NCIRS

National Centre
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Australian Immunisation Register Data Transfer Study

Stage 2 Final Report

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Executive summary

Background

The Australian Immunisation Register (AIR) was first established as the Australian Childhood Immunisation Register (ACIR) in 1996. It expanded to a whole of life register in 2016. Completeness of data capture by the AIR has not been systematically assessed since 2001 when a study was conducted by the National Centre for Immunisation Research and Surveillance (NCIRS). In 2016 the Australian Government Department of Health (Health) funded NCIRS to undertake, with support from the Australian Government Department of Human Services (DHS) and state and territory health departments, a national study to assess the effectiveness of data transfer to AIR and identify ways to improve it.

Methods

This study used a cross-sectional design. The study population included 2400 children aged 9 to <12 months old, 15 to <18 months old, 21 to <24 months old and 51 to <54 months old, as at 4 October 2017, and who were recorded in the AIR as at least three months overdue for at least one vaccine antigen as per the National Immunisation Program (NIP) schedule. Overdue records for each of the six participating jurisdictions (New South Wales, Northern Territory, Queensland, Victoria, South Australia and Western Australia) were extracted and randomised, with each jurisdiction assigned 400 records pertaining to a single vaccine antigen and dose (e.g. measles dose 1 or pertussis dose 3), for follow-up to determine the accuracy of the overdue information. Follow-up by participating sites (primary health networks and/or jurisdictional health departments) occurred over a seven-week period through contact with the last known immunisation provider or parent/carer if no provider was listed, using a standard questionnaire. Records were assessed to determine if they were accurate (i.e. truly overdue for the relevant antigen and dose) or inaccurate (i.e. actually up to date for the relevant antigen and dose), with relevant explanatory codes assigned. Other variables included in analysis were Aboriginal and Torres Strait Islander status; area coverage level; provider type; method of data transfer to AIR; vaccine antigen and dose number; and geographic remoteness category.

Following initial descriptive analysis, all 400 records from the Northern Territory were excluded from further analysis because of major data variance skewing overall results. Of the remaining 2000 records, 892 could not be assessed, mainly due to inability to contact providers or parents. Of the 1108 records assessed, 203 were excluded from further analysis as these were no longer overdue in AIR at the commencement of follow-up, leaving 905 records in the final analysis.

Frequency counts were generated at the national and jurisdictional levels, with error rate (proportion of overdue AIR records actually up to date due to an identified error) calculated for all categories. Logistic regression analysis was undertaken to assess factors associated with records being misclassified as overdue when they were actually up to date.

Results

Of the 905 records included in the final analysis, 86% were assessed as accurate (truly overdue) and 14% as inaccurate (i.e. the child appeared overdue despite being actually up to date for the relevant antigen). The error rate ranged from 3% in Victoria to 29% in New South Wales.

Of the 124 records determined to be incorrectly assessed as overdue due to an error in the record, the most common reason for error related to failure of transfer of vaccination encounter information from practice management software (PMS) to AIR (58%); 27% related to duplicate records; 11% related to online AIR Secure Site error; and 4% to use of paper forms.

Further analysis of the 72 records assessed as being up to date with error identified as failure of transfer of vaccination encounter information from PMS to AIR revealed:

- 43% had documentation in the PMS indicating that the information appeared to have been successfully transmitted to AIR, but the AIR record was not up to date
- 26% were due to practice-level data entry error in relation to the vaccination encounter
- 11% were documented as PMS transmission failure due to either a demographic error or a missing Medicare card in the record
- 8% were documented as PMS transmission failure with no obvious errors in encounter, demographic or Medicare information
- 11% were reported as due to unspecified PMS-related errors.

The error rate was higher in records from remote areas (23%) than in records from regional and major city locations (both 13%). The error rate by transfer method was highest for paper-based forms (54%) and via the online AIR Secure Site (26%), and lowest for PMS (13%).

Multivariate analysis identified four statistically significant associations for whether an overdue AIR record may be actually up to date due to error: transfer to AIR via paper-based methods (odds ratio [OR] 8.5); living in remote areas (OR 4.5); being in the age cohort 9 to <12 months old (OR 3.9); and transfer to AIR via the online AIR Secure Site (OR 2.2).

Discussion

The overall error rate of 14% in this study is lower than that found in the only recent published Australian study auditing all children overdue for one or more vaccinations, a 2013 audit of Sydney's eastern suburbs children aged 12 to <15 months, which identified an error rate of 33%, although that study assessed 'fully immunised' status rather than specific antigens.[i] The lower error rate in Victoria (3%) could be partly due to the strict No Jab No Play legislation relating to childcare service enrolment, which has been in place in that state since 2016.

The most commonly identified source of error was failure of transfer of vaccination encounter data from PMS to AIR. Approximately half of these cases were due to practice-level issues; however, for the remainder it was not possible to determine the proportion related to issues with PMS, AIR receipt or combination thereof. Our cross-sectional analysis did not also identify instances of error where data were subsequently retransferred successfully.

Conclusion

This study represents the first attempt at the national level since 2001 to systematically audit the accuracy of AIR data. On the basis of our findings, the most influential areas in which data recording, transfer and handling could be improved to optimise the effectiveness of data transfer to AIR include:

1. data entry for all methods of transfer to AIR
2. processes for transfer of vaccination encounter information to AIR
3. data management to reduce duplicate records
4. engagement with and enhancing support to immunisation providers.

Recommendations

Recommendations to reduce errors in vaccination encounter data in the AIR include:

1. Initiatives to improve data entry of vaccination encounters

The Australian Government Department of Health (Health) should consider initiatives, in collaboration with the Australian Government Department of Human Services (DHS), state and territory health departments and primary health networks, to support providers to accurately record vaccination encounters. This may include development of education materials for providers and relevant stakeholders aiming to reduce data entry errors. Education materials or information targeting providers could focus on checking the possibility of an existing record before creating a new record, checking patient vaccination history before entering an encounter and using the 'generic' vaccine option when recording overseas vaccination history.

Providers who send paper-based records to AIR should continue to be encouraged to transition to electronic methods of transmission where possible, noting that almost 99% of submissions to the AIR are now electronic.

2. Initiatives to improve data transfer via practice management software

Health, in collaboration with DHS, should consider ways to reduce failure of data transfer to AIR via practice management software.

[i] Ferson MJ, Orr K. Some truths about the 'low' childhood vaccination coverage in Sydney's eastern suburbs. Med J Aust 2015; 203(3): 153, e.1.

3. *Initiatives to improve data management*

Health, in collaboration with DHS, state and territory health departments and primary health networks, should consider ways to improve identification and correction of AIR records that contain errors (e.g. misspelt names, incorrect recording of order of first and surnames, and inclusion of middle names with hyphenation) to assist in reducing the number of duplicate records.

4. *Future studies*

Health should consider regular future studies of overdue records in AIR to identify errors in vaccination encounter data. Such studies could be similar to this study, refined with the following potential additions:

- identifying reason(s) for overdue records being up to date on AIR at follow-up (i.e. whether due to delayed vaccination or rectification of previous data transfer error)
- undertaking specific investigation to determine reasons for the higher error rate in AIR records of children aged 9 to <12 months
- conducting interviews of providers and other stakeholders involved in follow-up of overdue children and data cleaning to explore their experiences.

Background

The Australian Immunisation Register (AIR) was first established as the Australian Childhood Immunisation Register (ACIR) in 1996. It expanded to a whole of life register in 2016. The AIR is used for a range of purposes, including assessing vaccination status and planning catch-ups; assessing regional and national vaccine coverage; assessing eligibility for family payments; and enabling program responses to public health concerns.

The effectiveness of transfer of data to the AIR has not been systematically assessed since 2001, when the National Centre for Immunisation Research and Surveillance (NCIRS) conducted a national study examining the accuracy of ACIR by comparing self-reported vaccination records by parents at telephone interview against their child's ACIR record. This study estimated that missing data led to the ACIR underestimating the true level of vaccine coverage at the national level by 2–3%.[1]

In 2016, the Australian Government Department of Health (Health) funded NCIRS to undertake a two-stage project, with support from the Australian Government Department of Human Services (DHS) and state and territory health departments, to:

assess the completeness of information in the AIR and, where the AIR record does not match parent or provider held record, investigate the factor(s) responsible and quantify their relative importance, and using this information to develop recommendations for improving the effectiveness of data transfer to the AIR.

In early 2017, NCIRS completed Stage 1 of this project, which identified relevant published and unpublished studies across Australia assessing the effectiveness of the transfer of immunisation data to the AIR.[2]

Information from these studies was collated and analysed to identify key issues and barriers in relation to the timely and accurate transfer of data. These included children vaccinated overseas and their data either not entered or inaccurately entered into AIR; electronic data transfer issues from practice software to AIR; and data entry and AIR data handling issues.

This report details Stage 2 of the project.

Aim

To assess the completeness of immunisation records in the AIR and identify ways to improve it.

Specific objectives

Undertake a study of the records of children reported as overdue for vaccinations on the AIR. If incomplete or erroneous data are identified, investigate and identify causes of inaccuracy of the data.

1. Evaluate whether these factors vary by:
   a geographical area
   b level of coverage (low/medium/high)
   c provider type
   d method of data submission (including specific practice management software type).
2. Provide a report which details:
   a the most influential areas in which data quality could be improved
   b recommendations on the most practical means to address these issues.

Methodology

Ethical considerations

Ethical approval for this study was sought and granted by Australian National University Human Research Ethics Committee, protocol #2017/370.

Study type and population

This study was conducted using a cross-sectional design. The study population was children aged 9 to <12 months, 15 to <18 months, 21 to <24 months and 51 to <54 months old as of 4 October 2017, and who were recorded as at least three months overdue for at least one vaccine antigen in the AIR as per the National Immunisation Program (NIP) schedule.

Extraction of population sample

Each study site extracted an 11A report produced by the AIR. These reports were used to identify the study sample for this study. The 11A report identifies individuals who are due or overdue for vaccination, by their locality, and can be broken down by postcode and age range. An 11A report provides the following information:[3]

- individual's details – name, address and overdue status
- immunisation history of each individual – all vaccines recorded on the AIR at the time the report is produced
- due/overdue vaccine antigens (e.g. measles, pertussis)
- last immunisation provider's details – name, address and phone number
- natural immunity/medical contraindication details.

Participating sites

All eight state and territory jurisdictional immunisation coordinators (JICs) were invited to participate in the study. Individual discussions were held with each JIC or their nominee to ascertain their capacity to participate.

Following these discussions, in some states and territories, Primary Health Networks (PHNs) were approached to determine whether they could assist their relevant jurisdiction in participating in the study. Six jurisdictions agreed to participate; they had varying partnerships with PHNs (refer to Table 1).

Table 1. Participating sites

State/Territory	Participating sites
New South Wales	Hunter, New England and Central Coast PHN, South Eastern Sydney PHN, Murrumbidgee PHN, South Western Sydney PHN, Northern Sydney PHN, Western NSW PHN
Northern Territory	NT Health
Western Australia	WA Health, WA PHN Alliance
Queensland	Queensland Health
South Australia	SA Health, SA PHN Immunisation Hub
Victoria	Department of Health and Human Services

Questionnaire development

A questionnaire for this study (refer to Appendix A) was developed after reviewing previous study questionnaires that were identified in Stage 1 of this project and other examples that were being used by jurisdictions and PHNs.

Following review and feedback from sites, 44 numeric codes were included to categorise the reason why a child was overdue or actually up-to-date due to an identified error, along with other relevant categories. The questionnaire provided follow-up sites with a written script and aimed to collect the following information for each record: Aboriginal or Torres Strait Islander status of the child; the type of provider recording the immunisation encounter; primary method for transmitting immunisation encounters to AIR; whether the online AIR Secure Site was used; method of advising AIR of vaccinations given overseas; medical contraindications and natural immunity. Each record was assigned one of the 44 numeric codes.

Pilot

All participating sites were invited to pilot the study questionnaire to provide feedback on its usability and whether the codes provided were suitable.

Pilot sites were requested to extract an 11A overdue report from AIR for their region and select the first five children's records that appeared on the report and who were aged between 9 months and 5 years, were at least three months overdue and were linked to a provider.

Sites were given one week to complete the pilot from 15 September 2017 to 22 September 2017. Six sites participated in the pilot and provided feedback. Following feedback, minor changes were made to the questionnaire and instructions.

Sample size calculation and allocation of records

Required sample sizes were calculated using a 95% confidence interval, 0.05 level of precision and an estimated error rate of overdue records that are actually up to date (due to an identified error) of 45%.[1,4,5] The estimated sample size was calculated to be 400 records for each participating state and territory to provide power to an 80% level to detect differences within and among jurisdictions for analysis by up to two variables (e.g. age cohort, coverage level, error type, geographic area remoteness classification, provider type and/or method of data submission). More in-depth stratification involving three or more variables required grouping at a combined level to reach sufficient power.

Within the sample size of 400 records per jurisdiction, sample sizes for the milestone ages of 6 months, 12 months, 18 months and 48 months were also calculated (refer to Appendix B) on the basis of the preliminary analysis of AIR data, with weights applied by coverage area, defined as:

- low coverage area (<90%)
- medium coverage area (90–<95%)
- high coverage area (≥95%).

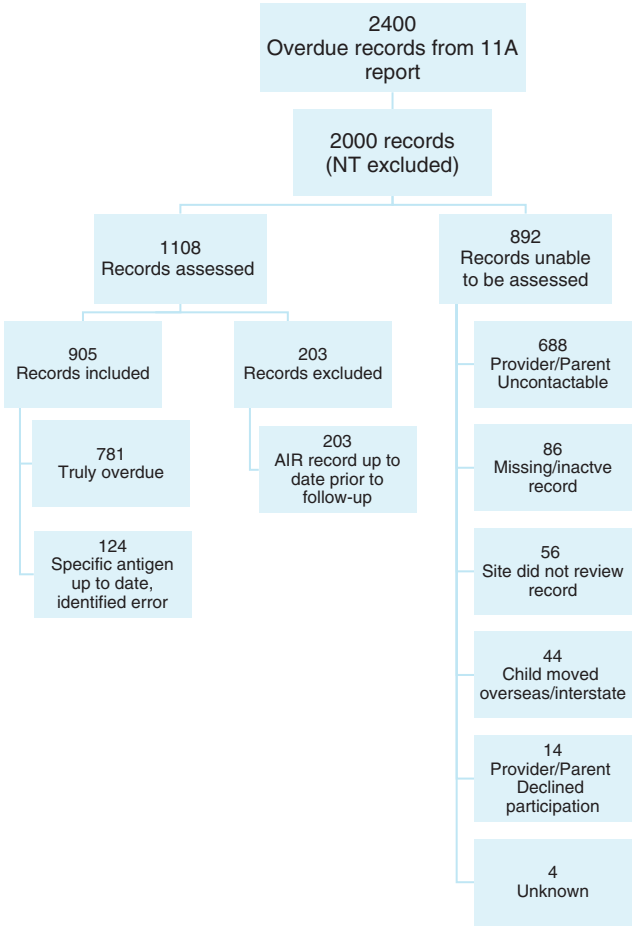
Overdue AIR records were randomised and allocated to jurisdictions for follow up in strict accordance with these sample size calculations.

Data collection and handling

Collection and handling of study data involved a four-stage process:

1. Participating sites extracted 11A files via the online AIR Secure Site. The extracted files were emailed to Health Protection NSW (HPNSW), NSW Health, for data handling via the secure platform Accellion Mobile File Sharing Solution. This was to ensure confidentiality of identified information.
2. Upon receipt at HPNSW, 11A files from all sites were merged and then combined by jurisdiction. Records relating to a specific overdue antigen were then selected on the basis of pre-determined date of birth and coverage level cut-offs, with all records not satisfying the criteria excluded and deleted from the dataset. For each participating jurisdiction, 400 records were randomly selected, divided up equally among the participating sites in that jurisdiction and electronically sent to sites via the secure platform Accellion Mobile File Sharing Solution.
3. Participating sites studied the provided records using the study questionnaire and site instructions. The questionnaire provided guidelines and suggested dialogue for liaising with the last known provider, or parent/carer contact if no provider was listed. In NSW, PHNs, which extract 11A reports, are not provided with telephone contact details of the

Figure 1. Categorisation of records



parents/carers of overdue children. In NSW, if no provider was listed for follow-up, letters were mailed from one central site, using the relevant PHN letterhead, to families asking them to contact the relevant site. Sites were given an initial four weeks from 13 October 2017, with a subsequent three-week extension, to complete the study.

4. Upon completion of the study, participating sites emailed de-identified data to NCIRS for analysis. Files were downloaded to the secure NCIRS server and placed on secure network drives accessible to selected NCIRS study staff only.

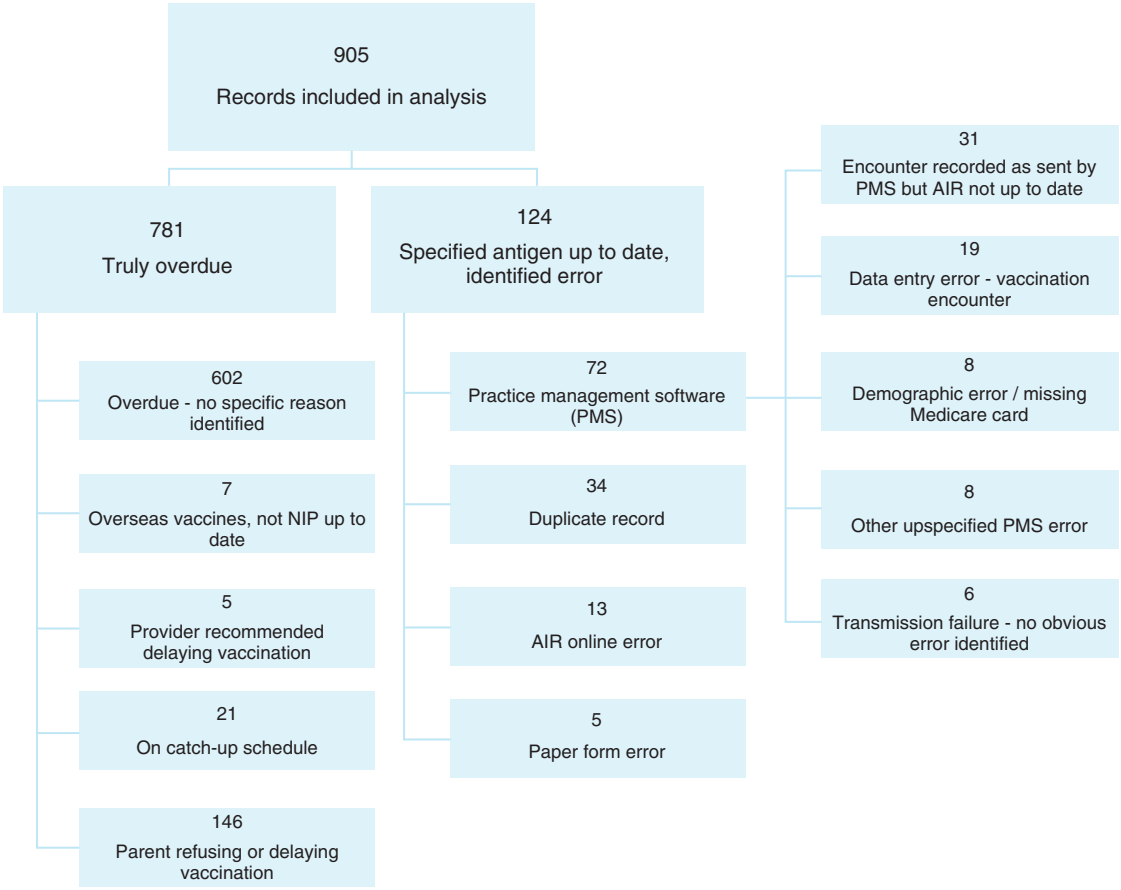
Records excluded/included in final analysis

All 400 records from the Northern Territory (NT) were excluded from the study as initial descriptive analysis identified major variance with other jurisdictions and resultant skewing of overall results (refer to Appendix C). This largely related to 235 NT records being 'baby of' duplicate records, due to the now-ceased process whereby data on doses of hepatitis B vaccine given at birth were sent from the Northern Territory Immunisation Register (NTIR) to AIR, recorded as 'baby of [mother's name]' – the NT and DHS are working together to identify and remove these duplicates (personal communication, Holly Carmichael, NT Health, January 2018).

Of the remaining records, 892 could not be assessed: 688 due to no contact being made with provider or parent/carer; 86 reported by the provider to be missing or inactive; 56 could not be reviewed during the allocated timeframe; 44 reported by providers or parents/carers to be for children who had moved overseas or interstate; 14 because provider or parent/carer refused to participate; and for 4 the reason was not identified.

Of the 1108 records studied, 203 were excluded from further analysis as they were already recorded as up-to-date on AIR at the time follow-up was scheduled to commence; that is, they had been updated in the period between the date of 11A report extraction and commencement of follow-up. This left 905 records in the final analysis. Appendix D provides a full list and description of error code categories.

Figure 2. Categorisation of records included in final analysis



Data analysis

Data were analysed using Stata Statistical Software.

A number of variables were analysed:

- overdue status (generated) – truly overdue or actually up to date (due to an error in the AIR record), as identified by study site follow-up
- Indigenous status (collected) – Indigenous/other
- area coverage category (generated) – high, medium, low
- provider type category (collected)
- transfer method category (collected)
- vaccine antigen and dose number (provided by 11A reports)
- weighting (generated)
- Accessibility/Remoteness Index of Australia (ARIA++) category (generated) – remote, regional, major cities.[ii,6]

Frequency counts were generated at jurisdictional and combined levels to provide descriptive statistics on AIR transfer-related data. The error rate (proportion of overdue AIR records actually up to date due to identified error) was also calculated for all categories.

To determine any associations between a record being misclassified as overdue for the relevant antigen and various explanatory variables, weighted univariate logistic regression was performed on the 905 records included in the final analysis. The following weights were assigned to each record to account for over- and under-sampling of records on the basis of area coverage level: 0.34 to records from low-coverage areas, 1.09 to records from medium-coverage areas and 2.52 to records from high-coverage areas. The following variables were tested for significance: area coverage level, Indigenous status, remoteness, provider type, transfer method, age cohort, and vaccine and dose number. All variables

[ii]For analysis we combined the two 'Regional' categories ('Inner Regional' and 'Outer Regional') into one category and the two 'Remote' categories ('Remote' and 'Very Remote') into one category.

Table 2. Error rate calculation by jurisdiction

Category	Jurisdiction					
	NSW	QLD	SA	VIC	WA	Total
Actually up to date	47	19	36	4	18	124
Truly overdue	118	205	152	151	155	781
Total	165	224	188	155	173	905
Error rate[a]	28.5%	8.5%	19.2%	2.6%	10.4%	13.7%

[a]Number of records actually up to date divided by the total number of records, multiplied by 100.

Table 3. Practice management software (PMS) transfer to AIR – error type by PMS brand

Practice-level data entry error – vaccination encounter	MD/ Pracsoft	Best Practice	Other PMS brand[a]	PMS brand not identified	Total
9 Wrong vaccine name recorded	1	1	0	1	3
10 Vaccine sequence/dose number incorrect or not recorded	2	0	2	1	5
12 Vaccination recorded in notes section of patient record, not immunisation tab, and encounter not transmitted	0	0	1	1	2
13 Nurse listed as provider and encounter not transmitted	1	0	0	0	1
23 Overseas history not completed correctly	0	2	0	5	7
49 Other practice-level data error	1	0	0	0	1
No Medicare number					
17 No Medicare card for record, transmission failed	1	1	0	0	2
Child demographic error					
18 Child demographic error, transmission failed	3	2	0	1	6
Transmission failure due to documented practice software issue					
19 Other practice software error, transmission failed	3	3	0	0	6
Recorded by PMS as having been transmitted to AIR					
20 Encounter recorded by PMS as sent but AIR record not up to date	8	12	8	3	31
Unspecified PMS-related error					
21 Practice could not determine exact nature of error	3	3	0	2	8

[a]Includes ZedMed, Communicare, Winvaxx and two identified as 'other' brands.

with a p value <0.25 were then included in the weighted main effects model. Tests for multicollinearity were conducted and variables reviewed for confounding. A base model was constructed which included all significant variables identified. Variables were then eliminated sequentially using a stricter cut-off p value of ≤ 0.05 to arrive at a final model. A main effects model without interaction terms was used as this study focused on associations rather than predictions. After the completion of the main effects model, testing for model fit was conducted using Akaike information criterion (AIC) and Bayesian information criterion (BIC) diagnostics.

Results

Overall summary of classification and analysis

Figure 1 provides a breakdown of how the 2400 overdue AIR records provided to participating sites for follow-up were categorised. Figure 2 provides breakdown of how the 905 records included in the final analysis were ultimately categorised into either truly overdue (781, 86%) or up to date due to identified error in AIR record (124, 14%), and relevant subcategories. A total of 892 records could not be assessed for various reasons, the main being that the provider or parent could not be contacted after numerous attempts (688, 77%).

Table 4. National[a] frequencies and error rates by category

	Up to date N	Truly overdue N	Error rate[b] %
Coverage level			
Low (<90%)	63	384	14.1
Medium (90–<95%)	37	223	14.2
High (≥95%)	24	174	12.1
Total	124	781	13.7
ARIA+ remoteness			
Remote	6	20	23.1
Regional	19	126	13.1
City	97	629	13.4
Total	122	775	13.6
Provider type			
General practitioner	91	472	16.2
Local council	9	99	8.3
Aboriginal health worker/community health centre	8	61	11.6
Other[c]	9	17	34.6
Jurisdictional health department	4	5	44.4
Total	121	654	16.1
Transfer method			
Practice Management Software	77	553	12.6
Pracsoft (Medical Director)	*26*	*170*	*13.3*
Best Practice	*33*	*197*	*14.3*
Other	*18*	*186*	*8.8*
Paper-based	7	6	53.9
Online AIR Secure Site	23	67	25.6
Other[d]	1	7	12.5
Total	108	633	14.6
Age cohort			
9 to <12 months	36	137	20.8
15 to <18 months	24	171	12.3
21 to <24 months	28	203	12.1
51 to <54 months	36	270	11.8
Total	124	781	13.7

[a]Includes NSW, Victoria, Queensland, Western Australia and South Australia; data with NT included can be found in Appendix C.
[b]Number of records actually up to date divided by the total number of records, multiplied by 100.
[c]Includes public hospital, private hospital, public health unit, The Royal Flying Doctor Service.
[d]Other transfer method not included in the listed categories, these were not specified.

Error rate

The calculated error rate (proportion of assessed overdue records that were actually up to date due to an identified error) ranged from 2.6% in Victoria to 28.5% in NSW, with an overall rate of 13.7% (refer to Table 2).

Descriptive analysis – national level

A total of 124 records were assessed to be incorrect because of to the following identified errors: failure of transfer of vaccination encounter information from PMS to AIR (72, 58%); duplicate records (34, 27%); AIR online error (13, 10%); and error arising from use of paper forms (5, 4%).

Of the 72 records with error identified as failure of transfer of vaccination encounter information from PMS to AIR: 31 (43%) were recorded by the PMS as having been transmitted to AIR but the AIR record remained incorrect, the reason for this is unknown; 19 (26%) were due to practice-level data entry error in relation to the encounter; 8 (11%) were documented as

Table 5. Records determined to be actually up to date by error category and jurisdiction

Error category	Jurisdiction					
	NSW	QLD	SA	VIC	WA	Total
Use of paper forms	5 (10.6%)	0	0	0	0	5 (4%)
Online AIR Secure Site data entry	4 (8.5%)	1 (5.3%)	6 (16.7%)	0	2 (11.1%)	13 (10.5%)
Transfer from practice management software to AIR	28 (59.6%)	10 (52.7%)	19 (52.8%)	3 (75.0%)	12 (66.6%)	72 (58.0%)
Duplicate record	10 (21.3%)	8 (42.2%)	11 (30.6%)	1 (25%)	4 (22.2%)	34 (27.4%)
Total	47	19	36	4	18	124

Table 6. Records determined to be truly overdue by category and jurisdiction

Category	Jurisdiction					
	NSW	QLD	SA	VIC	WA	Total
Overdue – no specific reason identified	96 (81.4%)	103 (50.2%)	129 (84.9%)	142 (94.0%)	132 (85.2%)	602 (77.1%)
Overseas vaccines, not NIP up to date	0	3 (1.5%)	2 (1.3%)	0	2 (1.39%)	7 (0.9%)
Provider recommended delaying vaccination	4 (3.4%)	0	0	0	1 (0.7%)	5 (0.6%)
On catch-up schedule	4 (3.4%)	3 (1.5%)	7 (4.6%)	0	7 (4.5%)	21 (2.7%)
Parent refusing or delaying vaccination	14 (11.9%)	96 (46.8%)	14 (9.2%)	9 (6.0%)	13 (8.4%)	146 (18.7%)
Total	118	205	152	151	155	781

PMS transmission failure due to either a demographic error or a missing Medicare card in the record; 6 (8%) were documented as PMS transmission failure with no obvious errors in encounter, demographic or Medicare information; and 8 (11%) were reported as due to unspecified PMS-related errors. Breakdown of error type by PMS brand is detailed in Table 3.

Table 4 shows that the error rate by age cohort was higher in the 9 to <12 months cohort (21%) compared to the other three age cohorts (12%). Of the 36 records in the 9 to <12 months cohort where an error was identified, the most common reasons were duplicate records (11) and encounter recorded by PMS as sent but AIR record not up to date (11). The lowest error rate by provider type was for local councils (8%) followed by general practitioners (16%), and the highest for jurisdictional health departments (44%, 4/5) and 'other' provider types, which included public and private hospitals, public health units and flying doctor services (35%). The error rate in records from remote areas was higher (23%, 6/26) than that in records from regional (13%) and major city locations (13%). The error rate by transfer method was highest for paper-based methods, (54%, 6/13) and via the online AIR Secure Site (26%), and lowest for PMS (13%).

Descriptive analysis – jurisdictional level

Records up to date due to identified error

Records determined to be actually up to date for the relevant antigen because of error(s) identified in the AIR record were compared by jurisdiction and error category (refer to Table 5). The number of errors due to failure of transfer of information from PMS to AIR was highest in NSW (20). The number of errors related to practice-level data entry, use of paper forms and online AIR Secure Site data entry was 6 or less per jurisdiction, and the number of duplicate records was 11 or less.

Table 7. Weighted univariate logistic regression results for significant variables with p < 0.25[a]

Explanatory variable	TOTAL	
	OR[b] (95% CI[c])	P value
Remoteness status		
Remote	3.49 (0.92–13.27)	0.066
Provider type		
Other[d]	3.46 (1.18–10.13)	0.023
Transfer method		
Paper-based	6.63 (1.80–24.47)	0.005
Online AIR Secure Site	2.15 (1.09–4.22)	0.027
Age cohort		
9 to <12 months	2.85 (1.48–5.49)	0.002
15 to <18 months	1.07 (0.53–2.19)	0.848
21 to <24 months	0.92 (0.45–1.85)	0.808
51 to <54 months	ref	ref
Vaccine antigen and dose[e]		
Diphtheria dose 1	ref	ref
Diphtheria dose 3	0.16 (0.01–2.08)	0.162
Hepatitis B dose 1	0.15 (0.01–1.88)	0.141
Hepatitis B dose 2	3.25 (0.42–23.38)	0.242
Measles dose 2	0.21 (0.02–2.74)	0.232
Mumps dose 1	0.14 (0.01–1.72)	0.125
Pertussis dose 1	0.13 (0.01–1.68)	0.119
Pertussis dose 2	4.89 (0.85–28.24)	0.076
Pneumococcal dose 2	4.9 (0.68–35.20)	0.114

[a]Includes data from NSW, Victoria, Queensland, Western Australia and South Australia.
[b]Odds ratio.
[c]Confidence interval.
[d]Public hospital, private hospital, public health unit or The Royal Flying Doctor Service.
[e]All other antigen and dose combinations had p value >0.25.
Ref = Reference group

Truly overdue records

Records determined to be truly overdue were compared by jurisdiction and category (refer to Table 6). The highest proportion of truly overdue records because of parents refusing or delaying vaccination was in Queensland (26%), followed by Western Australia (20%), Victoria (19%), South Australia (19%) and NSW (15%). The number on catch-up schedules, those who had received overseas vaccinations which were recorded on AIR but were still not up to date according to the NIP schedule and where providers had recommended delaying vaccination, was less than 10 for each jurisdiction.

Detailed data tables and summaries of categorisation of records unable to be assessed; NT-specific error rates and categories; and descriptive analysis results at jurisdictional level can be found in Appendices E, F and G, respectively.

Weighted univariate logistic regression results

Logistic regression analysis was performed on the 905 records included in the final analysis. Explanatory variable categories found to be significant on the basis of p value <0.25 are shown in Table 7. These categories included remoteness status, provider type, transfer method, age cohort, and vaccine antigen and dose. These variables were included in the initial weighted multivariate logistic regression model. The variables coverage level and Indigenous status had p values ≥0.25 and were excluded from further analysis.

Weighted multivariate logistic regression results

The final weighted model showed statistically significant associations, with p values <0.05, between an overdue record being actually up to date due to identified error and the following: living in a remote area (OR 4.53 [1.10–18.59] p = 0.036);

Table 8. Weighted main effects model results[a]

Explanatory variable	TOTAL	
	OR[b] (95% CI[c])	P value
Remoteness status		
Remote	4.53 (1.10–18.59)	0.036
Regional	ref	ref
Major cities	1.09 (0.53–2.26)	0.813
Transfer method		
Practice software	ref	ref
Paper-based	8.53 (2.08–35.06)	0.003
Online AIR Secure Site	2.19 (1.03–4.69)	0.043
Other	5.03 (0.60–42.10)	0.136
Age cohort		
9 to <12 months	3.93 (1.84–8.40)	<0.001
15 to <18 months	1.17 (0.54–2.54)	0.687
21 to <24 months	1.31 (0.61–2.80)	0.487
51 to <54 months	ref	ref

[a]Includes data from NSW, Victoria, Queensland, Western Australia and South Australia.
[b]Odds ratio.
[c]Confidence interval.
Ref = Reference group

transfer to AIR via paper-based methods (OR 8.53 [2.08–35.06] p = 0.003) or via online AIR Secure Site (OR 2.19 [1.03–4.69] p = 0.043); and being in the age cohort 9 to <12 months old (OR 3.93 [1.84–8.40] p < 0.001) (refer to Table 8). AIC and BIC diagnostics were conducted to examine overall model fit, with the main effects model (AIC = 578.2, BIC = 619.5) and the base model (AIC = 581.7, BIC = 770.4) indicating that the main effects model was a more precise fit, and thus more accurate, than the base model.

Discussion

The error rate of 14% found in this study is lower than that found in the only recent published Australian study auditing all children overdue for one or more vaccinations, a 2013 audit of Sydney's eastern suburbs children aged 12 to <15 months, which identified an error rate of 33%,[5] although that study assessed 'fully immunised' status rather than specific antigens as in our study, so it is not strictly comparable.

Apart from the NT, which was excluded from the analysis due to major data variance, the calculated error rate by jurisdiction in our study was highest in NSW (29%) and lowest in Victoria at 3%. It is possible that the low rate in Victoria could be partly due to the No Jab No Play legislation in place in that state since 2016,[7] which imposes strict immunisation requirements for enrolment in childcare services.

In the 124 AIR records in which an error was identified, the most commonly identified source of error was failure of transmission from PMS to AIR (72, 58%). Of these 72 records, 33 (46%) had documented issues (including data entry error and PMS-specific issues) at the practice level; for the remaining 39 (54%) it was not possible, on the basis of our study methodology, to determine the proportion related to issues with PMS, AIR receipt or combination thereof. Two unpublished studies, one in NSW and one in WA, which audited episodes of vaccination in general practices using Best Practice PMS, found that data did not successfully transmit to AIR for 23% of encounters.[2] While it is unclear to what extent this is representative of PMS more broadly, our cross-sectional analysis of AIR records did not identify instances where data were subsequently retransmitted successfully when transmission failure was identified by providers or patients (e.g. on receipt of AIR statements, particularly in the context of No Jab No Pay and No Jab No Play policies).

The next most common source of error identified was duplicate records (34, 27%), of which 29 records had different spelling of their first and/or surnames. The NT Immunisation Register allows users to search for multiple spellings in an 'also known as' field or for parts of names, which may facilitate the identification of duplicates.

Practice-level data entry error was identified in 19 records where there was failure of transmission from PMS to AIR, including 7 relating to vaccinations given overseas. Improved provider understanding of data entry requirements and procedures may be required to minimise such errors. This study was not specifically designed to estimate the true level of under-recording of overseas vaccinations in AIR – recent studies in WA using a different, and likely more sensitive methodology (telephone contact with parents), identified a higher proportion of overdue children with overseas vaccinations not recorded in ACIR – 7% for children with some vaccinations recorded[8] and 44% for children with no vaccinations recorded on ACIR.[2]

In total, 146 (16%) of the 905 overdue AIR records assessed were identified as truly overdue due to parent refusing or delaying vaccination. This proportion is lower than that in a previous study which showed that around 40% of incomplete vaccination is likely due to vaccination objection,[9] and may be an underestimate.

The multivariate analysis in our study identified four statistically significant variables for whether an overdue AIR record may be actually up to date due to error: transfer to AIR via paper-based methods (OR 8.5); living in remote area (OR 4.5); being in the age cohort 9 to <12 months old (OR 3.9); or transfer to AIR via the online AIR Secure Site (OR 2.2).

DHS currently identifies providers who regularly use paper-based methods and provides them with information regarding more accurate methods of data transmission – enhancement of this activity may be of benefit. Issues in remote areas may differ, and need to be further investigated. The reasons for the age cohort 9 to <12 months having a significant association with AIR record error also require further investigation. While basic text-based instructions are provided on the online AIR Secure Site regarding how to record encounters, more detailed instructions, including examples and screenshots, may be of benefit.

However, the importance of the associations identified in multivariate analysis should not be overemphasised. Given that a large proportion of the Australian population lives in major cities and regional areas, and that PMS is the predominant method of transfer to AIR, initiatives to reduce error rates across these areas also have potential for considerable overall benefit, despite lower baseline levels of error. Supporting all providers with appropriate education and resources on the proper procedures for data entry at all relevant points, including how to avoid common errors, is important.

There are a number of limitations to this study. The ACT and Tasmania were unable to participate in the study, and NT data needed to be excluded from analysis because of major data variance from other jurisdictions. A total of 44% of the assigned records from the other five jurisdictions could not be assessed; it is not known whether data from these records might differ from those assessed. The power of our study to detect differences at the jurisdictional level, and by other factors such as remoteness, was lower than anticipated due to the number of records that could not be assessed and the lower than expected error rate. A total of 229 records were no longer overdue on AIR at the time of follow-up; it is not known what proportion of these represent children who were vaccinated late versus records that were inaccurate and subsequently updated via provider transfer or DHS intervention – future studies could investigate this. Among the AIR records that were assessed as actually up to date due to identified error, there were 11 instances where two records relating to the same child were assigned and followed up for overdue antigens usually given in a combination vaccine at the same schedule point.

Conclusions

This study represents the first attempt at the national level since 2001 to systematically study the accuracy of AIR data. While the error rate was lower than anticipated, based on previous studies, there remains room for further improvement.

On the basis of our study findings, the most influential areas in which data recording, transfer and handling could be improved to optimise the effectiveness of data transfer to AIR include:

1. data entry for all methods of transfer to AIR
2. processes for transfer of immunisation encounter information to AIR
3. data management to reduce duplicate records
4. engagement with and enhancing support to immunisation providers, particularly those in remote settings.

Future studies to monitor the effectiveness of vaccination encounter data transfer to the AIR should be informed by lessons learnt in this study, as well as challenges identified during the course of the project (refer to Appendix H).

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Appendices

Appendix A: Study questionnaire

Data Transfer Study 2017 – Stage 2

Guidance for liaising with provider in NSW, Victoria, South Australia and Western Australia

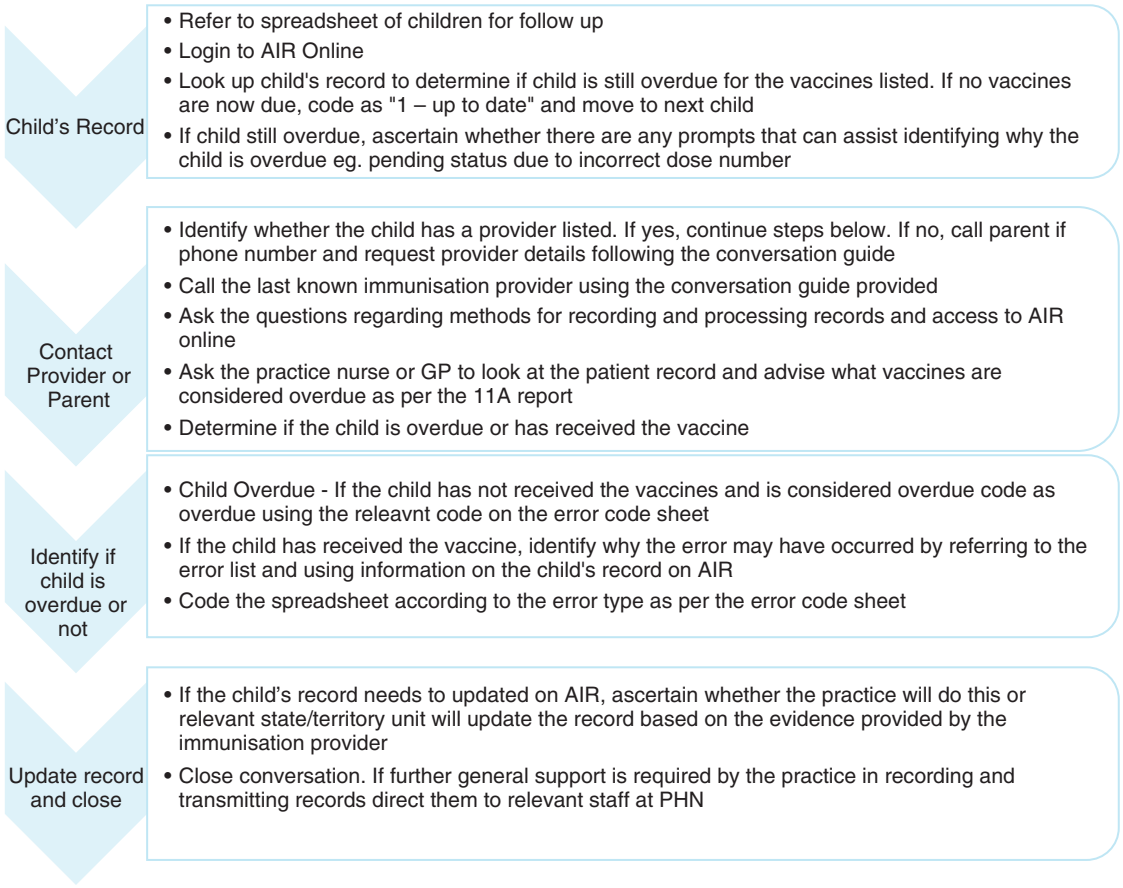
Background

NCIRS is undertaking a study to assess the effectiveness of the data recording, handling and transfer of immunisation encounters to the AIR and identify any barriers for the timeliness and accuracy of data. This project is a partnership between NCIRS, the Australian Government Department of Health, the Australian Government Department of Human Services and state and territory Jurisdictional Immunisation Coordinators. On completion of this study, a report will be produced that will identify the most influential areas in which data recording, transfer and handling could be improved and recommendations on the most practical ways to do so.

Guide

The following information is a guide for site investigators to use to follow up overdue children with their last know immunisation provider or for families who are not linked to a provider.

The following diagram outlines the key step in reviewing the 11A report and following up with the provider. Further detail is provided on the conversation guide below.



Step	Action	Question/Task
1.	Refer to spreadsheet of overdue children and identify child's record on AIR online to determine if spreadsheet still accurate. Check Immunisation History to see if any encounters are partially processed. If so, use this information to assist in identifying the error when liaising with the provider.	If the spreadsheet is accurate proceed with step 2. If AIR record is now up to date, record date of vaccine given and code error as 1 (see error code attachment). No further action for this child is required
2a.	If the child is linked to a provider: Identify how many children are linked to that provider. Call provider, identify yourself and ask to speak to the nurse, GP or Practice Manager who can assist with immunisation records If a practice has more than 3 records to be reviewed, provide an option: to call at another time or fax list (Go to step 2b if child is not linked to a provider)	Hello, my name is XX. I am calling from XX. We are currently checking children's immunisation records to determine if the information regarding overdue children is accurate. This is routine follow up for children listed as overdue and is being conducted nationally to determine if there are any common errors in the transfer of information to the AIR. Any information collected regarding errors will be de-identified and contain no patient information. I have x number of children that have been to your practice and are listed overdue for immunisations. I would be grateful if you could check these patient records and we will also just ask your methods for sending immunisation information to the AIR. It will take up to 10 minutes (*estimate 5 minutes per patient*). *If more than 3 children on list for one provider:* Do you have some time now to look up the records of the children as it make take a few minutes per child. If not, could you please advise a suitable time to call or whether they would like a list of children faxed to practice and a follow up phone call. If one of these Record outcome in Notes section of spreadsheet. Continue to Step 3
2b.	If the child is not linked to a provider: A phone call is to be made to the parent/carer if a phone number is listed on the 11A report. • If a phone number is available, call number using script. • If no contact is made after 2 telephone calls, code "no contact made" and no further action.	Hello, my name is XX. I am calling from XX. We are currently checking children's immunisation records to determine if the information regarding overdue children is accurate. This is routine follow up for children listed as overdue and is being conducted nationally to determine if there are any common errors in the transfer of information to the Australian Immunisation Register. Any information collected regarding errors will be de-identified and contain no patient information. We will be following up records with your last medical provider. If you would like to participate, could you please provide a name and location of the GP/Council or other immunisation provider that you last visited? If parent/carer gives the provider details record provider details and commence step 2a detailed above. If the parent/carer: • does not want to participate • advises they are a conscientious objector or vaccine hesitant • has a language barrier thank them for their time and close call. Record code.

(***Continued***)

(Continued)

Step	Action	Question/Task
		If parent/carer advises that immunisation record needs to be updated or they want to catch-up on vaccines, refer the parent/carer to call their local immunisation provider to make an appointment. Record code.
3.	Advise provider: I need to identify how you record and send immunisations to the Australian Immunisation Register.	Ask questions 1–5 in the questionnaire relating to the recording and transfer systems that are used.
4.	Ask the provider to open the child's record. (Refer to the patient names in the spreadsheet)	Ask: Does this patient identify as Aboriginal or Torres Strait Islander. Record yes/no/unknown Ask: Has the child had any of the following vaccinations? (list the vaccines that the child is overdue)
5.	If NO to Step 4 regarding vaccinations:	Suggest that they may need to remind the patient that they are overdue and ask provider if they are a known objector or delaying vaccine (mark using error codes in the 'overdue' category). Check next patient if applicable. If no other patients, thank provider for their time. Code spreadsheet accordingly.
	If YES to Step 4 regarding vaccinations:	If yes, ask what date the vaccine was given and insert date in spreadsheet. Try and determine why the encounter has not been transmitted. Using PMS • If the record was sent by PMS, try to determine where the error occurred in recording or transmitting the encounter *(refer to page 6 for common errors).* Useful prompts include missing Medicare number, sequence number missing, wrong vaccine recorded. Using Paper Based • Do they have a record of sending the form to AIR? If could not determine where error has occurred, code accordingly (error code 7) Using AIR Secure Site (online) • Do they have a Claim ID number recorded in the patient notes to confirm the successful entry? If could not determine where error has occurred, code accordingly (error code 8) List an error code in the spreadsheet Determine whether you or the provider will resend the information to AIR if the patient record needs to be updated.
6.	Check next patient if applicable. If no other patients, thank provider for their time. Code spreadsheet accordingly.	

Questionnaire for liaising with Provider

Questions identifying how practice records and transfers encounters to AIR.		
Provider/Practice Name:		Tel:
☐ A. General Practitioner	☐ B. Council	☐ C. Aboriginal health service/worker
☐ D. Community health centre	☐ E. No provider listed	☐ F. Other: Public hospital; Private hospital; Public health unit; Flying doctor service; Private hospital

Method of Recording and transmitting encounters

1.	What is your primary method for transmitting Immunisation encounters to the Australian Immunisation Registry (AIR)?	Practice Software (please specify) Go to Q3 ☐ A. Medical Director/PracSoft, version _____ ☐ B. Best Practice, version _____ ☐ C. ZedMed, version _____ ☐ D. MedTech, version _____ ☐ E. IMPS, version _____ ☐ F. Genie, version _____ ☐ G. E-Claims ☐ H. Other _____ specify in version column Paper-based – Go to Q2 ☐ I. Immunisation encounter (purple) form (N/A to QLD) ☐ J. Immunisation history form ☐ K. Practice letterhead ☐ L. Other (specify) _____ AIR Secure Site (Online) Go to Q3 ☐ M. AIR Secure Site (online) direct ☐ N. via PRODA ☐ O. via HPOS VIVAS (QLD Only) Go to Q3 ☐ P. Send paper forms to VIVAS NTIR (NT Only) ☐ Q. Send to NTIR OTHER Go to Q3 ☐ R. Other (please specify) _____
2.	If paper-based records are transmitted, what method do you use for sending these records to AIR:	☐ A. Post ☐ B. Fax ☐ C. Email ☐ D. Unsure ☐ E. Other
3.	Does your practice or general practitioners have online access to the AIR Secure Site (Online)	☐ A. Yes ☐ B. No ☐ C. Don't know
4.	What is your practices method for transferring Overseas History to AIR?	☐ A. Complete and send Overseas history form ☐ B. AIR Secure Site (online) ☐ C. Telephone AIR ☐ D. VIVAS (QLD Only) ☐ E. NTIR (NT Only) ☐ F. Unsure ☐ G. Other
5.	What is your practices method of advising AIR of a medical contraindication or natural immunity to an immunisation?	☐ A. Complete & send Immunisation Medical Exemption Form ☐ B. AIR Secure Site (online) ☐ C. Telephone AIR ☐ D. VIVAS (QLD Only) ☐ E. NTIR (NT Only) ☐ F. Unsure ☐ G. Other

Error codes by Category

Use this information when identifying errors and recording codes in spreadsheet. If more than one error is identified, you can record up to 3 errors in the data collection spreadsheet

Category	Description	Code
Up to date	AIR record was checked before calling provider and child's record now up to date	1.
Overdue	Child overdue according to providers record	2.
(Followed up with Provider)	Parents/carers have refused vaccination – reported by provider	3.
	Parents/carers delaying vaccination, no medical contraindication – reported by provider	4.
	Provider recommended delaying vaccination due to illness	5.
	Parent/carer delaying vaccination due to illness – reported in patients notes held by provider	6.
Paper based forms	Vaccine given. Practice sent paper record sent to AIR.	7.
AIR Secure Site (Online) entry	Vaccine given. Practice uploaded encounter on AIR.	8.
Data entry error	Wrong vaccine name recorded – e.g. Infanrix (Hexa, IPV); MMR instead of MMRV	9.
	Vaccine sequence/dose number incorrect or not recorded	10.
	Vaccine batch number incorrect or not recorded	11.
	Immunisation recorded in notes section of patient record, not immunisation tab and encounter has not been transmitted	12.
	Nurse listed as provider and encounter has not been transmitted	13.
Clinical error	Wrong vaccine given	14.
	Vaccine given too early to be recognised by AIR	15.
	Interval between doses was not accepted by AIR	16.
Practice Software Failure	No Medicare card for child, transmission failed	17.
	Child demographic error (e.g. DOB or address wrong or postcode missing), transmission failed	18.
	Other Practice Software error, transmission failed	19.
	No error detected. Encounter sent but AIR record not up to date.	20.
	Practice could not determine error	21.
Overseas history/schedule	Vaccines given overseas, patient not up to date with NIP	22.
	Overseas history not completed correctly or submitted to AIR	23.
	On catch up – AIR have not been notified	24.
	On catch up – 6 month catch up period has expired	25.
Medical Contraindication/ Natural Immunity	Patient had immunisation medical exemption form completed and sent to AIR.	26.
	Patient has natural immunity recorded (e.g. varicella) or medical contraindication but no form completed and submitted to AIR	27.
Provider unknown	Current provider is not the provider in which the immunisation is overdue (e.g. overdue for 2 months, but this provider has only seen the child since 12 months of age)	28.
Duplicate record	Duplicate record – different first name or surname	29.
	Duplicate record – 'Baby of'	30.
	Duplicate record – other	31.
Inactive or Overseas patient	Inactive patient at practice (patient not seen in the last 12 months)	32.
	Child moved overseas, confirmed	33.
	Child moved overseas, speculated	34.

(*Continued*)

(Continued)

Category	Description	Code
		35.
	Child moved within Australia	36.
Not linked to a provider	No contact details available. No contact made	37.
	Parent/carer could not be contacted using phone number available	38.
	Parent/carer called, did not want to participate	39.
	Parent/carer called, advised they were a conscientious objector, vaccine hesitant or delaying vaccine (no illness)	40.
	Parent/carer called, advised they delaying vaccination due to illness	41.
	Parent/carer called, they want to update records or have catch up vaccines, directed to contact their immunisation provider	42.
	Parent/carer called. Language barrier. No progress	43.
Other	Specify	44.
Unknown	Could not determine error	45.

Appendices

AIR	Australian Immunisation Register
AIR Secure Site	Refers to the online website that can be accessed by providers to view and update immunisation records
BP	Best Practice – Practice Management Software Program
HPOS	Health Professionals Online Services – An online platform for providers to login to AIR online
MD	Medical Director. Practice Management Software Program
PRODA	Provider Digital Access – An online platform for providers to login to AIR online

Common Errors in Practice Software

All Software	• Incorrect demographic details - Missing postcode - State or Territory appears in Suburb Field - PO Box listed as address • Missing or incorrect sequence number • Vaccine recorded in patient notes and not in immunisation tab • Provider details incorrect • Nurse listed as provider (AIR will not accept nurses as provider)
Medical Director specific	• No Medicare Card listed (MD does not transmit without a Medicare card)
ZedMed	• Menitorix listed as dose 4

Appendix B: Detailed sample size requirements by jurisdiction, coverage level and milestone age

	Low coverage[a]				Medium coverage[b]				High coverage[c]				
	9–<12 mo.	15–<18 mo.	21–<24 mo.	51–<54 mo.	9–<12 mo.	15–<18 mo.	21–<24 mo.	51–<54 mo.	9–<12 mo.	15–<18 mo.	21–<24 mo.	51–<54 mo.	Total
NSW	39	45	47	69	24	27	28	41	16	18	18	28	400
VIC	40	47	44	69	24	28	27	41	16	18	18	28	400
WA	39	49	48	64	23	29	29	39	15	20	19	26	400
NT	47	41	62	50	28	25	37	30	19	16	25	20	400
QLD	40	40	52	68	24	24	31	41	16	16	21	27	400
SA	37	40	45	78	22	24	27	47	15	16	18	31	400
Total	242	262	298	398	145	157	179	239	97	104	119	160	2400

[a]50% of all records collected, 200 records per jurisdiction.
[b]30% of all records collected, 120 records per jurisdiction.
[c]20% of all records collected, 80 records per jurisdiction.

Appendix C: National descriptive data including the NT data

National frequencies, proportions and error rates, by category, for all participating jurisdictions[a]

	Up to date N (% of total)	Truly overdue N (% of total)	Error rate %
Coverage level			
Low (<90%)	215 (52.1)	406 (48.4)	34.6
Medium (90 to <95%)	112 (27.1)	250 (29.8)	30.9
High (≥95%)	86 (20.8)	183 (21.8)	32.0
Total	413	839	33.0
ARIA+ remoteness			
Remote	238 (58.3)	49 (5.9)	82.9
Regional	73 (17.9)	151 (18.2)	32.6
City	97 (23.8)	629 (75.9)	13.4
Total	408	829	33.0
Provider type			
General practitioner	92 (22.5)	479 (68.3)	16.1
Local council	9 (2.2)	99 (14.1)	8.3
Aboriginal health worker	25 (6.1)	20 (2.9)	55.6
Community health centre	34 (8.3)	79 (11.3)	30.1
Other[b]	11 (2.7)	17 (2.4)	39.3
Jurisdictional health department	238 (58.2)	7 (1)	97.1
Total	409	701	36.9
Transfer method			
Practice management software	82 (20.7)	556 (81.6)	12.9
Paper-based	7 (1.8)	6 (0.9)	53.9
Online AIR Secure Site	23 (5.8)	67 (9.8)	25.6
NT Immunisation Register	283 (71.5)	43 (6.3)	86.8
Other[c]	1 (0.3)	9 (1.3)	10.0
Total	396	681	36.8
Age cohort			
9 to <12 months	122 (29.5)	140 (16.7)	46.6
15 to <18 months	95 (23)	177 (21.1)	34.9
21 to <24 months	78 (18.9)	237 (28.3)	24.8
51 to <54 months	118 (28.6)	285 (340)	29.3
Total	413	839	33.0

[a]Participating jurisdictions include: New South Wales, Northern Territory, Queensland, South Australia, Victoria, and Western Australia.
[b]Other provider type included public hospital, private hospital, public health unit, and flying doctor services.
[c]Other transfer method not included in the listed categories; these were not specified.

Appendix D: Codes assigned to each record by category groupings

Code category	Code assigned to records
Overdue	
Truly overdue	
2	Child overdue according to provider's record
14	Wrong vaccine given
15	Vaccine given too early to be recognised by AIR
16	Interval between doses was not accepted by AIR
26	Patient had immunisation exemption form completed and sent to AIR
27	Patient has natural immunity recorded or medical contradiction but no form completed and submitted to AIR
40	Parent/carer called, advised they are delaying vaccination due to illness
41	Parent/carer called, they want to update records or have catch-up vaccines, directed to contact their immunisation provider
47	No vaccines recorded – only on register from Medicare card
50	Other – include as overdue
Overseas vaccines, not NIP up to date	
22	Vaccines given overseas, patient not up to date with NIP
Provider delaying vaccination	
5	Provider recommended delaying vaccination due to illness
Parental refusal or delay	
3	Parents/carers have refused vaccination – reported by provider
4	Parents/carers delaying vaccination, no medical contradiction, reported by provider
6	Parent/carer delaying vaccination due to illness – reported in patients' notes held by the provider
39	Parent/carer called, advised they were a conscientious objector, vaccine hesitant, or delaying vaccine (no illness)
On catch-up schedule	
24	On catch-up – AIR have not been notified
25	On catch-up – 6 month catch-up period has expired
Up to Date	
Paper form/AIR online error	
7	Vaccine given, practice sent paper record to AIR
8	Vaccine given, practice uploaded encounter on AIR
Failure of transfer from PMS to AIR	
Practice-level data error – vaccination encounter	
9	Wrong vaccine name recorded – e.g. Infanrix (Hexa, IPV); MMR instead of MMRV
10	Vaccine sequence/dose number incorrect or not recorded
11	Vaccine batch number incorrect or not recorded
12	Immunisation recorded in notes section of patient record, not immunisation tab and encounter not transmitted
13	Nurse listed as provider and encounter not transmitted
23	Overseas history not completed correctly
49	Other
Other documented practice level issue	
17	No Medicare card for record, transmission failed
18	Child demographic error, transmission failed
19	Other practice software error, transmission failed
Unclear whether error related to PMS, AIR receipt or combination thereof	
20	No error detected, encounter sent but AIR record not up to date

(*Continued*)

(Continued)

Code category	Code assigned to records
21	Practice could not determine error
Duplicate 'Baby of' record	
30	Duplicate record – 'Baby of'
Other duplicate record	
29	Duplicate record – different first name or surname
31	Duplicate record – other
Lost to Follow-Up	
No contact made/participation	
36	No contact details available, no contact made
37	Parent/carer could not be contacted using phone number available
38	Parent/carer called, did not want to participate
45	Lost to follow-up
48	Record not followed-up by site
Missing/inactive record	
28	Current provider is not the provider in which the immunisation is overdue
32	Inactive patient at practice (patient not seen in the last 12 months)
46	Practice can't find patient's record in the system
Site hasn't reviewed record	
52	Records not followed up by site
Child moved overseas/interstate	
33	Child moved overseas, confirmed
34	Child moved overseas, speculated
35	Child moved within Australia
Unknown	
44	Could not determine error
51	Other- include as lost to follow-up
Excluded	
AIR record up to date upon follow-up	
1	AIR record was checked before calling provider and the record is now up to date

Appendix E: Categorisation of records unable to be assessed by jurisdiction, excluding the NT

Category	Jurisdiction					
	NSW	QLD	SA	VIC	WA	Total
No contact made/declined participation	157 (74.4%)	109 (84.5%)	162 (86.2%)	108 (63.5%)	166 (85.6%)	702 (78.7%)
Missing or inactive record	41 (19.4%)	6 (4.7%)	14 (7.5%)	5 (2.9%)	20 (10.3%)	86 (9.6%)
Child moved overseas or interstate	11 (5.2%)	14 (10.9%)	11 (5.9%)	1 (0.6%)	7 (3.6%)	44 (4.9%)
Unknown	2 (1.0%)	0	1 (0.5%)	0	1 (0.5%)	4 (0.5%)
Total	211	129	188	170[a]	194	892[a]

[a]Includes 56 records not reviewed by VIC.

Appendix F: NT-specific error categories and rates

NT error rate	
Actually up to date	289
Truly overdue	58
Total	347
Error rate	83.30%
NT records determined to be actually up to date by error category	
Paper form or AIR online error	0
Transfer from practice management software to AIR	6 (2.1%)
'Baby of' record	235 (81.3%)
Other duplicate record	48 (16.6%)
Total	289
NT records determined to be truly overdue by category	
Overdue – no specific reason identified	41 (70.7%)
Overseas vaccines, not NIP up to date	7 (12.1%)
Provider recommended delaying vaccination	0
On catch-up schedule	0
Parent refusing or delaying vaccination	10 (17.2%)
Total	58
NT records lost to follow-up by category	
No contact made/declined participation	4 (14.8%)
Missing or inactive record	3 (11.1%)
Child moved overseas or interstate	20 (74.1%)
Unknown	0
Total	27

Appendix G: Descriptive analysis by jurisdiction

New South Wales

	Up to date	Truly overdue	Error rate%
Coverage level			
Low (<90%)	23 (48.9%)	55 (46.6%)	29.5
Med (90–<95%)	17 (36.2%)	33 (28.0%)	34
High (≥95%)	7 (14.9%)	30 (25.4%)	18.9
Total	47	118	28.5
Remoteness status			
Remote	1 (2.2%)	7 (6.1%)	12.5
Regional	5 (10.9%)	16 (14.0%)	23.8
Major Cities	40 (87.0%)	91 (79.8%)	30.5
Total	46	114	28.8
Provider type			
GP	43 (91.5%)	101 (85.6%)	42.2
Council	0	3 (2.5%)	0
AHW	0	5 (4.2%)	0
CHC	0	5 (4.2%)	0
None listed	1 (2.1%)	3 (2.5%)	25
Other	3 (6.4%)	1 (0.9%)	75
State HD	0	0	0
Total	47	118	28.5
Transfer method			
Practice management software	33 (76.7%)	95 (83.3%)	25.8
Paper-based	3 (7.0%)	2 (1.8%)	60
Online AIR Secure Site	7 (16.3%)	17 (14.9%)	29.2
Other	0	0	0
Total	43	114	27.4
Age cohort			
9 to <12 months	11 (23.4%)	24 (20.3%)	31.4
15 to <18 months	11 (23.4%)	37 (31.4%)	22.9
21 to <24 months	15 (31.9%)	28 (23.7%)	34.9
51 to <54 months	10 (21.3%)	29 (24.6%)	25.6
Total	47	118	28.5

Northern Territory

	Up to date	Truly overdue	Error rate%
Coverage level			
Low (<90%)	152 (52.6%)	22 (37.9%)	87.4
Med (90–<95%)	75 (26.0%)	27 (46.6%)	73.5
High (≥95%)	62 (21.5%)	9 (15.5%)	87.3
Total	289	58	83.3
Remoteness status			
Remote	232 (81.1%)	29 (53.7%)	88.9
Regional	54 (18.9%)	25 (46.3%)	68.4
Major Cities	0	0	0
Total	286	54	84.1

(*Continued*)

(Continued)

	Up to date	Truly overdue	Error rate%
Provider type			
GP	1 (0.4%)	7 (12.1%)	12.5
Council	0	0	0
AHW	25 (8.7%)	8 (13.8%)	75.8
CHC	26 (9%)	30 (51.7%)	46.4
None listed	1 (0.4%)	11 (19.0%)	8.3
Other	2 (0.7%)	0	100
State HD	234 (81.0%)	2 (3.5%)	99.2
Total	289	58	83.3
Transfer method			
Practice management software	5 (1.7%)	3 (6.3%)	62.5
Paper-based	0	0	0
AIR Online	0	0	0
NT Immunisation Register	283 (98.3%)	43 (89.6%)	86.8
Other	0	2 (4.2%)	0
Total	288	48	85.7
Age cohort			
9 to <12 months	86 (29.8%)	3 (5.2%)	96.6
15 to <18 months	71 (24.6%)	6 (10.3%)	92.2
21 to <24 months	50 (17.3%)	34 (58.6%)	59.5
51 to <54 months	82 (28.4%)	15 (25.9%)	84.5
Total	289	58	83.3

Queensland

	Up to date	Truly overdue	Error rate%
Coverage level			
Low (<90%)	10 (52.6%)	97 (47.3%)	9.3
Med (90–<95%)	5 (26.3%)	63 (30.7%)	7.4
High (≥95%)	4 (21.1%)	45 (22.0%)	8.2
Total	19	205	8.5
Remoteness status			
Remote	0	4 (2.0%)	0
Regional	4 (21.1%)	52 (25.4%)	7.1
Major Cities	15 (79.0%)	149 (72.7%)	9.2
Total	19	205	8.5
Provider type			
GP	13 (68.4%)	91 (44.4%)	12.5
Council	2 (10.5%)	17 (8.3%)	10.5
AHW	0	3 (1.5%)	0
CHC	0	1 (0.5%)	0
None listed	0	89 (43.4%)	0
Other	0	0	0
State HD	4 (21.1%)	4 (2.0%)	50
Total	19	205	8.5

(*Continued*)

(Continued)

	Up to date	Truly overdue	Error rate%
Transfer method			
Practice management software	9 (69.2%)	92 (88.5%)	8.9
Paper-based	3 (23.1%)	0	100
Online AIR Secure Site	0	5 (4.8%)	0
Other	1 (7.7%)	7 (6.7%)	12.5
Total	13	104	11.1
Age cohort			
9 to <12 months	3 (15.8%)	41 (20%)	6.8
15 to <18 months	7 (36.8%)	42 (20.5%)	14.3
21 to <24 months	2 (10.5%)	61 (29.8%)	3.2
51 to <54 months	7 (36.8%)	61 (29.8%)	10.3
Total	19	205	8.5

South Australia

	Up to date	Truly overdue	Error rate%
Coverage level			
Low (<90%)	19 (52.8%)	76 (50.0%)	20
Med (90–<95%)	10 (27.8%)	40 (26.3%)	20
High (≥95%)	7 (19.4%)	36 (23.7%)	16.3
Total	36	152	19.1
Remoteness status			
Remote	1 (2.8%)	4 (2.6%)	20
Regional	5 (13.9%)	19 (12.5%)	20.8
Major Cities	30 (83.3%)	129 (84.9%)	18.9
Total	36	152	19.1
Provider type			
GP	23 (63.9%)	87 (57.2%)	20.9
Council	3 (8.3%)	34 (22.4%)	8.1
AHW	0	3 (2.0%)	0
CHC	3 (8.3%)	3 (2.0%)	50
None listed	2 (5.6%)	22 (14.5%)	8.3
Other	5 (13.9%)	3 (2.0%)	62.5
State HD	0	0	0
Total	36	152	19.1
Transfer method			
Practice management software	17 (56.7%)	108 (83.1%)	13.6
Paper-based	1 (3.3%)	4 (3.1%)	20
Online AIR Secure Site	12 (40.0%)	18 (13.9%)	40
Other	0	0	0
Total	30	130	18.8
Age cohort			
9 to <12 months	14 (38.9%)	23 (15.1%)	37.8
15 to <18 months	2 (5.6%)	31 (20.4%)	6.1
21 to <24 months	6 (16.7%)	29 (19.1%)	17.1
51 to <54 months	14 (38.9%)	69 (45.4%)	16.9
Total	36	152	19.1

Victoria

	Up to date	Truly overdue	Error rate%
Coverage level			
Low (<90%)	2 (50.0%)	76 (50.3%)	2.6
Med (90–<95%)	0	46 (30.5%)	0
High (≥95%)	2 (50.0%)	29 (19.2%)	6.5
Total	4	151	2.9
Remoteness status			
Remote	0	0	0
Regional	2 (50.0%)	25 (16.6%)	7.4
Major Cities	2 (50.0%)	126 (83.4%)	1.6
Total	4	151	2.9
Provider type			
GP	1 (25.0%)	98 (64.9%)	1.0
Council	3 (75.0%)	41 (27.2%)	6.8
AHW	0	1 (0.7%)	0
CHC	0	0	0
None listed	0	8 (5.3%)	0
Other	0	3 (2.0%)	0
State HD	0	0	0
Total	4	151	2.9
Transfer method			
PMS	4 (100.0%)	142 (100.0%)	2.7
Paper-based	0	0	0
Online AIR Secure Site	0	0	0
Other	0	0	0
Total	4	142	2.7
Age cohort			
9 to <12 months	2 (50.0%)	28 (18.5%)	6.7
15 to <18 months	0	32 (21.2%)	0
21 to <24 months	0	39 (25.8%)	0
51 to <54 months	2 (50.0%)	52 (34.4%)	3.7
Total	4	151	2.9

Western Australia

	Up to date	Truly overdue	Error rate%
Coverage level			
Low (<90%)	9 (50.0%)	80 (51.6%)	10.1
Med (90–<95%)	5 (27.8%)	41 (26.5%)	10.9
High (≥95%)	4 (22.2%)	34 (21.9%)	10.5
Total	18	155	10.4
Remoteness status			
Remote	4 (23.5%)	5 (3.3%)	44.4
Regional	3 (17.7%)	14 (9.2%)	17.5
Major Cities	10 (58.8%)	134 (87.6%)	6.9
Total	17	153	10
Provider type			
GP	11 (61.1%)	95 (61.3%)	17.7
Council	1 (5.6%)	4 (2.6%)	20

(*Continued*)

(Continued)

	Up to date	Truly overdue	Error rate%
AHW	0	0	0
CHC	5 (27.8%)	40 (25.8%)	11.1
None listed	0	5 (3.2%)	0
Other	1 (5.6%)	10 (6.5%)	9.1
State HD	0	1 (0.7%)	0
Total	18	155	10.4
Transfer method			
Practice Management Software	14 (77.8%)	116 (81.1%)	10.8
Paper-based	0	0	0
Online AIR Secure Site	4 (22.2%)	27 (18.9%)	12.9
Other	0	0	0
Total	18	143	11.2
Age cohort			
9 to <12 months	6 (33.3%)	21 (13.6%)	22.2
15 to <18 months	4 (22.2%)	29 (18.7%)	12.1
21 to <24 months	5 (27.8%)	46 (29.7%)	9.8
51 to <54 months	3 (16.7%)	59 (38.1%)	4.8
Total	18	155	10.4

Appendix H: Study challenges

A number of challenges were identified during the conduct of the study, as detailed below.

Resource intensive

Most sites identified during the course of the project that the human resources required to undertake the study were significant, particularly in jurisdictions where one organisation was solely responsible for the follow-up, with the study being conducted in addition to normal work duties. Follow-up of providers was also identified by sites to be challenging and time-consuming. Sites reported that reception staff were often hesitant to refer the call to the nurse or GP, providers were often unavailable or a follow-up or return call was required. It was also difficult to find the most appropriate contact where the provider was a hospital.

Disease outbreaks and other compounding factors

A number of factors impacted some sites' capacity to participate and/or complete the study on time. These included:

- invasive meningococcal disease outbreak
- significant influenza season
- introduction and roll out of the ACWY meningococcal vaccine in high schools.

11A reports

The study required the sites to extract 11A reports and then for a central site to assist with merging the raw data. One of the AIR 11A reports from SA did not extract properly, resulting in a large number of records unlinked to providers and affecting 172 out of 400 records. One of the SA sites manually added additional information where available from the AIR. It is not possible to retrospectively extract 11A reports.

Merging 11A reports required significant skill and experience to make the output user-friendly and to ensure all relevant information regarding each record was provided in a single file.

Follow up

919 records in this study could not be followed up; 394 of these were not linked to a provider and either had no parent/carer telephone number listed or the parent/carer was not contactable.

Error rate

The error rate was lower than expected. As a result, the power of our study to detect differences at the jurisdictional level was lower than anticipated.