Control and Prevention.[26] Influenza vaccination was measured as receipt during the preceding 12 months, diphtheria-tetanus-pertussis vaccination as receipt during the preceding 10 years and pneumococcal and herpes zoster vaccination as previous receipt of at least one dose of the relevant vaccine.[26] Grey literature searches identified 14 relevant websites, from national to international health body level.[35–51] Adolescent and adult immunisation coverage analysis and reporting methodologies, with particular focus on Australia and comparable countries with similar immunisation systems and/or schedules, are summarised below, with further detail provided in Appendices 2 and 3.

Adolescents

Of the 13 countries for which websites and relevant research papers were reviewed, Australia[11] and five other countries (New Zealand,[37,38,41] Norway,[18] Denmark,[25,52] Germany[34,51] and Finland[22,25]) have a centralised electronic registry for recording adolescent vaccinations. Four countries have electronic immunisation records but no centralised registry (the Netherlands,[22,53] Italy,[22,25] Ireland,[25,42] and France[20]) and three countries have no national electronic immunisation adolescent records and no centralised registry (United Kingdom,[22,25] United States,[49,54] and Canada[21]). All these countries assess coverage for HPV vaccine. The scheduled age for administration of HPV vaccine ranges from 9 to 15 years of age, with assessment age predominantly being 15 years of age, as recommended by the WHO for the purpose of comparison internationally and over time.[55] Other adolescent vaccines commonly assessed include the booster dose of diphtheria-tetanus-pertussis, meningococcal C/meningococcal ACWY, influenza and measles-mumps-rubella. Ten of the 13 countries report coverage for adolescent vaccines on an annual basis.

Adults

Of the 13 countries for which websites and relevant research papers were reviewed, six have a centralised electronic registry for recording adult vaccinations – Australia,[11] New Zealand (selected vaccines given in general practice and pharmacies),[38,39] Norway,[34] Denmark,[34] Germany[34] and Finland.[22] Two countries have electronic immunisation records but no centralised registry (the Netherlands[22] and Italy[22]) and two countries have no national electronic immunisation adult records and no centralised registry (United Kingdom,[22,56] and the United States,[24,26]). Of the remaining three countries (France, Canada and Ireland), none had a centralised electronic registry for adults and there was not enough information available to determine if they had national electronic immunisation records for adults. Almost all countries assess adult vaccination coverage for influenza vaccine. Other adult vaccines commonly assessed include zoster, pneumococcal and booster dose/s of diphtheria-tetanus-pertussis vaccines. Six of the 13 countries report coverage for adult vaccines on an annual basis. For the other countries, it was difficult to find information, either in research papers or national health websites, on adult vaccination coverage calculation methodologies, especially in English.

Key stakeholder interviews

Sixteen key stakeholders were invited to participate in the study, of which 15 agreed and were able to be interviewed within the study time frame. Ten interviewees invited additional colleagues to attend the interview, making a total of 37 participants across 15 interviews. One group sent

written responses in addition to participating in the virtual interview. Interviewees included immunisation experts (*n*=3), ATAGI member (*n*=1), staff from the Department (Immunisation Branch, HERD and Population Health Division; *n*=10) and JICs and their nominees (*n*=23).

The stakeholders interviewed identified strengths and limitations of current approaches to assessment and reporting of vaccination coverage in adolescents and adults. In particular, the national whole-of-life AIR was perceived to be a key asset allowing comparison of vaccination data across Australian jurisdictions and internationally. Box 1 summarises key stakeholder perspectives and recommendations.

Box 1: Stakeholder perspectives and recommendations on adolescent and adult coverage assessment and reporting by thematic domain

Domain	Stakeholder perspectives/recommendations
Objectives of adolescent/adult coverage assessment and reporting	Key objectives of coverage assessment and reporting include monitoring of vaccination program delivery, program performance and effectiveness, and identification of vaccination coverage gaps. Where possible coverage should be assessed/reported by: • risk-based cohorts including medically at-risk • small area (e.g. SA3) • ethnicity/culturally and linguistically diverse (CALD) populations.
Strengths of current Australian approaches	• Whole-of-life register (the AIR) • Mandatory reporting to the AIR • Ability to compare AIR data across jurisdictions and internationally • Comprehensive reporting for adolescent HPV vaccination (via annual NCIRS coverage reports)
Challenges of current Australian approaches	• Underreporting of vaccinations to the AIR, particularly for adults • Limited number of data fields in the AIR • Data not routinely linked with other datasets containing more comprehensive data fields • Lack of assessment/reporting of coverage data with geographical granularity • Data errors due to varying levels of immunisation provider experience and education in data entry • Denominator data issues arising from people dying, entering/leaving the country, or moving interstate without updating address details, which may impact AIR data quality and contribute to differences between AIR and ABS denominators • Lack of timeliness of coverage assessment, particularly for adolescents (e.g. HPV given at 12–13 years of age but not assessed until 15 years of age) • Lack of clarity around assessment methodology used in quarterly adolescent coverage reports sent to jurisdictions
Scope and calculation methods used in NCIRS annual	Strengths: • comprehensive and useful report utilising all variables available in the AIR • considerable work undertaken to develop a range of calculation methods for adolescent and adult coverage.

coverage report 2021	Limitations: • annual report with lag time (more frequent/timely data would be useful) • adolescent and adult coverage data are not reported at sub-jurisdictional levels (unlike for children).
At-risk populations	It would be useful to regularly assess coverage of the additional vaccines recommended for medically at-risk groups, Aboriginal and Torres Strait Islander adolescents/adults and pregnant women, and in other key groups such as CALD populations, acknowledging the following challenges: • Other than for Aboriginal and Torres Strait Islander adolescents/adults, assessment of coverage is not possible using the AIR alone (requires linkage to other datasets). • Many high prevalence conditions (e.g. asthma and obesity) are not well captured in relevant datasets. • There is difficulty in determining denominators. Linked data from the Multi-Agency Data Integration Project (MADIP) was the most commonly identified potential data source for use in assessing coverage in at-risk populations. One stakeholder also suggested bespoke linkages, e.g. of AIR, hospitalisation, death and perinatal data collections. It would be useful to evaluate how well comorbidities are/could be captured by practice management software, and the feasibility/potential usefulness of incorporating these data into the AIR.
Assessment of 'fully vaccinated' coverage	Divergent views expressed, with some stakeholders suggesting that a 'fully vaccinated' measure could be useful from a policy or program perspective, more so for adolescents than adults, while others disagreed or were unsure about the usefulness/appropriateness. Most believed such assessment would not be straightforward.
Reassessment of coverage at later date/s to assess catch-up vaccination	Stakeholders were generally supportive, of reassessment, with suggestions including: • HPV vaccine coverage at 15, 16, 17, 18, 19 and 20 years of age • meningococcal ACWY vaccine at 17, 18 and/or 19 years • zoster and 13-valent conjugate pneumococcal vaccine at 71, 72, 73, 74, 75, 76, 77, 78, 79 and 80 years.
Coverage assessment using AIR data	Stakeholder recommendations included: • Improve/maintain quality of AIR data.. • Consider a Microsoft BI or similar interface to allow more interactive and timely data for public access. • Consider both earlier and later assessment of adolescent vaccination coverage (e.g. HPV and dTpa at 13, 14, 15, 16, 17, 18 and 19 years). • Report more granular coverage data, e.g. by smaller geographic areas, so can better assess gaps in coverage. • Enhance training and education for health care providers around recording and reporting vaccination data to the AIR. • Provide clear and consistent guidelines on denominators (e.g. use of AIR versus ABS data). • Undertake sensitivity analyses using linked data to explore impact of different denominators on vaccination coverage. • Consider oversight committee or advisory group to enhance strategic approach to assessing coverage.

Comparison of coverage calculation methodologies currently used in Australia

Services Australia, under direction from the Department, provides quarterly reports to JICs on adolescent (from 2019) and adult (from 2017) vaccination coverage. NCIRS publishes annual adolescent and adult vaccination coverage data predominantly in its annual coverage reports. Differences in methods by age group and vaccine are outlined below.

Adolescents

HPV

Services Australia provides JICs with a report detailing jurisdictional data for HPV dose counts by age at time of dose (12, 13, 14, 15, ≥16 years), gender and provider type, and HPV vaccination coverage data for 12-month-wide cohorts assessed at ages 15, 16, 17 and 20 years. In its annual immunisation coverage reports, NCIRS calculates HPV vaccination coverage (for receipt of first dose and course completion) at 15 years of age by gender, Aboriginal and Torres Strait Islander status, socioeconomic status/remoteness of area of residence and jurisdiction using 12-month-wide cohorts.

Diphtheria-tetanus-pertussis

Services Australia reports for JICs include diphtheria-tetanus-pertussis vaccine coverage assessed at ages 15, 16, 17 and 20 years, calculated as proportion who have received at least 3 doses in total, with at least 1 dose given at ≥10 years of age. NCIRS reports coverage of the adolescent diphtheria-tetanus-pertussis dose at 15 years of age, calculated as the proportion of adolescents having received any dose of any diphtheria-tetanus-pertussis-containing vaccine at ≥10 years of age. We found that diphtheria-tetanus-pertussis-containing vaccination coverage calculated using the Services Australia method is 1.3–5.0 percentage points lower than the NCIRS method.

Meningococcal ACWY

Services Australia reports for JICs include meningococcal ACWY vaccine coverage assessed at ages 15, 16, 17 and 20 years. NCIRS calculates adolescent meningococcal ACWY vaccination coverage at 17 years of age as any dose of any meningococcal C containing vaccine given at ≥14 years of age, while Services Australia includes meningococcal ACWY vaccines only. We found that meningococcal ACWY vaccination coverage calculated using the Services Australia method is 0.0–0.4% lower, depending on age group/jurisdiction, than with the NCIRS method.

Composite measures

Services Australia reports for JICs include a 'fully vaccinated' composite measure for adolescent coverage (HPV, and adolescent doses of diphtheria-tetanus-pertussis and meningococcal ACWY vaccines) assessed at ages 15, 16, 17 and 20 years. NCIR S has not previously used any adolescent composite measures.

Adults

Influenza

The Department publishes weekly data on its website from April to December on the cumulative number of influenza vaccine doses (administered since 1 March of the relevant year) reported to the AIR by age at vaccination (<5 years, 5–64 years and ≥65 years, with no further breakdown provided), provider type, Aboriginal and Torres Strait Islander status and jurisdiction. Services Australia provides monthly reports to the Department and state/territory health departments on adult influenza vaccination coverage (1 dose only) by age group, with the age calculated as at 1 January each year. In its annual immunisation coverage reports, NCIRS calculates adult influenza vaccination coverage by age at vaccination (20 to <50 years, 50 to <65 years, 65 to <75 years and ≥75 years), Aboriginal and Torres Strait Islander status and jurisdiction, as the proportion of Medicare-eligible people registered on the AIR recorded as having received at least one dose of influenza vaccine during the relevant calendar year. Population denominators from the AIR are based on age calculated as at 30 June of the year of interest. Since 2022 NCIRS has also published on its website weekly cumulative influenza vaccination coverage by age at vaccination for influenza vaccines reported as given since 1 March to the date of AIR data extraction and with population denominators from the AIR based on age at date of AIR data extraction.

Zoster and pneumococcal

From 2017, Services Australia provides JICs with confidential quarterly 'AIR-20 Adult' reports on adult vaccination coverage for 1 dose of zoster vaccine (Zostavax only) and 1 dose of a pneumococcal vaccine (vaccine type not specified) by various age groups, jurisdiction, Primary Health Network (PHN), Australian Bureau of Statistics (ABS) Statistical Area 2s (SA2) and Statistical Area 3s (SA3) for the Department of Health and state/territory health departments. NCIRS routinely calculates zoster adult coverage by Aboriginal and Torres Strait Islander status and jurisdiction for adults aged 70–<71 years (those who turned 71 years of age during the relevant year) and adults who turned 72–79 years during the relevant year using 12-month-wide and 8-year-wide cohorts, respectively, and reports it in its annual immunisation coverage reports. NCIRS also routinely reports annually on adult 13vPCV vaccination coverage by Aboriginal and Torres Strait Islander status for adults 70–<71 years (those who turned 71 years of age during the

relevant year) and adults who turned 72–79 years during the relevant year using 12-month-wide and 8-year-wide cohorts, respectively.

Other differences between Services Australia/Department and NCIRS methods

- For the purposes of ascribing area of residence for children with multiple Medicare cards, Services Australia uses the postcode associated with the Medicare card with the lowest card number, whereas NCIRS uses the postcode associated with the most recent Medicare registration date (NCIRS does not receive Medicare numbers).
- NCIRS excludes all SIN records from all calculations, whereas Services Australia includes SINs in its confidential reports to JICs on Aboriginal and Torres Strait Islander-specific vaccines/doses.
- Services Australia excludes persons with an end date less than the 'Age Calculated' date, whereas NCIRS excludes persons with an end date less than the "Date of Processing Date" (three months after the 'Age Calculated' date). This slight difference in approach would make Services Australia's denominators slightly larger than what NCIRS calculates.
- Services Australia does not include persons with a 'returned mail indicator' in any analyses, whereas NCIRS is unable to do this as it doesn't receive this data field.

Burden of disease assessment

When compared to other vaccine preventable diseases, each of the diseases covered by vaccines in the adolescent and adult immunisation schedules has a high or moderate overall burden (influenza, invasive pneumococcal disease, HPV, pertussis and herpes zoster), individual burden (diphtheria and tetanus) or both (meningococcal disease) (Box 2).

Box 2. Overall and individual burden of diseases covered by vaccines in the adolescent and adult immunisation schedules

Disease	Overall burden, 2015	Individual burden, 2015
Influenza	• **5,674 DALY** (36.0% of total burden due to VPDs)	• **0.02 DALY per case**
Pneumococcal disease	• **3,795 DALY (**24.0% of total burden due to VPDs)	• **2.41 DALY per case**
HPV	• **3,710 DALY** (23.5% of total burden due to VPDs)	• **0.01 DALY per case**
Herpes zoster	• **1,152 DALY** (7.3% of total burden due to VPDs)	• **<0.01 DALY per case**
Meningococcal disease	• **645 DALY** (4.1% of total burden due to VPDs)	• **3.22 DALY per case**
Pertussis	• **259 DALY** (1.6% of total burden due to VPDs)	• **<0.01 DALY per case**
Diphtheria	• **15 DALY** (0.1% of total burden due to VPDs)	• **3.72 DALY per case**
Tetanus	• **14.2 DALY** (0.1% of total burden due to VPDs)	• **1.42 DALY per case**

DALY = Disability adjusted life years; VPD = vaccine preventable disease; HPV= human papillomavirus

Source: Australian Institute of Health and Welfare. The burden of vaccine preventable diseases in Australia. Canberra: AIHW; 2019.

Exploratory AIR data analysis

The results of AIR data analyses undertaken to explore optimal methods for assessing vaccination coverage for adolescents and adults, informed by findings from the literature review and stakeholder interviews, are presented below.

Adolescent vaccination coverage

HPV vaccine – appropriate age/s to assess to optimise timeliness and utility

As of February 2023, a single dose of HPV vaccine is funded on the NIP for adolescents in Year 7 as part of school-based vaccination programs run by each state/territory. Adolescents in Year 7 are typically aged 12–13 years; however, some may be younger or older. HPV vaccines had previously been administered as a 3-dose (2007–2017) and 2-dose (2018–2022) schedule, with some jurisdictions offering in Year 8. We assessed coverage as receipt of ≥1 HPV vaccine dose at ≥9 years of age (the age from which HPV vaccine is registered for use).

2003 birth cohort (turning 19 years of age in 2022) – assessment of age at vaccination

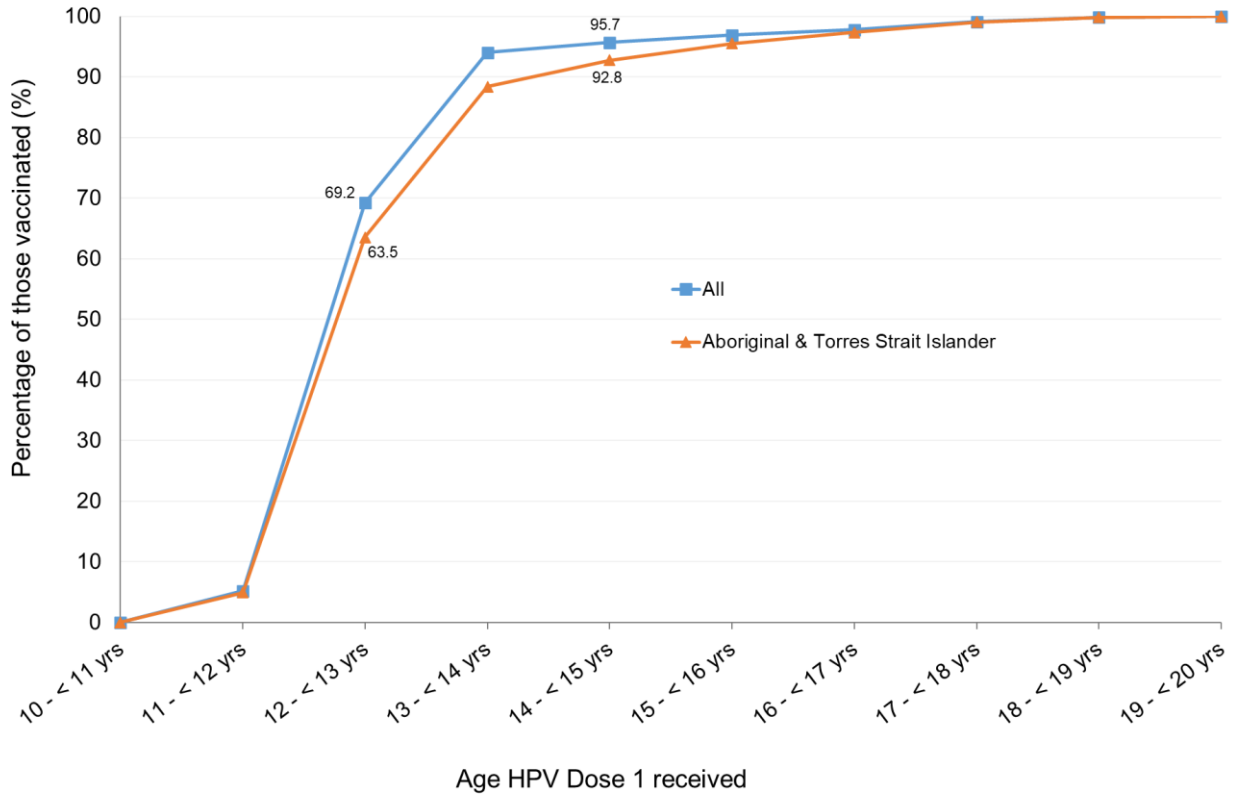
Of adolescents turning 19 years of age in 2022 and vaccinated with a dose of HPV vaccine by 31 December 2022, 69.2% overall were vaccinated by 13 years of age and 95.7% by 15 years of age, compared to 63.5% and 92.8% of vaccinated Aboriginal and Torres Strait Islander adolescents, respectively (Figure 1). There was substantial variation in timing of vaccination by jurisdiction, predominantly occurring in this cohort at 13 years of age in South Australia and Western Australia compared to 12 years in other jurisdictions (Table 1). However >95% of vaccinated adolescents in each Australian jurisdiction had received a dose of HPV vaccine by 16 years of age, and by 17 years for Aboriginal and Torres Strait Islander adolescents (Table 1).

2003-2009 birth cohorts (turning 13-19 years of age in 2022)

Assessing a broader range of year-wide birth cohorts, 72.0% of adolescents turning 13 years of age in 2022 had received a dose of HPV vaccine by 31 December 2022, as did 82.1% of those turning 14 years and 84.7% of those turning 15 years, with less marked differences in older cohorts (Figure 2). Coverage in Aboriginal and Torres Strait Islander adolescents was 11.6 percentage points lower than overall coverage in those turning 13 years of age in 2022, but the disparity decreased with increasing age, with coverage 2.0 percentage points higher in Aboriginal and Torres Strait Islander adolescents turning 19 years of age than other adolescents (Figure 2). HPV vaccination coverage varied by jurisdictions, with coverage in South Australia notably lower

(35–59 percentage points) for the cohort turning 13 years in 2022 (the final year where the program was delivered in Year 7 before changing to Year 8) (Table 2).

Figure 1. Cumulative percentage of adolescents turning 19 years of age in 2022* and vaccinated with a dose of HPV vaccine by age at vaccination and Aboriginal and Torres Strait Islander status, Australia, 2022**



* Adolescent cohort born in 2003.

** Shown as cumulative percentage vaccinated by 31 December 2022 (number of Medicare-registered adolescents in the 2003 cohort with a record on the AIR of having received a dose of HPV vaccine at particular age / total number of Medicare-registered adolescents in the 2003 cohort with a record on the AIR of having received a dose of HPV vaccine, expressed as a percentage).

Source: Australian Immunisation Register, data as at 8 January 2023.

Table 1. Cumulative percentage of adolescents* turning 19 years of age in 2022* and vaccinated with a dose of HPV vaccine by age at vaccination, Aboriginal and Torres Strait Islander status and state/territory, 2022**

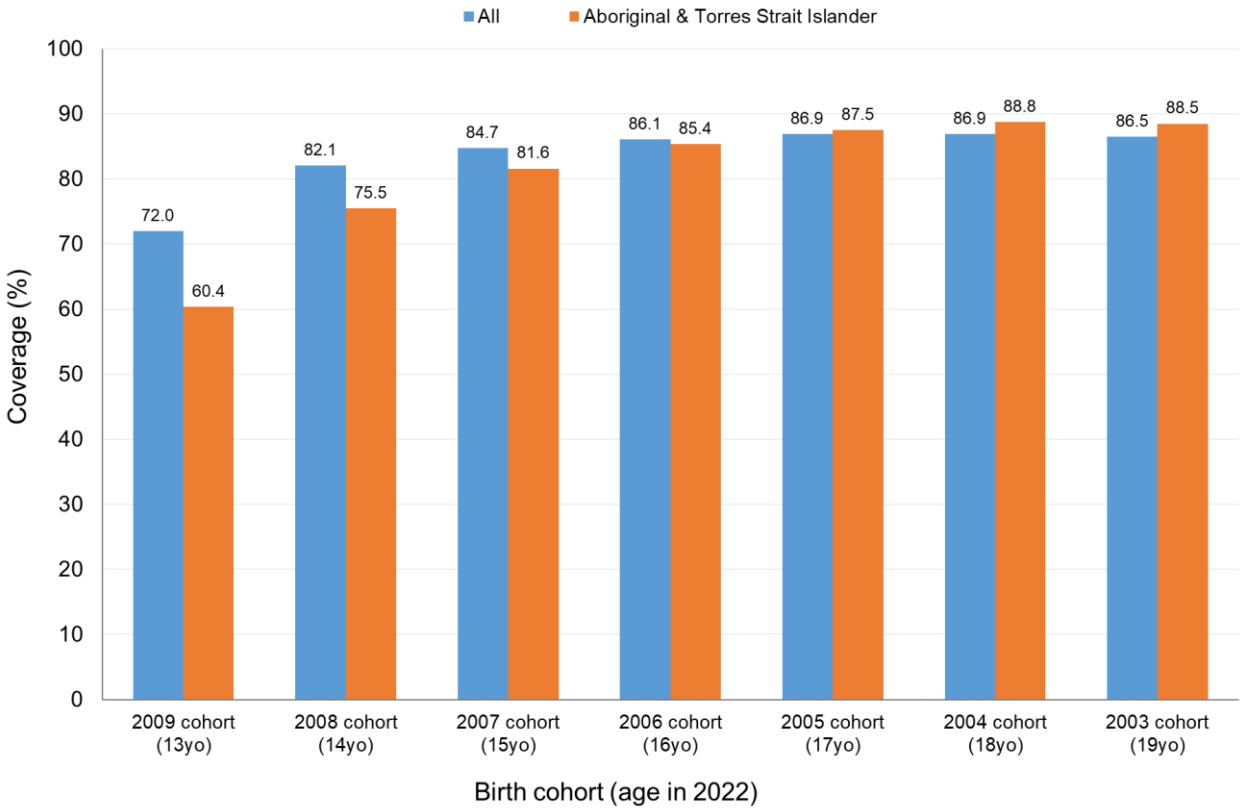
	All							
	ACT	**NSW**	**VIC**	**QLD**	**SA**	**WA**	**TAS**	**NT**
10 – < 11 years	0.1	0.1	0.1	0.0	0.0	0.1	0.2	0.1
11 – < 12 years	7.7	11.8	3.9	0.7	0.4	0.5	0.8	14.3
12 – < 13 years	85.0	86.7	78.6	70.6	11.8	25.3	68.8	78.2
13 – < 14 years	94.6	95.2	94.8	92.9	89.8	93.0	95.5	91.4
14 – < 15 years	95.8	96.0	95.9	94.6	95.4	95.6	96.7	95.1
15 – < 16 years	96.7	97.0	96.9	96.2	96.6	97.1	97.7	97.2
16 – < 17 years	97.8	97.8	97.8	97.4	97.7	98.0	98.4	98.2
17 – < 18 years	99.0	99.1	99.0	99.0	99.0	99.2	99.5	99.3
18 – < 19 years	99.7	99.8	99.8	99.8	99.8	99.9	99.9	99.9
19 – < 20 years	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Aboriginal and Torres Strait Islander							
	ACT	**NSW**	**VIC**	**QLD**	**SA**	**WA**	**TAS**	**NT**
10 – < 11 years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11 – < 12 years	5.4	8.8	3.4	0.8	0.4	0.8	0.3	12.2
12 – < 13 years	78.5	80.7	70.8	61.6	17.3	22.4	67.6	71.3
13 – < 14 years	94.6	93.7	92.4	85.7	76.5	80.9	93.0	87.8
14 – < 15 years	96.1	95.5	94.1	90.4	89.2	88.8	95.0	94.3
15 – < 16 years	96.9	97.2	96.2	93.6	92.7	94.1	96.4	97.2
16 – < 17 years	96.9	98.3	97.2	95.9	95.9	97.2	97.0	98.7
17 – < 18 years	99.2	99.2	99.0	98.7	98.3	99.1	98.5	99.6
18 – < 19 years	99.2	99.8	99.7	99.8	99.6	99.9	100.0	99.9
19 – < 20 years	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Adolescent cohort born in 2003.

** Shown as cumulative percentage vaccinated by 31 December 2022 (number of Medicare-registered adolescents in the 2003 cohort with a record on the AIR of having received a dose of HPV vaccine at particular age / total number of Medicare-registered adolescents in the 2003 cohort with a record on the AIR of having received a dose of HPV vaccine, expressed as a percentage).

Source: Australian Immunisation Register, data as at 8 January 2023.

Figure 2. Coverage* of a dose of HPV vaccine by birth cohort/age** and Aboriginal and Torres Strait Islander status, Australia, 2022



* Calculated using the number of Medicare-registered adolescents in each year-wide cohort with an AIR record of having received a dose of HPV vaccine by 31 December 2022 (inclusive) as the numerator and the total number of Medicare-registered adolescents in the relevant age cohort as the denominator, expressed as a percentage.

** Age assessed as at 31 December 2022.

Source: Australian Immunisation Register, data as at 8 January 2023.

Table 2. Coverage* of a dose of HPV vaccine by birth cohort/age,** Aboriginal and Torres Strait Islander status and state/territory, 2022

	All							
	ACT	**NSW**	**VIC**	**QLD**	**SA**	**WA**	**TAS**	**NT**
2009 cohort (13yo)	83.7	76.0	76.2	73.1	25.0	76.4	69.9	59.6
2008 cohort (14yo)	88.4	83.6	83.5	79.4	79.5	81.3	80.8	72.8
2007 cohort (15yo)	89.2	85.8	86.0	81.9	84.7	84.3	82.8	81.0
2006 cohort (16yo)	90.4	87.1	87.6	83.1	86.2	85.0	86.6	85.1
2005 cohort (17yo)	90.2	87.7	88.3	84.3	87.6	85.6	88.4	88.1
2004 cohort (18yo)	89.8	87.4	88.5	84.3	87.3	85.6	89.3	90.4
2003 cohort (19yo)	89.2	87.0	88.0	83.6	87.7	85.5	88.9	89.1
	Aboriginal and Torres Strait Islander							
	ACT	**NSW**	**VIC**	**QLD**	**SA**	**WA**	**TAS**	**NT**
2009 cohort (13yo)	78.6	67.7	65.0	61.1	21.0	61.3	65.5	46.1
2008 cohort (14yo)	82.2	81.7	76.4	74.5	57.1	73.3	79.9	64.1
2007 cohort (15yo)	85.8	85.7	81.2	79.5	70.9	81.3	83.3	78.4
2006 cohort (16yo)	85.5	89.5	85.6	82.9	77.1	82.5	87.1	86.0
2005 cohort (17yo)	84.3	90.5	85.8	86.6	79.9	84.1	88.1	89.6
2004 cohort (18yo)	89.9	89.4	90.6	88.1	80.3	86.2	89.6	94.0
2003 cohort (19yo)	89.0	90.0	88.4	86.2	85.7	87.4	87.6	92.8

* Calculated using the number of Medicare-registered adolescents in each year-wide cohort with an AIR record of having received a dose of HPV vaccine by 31 December 2022 (inclusive) as the numerator and the total number of Medicare-registered adolescents in the relevant age cohort as the denominator, expressed as a percentage.

** Age assessed as at 31 December 2022.

Source: Australian Immunisation Register, data as at 8 January 2023.

Comparison of coverage using calendar year birth cohort method with WHO recommended method

HPV vaccination coverage in adolescents turning 15 years of age using the birth cohort method described above includes vaccine doses given on or after an individual's 15th birthday, if before the end of the relevant year, for purposes of better alignment and interpretability in relation to school program delivery. We calculated that coverage using our method was 0.4 of a percentage point higher than the WHO-recommended method for international comparison (which excludes vaccine doses received on or after the 15th birthday), ranging from 0.3 of a percentage point in New South Wales to 1.2 percentage points in the Australian Capital Territory, and 1.1 percentage points higher for Aboriginal and Torres Strait Islander adolescents overall (ranging from 0.7 of a percentage point in the Australian Capital Territory and Victoria to 1.7 percentage points in the Northern Territory) (Table 3).

Table 3. HPV dose 1 vaccination coverage in adolescents turning 15 years in 2022,* by whether vaccine doses given at ≥15 years included, and Aboriginal and Torres Strait Islander status, Australia, 2022

	All		Aboriginal and Torres Strait Islander	
	Coverage (%) where only doses given <15 years included**	Coverage (%) where doses given ≥15 years also included***	Coverage (%) where only doses given <15 years included**	Coverage (%) where doses given ≥15 years also included***
ACT	88.0	89.2	85.1	85.8
NSW	85.5	85.8	84.9	85.7
VIC	85.6	86.0	80.5	81.2
QLD	81.5	81.9	78.2	79.5
SA	84.2	84.7	69.5	70.9
WA	83.9	84.3	80.2	81.3
TAS	82.2	82.8	82.5	83.3
NT	80.0	81.0	76.7	78.4
AUSTRALIA	**84.3**	**84.7**	**80.5**	**81.6**

* Cohort born in 2007.

** Coverage is calculated using the number of Medicare-registered adolescents the 2007 cohort with an AIR record of having received a dose of HPV vaccine before their 15th birthday as the numerator and the total number of Medicare-registered adolescents in the 2007 cohort as the denominator, expressed as a percentage.

*** Coverage is calculated using the number of Medicare-registered adolescents the 2007 cohort with an AIR record of having received a dose of HPV vaccine before or after their 15th birthday as the numerator and the total number of Medicare-registered adolescents in the 2007 cohort as the denominator, expressed as a percentage.

Source: Australian Immunisation Register, data as at 8 January 2023.

Adolescent diphtheria-tetanus-pertussis booster vaccine dose – appropriate age/s to assess to optimise timeliness and utility

An adolescent booster dose of dTpa vaccine is funded on the NIP for adolescents as part of school-based vaccination programs run in each state/territory. As of 2023 all jurisdictions offer dTpa vaccine in Year 7, although previously some have offered the vaccine in Year 8. We assessed coverage as receipt of ≥1 dose of any diphtheria-tetanus-pertussis-containing vaccine (allowing for vaccine brand data entry errors) at ≥10 years of age.

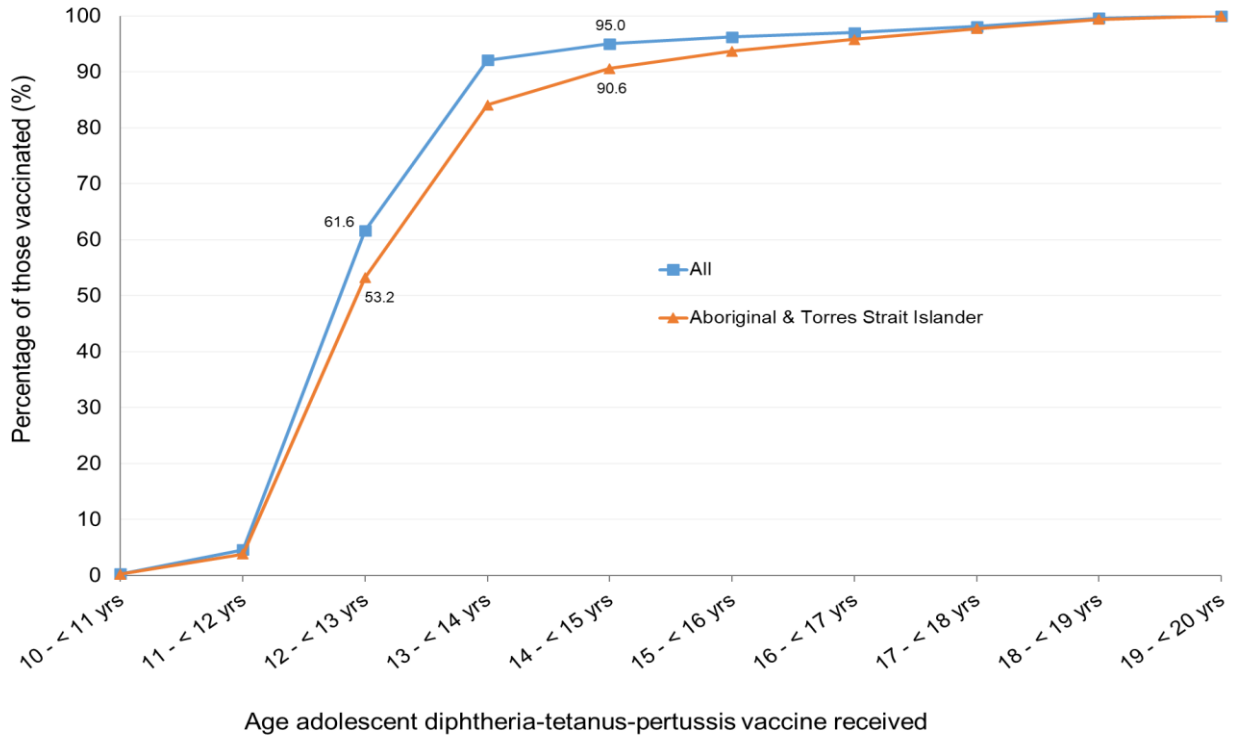
2003 birth cohort (turning 19 years of age in 2022) – assessment of age at vaccination

Of adolescents turning 19 years of age in 2022 and vaccinated with a dose of diphtheria-tetanus-pertussis vaccine as an adolescent (i.e. at ≥10 years) by 31 December 2022, 61.6% had received a dose by 13 years of age and 95.0% by 15 years of age, compared to 53.2% and 90.6% of vaccinated Aboriginal and Torres Strait Islander adolescents, respectively (Figure 3). Timing of vaccination varied by jurisdiction (Table 4), with pattern similar to that seen for HPV.

2003-2009 birth cohorts (turning 13-19 years of age in 2022)

Assessing a broader range of year-wide birth cohorts, 73.0% of adolescents turning 13 years of age in 2022 had received a dose of diphtheria-tetanus-pertussis vaccine as an adolescent by 31 December 2022, 83.9% of those turning 14 years and 86.9% of those turning 15 years, with less marked differences in older cohorts (Figure 4). Coverage in Aboriginal and Torres Strait Islander adolescents was 12.2 percentage points lower than overall coverage in those turning 13 years of age in 2022, but the disparity decreased with increasing age reaching less than a percentage point in Aboriginal and Torres Strait Islander adolescents turning 18 and 19 years of age (Figure 4). Coverage varied by jurisdiction, with pattern similar to that seen for HPV (Table 5).

Figure 3. Cumulative percentage of adolescents turning 19 years of age in 2022* and vaccinated with an adolescent dose of diphtheria-tetanus-pertussis vaccine, by age at vaccination and Aboriginal and Torres Strait Islander status, Australia, 2022**



* Adolescent cohort born in 2003.

** Shown as cumulative percentage vaccinated by 31 December 2022 (number of Medicare-registered adolescents in the 2003 cohort with a record on the AIR of having received an adolescent (i.e. ≥10 years of age) dose of dTpa vaccine or DTPa vaccine at each particular age / total number of Medicare-registered adolescents in the 2003 cohort with a record on the AIR of having received an adolescent (i.e. ≥10 years of age) dose of dTpa vaccine or DTPa vaccine, expressed as a percentage).

Source: Australian Immunisation Register, data as at 8 January 2023.

Table 4. Cumulative percentage of adolescents turning 19 years of age in 2022* and vaccinated with an adolescent dose of diphtheria-tetanus-pertussis vaccine by age at vaccination, Aboriginal and Torres Strait Islander status and state/territory, 2022**

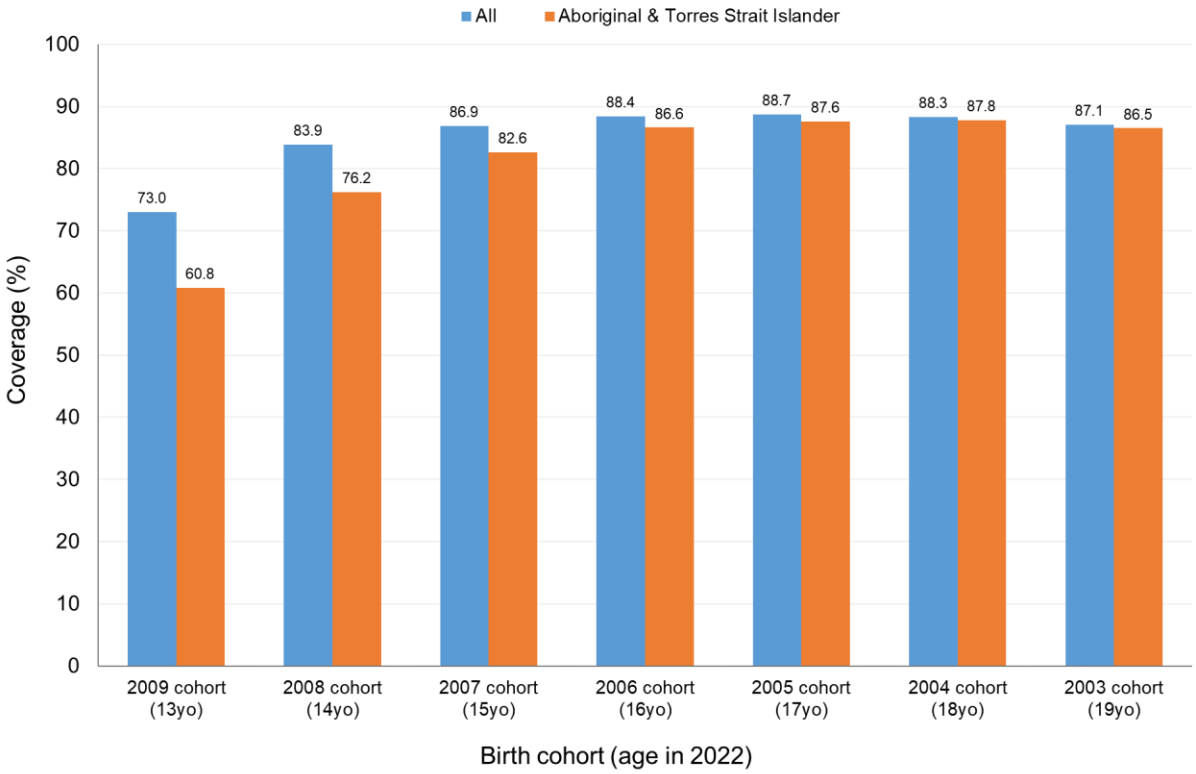
	All							
	ACT	**NSW**	**VIC**	**QLD**	**SA**	**WA**	**TAS**	**NT**
10 – < 11 years	0.3	0.2	0.3	0.2	0.4	0.3	0.3	0.6
11 – < 12 years	7.7	9.9	3.1	1.2	1.0	1.0	1.2	2.5
12 – < 13 years	79.6	84.2	72.3	60.2	6.7	9.5	60.6	20.5
13 – < 14 years	90.6	94.9	93.6	91.7	79.9	90.4	89.9	81.0
14 – < 15 years	92.2	96.1	95.1	93.8	95.0	95.5	91.6	90.8
15 – < 16 years	93.3	97.1	96.2	95.3	96.2	96.9	92.8	94.9
16 – < 17 years	94.1	97.7	97.0	96.4	97.3	97.7	93.9	96.6
17 – < 18 years	95.7	98.5	98.0	97.9	98.3	98.7	95.7	98.1
18 – < 19 years	99.2	99.7	99.6	99.6	99.7	99.7	99.2	99.5
19 – < 20 years	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Aboriginal and Torres Strait Islander							
	ACT	**NSW**	**VIC**	**QLD**	**SA**	**WA**	**TAS**	**NT**
10 – < 11 years	0.0	0.2	0.3	0.1	0.5	0.1	0.0	0.6
11 – < 12 years	5.2	8.6	3.5	1.0	0.7	0.8	1.0	2.7
12 – < 13 years	70.4	79.1	64.0	57.0	9.6	11.4	60.5	17.9
13 – < 14 years	88.7	92.4	89.1	84.4	65.9	74.3	87.2	71.9
14 – < 15 years	93.9	94.4	91.1	89.7	86.3	86.8	90.1	86.9
15 – < 16 years	93.9	96.1	93.2	92.3	89.5	92.1	91.7	93.5
16 – < 17 years	94.8	97.2	94.1	94.8	92.9	95.7	93.6	96.5
17 – < 18 years	95.7	98.3	96.8	97.5	96.1	98.0	95.5	97.8
18 – < 19 years	98.3	99.7	99.1	99.2	99.3	99.7	98.4	99.4
19 – < 20 years	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Adolescent cohort born in 2003.

** Shown as cumulative percentage vaccinated by 31 December 2022 (number of Medicare-registered adolescents in the 2003 cohort with a record on the AIR of having received an adolescent (i.e. ≥10 years of age) dose of dTpa vaccine or DTPa vaccine at each particular age / total number of Medicare-registered adolescents in the 2003 cohort with a record on the AIR of having received an adolescent (i.e. ≥10 years of age) dose of dTpa vaccine or DTPa vaccine, expressed as a percentage).

Source: Australian Immunisation Register, data as at 8 January 2023.

Figure 4. Coverage* of adolescent dose of diphtheria-tetanus-pertussis vaccine by birth cohort/age and Aboriginal and Torres Strait Islander status, Australia, 2022**



* Calculated using the number of Medicare-registered adolescents in each year-wide cohort with an AIR record of having received an adolescent (i.e. ≥10 years of age) dose of a dTpa or DTPa vaccine given by 31 December 2022 (inclusive) as the numerator and the total number of Medicare-registered adolescents in the relevant age cohort as the denominator, expressed as a percentage.

** Age assessed as at 31 December 2022.

Source: Australian Immunisation Register, data as at 8 January 2023.

Table 5. Coverage* of adolescent diphtheria-tetanus-pertussis vaccine dose by birth cohort/age, Aboriginal and Torres Strait Islander status and state/territory, 2022**

	All							
	ACT	**NSW**	**VIC**	**QLD**	**SA**	**WA**	**TAS**	**NT**
2009 cohort (13yo)	76.7	76.4	77.4	74.6	27.3	78.8	68.4	61.0
2008 cohort (14yo)	84.1	85.4	85.1	81.5	82.4	84.3	80.8	73.2
2007 cohort (15yo)	88.7	87.9	87.8	84.6	87.6	87.5	84.5	81.1
2006 cohort (16yo)	90.3	89.4	89.4	85.8	89.4	88.6	87.8	85.3
2005 cohort (17yo)	89.3	89.4	89.4	86.5	90.2	89.0	86.7	88.1
2004 cohort (18yo)	87.8	88.9	89.2	86.4	89.4	88.9	83.4	87.2
2003 cohort (19yo)	82.3	88.3	87.6	85.0	88.4	88.4	80.9	85.8
	Aboriginal and Torres Strait Islander							
	ACT	**NSW**	**VIC**	**QLD**	**SA**	**WA**	**TAS**	**NT**
2009 cohort (13yo)	62.8	67.9	64.9	62.1	23.0	62.1	63.6	47.2
2008 cohort (14yo)	71.9	82.9	75.9	75.9	58.5	74.3	77.9	63.4
2007 cohort (15yo)	82.8	86.6	81.5	81.3	73.2	82.7	85.3	76.8
2006 cohort (16yo)	83.0	90.5	87.1	84.5	80.8	84.5	90.0	84.8
2005 cohort (17yo)	76.9	90.2	87.1	86.8	83.5	85.7	86.5	87.3
2004 cohort (18yo)	85.2	88.2	87.9	89.4	81.4	86.3	83.3	88.0
2003 cohort (19yo)	78.8	89.2	86.6	85.9	80.9	85.8	78.7	86.6

* Calculated using the number of Medicare-registered adolescents in each year-wide cohort with an AIR record of having received an adolescent (i.e. ≥10 years of age) dose of a dTpa or DTPa vaccine given by 31 December 2022 (inclusive) as the numerator and the total number of Medicare-registered adolescents in the relevant age cohort as the denominator, expressed as a percentage.

** Age assessed as at 31 December 2022.

Source: Australian Immunisation Register, data as at 8 January 2023.

We also assessed coverage of receipt of dTpa vaccine brand doses only – that is, excluding paediatric DTPa brand doses – and found that while coverage was similar in younger cohorts (0.4–0.5 of a percentage point lower in those turning 14 and 15 years in 2022), it was lower in older cohorts (4.2 percentage points in those turning 16 years, 9.4 in those turning 17, and 5.8 in those turning 18), largely due to disparities in Queensland, Victoria and Western Australia (data not shown).

Meningococcal ACWY – appropriate age/s to assess to optimise timeliness and utility

An adolescent dose of meningococcal ACWY vaccine is funded on the NIP for adolescents in Year 10 as part of school-based vaccination programs in each state/territory. Adolescents in Year 10 are typically aged 15–16 years; however, some may be younger or older. State/territory funded programs for adolescents across a range of ages were also in place in some jurisdictions prior to inclusion on the NIP. We assessed coverage as receipt of any dose of any meningococcal C containing vaccine (allowing for vaccine brand data entry errors) given at ≥10 years of age.

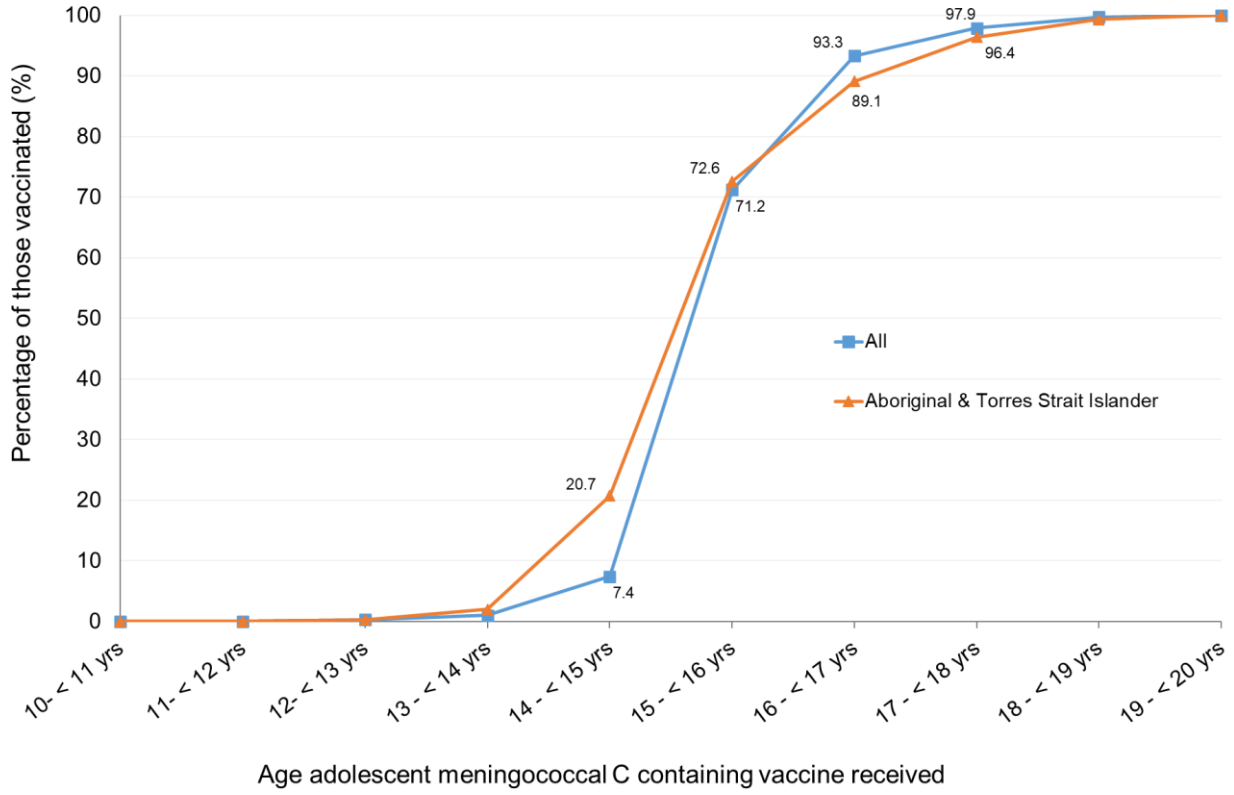
2003 birth cohort (turning 19 years of age in 2022) – assessment of age at vaccination

Of adolescents turning 19 years of age in 2022 and vaccinated with a dose of adolescent meningococcal C containing vaccine as an adolescent (i.e. at ≥10 years) by 31 December 2022, 71.2% had received a dose by 16 years of age and 97.9% by 18 years, compared to 72.6% and 96.4% of vaccinated Aboriginal and Torres Strait Islander adolescents, respectively (Figure 5). Timing of vaccination varied by jurisdiction with a notably higher proportion of adolescents vaccinated by 15 years of age in Tasmania and the Northern Territory, possibly due to state/territory vaccination programs implemented in response to meningococcal disease outbreaks, with >50% of vaccinated adolescents in each jurisdiction having received a dose by 16 years and >95% by 18 years of age (Table 6). A substantially higher proportion of vaccinated Aboriginal and Torres Strait Islander adolescents received a dose by 15 years of age than overall in Queensland, South Australia, Western Australia and the Northern Territory, possibly due to targeted state/territory vaccination programs in response to outbreaks (Table 6).

2003-2009 birth cohorts (turning 13-19 years of age in 2022)

Assessing a broader range of year-wide birth cohorts, 77.0% of adolescents turning 17 years in 2022 had received a dose of meningococcal C containing vaccine as an adolescent by 31 December 2022, 80.1% of those turning 18 years and 79.8% in those turning 19 years. Coverage in Aboriginal and Torres Strait Islander adolescents was several percentage points higher than overall in those turning 14 and 15 years, but lower in older age cohorts, ranging from 13.0 percentage points lower at 16 years to 6.5 percentage points lower at 19 years (Figure 6). Coverage varied by jurisdiction, being substantially higher in Tasmania and Northern Territory in the 14 and 15 year age cohorts, possibly due to jurisdictional outbreak-related vaccination programs, with a similar pattern in Aboriginal and Torres Strait Islander cohorts (Table 7).

Figure 5. Cumulative percentage of adolescents turning 19 years of age in 2022* and vaccinated with an adolescent dose of meningococcal C containing vaccine by age at vaccination and Aboriginal and Torres Strait Islander status, Australia, 2022**



* Adolescent cohort born in 2003.

** Shown as cumulative percentage vaccinated by 31 December 2022 (number of Medicare-registered adolescents in the 2003 cohort with a record on the AIR of having received an adolescent (i.e. ≥10 years of age) dose of meningococcal C containing vaccine at each particular age / total number of Medicare-registered adolescents in the 2003 cohort with a record on the AIR of having received an adolescent (i.e. ≥10 years of age) dose of meningococcal C containing vaccine, expressed as a percentage).

Source: Australian Immunisation Register, data as at 8 January 2023.

Table 6. Cumulative percentage of adolescents turning 19 years of age in 2022* and vaccinated with an adolescent dose of meningococcal C containing vaccine by age at vaccination, Aboriginal and Torres Strait Islander status and state/territory, 2022**

	All							
	ACT	**NSW**	**VIC**	**QLD**	**SA**	**WA**	**TAS**	**NT**
10 – < 11 years	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
11 – < 12 years	0.1	0.0	0.2	0.0	0.1	0.1	0.0	0.0
12 – < 13 years	0.4	0.3	0.7	0.4	0.5	0.4	0.1	0.3
13 – < 14 years	0.7	0.7	1.4	1.1	1.6	1.6	0.7	4.1
14 – < 15 years	7.4	3.3	3.9	14.0	3.3	9.3	29.4	47.4
15 – < 16 years	80.4	70.7	58.7	80.2	51.8	88.0	89.1	87.8
16 – < 17 years	95.1	93.6	93.0	93.9	84.9	96.3	96.2	93.3
17 – < 18 years	98.2	98.0	98.0	98.0	95.1	98.8	98.6	97.5
18 – < 19 years	99.6	99.7	99.7	99.7	99.3	99.8	99.8	99.3
19 – < 20 years	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

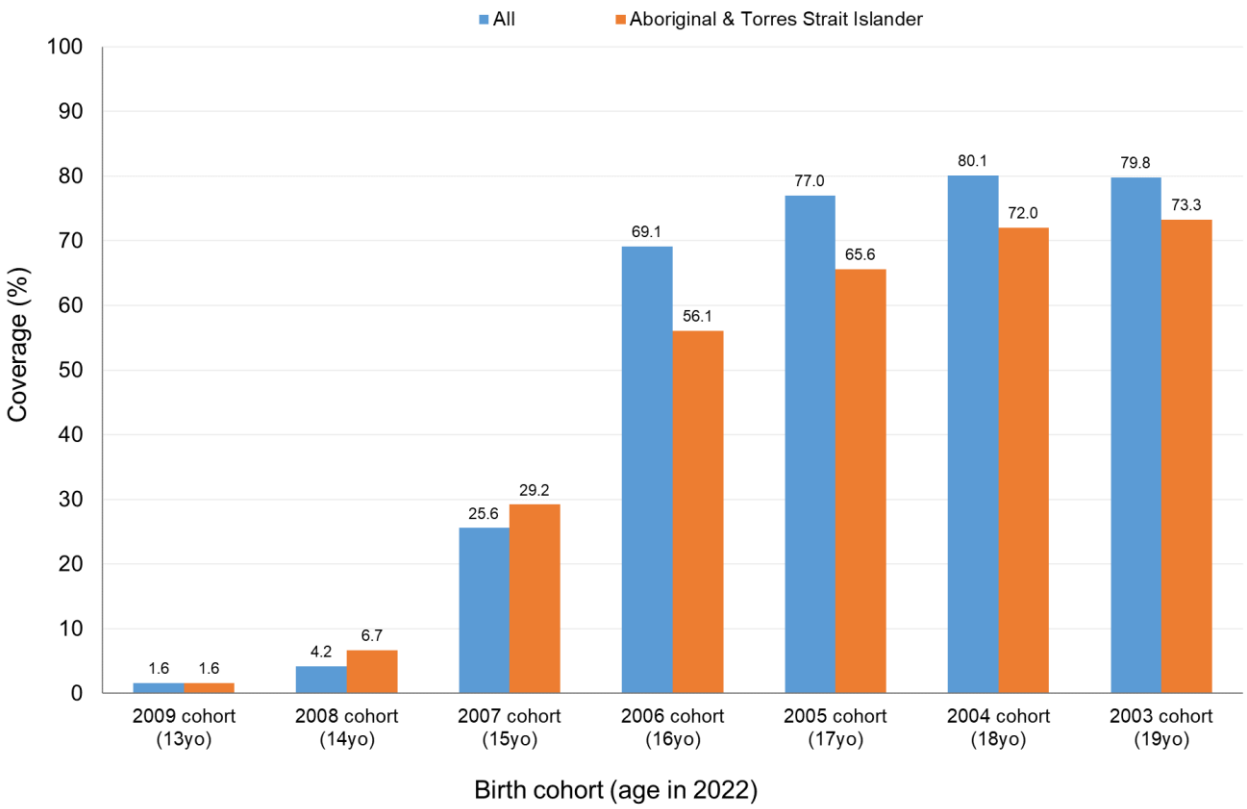
	Aboriginal and Torres Strait Islander							
	ACT	**NSW**	**VIC**	**QLD**	**SA**	**WA**	**TAS**	**NT**
10 – < 11 years	0.0	0.0	0.2	0.0	0.0	0.0	0.3	0.0
11 – < 12 years	0.0	0.0	0.2	0.0	0.0	0.1	0.3	0.0
12 – < 13 years	0.0	0.4	0.7	0.2	0.3	0.3	0.6	0.2
13 – < 14 years	0.0	0.8	1.5	0.9	7.0	3.3	1.5	5.8
14 – < 15 years	8.5	4.1	7.0	24.0	21.2	15.9	23.6	63.7
15 – < 16 years	76.4	65.2	53.9	75.7	54.7	77.9	83.6	89.1
16 – < 17 years	92.4	88.1	84.7	88.1	84.6	90.8	94.0	95.1
17 – < 18 years	98.1	95.9	95.8	96.3	95.5	97.4	97.0	97.9
18 – < 19 years	100.0	99.3	99.5	99.3	99.7	99.5	99.4	99.4
19 – < 20 years	100.0	100.0	100.2	100.0	100.0	100.0	100.0	100.0

* Adolescent cohort born in 2003 (aged 19 years in 2022).

** Shown as cumulative percentage vaccinated by 31 December 2022 (number of Medicare-registered adolescents in the 2003 cohort with a record on the AIR of having received an adolescent (i.e. ≥10 years of age) dose of meningococcal C containing vaccine at each particular age / total number of Medicare-registered adolescents in the 2003 cohort with a record on the AIR of having received an adolescent (i.e. ≥10 years of age) dose of meningococcal C containing vaccine, expressed as a percentage).

Source: Australian Immunisation Register, data as at 8 January 2023.

Figure 6. Coverage* of adolescent meningococcal C containing vaccine by birth cohort/age** and Aboriginal and Torres Strait Islander status, Australia, 2022



* Calculated using the number of Medicare-registered adolescents in each year-wide cohort with an AIR record of having received an adolescent (i.e. ≥10 years of age) dose of meningococcal C containing vaccine given by 31 December 2022 (inclusive) as the numerator and the total number of Medicare-registered adolescents in the relevant age cohort as the denominator, expressed as a percentage.

** Age assessed as at 31 December 2022.

Source: Australian Immunisation Register, data as at 8 January 2023.

Table 7. Coverage* of adolescent meningococcal C containing vaccine by birth cohort/age,** Aboriginal and Torres Strait Islander status and state/territory, 2022

	All							
	ACT	**NSW**	**VIC**	**QLD**	**SA**	**WA**	**TAS**	**NT**
2009 cohort (13yo)	1.5	1.4	1.8	1.2	1.7	2.3	1.4	5.7
2008 cohort (14yo)	2.7	2.4	3.3	2.7	3.5	4.5	47.8	30.7
2007 cohort (15yo)	24.0	21.1	16.3	30.4	25.9	36.5	72.2	71.9
2006 cohort (16yo)	79.3	66.3	69.8	66.6	75.4	71.9	83.2	79.9
2005 cohort (17yo)	85.2	75.1	78.0	74.9	82.5	78.7	83.9	81.9
2004 cohort (18yo)	86.9	80.0	80.1	77.7	83.0	81.8	86.1	81.9
2003 cohort (19yo)	85.1	80.1	81.9	78.4	69.3	82.3	82.7	78.1
	Aboriginal and Torres Strait Islander							
	ACT	**NSW**	**VIC**	**QLD**	**SA**	**WA**	**TAS**	**NT**
2009 cohort (13yo)	0.0	0.4	1.3	0.5	1.0	4.7	0.8	5.7
2008 cohort (14yo)	1.4	0.6	1.8	4.2	5.3	9.1	53.1	22.6
2007 cohort (15yo)	17.2	11.6	10.9	32.7	25.7	33.8	72.7	76.3
2006 cohort (16yo)	57.2	46.9	46.9	56.4	56.5	55.9	83.9	85.5
2005 cohort (17yo)	61.2	59.8	59.3	68.3	63.9	62.3	84.6	87.8
2004 cohort (18yo)	73.0	67.6	66.6	72.3	67.9	70.6	88.4	87.0
2003 cohort (19yo)	72.6	70.2	68.7	73.9	61.3	75.2	83.5	82.6

* Calculated using the number of Medicare-registered adolescents in each year-wide cohort with an AIR record of having received an adolescent (i.e. ≥10 years of age) dose of meningococcal C containing vaccine given by 31 December 2022 (inclusive) as the numerator and the total number of Medicare-registered adolescents in the relevant age cohort as the denominator, expressed as a percentage.

** Age assessed as at 31 December 2022.

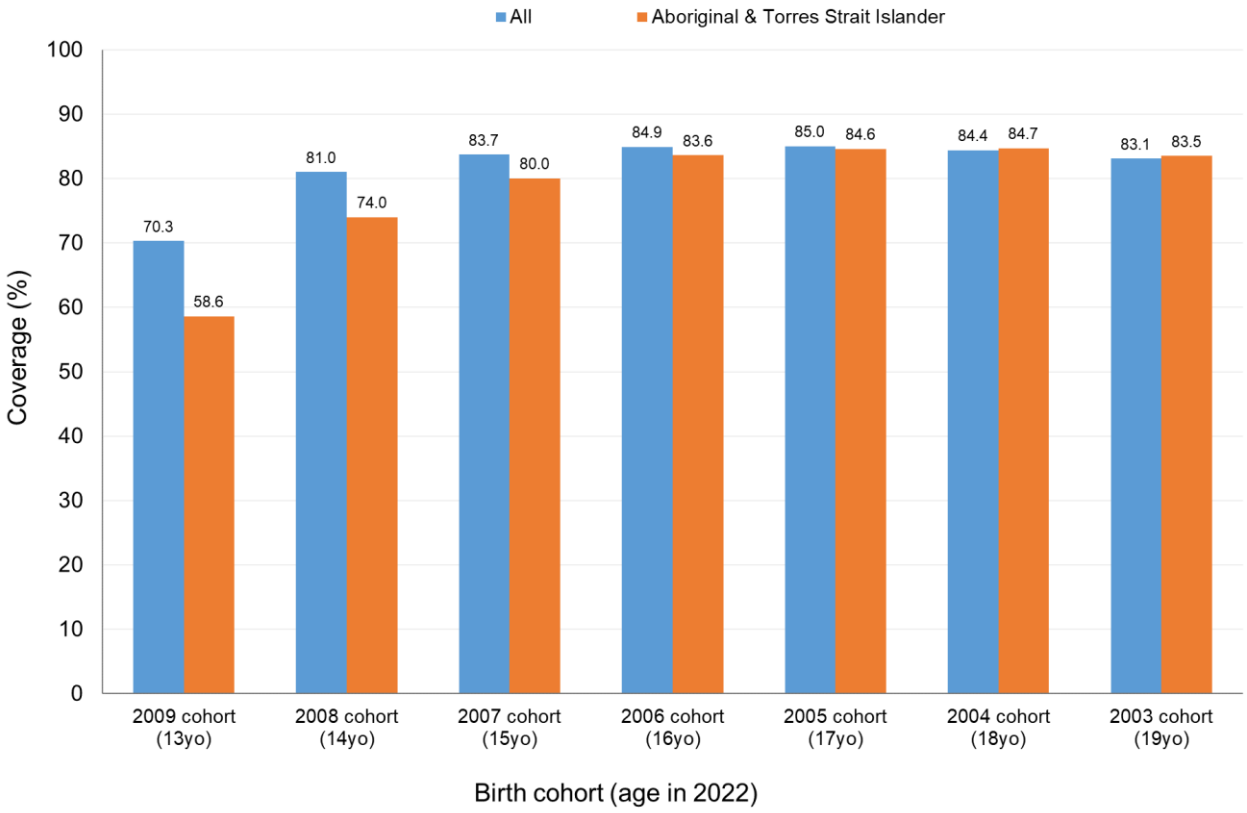
Source: Australian Immunisation Register, data as at 8 January 2023.

Adolescent composite measures of vaccination coverage

HPV + diphtheria-tetanus-pertussis

Using a composite measure (receipt of both an HPV vaccine dose and an adolescent dose of diphtheria-tetanus-pertussis vaccine by 31 December 2022), coverage was 70.3% for adolescents turning 13 years of age in 2022, 81.0% in those turning 14 years and 83.7% in those turning 15 years, with coverage similar or slightly lower in older cohorts (Figure 7). Coverage in Aboriginal and Torres Strait Islander adolescents was 11.7 percentage points lower than overall at 13 years but the disparity decreased in older cohorts with coverage 0.4 of a percentage point higher than overall at 19 years (Figure 7). Coverage varied by jurisdiction, with variation greatest in the youngest cohorts, consistent with the patterns reported above for individual vaccine coverage (Table 8).

Figure 7. Adolescent coverage calculated using composite measure (dose of HPV vaccine and adolescent dose of diphtheria-tetanus-pertussis vaccine)* by birth cohort/age and Aboriginal and Torres Strait Islander status, Australia, 2022**



* Calculated using the number of Medicare-registered adolescents in each year-wide cohort with an AIR record of having received a dose of HPV vaccine and an adolescent (i.e. ≥10 years of age) dose of a dTpa or DTPa vaccine given by 31 December 2022 (inclusive) as the numerator and the total number of Medicare-registered adolescents in the relevant age cohort as the denominator, expressed as a percentage.

** Age assessed as at 31 December 2022.

Source: Australian Immunisation Register, data as at 8 January 2023.

Table 8. Adolescent coverage calculated using a composite measure (dose of HPV vaccine and adolescent dose of diphtheria-tetanus-pertussis vaccine)* by birth cohort/age, Aboriginal and Torres Strait Islander status and state/territory, 2022**

	All							
	ACT	**NSW**	**VIC**	**QLD**	**SA**	**WA**	**TAS**	**NT**
2009 cohort (13yo)	74.5	73.9	74.7	71.8	24.7	75.6	65.7	57.2
2008 cohort (14yo)	82.1	82.8	82.3	78.3	78.9	80.6	78.0	69.8
2007 cohort (15yo)	86.0	85.1	84.9	80.9	84.1	83.7	81.3	78.1
2006 cohort (16yo)	88.0	86.2	86.3	81.7	85.5	84.2	84.2	82.4
2005 cohort (17yo)	86.5	86.2	86.1	82.3	86.2	84.7	83.4	85.1
2004 cohort (18yo)	84.6	85.3	85.7	81.9	84.8	84.2	80.1	84.9
2003 cohort (19yo)	79.3	84.7	84.0	80.0	83.6	83.6	77.4	82.3
	Aboriginal and Torres Strait Islander							
	ACT	**NSW**	**VIC**	**QLD**	**SA**	**WA**	**TAS**	**NT**
2009 cohort (13yo)	61.4	66.0	63.3	60.0	20.5	60.0	61.8	42.6
2008 cohort (14yo)	69.9	80.8	74.4	73.6	56.0	72.2	75.5	59.7
2007 cohort (15yo)	79.9	84.6	79.1	78.6	69.6	80.1	81.3	73.7
2006 cohort (16yo)	79.9	88.0	84.2	81.5	75.8	81.1	84.7	81.8
2005 cohort (17yo)	75.3	87.5	82.7	84.1	78.1	81.8	82.4	85.2
2004 cohort (18yo)	83.1	85.2	85.5	85.9	75.6	82.8	80.5	86.5
2003 cohort (19yo)	76.1	86.5	82.4	82.4	76.7	83.0	76.2	84.8

* Calculated using the number of Medicare-registered adolescents in each year-wide cohort with an AIR record of having received a dose of HPV vaccine and an adolescent (i.e. ≥10 years of age) dose of a dTpa or DTPa vaccine given by 31 December 2022 (inclusive) as the numerator and the total number of Medicare-registered adolescents in the relevant age cohort as the denominator, expressed as a percentage.

** Age assessed as at 31 December 2022.

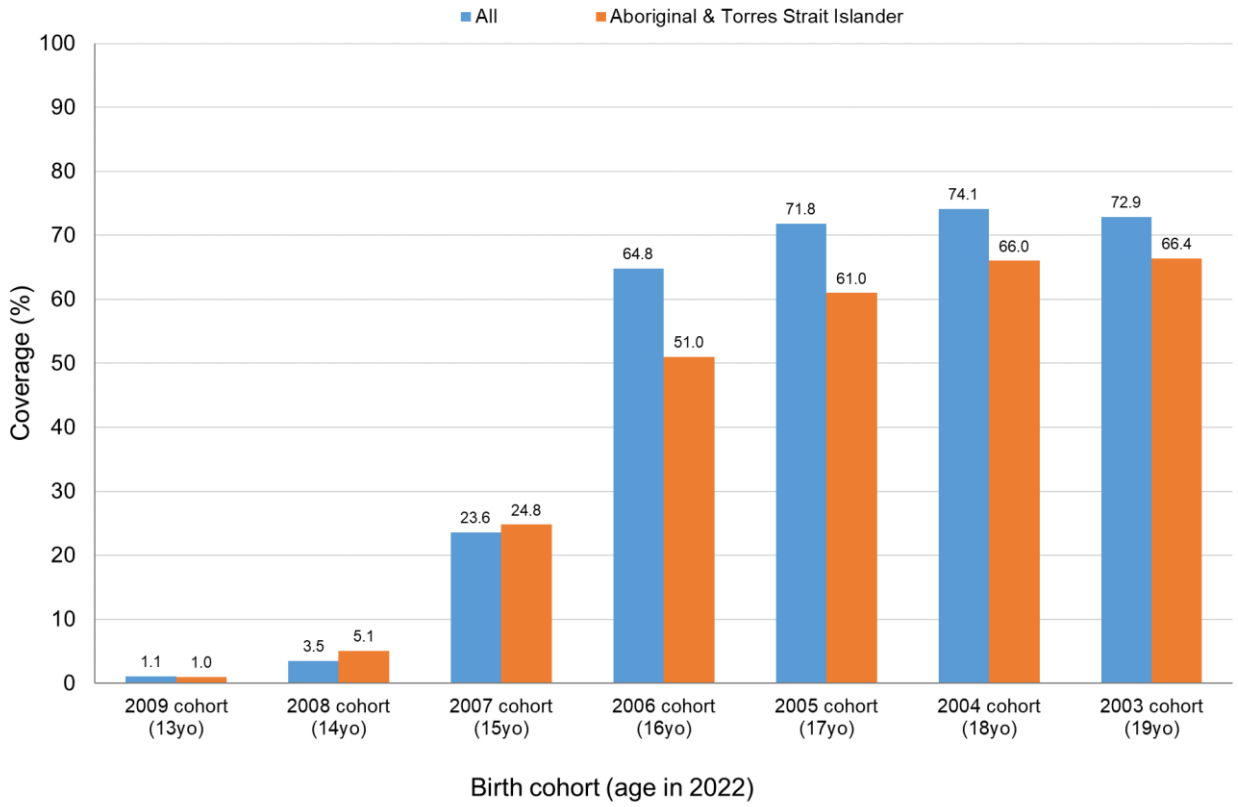
Source: Australian Immunisation Register, data as at 8 January 2023.

HPV + diphtheria-tetanus-pertussis + meningococcal ACWY

Using a different composite measure (receipt of a dose of HPV vaccine and adolescent doses of diphtheria-tetanus-pertussis and meningococcal C containing vaccine), coverage was 23.6% in adolescents turning 15 years in 2022, 64.8% in those turning 16 years, 71.8% in those turning 17 years and 74.1% in those turning 18 years. Coverage in Aboriginal and Torres Strait Islander adolescents was one to two percentage points higher than overall coverage in adolescents turning 14 and 15 years in 2022, but lower in older cohorts, although disparity decreased with increasing age, ranging from 13.8 percentage points lower in those turning 16 years to 6.5 percentage points lower in those turning 19 years (Figure 8). Coverage varied by jurisdiction, with variation greatest in the younger cohorts, consistent with the patterns reported above for individual vaccine coverage (Table 9). Coverage in adolescents turning 18 years was above 70% in each jurisdiction overall, ranging from 70.7% in Queensland to 78.6% in the Australian Capital Territory, but in Aboriginal and Torres Strait Islander adolescents only in Tasmania (73.7%) and the Northern Territory (78.6%) (Table 9). Coverage calculated with meningococcal ACWY vaccine, rather than

meningococcal C containing vaccine, in the composite measure was approximately half a percentage point lower across age cohorts turning 16–19 years in 2022 (data not shown) – for example, 73.5% overall and 65.6% for Aboriginal and Torres Strait Islander adolescents turning 18 years in 2022.

Figure 8. Adolescent coverage calculated using a composite measure (dose of HPV vaccine and adolescent doses of diphtheria-tetanus-pertussis and meningococcal C containing vaccine)* by birth cohort/age and Aboriginal and Torres Strait Islander status, Australia, 2022**



* Calculated using the number of Medicare-registered adolescents in each year-wide cohort with an AIR record of having received a dose of HPV vaccine, and adolescent (i.e. ≥10 years of age) doses of dTpa or DTPa vaccine and meningococcal C containing vaccine given by 31 December 2022 (inclusive) as the numerator and the total number of Medicare-registered adolescents in the relevant age cohort as the denominator, expressed as a percentage.

** Age assessed as at 31 December 2022.

Source: Australian Immunisation Register, data as at 8 January 2023.

Table 9. Adolescent coverage calculated using a composite measure (dose of HPV vaccine and adolescent doses of diphtheria-tetanus-pertussis and meningococcal C containing vaccines)* by birth cohort/age, Aboriginal and Torres Strait Islander status and state/territory, 2022**

	All							
	ACT	**NSW**	**VIC**	**QLD**	**SA**	**WA**	**TAS**	**NT**
2009 cohort (13yo)	1.2	1.0	1.3	0.9	0.5	1.8	0.9	3.9
2008 cohort (14yo)	2.2	1.9	2.7	2.1	2.8	3.8	39.9	25.7
2007 cohort (15yo)	22.2	19.8	14.9	28.0	24.1	34.0	63.0	61.1
2006 cohort (16yo)	74.5	62.9	65.8	61.3	70.6	67.1	74.8	71.2
2005 cohort (17yo)	78.8	70.7	73.1	68.6	77.0	73.7	74.9	74.5
2004 cohort (18yo)	78.6	74.6	74.8	70.7	76.5	75.9	73.2	75.1
2003 cohort (19yo)	73.1	74.3	75.0	70.3	63.4	75.9	69.0	70.3
	Aboriginal and Torres Strait Islander							
	ACT	**NSW**	**VIC**	**QLD**	**SA**	**WA**	**TAS**	**NT**
2009 cohort (13yo)	0.0	0.3	1.1	0.3	0.3	3.6	0.5	3.0
2008 cohort (14yo)	1.4	0.4	1.4	3.1	3.2	7.3	41.1	17.0
2007 cohort (15yo)	11.9	10.8	9.8	27.8	20.3	30.2	61.0	59.7
2006 cohort (16yo)	53.5	44.6	43.7	50.8	48.5	51.4	73.7	73.2
2005 cohort (17yo)	54.5	56.0	54.9	62.6	56.5	58.2	74.2	78.8
2004 cohort (18yo)	67.6	62.6	62.5	66.8	57.8	65.4	73.8	78.6
2003 cohort (19yo)	61.0	65.1	61.9	66.5	53.7	69.0	67.9	74.5

* Coverage is calculated using the number of Medicare-registered adolescents in each year-wide cohort with an AIR record of having received a dose of HPV vaccine, and adolescent (i.e. ≥10 years of age) doses of dTpa or DTPa vaccine and meningococcal C containing vaccine given by 31 December 2022 (inclusive) as the numerator and the total number of Medicare-registered adolescents in the relevant age cohort as the denominator, expressed as a percentage.

** Age assessed as at 31 December 2022.

Source: Australian Immunisation Register, data as at 8 January 2023.

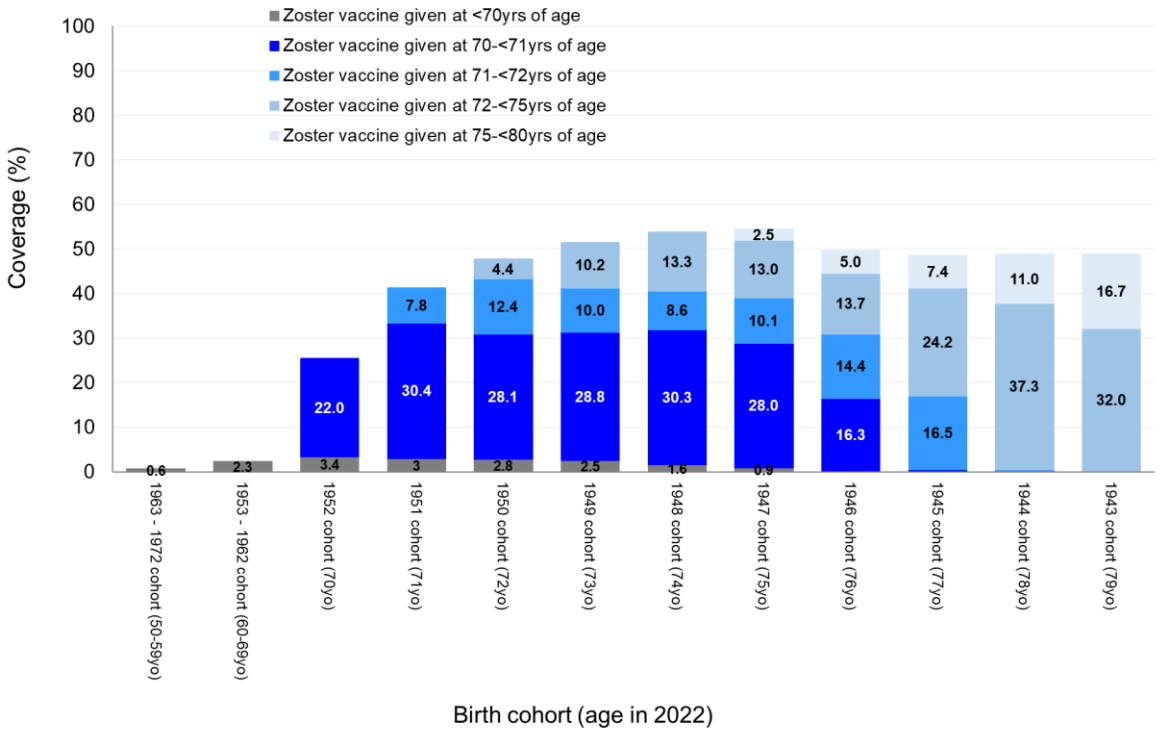
Adult vaccination coverage

Zoster vaccine – appropriate age/s to assess to optimise timeliness and utility

A single dose of Zostavax vaccine has been funded on the NIP since November 2016 for all adults at 70 years of age and via a catch-up program for adults aged 71–79 years. Shingrix vaccine has been available on the private market since June 2021. We assessed coverage as receipt of either one dose of Zostavax vaccine or two doses of Shingrix.

The majority of adults turning 70–75 years in 2022 who had received zoster vaccine by 31 December 2022 were vaccinated at the 70-year schedule point, although with a substantial proportion vaccinated through the catch-up program, whereas adults turning 76–79 years were predominantly vaccinated through the catch-up program (Figure 9). Coverage was highest for adults turning 75 years (54.5% overall, ranging from 37.4% in the Northern Territory to 63.7% in the Australian Capital Territory [Table 10]). Coverage patterns were similar for Aboriginal and Torres Strait Islander adults (Figure 10).

Figure 9. Zoster vaccination coverage* in adults by birth cohort and age at vaccination, Australia, 2022**

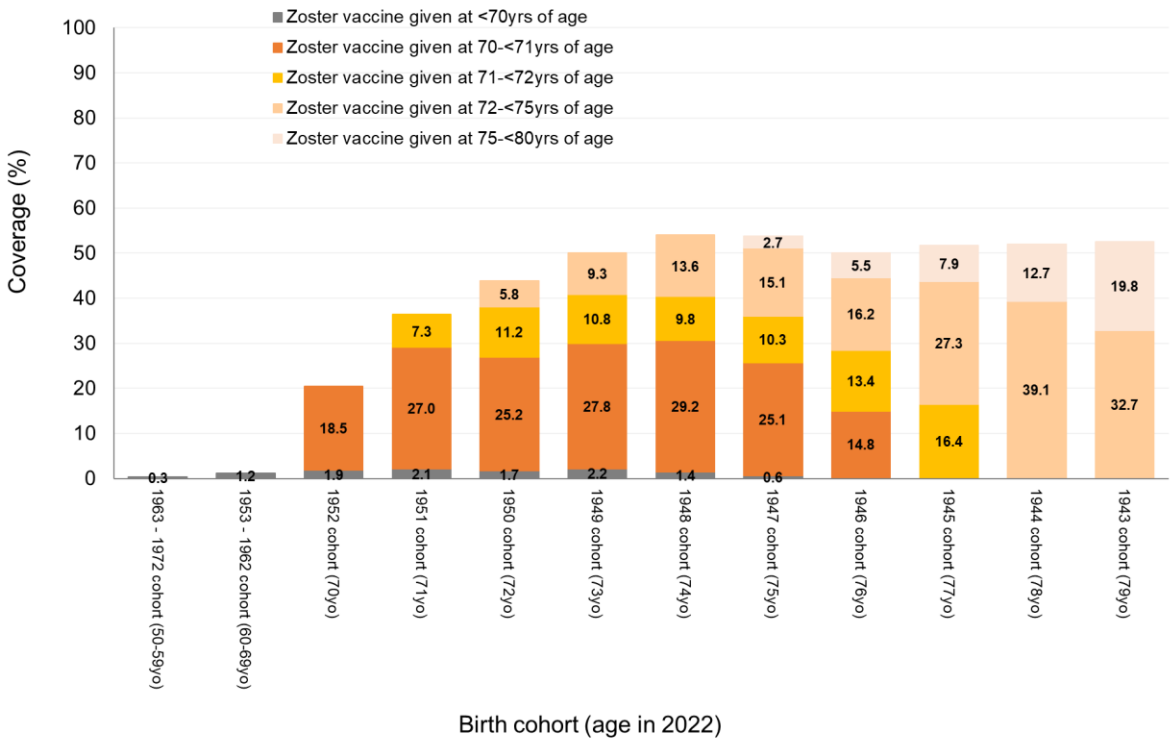


* Calculated using the number of Medicare-registered adults in each cohort with an AIR record of having received either 1 dose of Zostavax vaccine or 2 doses of Shingrix vaccine as the numerator and the total number of Medicare-registered adults in the relevant cohort as the denominator, expressed as a percentage. Vaccinations given up to 31 December 2022 (inclusive) are included in the numerator.

** Age assessed as at 31 December 2022.

Source: Australian Immunisation Register, data as at 8 January 2023.

Figure 10. Zoster vaccination coverage* in Aboriginal and Torres Strait Islander adults by birth cohort** and age at vaccination, Australia, 2022



* Calculated using the number of Medicare-registered adults in each cohort with an AIR record of having received either 1 dose of Zostavax vaccine or 2 doses of Shingrix vaccine as the numerator and the total number of Medicare-registered adults in the relevant cohort as the denominator, expressed as a percentage. Vaccinations given up to 31 December 2022 (inclusive) are included in the numerator.

** Age assessed as at 31 December 2022.

Source: Australian Immunisation Register, data as at 8 January 2023.

Table 10. Zoster vaccination coverage* in adults by birth cohort/age** and state/territory, Australia, 2022

	All							
	ACT	NSW	VIC	QLD	SA	WA	TAS	NT
1952 cohort (70yo)	29.5	23.3	24.4	29.2	29.7	23.7	27.6	12.0
1951 cohort (71yo)	44.9	36.1	38.4	52.5	46.6	37.3	43.7	21.8
1950 cohort (72yo)	58.2	42.6	44.5	59.1	53.3	43.4	49.8	24.3
1949 cohort (73yo)	60.2	46.8	48.8	61.5	55.7	47.9	54.8	31.2
1948 cohort (74yo)	60.9	49.0	51.8	63.0	58.2	51.1	58.4	36.5
1947 cohort (75yo)	63.7	50.3	52.0	61.7	58.3	53.7	61.1	37.4
1946 cohort (76yo)	55.9	45.3	47.1	56.5	55.4	49.9	53.7	33.6
1945 cohort (77yo)	55.7	44.1	45.8	55.6	54.1	49.9	52.6	31.9
1944 cohort (78yo)	55.3	44.7	45.8	55.6	54.8	49.8	52.7	33.7
1943 cohort (79yo)	54.9	45.0	45.9	55.3	54.7	50.3	51.7	33.9

* Calculated using the number of Medicare-registered adults in each age cohort with an AIR record of having received either 1 dose of Zostavax vaccine or 2 doses of Shingrix vaccine as the numerator and the total number of Medicare-registered adults in the relevant age cohort as the denominator, expressed as a percentage. Vaccinations given up to 31 December 2022 (inclusive) are included in the numerator.

** Age assessed as at 31 December 2022.

Note: Aboriginal and Torres Strait Islander data are not presented by jurisdiction due to the relatively small denominators.

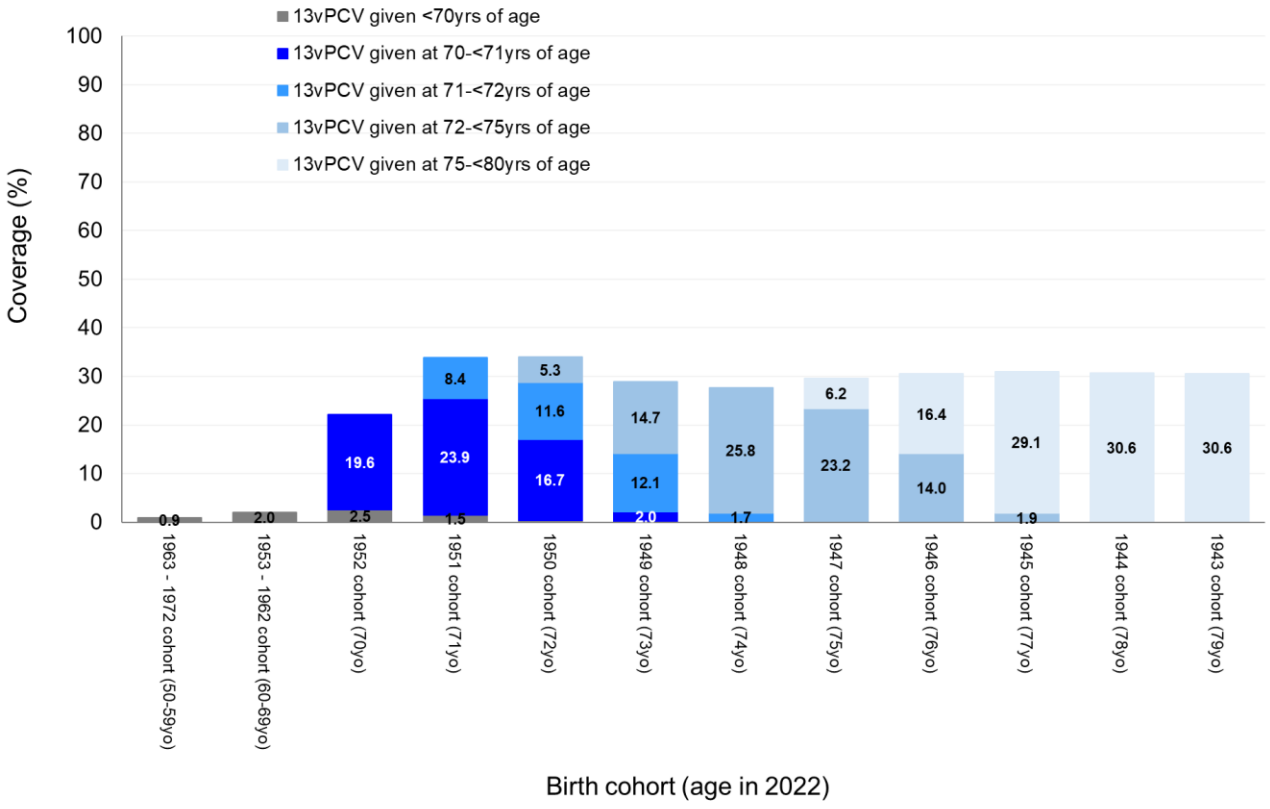
Source: Australian Immunisation Register, data as at 8 January 2023.

13vPCV – appropriate age/s to assess to optimise timeliness and utility

A single dose of 13vPCV has been funded on the NIP since July 2020 for all adults from 70 years of age and all Aboriginal and Torres Strait Islander adults from 50 years of age. Prior to this 23vPPV was funded for all adults from 65 years of age and Aboriginal and Torres Strait Islander adults from 50 years. We assessed coverage as receipt of a single dose of 13vPCV.

Overall 13vPCV coverage was 22.1% in adults turning 70 in 2022 and 33.8% in those turning 71, with a high proportion of doses in both these cohorts given at 70 years of age and coverage a few percentage points lower in older cohorts (Figure 11). Coverage in each jurisdiction was highest either in those turning 71 or 72 years (Table 11). Coverage in Aboriginal and Torres Strait Islander adults was 13.8% in those turning 50–59 years in 2022, 18.4% in those turning 60–69 years, 29.1% in those turning 70 years, 37.9% in those turning 71 and 72 years and several percentage points lower in older cohorts, with great variation in age at vaccination (Figure 12).

Figure 11. 13vPCV coverage* in adults by birth cohort and age at vaccination, Australia, 2022**

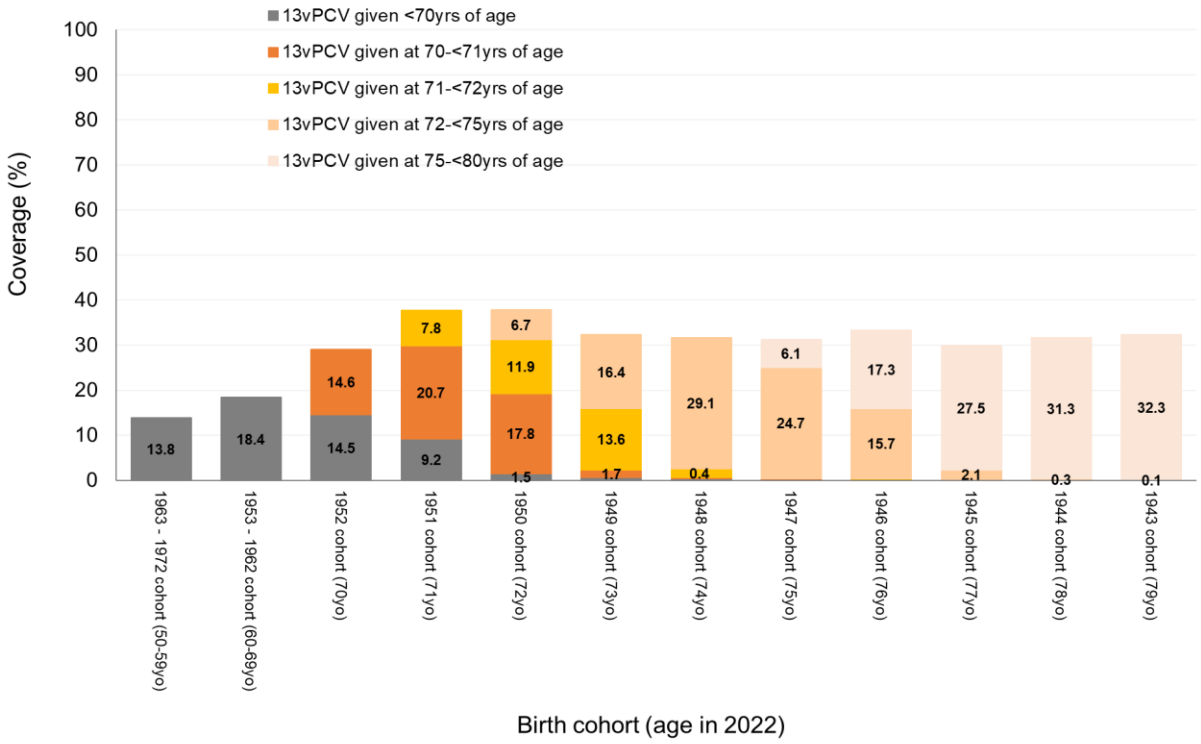


* Calculated using the number of Medicare-registered adults in each age cohort with an AIR record of having received a dose of 13vPCV as the numerator and the total number of Medicare-registered adults in the relevant age cohort as the denominator, expressed as a percentage. Vaccinations given up to 31 December 2022 (inclusive) are included in the numerator.

** Age assessed as at 31 December 2022.

Source: Australian Immunisation Register, data as at 8 January 2023.

Figure 12. 13vPCV coverage* in Aboriginal and Torres Strait Islander adults by birth cohort** and age of vaccination, Australia, 2022



* Calculated using the number of Medicare-registered adults in each age cohort with an AIR record of having received a dose of 13vPCV as the numerator and the total number of Medicare-registered adults in the relevant age cohort as the denominator, expressed as a percentage. Vaccinations given before or after 71 years of age and up to 31 December 2022 (inclusive) are included in the numerator.

** Age assessed as at 31 December 2022.

Source: Australian Immunisation Register, data as at 8 January 2023.

Table 11. 13vPCV coverage* in adults by birth cohort/age** and state/territory, Australia, 2022

	All							
	ACT	NSW	VIC	QLD	SA	WA	TAS	NT
1952 cohort (70yo)	25.9	19.4	20.8	25.3	27.7	21.5	27.5	15.2
1951 cohort (71yo)	39.4	29.0	32.8	38.1	42.5	33.4	41.6	22.6
1950 cohort (72yo)	39.2	29.2	34.2	36.6	43.9	34.7	41.8	19.5
1949 cohort (73yo)	32.6	24.9	30.0	28.9	39.2	29.4	36.1	17.4
1948 cohort (74yo)	31.4	23.7	28.9	27.5	37.9	28.7	34.3	17.4
1947 cohort (75yo)	34.0	25.4	30.4	29.9	39.0	29.7	38.0	18.5
1946 cohort (76yo)	35.4	26.1	31.4	31.1	40.6	31.4	36.2	18.7
1945 cohort (77yo)	35.7	26.8	31.4	32.1	40.6	32.6	37.3	16.4
1944 cohort (78yo)	36.4	26.4	31.6	31.2	41.0	31.9	36.6	16.5
1943 cohort (79yo)	33.9	26.3	31.2	31.3	41.4	32.3	38.8	16.0

* Calculated using the number of Medicare-registered adults in each age cohort with an AIR record of having received a dose of 13vPCV as the numerator and the total number of Medicare-registered adults in the relevant age cohort as the denominator, expressed as a percentage. Vaccinations given before or after 71 years of age and up to 31 December 2022 (inclusive) are included in the numerator.

** Age assessed as at 31 December 2022.

Note: Coverage for Aboriginal and Torres Strait Islander adults by jurisdiction is not presented due to relatively small denominators.

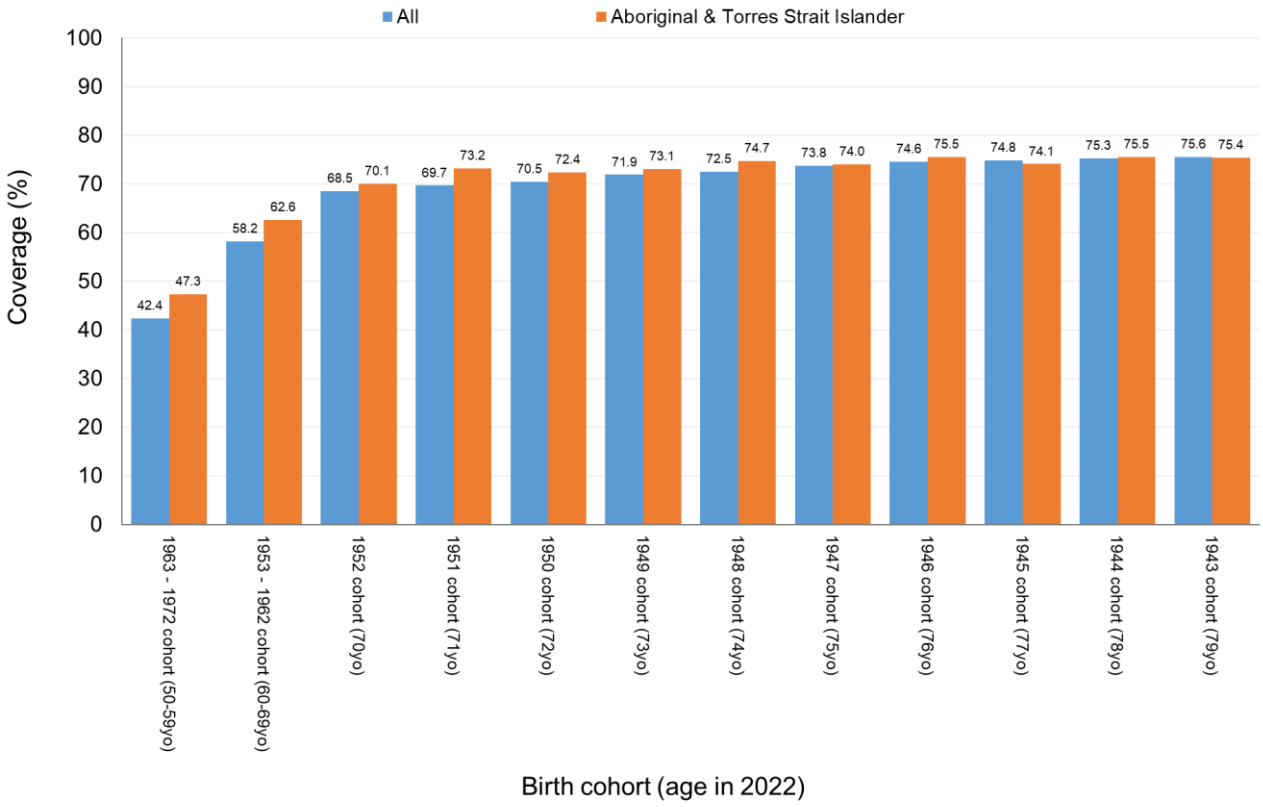
Source: Australian Immunisation Register, data as at 8 January 2023.

Seasonal influenza vaccine

Under the NIP, influenza vaccination is funded annually for all adults aged ≥65 years, and all Aboriginal and Torres Strait Islander individuals aged ≥6 months. We assessed coverage as receipt of ≥1 dose of influenza vaccine in 2022.

Coverage of influenza vaccine received in 2022 for cohorts turning 50–79 years in 2022 increased with increasing age, reaching 75.6% overall in those turning 79 years, with coverage in Aboriginal and Torres Strait Islander adults aged 50–76 years higher than overall coverage (Figure 13). Coverage varied by jurisdiction in 2022, with overall coverage in the Northern Territory approximately 30 percentage points lower in each age cohort (Table 12).

Figure 13. Seasonal influenza vaccination coverage* by birth cohort/age and Aboriginal and Torres Strait Islander status, Australia, 2022**



* Calculated using the number of Medicare-registered adults in each age cohort with an AIR record of having received a dose of seasonal influenza vaccine between 1 January – 31 December 2022 (inclusive) as the numerator and the total number of Medicare-registered adults in the relevant age cohort as the denominator, expressed as a percentage.

** Age assessed as at 31 December 2022.

Source: Australian Immunisation Register, data as at 8 January 2023.

Table 12. Seasonal influenza vaccination coverage* by birth cohort/age** and state/territory, 2022

	All							
	ACT	**NSW**	**VIC**	**QLD**	**SA**	**WA**	**TAS**	**NT**
1952 cohort (70yo)	71.4	66.0	70.3	67.6	76.1	67.8	75.7	43.7
1951 cohort (71yo)	72.5	67.4	71.3	68.8	76.9	69.5	76.0	48.1
1950 cohort (72yo)	73.2	67.9	72.3	69.9	77.8	70.2	77.8	41.4
1949 cohort (73yo)	73.6	69.4	73.2	71.5	78.4	72.1	78.5	47.0
1948 cohort (74yo)	73.5	69.9	74.0	72.4	79.2	72.1	79.5	47.0
1947 cohort (75yo)	76.5	71.7	74.5	73.4	80.1	73.9	80.3	50.7
1946 cohort (76yo)	77.6	72.1	75.7	74.6	81.2	74.7	80.2	46.7
1945 cohort (77yo)	77.3	72.7	75.3	75.0	80.6	75.2	80.8	43.0
1944 cohort (78yo)	78.0	73.4	76.2	74.7	82.1	75.7	80.1	44.6
1943 cohort (79yo)	76.3	73.5	76.3	75.4	81.5	76.9	81.2	45.9

* Calculated using the number of Medicare-registered adults in each age cohort with an AIR record of having received a dose of seasonal influenza vaccine between 1 January – 31 December 2022 (inclusive) as the numerator and the total number of Medicare-registered adults in the relevant age cohort as the denominator, expressed as a percentage.

** Age assessed as at 31 December 2022.

Note: Coverage for Aboriginal and Torres Strait Islander adults by jurisdiction is not presented due to relatively small denominators.

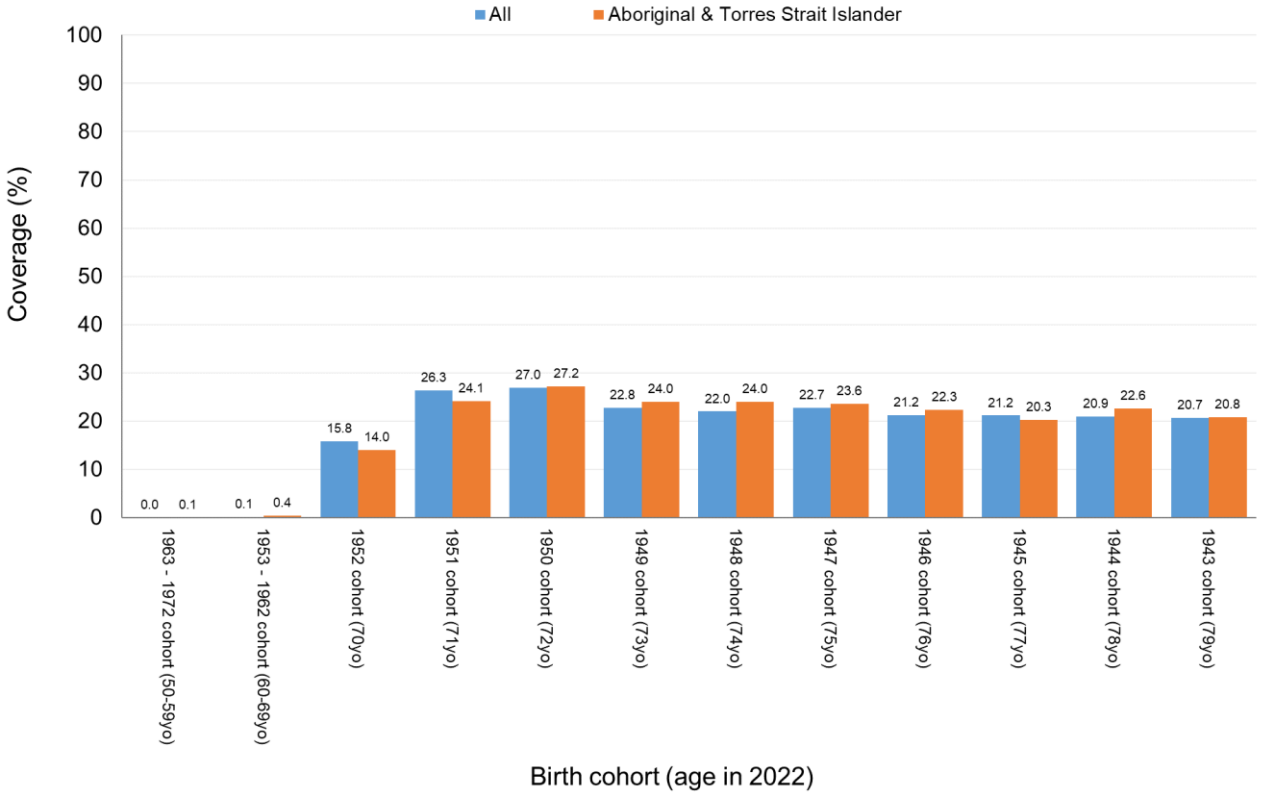
Source: Australian Immunisation Register, data as at 8 January 2023.

Adult composite measures of vaccination coverage

Zoster + 13vPCV

Using a composite measure (receipt of either 1 dose of Zostavax or 2 doses of Shingrix, plus an adult dose of 13vPCV), coverage was 15.8% overall in adults turning 70 years in 2022, 26.3% in those turning 71 years, and 27.0% in those turning 72 years, with coverage in older cohorts several percentage points lower (Figure 14). Coverage in Aboriginal and Torres Strait Islander adults followed a similar pattern (Figure 14). Coverage varied by jurisdiction, with coverage for each age cohort notably lower in the Northern Territory than other jurisdictions (Table 13).

Figure 14. Adult coverage calculated using composite measure (a dose of Zostavax or 2 doses of Shingrix vaccine, plus an adult dose of 13vPCV)* by birth cohort/age and Aboriginal and Torres Strait Islander status, Australia, 2022**



* Calculated using the number of Medicare-registered adults in each age cohort with an AIR record of having received either 1 dose of Zostavax vaccine or 2 doses of Shingrix vaccine, plus an adult dose of 13vPCV as the numerator and the total number of Medicare-registered adults in the relevant age cohort as the denominator, expressed as a percentage. Vaccinations given up to 31 December 2022 (inclusive) are included in the numerator.

** Age assessed as at 31 December 2022.

Source: Australian Immunisation Register, data as at 8 January 2023.

Table 13. Adult coverage calculated using composite measure (a dose of Zostavax or 2 doses of Shingrix vaccine, plus an adult dose of 13vPCV)* by birth cohort/age** and state/territory, Australia, 2022

	All							
	ACT	**NSW**	**VIC**	**QLD**	**SA**	**WA**	**TAS**	**NT**
1952 cohort (70yo)	19.5	13.6	14.4	19.0	20.6	15.1	19.7	7.7
1951 cohort (71yo)	31.8	22.2	24.3	32.6	33.6	24.9	31.5	14.1
1950 cohort (72yo)	33.0	22.9	25.5	31.7	35.4	26.1	31.6	13.4
1949 cohort (73yo)	27.0	19.4	22.6	24.8	31.2	22.5	27.4	12.1
1948 cohort (74yo)	26.5	18.5	22.0	23.6	30.3	22.3	26.6	13.1
1947 cohort (75yo)	28.2	19.3	22.0	24.9	30.4	23.0	29.2	14.2
1946 cohort (76yo)	26.7	18.0	20.2	23.4	28.8	22.3	24.7	13.2
1945 cohort (77yo)	26.1	18.1	19.7	23.7	28.3	22.7	25.4	12.0
1944 cohort (78yo)	26.8	17.6	19.8	23.2	28.9	22.4	24.2	11.8
1943 cohort (79yo)	24.8	17.5	19.3	23.0	28.7	22.5	25.4	12.0

* Calculated using the number of Medicare-registered adults in each age cohort with an AIR record of having received either 1 dose of Zostavax vaccine or 2 doses of Shingrix vaccine, plus a dose of 13vPCV as the numerator and the total number of Medicare-registered adults in the relevant age cohort as the denominator, expressed as a percentage. Vaccinations given up to 31 December 2022 (inclusive) are included in the numerator.

** Age assessed as at 31 December 2022.

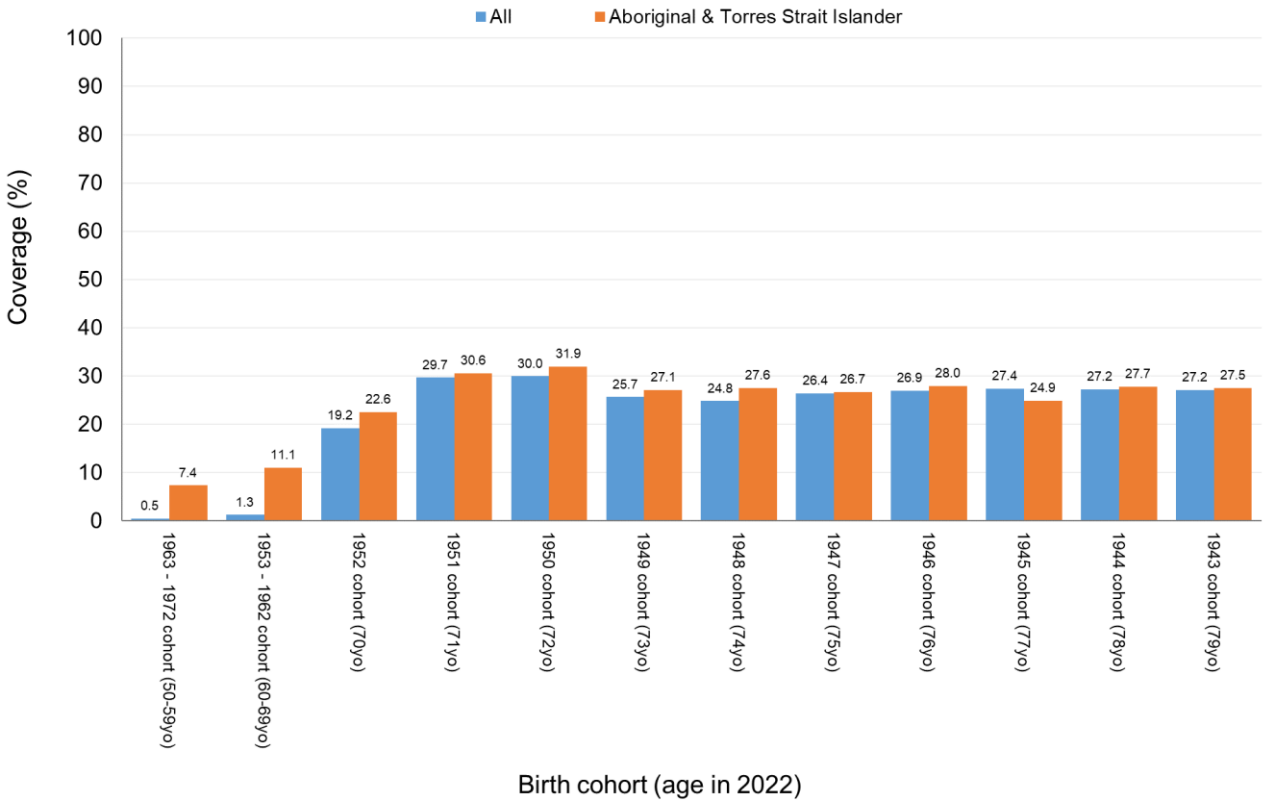
Note: Coverage for Aboriginal and Torres Strait Islander adults by jurisdiction is not presented due to relatively small denominators.

Source: Australian Immunisation Register, data as at 8 January 2023.

13vPCV + influenza

Using a different composite measure (receipt of an adult dose of 13vPCV, and a dose of influenza vaccine given in 2022), coverage was 19.2% overall for adults turning 70 years in 2022, 29.7% for those turning 71 years and 30.0% for those turning 72 years, with coverage in older cohorts several percentage points lower (Figure 15). Coverage in Aboriginal and Torres Strait Islander adults followed a similar pattern and was higher in most age cohorts (Figure 15). Coverage varied by jurisdiction, with coverage for each age cohort notably lower in the Northern Territory than other jurisdictions (Table 14).

Figure 15. Adult coverage calculated using composite measure (adult dose of 13vPCV, plus dose of influenza vaccine given in 2022) by birth cohort/age and Aboriginal and Torres Strait Islander status, Australia, 2022**



* Calculated using the number of Medicare-registered adults in each age cohort with an AIR record of having received an adult dose of 13vPCV, and a dose of seasonal influenza vaccine (given in 2022) as the numerator and the total number of Medicare-registered adults in the relevant age cohort as the denominator, expressed as a percentage. 13vPCV vaccinations up to 31 December 2022 (inclusive) are included in the numerator. Seasonal influenza vaccinations 1 January – 31 December 2022 (inclusive) are included in the numerator.

** Age assessed as at 31 December 2022.

Source: Australian Immunisation Register, data as at 8 January 2023.

Table 14. Adult coverage calculated using composite measure (adult dose of 13vPCV, plus influenza vaccine given in 2022)* by birth cohort/age** and state/territory, Australia, 2022

	All							
	ACT	**NSW**	**VIC**	**QLD**	**SA**	**WA**	**TAS**	**NT**
1952 cohort (70yo)	23.0	16.7	18.1	21.8	24.8	18.7	23.8	11.4
1951 cohort (71yo)	35.2	25.4	28.8	33.6	38.2	29.3	36.3	17.9
1950 cohort (72yo)	35.0	25.5	30.1	32.2	39.9	30.3	36.8	14.9
1949 cohort (73yo)	29.4	21.9	26.7	25.6	35.7	26.3	32.0	14.0
1948 cohort (74yo)	28.5	21.0	26.1	24.7	34.4	25.7	30.5	14.1
1947 cohort (75yo)	30.4	22.6	27.1	26.9	35.7	26.9	34.2	15.7
1946 cohort (76yo)	31.3	22.8	27.8	27.5	36.7	28.2	31.6	15.7
1945 cohort (77yo)	31.8	23.4	27.9	28.4	36.7	29.0	32.8	13.7
1944 cohort (78yo)	32.2	23.2	28.1	27.5	37.1	28.8	31.6	14.0
1943 cohort (79yo)	30.6	23.0	27.8	27.6	37.2	28.8	34.3	14.4

* Calculated using the number of Medicare-registered adults in each age cohort with an AIR record of having received an adult dose of 13vPCV and a dose of seasonal influenza vaccine (given in 2022) as the numerator and the total number of Medicare-registered adults in the relevant age cohort as the denominator, expressed as a percentage. 13vPCV vaccinations up to 31 December 2022 (inclusive) are included in the numerator. Seasonal influenza vaccinations 1 January – 31 December 2022 (inclusive) are included in the numerator.

** Age assessed as at 31 December 2022.

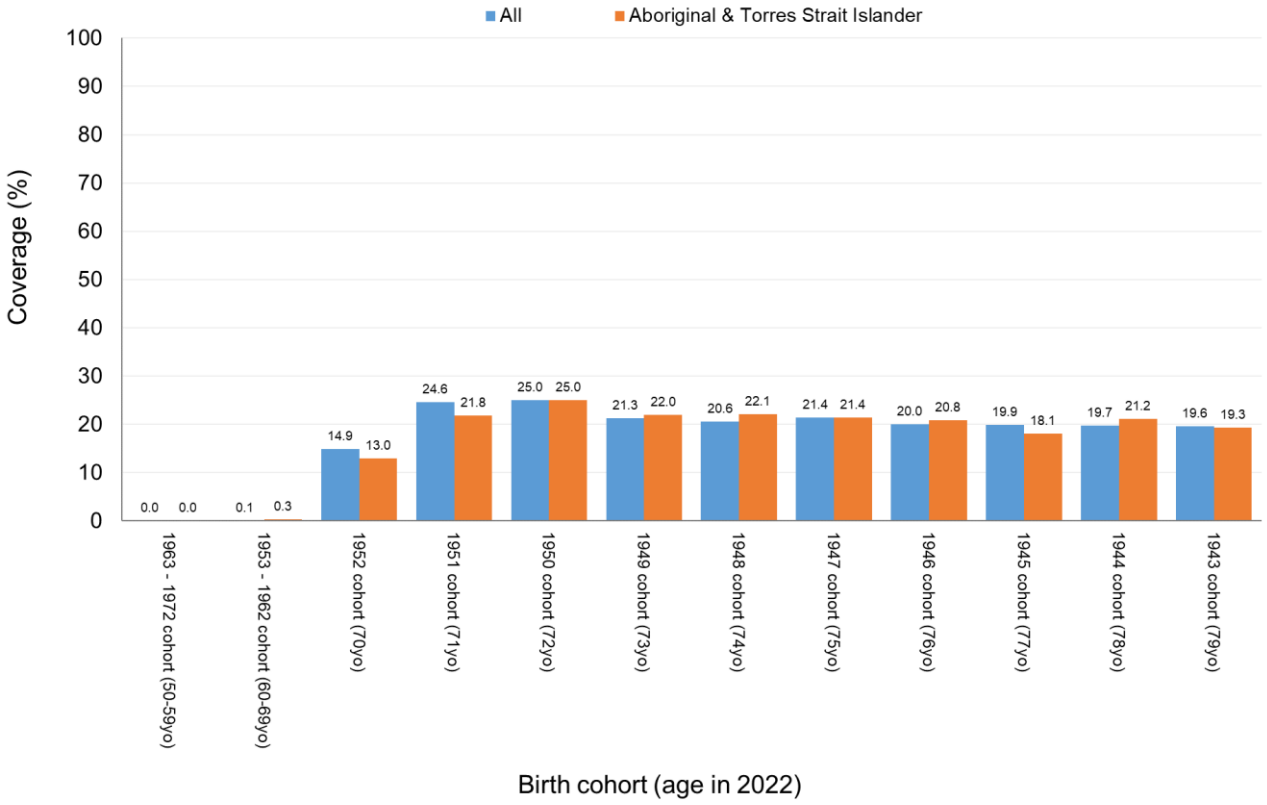
Note: Coverage for Aboriginal and Torres Strait Islander adults by jurisdiction is not presented due to relatively small denominators.

Source: Australian Immunisation Register, data as at 8 January 2023.

Zoster + 13vPCV + influenza

Using a third composite measure (receipt of either 1 dose of Zostavax or 2 doses of Shingrix, an adult dose of 13vPCV, and a dose of influenza vaccine given in 2022), coverage was 14.9% overall for adults turning 70 years in 2022, 24.6% for those turning 71 years and 25.0% for those turning 72 years, with coverage in older cohorts several percentage points lower (Figure 16). Coverage varied by jurisdiction, with coverage for each age cohort notably lower in the Northern Territory than other jurisdictions (Table 15).

Figure 16. Adult coverage calculated using composite measure (1 dose of Zostavax or 2 doses of Shingrix, an adult dose of 13vPCV, plus influenza vaccine given in 2022) by birth cohort/age and Aboriginal and Torres Strait Islander status, Australia, 2022**



* Coverage is calculated using the number of Medicare-registered adults in each age cohort with an AIR record of having received either 1 dose of Zostavax vaccine or 2 doses of Shingrix vaccine, a dose of 13vPCV, and a dose of seasonal influenza vaccine (given in the previous 12 months) as the numerator and the total number of Medicare-registered adults in the relevant age cohort as the denominator, expressed as a percentage. Zoster vaccine and 13vPCV given before or after 71 years of age and up to 31 December 2022 (inclusive) are included in the numerator. Seasonal influenza vaccine given 1 January – 31 December 2022 (inclusive) are included in the numerator.

** Age assessed as at 31 December 2022.

Source: Australian Immunisation Register, data as at 8 January 2023.

Table 15. Coverage* for a third adult composite measure (Zostavax or Shingrix, plus 13vPCV plus influenza vaccine)* by birth cohort/age** and state/territory, 2022

	All							
	ACT	**NSW**	**VIC**	**QLD**	**SA**	**WA**	**TAS**	**NT**
1952 cohort (70yo)	18.7	12.8	13.6	17.8	19.7	14.3	18.6	6.9
1951 cohort (71yo)	30.1	20.7	22.9	30.1	31.8	23.2	29.2	13.0
1950 cohort (72yo)	30.9	21.2	23.9	29.0	33.6	24.3	29.5	12.0
1949 cohort (73yo)	25.5	18.0	21.2	23.0	29.8	21.3	25.9	11.0
1948 cohort (74yo)	25.2	17.2	20.8	22.0	28.8	20.9	25.0	11.4
1947 cohort (75yo)	26.9	18.1	20.7	23.3	29.0	21.7	27.6	13.0
1946 cohort (76yo)	25.2	16.9	19.1	21.9	27.6	21.1	23.4	12.1
1945 cohort (77yo)	25.1	17.0	18.6	22.3	27.0	21.3	23.9	10.6
1944 cohort (78yo)	25.6	16.6	18.8	21.7	27.5	21.3	22.8	10.8
1943 cohort (79yo)	23.5	16.5	18.4	21.6	27.3	21.3	24.1	11.1

* Calculated using the number of Medicare-registered adults in each age cohort with an AIR record of having received either 1 dose of Zostavax vaccine or 2 doses of Shingrix vaccine, an adult dose of 13vPCV, and a dose of seasonal influenza vaccine (given in 2022) as the numerator and the total number of Medicare-registered adults in the relevant age cohort as the denominator, expressed as a percentage. Zoster and 13vPCV vaccinations given up to 31 December 2022 (inclusive) are included in the numerator. Seasonal influenza vaccinations given 1 January – 31 December 2022 (inclusive) are included in the numerator.

** Age assessed as at 31 December 2022.

Note: Coverage for Aboriginal and Torres Strait Islander adults by jurisdiction is not presented due to relatively small denominators.

Lag period – analysis of options to enhance timeliness of adolescent and adult data

Vaccination coverage calculations in Australia have traditionally been undertaken using a 3-month lag period – that is, AIR data from 3 months after the end of the relevant period are used to allow for delayed notifications of vaccination encounters to AIR. However, for all individual vaccine and composite measures assessed there was minimal difference in coverage when using a shorter 1-month lag period compared with 3 months, for all age milestones assessed and by Aboriginal and Torres Strait Islander status (Table 16).

Table 16. Vaccination coverage (%) in adolescents and adults by vaccine/composite measure, age assessment milestone, and Aboriginal and Torres Strait Islander status, comparing 3-month and 1-month lag periods, 2022, Australia

Vaccine / composite measure	Age milestone	Data as at 3 April 2022 (3-month lag)		Data as at 6 February 2022 (1-month lag)	
		All	Aboriginal and Torres Strait Islander	All	Aboriginal and Torres Strait Islander
HPV Dose 1	15 years*	85.7	84.1	85.7	84.2
dTpa	15 years*	88.0	85.3	88.0	85.3
Adolescent composite measure of coverage (HPV Dose 1 + dTpa)	15 years*	84.3	82.2	84.3	82.2
meningococcal ACWY	17 years**	76.1	57.8	76.1	58.1
Adolescent composite measure of coverage (HPV Dose 1 + dTpa + meningococcal ACWY)	17 years**	70.1	52.7	70.1	52.9
Zoster	70 years#	30.6	26.5	30.5	26.6
13vPCV	70 years#	17.2	18.8	17.1	19.0
Flu in previous 12 mths	70 years#	64.6	66.4	64.6	66.5
Adult composite measure of coverage (Zoster + 13vPCV)	70 years#	17.8	15.9	17.7	15.9
Adult composite measure of coverage (Zoster + 13vPCV + Flu in previous 12 mths)	70 years#	16.1	13.8	16.1	13.8

* Adolescent cohort born in 2007 (aged 15 years in 2022).
** Adolescent cohort born in 2005 (aged 17 years in 2022).
# Adult cohort born in 1951 (turning 71 years in 2022).

Source: Australian Immunisation Register, data as at 3 April 2022 for 3-month lag data and 6 February 2022 for 1-month lag data.

MADIP-linked data analysis

Currently the AIR-MADIP data platform is not routinely linked to validated disease-specific databases to enable the ascertainment of medically at-risk groups, limiting the capacity to examine vaccine coverage by such characteristics. However, within the MADIP, linked 2021 Census, MBS and Pharmaceutical Benefit Scheme (PBS) data could be used either as self-reported or proxy measures of some comorbidities. The 2021 Census included questions on whether individuals had been told by a doctor or nurse that they had certain conditions (arthritis, asthma, cancer, dementia, diabetes, heart disease, kidney disease, lung condition, mental health condition, stroke). The MBS contains information on medical services that can relate to a specific condition and the PBS data have been used to identify comorbid conditions[57] and to calculate comorbidity risk scores. While these self-reported and proxy measures can have some utility in very specific circumstances, there are still significant limitations to using these data to identify medically at-risk populations for coverage assessment.

NCIRS worked with HERD on the use of MBS item numbers for pregnancy ultrasound as a proxy for pregnancy at a particular gestation in order to assess pregnancy-related COVID-19 vaccine uptake. While the MBS item number was a crude measure and used in some internal reporting by the Department on vaccine uptake during pregnancy to stakeholders, it was limited in that not all women who are pregnant would have had an MBS-billed ultrasound, not all women with an MBS-billed ultrasound go on to complete the pregnancy, and there is imprecision regarding the timing of the ultrasound in relation to weeks of gestation. Linkage to perinatal data collected at a jurisdictional level on all births of at least 20 weeks' gestation to ascertain pregnancy-related vaccine coverage would be preferable and significantly more accurate in understanding uptake in this population.

PBS data have been used previously to ascertain conditions, such as diabetes,[58] where prescription drug use is strongly associated with a diagnosis. More recently, PBS data have been used to calculate comorbidity scores (Rx-risk) and potentially to identify medical risk conditions.[57] A validation project was conducted by researchers at the University of South Australia on the MADIP comparing some specified medical conditions identified using the PBS-based Rx-risk algorithms to hospital ICD-10 diagnostic codes in the National Integrated Health Services Information (NIHSI) Analysis Asset and self-reported conditions from the National Health Survey and Survey of Disability, Ageing and Caring (SDAC). This analysis found that using the Rx-risk, based on PBS data, was a reasonable proxy for some specific conditions (compared with self-report), but for many conditions it was still a poor indicator of disease. Self-report of chronic conditions collected on the 2021 Census[59] could also be used to identify adolescents and adults

with specific comorbidities, but the specificity of the comorbidity ascertained through the 2021 Census questions does not necessarily align with the definitions for medically at-risk conditions in the recommendations for targeted vaccination. For example, the Census asks people to self-report if they have a long-term ‘lung condition (including COPD or emphysema)’, but targeted pneumococcal vaccine recommendations list ‘chronic respiratory disease with specific inclusions’. Also, there are known limitations to self-reported medical conditions.

Discussion

Our review of published and grey literature found limited evidence on assessment and reporting of adolescent and adult vaccination coverage overseas, with HPV vaccination coverage most commonly assessed and reported in adolescents and influenza vaccination coverage in adults. Based on these findings Australia has some of the most comprehensive public reporting globally, predominantly via the NCIRS annual coverage reports, although this reporting has been in place for a much shorter time than for children and is much less extensive.

The key stakeholders we interviewed perceived the whole-of-life AIR to be a key asset allowing comparison of coverage data across Australian jurisdictions and internationally. Stakeholders considered current reporting of adolescent and adult vaccination coverage in Australia to be useful, particularly so in relation to the comprehensive reporting of adolescent HPV vaccination coverage,[60] but recommended more regular and timely reporting of coverage (especially in adolescents) and more geographical granularity.

Stakeholders strongly supported regular assessment and reporting of coverage both in Aboriginal and Torres Strait Islander adolescents and adults and in those medically at-risk, for whom additional vaccinations are funded under the NIP. Stakeholders also considered it would be useful to assess and report coverage in other key groups, such as CALD populations and aged/disability care residents. While coverage in Aboriginal and Torres Strait Islander adolescents and adults is already reported to some extent using the AIR, coverage in medically at-risk and other key groups is not able to be assessed using the AIR alone, with the AIR being linked to other datasets the most obvious route. Based on our work with HERD in this space, there are a small number of medical conditions, such as diabetes, that could be ascertained through proxy measures such as PBS and MBS codes using the currently available linked data in MADIP, and used for reporting of vaccination coverage in some adolescent and adult medically at-risk groups. However, linkage to morbidity data collections (such as for hospitalisation ICD-coded discharge data), or perinatal data collections for pregnancy vaccine uptake, would provide substantially more comprehensive and reliable information on medically at-risk groups to allow the monitoring of uptake in medically at-risk populations against objectives under the NIP. Other key groups, such as aged/disability care residents and CALD populations, can be at higher risk of vaccine preventable diseases and/or have lower uptake requiring targeted strategies. Within MADIP, linkage to the 2021 Census and other databases such as Commonwealth aged care data and the National Disability Insurance Scheme provides opportunities to better understand vaccination coverage in these populations. Work led by HERD has provided proof-of-concept of the capacity of linked data to better

characterise COVID-19 vaccination coverage in these groups. These methods could be extended to assessment of NIP vaccine coverage.

A finding of particular note from our literature review was the use, in the United States, of composite measures to assess coverage for vaccinations recommended in adolescents and adults,[24,26,33] an approach which has not been used in public reporting to date in Australia, although 'fully vaccinated' coverage has been reported in children for decades. Focusing composite measures on vaccinations routinely scheduled in the relevant age group (adolescents or adults), as is the case in the United States examples cited above, is more straightforward than attempting to include all vaccinations that should have been received at earlier ages. This is from both a programmatic monitoring perspective (e.g. can focus on adolescent vaccine uptake, primarily delivered through jurisdictional school-based programs, rather than catch-up of childhood vaccinations) and a data quality/logistic perspective (the cohort born in 2009 is the first where all-age vaccination could be contemporaneously captured, without interruption, following expansion of the register in 2016, which creates challenges for accurately estimating coverage in older adolescents and adults). Focusing assessment of coverage for individual adolescent vaccines to doses routinely scheduled in adolescents is similarly more straightforward. However, assessment of 'up-to-date' coverage for individual vaccines in adolescents, in accordance with Australian Immunisation Handbook recommendations (e.g. receipt of ≥3 doses of diphtheria-tetanus-pertussis-containing vaccine with ≥1 dose at ≥10 years of age), may also be appropriate as an indicator of public health importance. Where up-to-date adolescent coverage is reported, care should be taken to ensure a clear explanation of methods and data limitations, and how these differ from other approaches.

Optimal ages for assessment and reporting of adolescent and adult coverage for individual vaccines, and potential composite measures of coverage are outlined below, informed by our findings including analysis of relevant AIR data.

Adolescent coverage – individual vaccines

We found substantial variation in age of vaccination by jurisdiction for all individual vaccines, particularly at the younger ages, although a large part of this was due to jurisdictions having offered HPV and dTpa vaccination in different school years and meningococcal ACWY to a broader range of ages due to outbreaks. With all jurisdictions offering HPV and dTpa vaccination in Year 7 from 2023, this should be less of an issue. More regular and timely assessment and reporting of HPV and dTpa vaccination coverage, as requested by key stakeholders (particularly jurisdictional immunisation program representatives), could therefore be undertaken by Aboriginal

and Torres Strait Islander status at both jurisdictional and national levels (e.g. annually/quarterly for cohorts turning 13–19 years in the year of interest). While we showed that overall HPV and dTpa (with DTPa doses at ≥10 years of age included) vaccination coverage did not change much from 16 years of age onwards, nor meningococcal ACWY vaccination coverage from 18 years onwards, HPV and meningococcal ACWY vaccination coverage did continue to increase in Aboriginal and Torres Strait Islander adolescents. This latter finding highlights the importance of continuing to monitor and promote catch-up in older cohorts to ensure effectiveness and equity of catch-up vaccination programs, particularly in disadvantaged populations.

We found little difference (less than half a percentage point) in coverage calculated for receipt of meningococcal ACWY vaccine, rather than any meningococcal C containing vaccine, so use of this more specific definition is recommended. However, it is preferable to continue to include DTPa (paediatric formulation) doses received at ≥10 years of age in adolescent dTpa (adolescent/adult formulation) vaccination coverage estimates, due to data entry/transfer issues, particularly in older cohorts in Queensland, Victoria and Western Australia in the earlier years of the expanded register.

Of note, HPV vaccination coverage in adolescents turning 15 years of age using the methods described above includes vaccine doses given on or after an individual's 15th birthday, if before the end of the relevant year, for purposes of better alignment and monitoring of school-based programs, delivery of which is structured around calendar/school years. However, the WHO-recommended standard method for assessment of HPV coverage at 15 years includes only doses received before an individual's 15th birthday. While we found the difference in coverage using these two methods to be small (less than half a percentage point higher for the calendar year based approach than the WHO approach), national reporting to WHO at the 15-year milestone should continue to use the WHO method for purposes of consistency and international comparison.

Adolescent coverage – potential composite measures

Coverage of all vaccines funded on the NIP for adolescents in Australia is important to monitor. In line with the patterns seen for individual vaccine coverage, a composite measure comprising receipt of both an HPV vaccine dose and an adolescent dose of dTpa vaccine (or DTPa doses at ≥10 years of age) could be assessed and reported by Aboriginal and Torres Strait Islander status at jurisdictional and national levels annually for 1-year-wide age cohorts turning 13–19 years in the year of interest. If a single assessment age milestone needs to be prioritised (e.g. for performance monitoring purposes), coverage of this composite measure in adolescents turning 15 years of age

could be most appropriate, given the small changes in overall coverage after this age and that 15 years is the WHO-recommended standard age for HPV vaccination coverage assessment, including in cervical cancer elimination planning. Coverage for adolescents turning 15 years in 2022 using this composite measure was 83.7% overall and 80.0% for Aboriginal and Torres Strait Islander adolescents.

A second composite measure, comprising receipt of an HPV vaccine dose, an adolescent dose of dTpa vaccine (or DTPa dose at ≥10 years of age) and a dose of meningococcal ACWY vaccine (noting the minimal impact on coverage of using this more specific definition, rather than meningococcal C containing vaccine), could be assessed and reported at both jurisdictional and national levels annually for cohorts turning 16–19 years in the year of interest. If a single assessment age milestone needs to be prioritised (e.g. for performance monitoring purposes), coverage of this composite measure in adolescents turning 18 years of age could be most appropriate, as this would capture most vaccinations given to adolescents before they finish school.

Adult coverage – individual vaccines

The majority of zoster-vaccinated adults turning 70–75 years of age in 2022 (and hence eligible for vaccination with the live attenuated herpes zoster vaccine at 70 years following introduction of the program in late 2016) were vaccinated at 70, but a substantial proportion were vaccinated through the catch-up program, with coverage highest (54.5%) for adults turning 75 years. It will be important to continue to monitor coverage patterns by 1-year age cohort, particularly given the live attenuated zoster vaccination catch-up program is slated to finish in late 2023. In contrast, the highest coverage of 13vPCV, funded for all adults aged ≥70 years, was in adults turning 71 years of age, at 33.8%, while seasonal influenza coverage increased progressively by year of age.

Adult coverage – potential composite measures

Coverage of all vaccines funded on the NIP for adults in Australia is important to monitor. Composite measures comprising any combination of these vaccines could be assessed and reported by Aboriginal and Torres Strait Islander status at jurisdictional and national levels annually (and quarterly if indicated) for 1-year-wide age cohorts turning 70–79 years in the year of interest. However, 13vPCV + influenza could be the most appropriate measure for initial use, pending resolution of the uncertainty around future zoster vaccination scheduling. If a single assessment age milestone needs to be prioritised (e.g. for performance monitoring purposes), coverage of this composite measure in adults turning 71 years of age could be most appropriate

on a timeliness basis, given that 13vPCV is funded from 70 years. Coverage for adults turning 71 years of age in 2022 using this composite measure was 29.7% overall and 30.6% for Aboriginal and Torres Strait Islander adults.

Other methodological considerations

Consistency of coverage assessment and reporting in Australia

AIR data on adolescent and adult vaccination coverage in Australia are primarily analysed and reported by Services Australia/the Department and NCIRS. We identified several differences in the methodologies used by these organisations, which could contribute to small differences in reported coverage estimates. Ongoing discussions between the three organisations are recommended to ensure timely and consistent methods are used where possible, with transparency and clarity around any differences and their impact on reported coverage. The agencies should also consider strategies, such as via provision of standardised protocols or templates, to promote consistency of analytic methods among other organisations which analyse and report coverage data (e.g. state/territory health departments) and researchers.

Lag periods

Compared to the current standard 3-month lag period (between the end of the relevant assessment period and the date of AIR data used), a shorter 1-month lag period resulted in minimal differences in vaccination coverage at both the adolescent and adult milestones assessed. This likely reflects improved timeliness of reporting to the AIR due to the increased use of electronic reporting and introduction of mandatory reporting in 2021. Using a 1-month data extraction lag would improve timeliness of coverage data reporting without loss of accuracy, and is recommended.

Assessment and reporting of coverage by gender

While HPV vaccination coverage is routinely assessed and reported by gender, analyses for other vaccines have been limited to date. Broader analysis and reporting of coverage for other adolescent and adult vaccines would be useful to explore gender-based differences in preventative care and health-seeking behaviours.

ABS versus AIR denominators

Several key stakeholders requested clear guidance on use of ABS and AIR denominators; however, this is outside the scope of this report. AIR denominators have been used historically for

all vaccination coverage assessment purposes in Australia, other than for COVID-19 vaccine coverage analyses in recent years. While there are important issues that need to be addressed in relation to assessing and optimising utility of these denominators, and guidance on their use is available, the issues are complex and require extensive analyses of linked data to effectively delineate.

Conclusions

Australia's assessment and reporting of adolescent and adult vaccination coverage is some of the most comprehensive globally, although with scope for expansion and refinement with relatively modest additional work. Such expansion should support efforts to improve efficiency and effectiveness of programs, and in turn, disease prevention, and should include assessment in groups with risk factors, who are targeted under the NIP. Composite measures should be considered to monitor overall NIP performance across the lifespan, similarly to the longstanding use of 'fully vaccinated' coverage measures in young children. The increasing use of new vaccines in adults, including COVID-19 (which may also warrant inclusion in composite coverage measures as vaccination recommendations become more stable), underpins the need to also evaluate and improve reporting of vaccines to the AIR in this age group, noting new mandatory reporting requirements.

Appendices

Appendix 1. Additional detail on methods used for AIR data analysis

Data source

This report uses AIR data as at 8 January 2023, with vaccinations given up to and including 31 December 2022 included in analyses.

Data analysis

Prior to conducting any analyses, duplicate records were removed – namely, AIR records where the PIN was identical, with the most recent record kept based on the Medicare registration date, and vaccination records where the PIN, vaccine type, vaccine dose and encounter date were identical.

Residential postcodes recorded on the AIR were used to assign individuals to a state/territory. Individuals with a SIN (i.e. not Medicare-registered) were excluded from all analyses, along with those with an 'end date' (applied to an AIR record when Medicare is notified that the person has died or left Australia permanently) before 8 January 2023.

Adolescent vaccination coverage was calculated using 12-month-wide birth cohorts of Medicare-registered adolescents, with reference to the age adolescents in relevant cohorts turned in 2022 (i.e. the cohorts born 2003–2009 and turning 13–19 years of age in 2022).

Adult vaccination coverage was calculated using 12-month-wide birth cohorts of Medicare-registered adults with reference to the age adults in relevant cohort turned in 2022 (i.e. the cohorts born 1943–1952 and turning 70–79 in 2022), along with 10-year-wide cohorts for adults turning 50–59 and 60–69 years in 2022.

Aboriginal and Torres Strait Islander status on the AIR is recorded as 'Aboriginal and Torres Strait Islander', 'non-Aboriginal and Torres Strait Islander' or 'unknown'. Individuals whose Aboriginal and Torres Strait Islander status was not specified (0.7% of persons on the AIR) were classified as non-Aboriginal and Torres Strait Islander for the purpose of analysis.

Appendix 2. Review of immunisation coverage analysis and reporting methodologies globally – adolescents

Country/organisation	Vaccine type and age assessed	Specific features of coverage calculation methodologies	Specific features of immunisation data sources	Routinely publicly reported (Yes/No/Not identified)
Australia[11]	HPV (1 dose and course completion by 15 years). dTpa (1 dose by 15 years). meningococcal ACWY (1 dose by 17 years). Influenza (at least 1 dose in relevant year, for 10–<15 and 15–< 20 years age groups).	Cohort method used. Only vaccines given on or before an adolescent's 15th or 17th birthday are included in relevant coverage calculations.[11]	Centralised national vaccination register.[11]	Yes – all reported annually (in NCIRS National Coverage Reports).[11]
WHO and UNICEF[27,55]	HPV (first dose and course completion by 15 years).	Coverage calculated for females only by 15 years by countries. Vaccinations over 15 years not assessed and reported.	These estimates are derived from the administrative and survey data reported annually to WHO through the WHO/UNICEF Joint Reporting Form.[27]	Yes – annually.[27]
UK[35,36]	HPV (1 dose by 14 years and 2 doses by 15 years). meningococcal ACWY (1 dose by 15 years).	UK Health Security Agency regional vaccination coverage is calculated by aggregating the appropriate local authority level data.[35]	Local authorities are requested to submit HPV, meningococcal ACWY and Td/IPV vaccine data for each school for the local authority annual	Yes – all reported annually.[35,36]

	Td/IPV (1 dose by 15 years). Influenza (assessed for the age groups 11–12, 12–13, 13–14, 14–15 and 15–16 years).		survey, via the ImmForm web-based system.[36] Coverage data collected at GP practice level can also be automatically uploaded via participating GP IT suppliers to the ImmForm website each quarter. Has no centralised registry for adolescent vaccinations.	
New Zealand[39,40,61]	HPV (assessed for 2 doses by 14 years; 3 doses for 15–26 years age group). *No information identified on assessment age for dTpa vaccine.*	HPV immunisation coverage is calculated by birth cohorts, by district and prioritised ethnicity.[62]	Adolescent HPV vaccines are recorded on the National Immunisation Register.[39,40]	Yes – HPV reported annually.[61]
Ireland[42,43]	HPV (assessed for 2 doses by 15 years). *No information identified on assessment age for dTpa and meningococcal ACWY vaccines.*	Denominator defined as the number of adolescents in the first year for second level schools and age equivalent in special schools and on the school roll on 30 September.[42] The numbers vaccinated do not include children vaccinated elsewhere	The National School Immunisation System (SIS), an electronic dataset, records all vaccinations for children of school age.[43]	Yes – HPV reported annually.[42]

		(e.g. abroad, or by General Practitioners).		
Denmark[19,23,25,28]	*No information identified on assessment age for HPV vaccine.*	Birth cohort analysis for HPV vaccination coverage.	HPV adolescent vaccination data are reported to the Danish Vaccination Register (DDV).[19,25] Birth cohort population provided by Statistics Denmark.	Yes – HPV reported annually.[19,25]
Norway[18,29]	*No information identified on assessment age for HPV, MMR, IPV and dT vaccines.*	Limited information regarding methodology available in English.	Centralised national vaccination register (SYSVAK).[18,45]	The system in Norway is linked to a web-based application that allows users to visualise in real-time the coverage at community level with a graphical snapshot of current or historical vaccination coverage trends.[34]
Netherlands[22,30]	*No information identified on assessment age for DT-IPV, MMR, meningococcal ACWY and HPV vaccines.*		Has electronic immunisation records but no centralised adolescent registry.	Not identified.
Germany[50,51,63]	*No information identified on assessment age for HPV and dTpa-IPV vaccines.*		Centralised national vaccination register.[34]	Not identified.

Italy[22,25,31]	*No information identified on assessment age for HPV, meningococcal ACWY and dTpa-IPV vaccines.*	No information available.	Has electronic immunisation records but no centralised registry.[22]	Not identified.
Finland[22,46]	*No information identified on assessment age for HPV and dTpa vaccines.*	Denominator used in coverage calculations: • Individuals who resided during follow-up in areas for which sufficient data are available in the National Vaccination Register. • Everyone is counted only once, in the population and vaccination count of the area in which they resided at the time of report generation.[46]	Has both a centralised registry and electronic immunisation records (Finnish national vaccination register).[22]	Not identified.
France[20,25,32,47]	3 doses HPV assessed at 15, 16 and 17 years (girls and boys. *No information identified on assessment age for meningococcal C and dTpa-IPV vaccines.*		No immunisation registry available in France for adolescents. Vaccine Reimbursement Database used to monitor coverage.[32,47] School surveys are also conducted every 2 years and used to assess vaccine coverage.[25,47]	Yes – HPV vaccine annually.[47]

Canada[21,48]	≥1 dose HPV (girls and boys, assessed at 14 years). ≥1 dose Hep B (assessed at 14 years). 1 dose meningococcal C or ACWY (assessed at 17 years). 1 dose dTpa (assessed at 17 years).	Childhood National Immunization Coverage Survey (cNICS). The survey is given to parents and guardians and measures the proportion of children/adolescents who have received all routine vaccinations by ages 2, 7, 14 or 17 years. cNICS measures coverage for all vaccines given to teens every second year.	Has no centralised registry. cNICS is a survey conducted every two years by Statistics Canada on behalf of the Public Health Agency of Canada since 2011.[48]	Yes – biennially.[48]
USA[33,49]	2 doses of meningococcal ACWY assessed at 17 years of age. *No information identified on the assessment age for dTpa, HPV and influenza vaccines.*	Adolescent composite completion measure of recommended HPV, meningococcal ACWY and dTpa vaccines among 17-year-old individuals in the United States.[33]	Has no centralised registry for adolescent vaccinations. Coverage calculated by annual NIS-Teen survey of approximately 20,000 12–17-year-olds (based on parental/self-report followed by paper questionnaire mailed to vaccination providers). TeenVaxView – local, state and federal health departments use surveys and other data sources such as immunisation	Yes – meningococcal ACWY annually.[49]

			information systems to estimate adolescent (dTpa, meningococcal ACWY, HPV and influenza) vaccination coverage and identify where additional efforts are needed to increase vaccination coverage. TeenVaxView is designed to help access to survey data collected by the CDC.[49]	

Appendix 3. Review of immunisation coverage analysis and reporting methodologies globally – adults

Country/organisation	Vaccine type and age assessed	Specific features of coverage calculation methodologies	Specific features of immunisation data sources	Routinely publicly reported (Yes/No/Not identified)
Australia[11]	Zoster assessed at 70 years and 71–79 years. Influenza assessed at 20–49 years, 50–64 years, 65–74 years and ≥75 years. 13vPCV assessed at 70 years and 71–79 years.	Cohort method used.	Centralised national vaccination register.[11]	Yes – annually (in NCIRS National Coverage Reports).[11]
UK[22,56]	Influenza (assessed at ≥65 years). Zoster (assessed in those turning 70 years old). *No information identified on the assessment age for pneumococcal vaccine.*	For zoster vaccine, the 70-year-old cohort is defined as the total number of registered patients turning 70 who received the vaccine before the end of the reporting period (numerator) as a proportion of the total number of patients turning 70 (denominator).[56] For adults turning 71 to 80 years old, zoster vaccine coverage is defined as the number of patients in each annual birth cohort, who received the vaccine before 23 December of	Has no centralised registry for adult vaccinations. [22] Coverage data are collected at GP practice level and automatically uploaded via participating GP IT suppliers to the ImmForm website each quarter.[56]	Yes – zoster vaccine quarterly and annually.[22,56]

		the relevant year (numerator) as a proportion of the total number of registered patients in that annual birth cohort (denominator).		
New Zealand[39]	*No information identified on the assessment age for dTpa, zoster and influenza vaccines.*		National immunisation register also for adult influenza, MMR and dTpa vaccinations given in general practice and pharmacies.[39] Adult vaccination data are collected from general practices which have an electronic patient management system (PMS) that can transfer data to the NIR.[39] 'ImmuniseNow' app allows pharmacists to report adult vaccinations to the NIR.	Not identified.
Ireland[44]	*No information identified on the assessment age for influenza, pneumococcal and dTpa vaccines.*	For the purpose of reporting on seasonal flu vaccination uptake the reporting period is considered to be September to August (the following year).	Has no centralised registry for adult vaccinations. Influenza uptake data are obtained from the HSE Primary Care Reimbursement Service,	Yes, seasonal reporting of influenza vaccine.[44]

			on number at GP clinics and pharmacies.[44]	
Denmark[19]	*No information identified on the assessment age for influenza and pneumococcal vaccines.*	No information available.	Centralised national vaccination register.[34]	The system in Denmark is linked to a web-based application that allows users to visualise in real-time the coverage at community level with a graphical snapshot of current or historical vaccination coverage trends.[34]
Norway[18]	*No information identified on the assessment age for influenza vaccine.*	Limited information regarding methodology available in English. Coverage statistics only calculated for vaccines in the Childhood Immunisation Programme.	Centralised national vaccination register (SYSVAK).[34] All influenza vaccinations are subject to notification to SYSVAK, and shall be registered without consent.[18]	The system in Norway is linked to a web-based application that allows users to visualise in real-time the coverage at community level with a graphical snapshot of current or historical vaccination coverage trends.[34]
Netherlands[22]	*No information identified on the assessment age for influenza vaccine.*		Has electronic immunisation records but no centralised registry.[22]	Yes, reports annually on adult influenza coverage.[22]
Germany[22]	*No information identified on the assessment age for influenza and pneumococcal vaccines.*	Only provides aggregated data on vaccinations at the population level.[34]	Centralised national vaccination register.[34]	Not identified.

Italy[22]	*No information identified on the assessment age for zoster, pneumococcal and influenza vaccines.*		Has adult electronic immunisation records but no centralised registry.[22]	Yes – annually for influenza.[22]
Finland[22]	*No information identified on the assessment age for influenza vaccine.*		Has both a centralised registry and electronic immunisation records. Vaccination data are collected directly from patient record systems.[22]	Yes – annually for influenza.[22]
France[22]	*No information identified on the assessment age for influenza, dT-IPV and pneumococcal vaccines.*	No information available.	No immunisation registry available in France for adults.[22] Analysis of vaccine reimbursement data from a comprehensive health insurance database (EGB) is not undertaken for adults.	Yes – annually for influenza.[22]
USA[24,26]	*No information identified on the assessment age for influenza, pneumococcal, zoster, dTpa, hepatitis A and hepatitis B vaccines.*	Proportion of adults aged ≥19 years who received an influenza vaccine in previous 12 months of interest. Proportion of adults aged ≥65 years who have ever received a pneumococcal vaccine and proportion	Has no centralised registry and no national electronic immunisation records. National Health Interview Survey (NHIS). Adult (aged >= 19 years) receipt of influenza, pneumococcal, herpes zoster, dTpa, hepatitis A,	Yes – annually for influenza, pneumococcal, zoster, and dTpa vaccines.[26]

		who have received at least 2 doses. Proportion of adults vaccinated calculated by age group (≥50, ≥60, 60–64 and ≥65 years) who have ever received a zoster vaccine, by vaccine type (at least 2 doses of the recombinant vaccine). Proportion of adults aged ≥19 years (including by age groupings 19–49, 50–64 and ≥65 years) who received a dTpa or any tetanus vaccine during preceding 10 years. Adult vaccination composite measure includes receipt of influenza (during preceding 12 months), 'ever received' pneumococcal (adults aged ≥65 years), 'ever received' zoster (adults aged ≥50 years) and dT/dTpa (during the preceding 10 years) vaccines. Age groups for composite measure: ≥19, 19–49, 50–64 and ≥ 65 years.[24,33]	hepatitis B and at least one dose of HPV vaccines assessed. The CDC's *Surveillance of Vaccination Coverage Among Adult Populations* report provides vaccination coverage data on the following vaccines: seasonal influenza, pneumococcal, herpes zoster, diphtheria-tetanus-pertussis, hepatitis A, hepatitis B, and HPV vaccination.[24,26]	

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