Evaluation of bacille Calmette-Guérin immunisation programs in Australia

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Abstract

Background: bacille Calmette-Guérin (BCG) immunisation programs in Australia are funded and operated by the individual states and territories. In recent years BCG vaccine shortages have required use of unregistered products. We aimed to evaluate BCG immunisation programs in Australia, with particular reference to program implementation and national consistency.

Methods: Between September and November 2015, 12 key stakeholders, representing Australian states and territories, completed surveys. We analysed BCG vaccination coverage data from the Australian Childhood Immunisation Register (ACIR), and data on adverse events following immunisation (AEFI) with BCG vaccine from the Therapeutic Goods Administration's Adverse Drug Reactions System, for 2001 to 2014.

Results: Access to BCG vaccination varies between jurisdictions, with some states providing this only in major city locations. Analysis of ACIR data suggests significant differences in vaccine delivery between jurisdictions, but varying levels of under-reporting to the ACIR were also acknowledged. The rate of BCG AEFI appeared to increase between 2011 and 2014; however, these data need to be interpreted with caution due to small numbers, likely under-reporting of both numerator (AEFI) and denominator (vaccine doses administered), and the general increase in reporting of AEFI related to other vaccines in children over this period.

Conclusions: BCG immunisation programs aim to prevent severe forms of tuberculosis in young children who live in or travel to high burden settings. A range of factors, particularly inconsistent vaccine supply are leading to low, variable and inequitable vaccine delivery across Australian jurisdictions. Improved BCG vaccination uptake and AEFI data quality are required for accurate monitoring of program delivery and vaccine safety – this is particularly important given the current need to use unregistered vaccines. Improved and consistent access to BCG vaccine is suggested to optimise equity for at-risk children Australia-wide. *Commun Dis Intell* 2017;41(1):E33–E48.

Keywords: adverse reaction; bacille Calmette-Guérin; immunisation; tuberculosis

Introduction

Bacille Calmette-Guérin (BCG) vaccine has been in use since 1921. Vaccination of young children is considered an important strategy in almost all national tuberculosis (TB) programs, particularly in countries with a high burden of TB.[1] As of 2013, the incidence of TB in Australia was 5.5 per 100,000 population,[2] one of the lowest rates of TB in the world.[3] However, 28% of Australia's population are overseas-born and many are from TB endemic countries.[4] People born overseas make up the majority of TB cases in Australia, with an incidence of 18.4 per 100,000 in 2013. The incidence of TB among the Australian-born population has remained relatively stable in recent years, although with a marked disparity between Aboriginal and Torres Strait Islander (henceforth referred to as Indigenous) and non-Indigenous populations (incidence 4.6 and 0.8 per 100,000, respectively, in 2013).[2]

There is strong evidence that BCG vaccination in infancy provides a more than 70% protection against severe disseminated forms of TB, including miliary TB and TB meningitis.[1] The efficacy of BCG vaccine against pulmonary TB in adults is less consistent and has ranged from 0% to 80% in controlled trials.[5] Australian national guidelines on the use of BCG vaccine (*The Australian Immunisation Handbook* and the National Tuberculosis Advisory Committee (NTAC) guidelines, *The BCG vaccine: information and recommendations for use in Australia*)[6,7] recommend vaccination principally for young children who will be travelling to or living in regions with a high prevalence of TB for extended periods (preferably 2–3 months prior to departure), and Indigenous neonates in communities with a high incidence of TB (currently implemented in Queensland, the Northern Territory and northern South Australia only).[6,7]

Unlike other childhood vaccines, BCG vaccine coverage in Australia is not routinely reported. In addition, unlike most other vaccines recommended and funded for use in children in Australia, BCG is not delivered under the National Immunisation Program (NIP).[8] Rather BCG immunisation programs are funded and operated by individual states and territories. In recent years recurrent BCG vaccine shortages have required states and territories to prioritise and conserve stocks and/or

use unregistered products. There was a shortage of BCG vaccine for several months in 2012 following a recall of the only BCG vaccine registered in Australia (BCG Vaccine, Sanofi Pasteur).[9] A replacement unregistered vaccine (BCG Vaccine, Danish Strain 1331, Statens Serum Institute (SSI) in Denmark) was sourced under Section 19A(3) of the *Therapeutic Goods Act 1989*,[10] which allows for importation of unregistered products from specified countries with comparable regulatory standards, during shortages of registered products. The SSI product was supplied from September 2012 to the end of 2015, when it also became unavailable. All alternative products currently available can only be sourced and supplied via the Authorised Prescriber Scheme or Special Access Scheme of the *Therapeutic Goods Act*.[10,11] The difficulties in sourcing appropriate alternative products have been exacerbated in recent years by a global BCG vaccine shortage.[12] Of note, subsequent to our study, the complex issues and barriers to the use of potentially available unregistered vaccines led to most Australian jurisdictions suspending their BCG immunisation programs. As of August 2016 only the New South Wales and Victorian programs were active, using an unregistered Polish vaccine.

BCG vaccine causes adverse events in about 5% of the recipients. Common adverse events include infection site abscess in 2.5%, lymphadenitis in 1%, and up to 1% require medical attention.[13] Serious or long-term complications are rare.[13,14] The vaccines used in Australia in recent years are derived from different BCG strains, each of which may have a different reactogenicity profile.[15] Only passive surveillance of adverse events following immunisation (AEFI) with BCG vaccine occurs in Australia.[16]

No national level evaluation of BCG immunisation programs in Australia has previously been conducted. In the context of the issues outlined above, we aimed to evaluate BCG immunisation programs in Australia, with particular reference to program implementation and national consistency, and to promote discussion on improving program delivery (Box).

Methods

Data sources

The data sources for each specific evaluation topic are summarised in Table 1.

Document review

We conducted a detailed search of the Australian Government Department of Health and state and territory government health web sites to identify relevant documents on BCG immunisation policy and programs, including guidelines, fact sheets, media releases, provider and patient resources (e.g. brochures, posters) and reports. Health departments were also asked to provide any additional relevant documents.

Key stakeholder survey

Key stakeholder surveys were conducted between September and November 2015 to gain an in-depth understanding of program implementation as well as strengths and weaknesses/challenges (Appendix). Purposive sampling, using a sampling matrix (Table 2), was used to recruit a representative sample across key stakeholder groups and jurisdictions. Jurisdictional-level TB program managers and coordinators were approached directly while immunisation providers and local program coordinators were referred by other participants (respondent-driven and snowballing sampling).

Box: Evaluation objectives

The specific objectives of the evaluation were:

1. to review policy and practice regarding the use of bacille Calmette-Guérin vaccine at a national and jurisdictional level in Australia; and
2. to describe and assess how bacille Calmette-Guérin vaccine programs are implemented across different states and territories in Australia, with specific regard to:
   a. availability, accessibility and awareness;
   b. vaccine uptake/coverage;
   c. reporting and follow-up of adverse events following immunisation related to bacille Calmette-Guérin vaccine;
   d. consistency between jurisdictional programs and with national guidelines; and
   e. strengths, challenges and recommendations.

Table 1: Summary of data sources used for each specific objective

Objective	Evaluation topics	Data sources
To review policy and practice regarding the use of bacille Calmette-Guérin vaccine at a national and jurisdictional level in Australia		Document review
To describe and assess how bacille Calmette-Guérin vaccine programs are implemented across different states and territories in Australia	Availability, accessibility and awareness	Key stakeholder survey
	Vaccine uptake/coverage	Australian Childhood Immunisation Register
	Reporting and follow-up of adverse events following immunisation related to bacille Calmette-Guérin vaccine	Key stakeholder survey Australian Adverse Drug Reactions System database
	Consistency between jurisdictional programs and with national guidelines	Document review
	Strengths, challenges and recommendations	Key stakeholder survey

Table 2: Matrix of interview participants

Participants	NSW	NT	Qld	Tas.	SA	Vic.	WA
Tuberculosis (TB) medical advisor			X	X	X	X	
Jurisdictional TB program manager/coordinator	X	X	X			X	X
Epidemiologist			X				
TB/chest clinic clinical nurse consultants			X				
Remote area immunisation provider			X				

X = One key informant.

No response from the Australian Capital Territory.

A semi-structured questionnaire was developed by staff from the National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases, based on previous national immunisation program evaluations. The questionnaire contained both open and closed questions and sought information on:

a. program implementation including availability and access to BCG vaccine for providers and consumers;

b. communication strategies and resources to engage providers and consumers';

c. reporting of BCG vaccination and AEFI; and

d. strengths and challenges of the program and recommendations for improvements.

The questionnaire was piloted and modified to incorporate feedback. All key stakeholders were sent the questionnaire by email and the completed questionnaires were returned within 2 to 4 weeks.

Australian Childhood Immunisation Register

Vaccination coverage estimates and the number of BCG doses administered were obtained from the Australian Childhood Immunisation Register (ACIR). The ACIR was established in 1996 and is the primary source of vaccination coverage data in Australia. Detailed description of the operation of ACIR has been published previously.[17] At the time of this evaluation the ACIR recorded details of vaccinations given to children aged less than seven years, irrespective of whether NIP funded or not. Analysis of ACIR data was undertaken for vaccinations notified between 2001 and 2014, for data released to NCIRS in April 2015.

Australian Adverse Drug Reactions System database

De-identified data on AEFI with BCG vaccine between 2001 and 2014 reported to the Therapeutic Goods Administration (TGA) and stored in the Australian Adverse Drug Reactions System (ADRS) database were extracted from a dataset released to NCIRS in March 2015. ADRS

is a national passive surveillance system for AEFI data reported to the TGA by state and territory health departments, health professionals, vaccine manufacturers and members of the public. All AEFI reports are assessed using internationally consistent criteria[18] before being entered into the ADRS database.

Data analysis

Both qualitative and quantitative data were analysed. Content analysis was conducted on interview transcripts to identify prominent themes. BCG vaccination data were extracted from the NCIRS ACIR dataset and analysed by year of administration of vaccine and age group. BCG vaccination coverage data were analysed by jurisdiction and Indigenous status using 12-month wide birth cohorts for children born in 2012, 2013 and 2014. The percentage vaccinated for each cohort was calculated using ACIR data as at 30 September 2015. BCG-related AEFI data extracted from the NCIRS ADRS dataset were analysed by year and whether classified as serious, with rates per 100,000 doses calculated. Quantitative data analysis was performed using SAS software version 9.4 (SAS Institute Inc. Cary, NC, USA) and Excel 2010 (Microsoft, Redmond, PA, USA).

Stakeholder engagement/sharing of lessons learnt

The National Tuberculosis Advisory Committee (NTAC) was consulted on the design of the evaluation and provided comment on a draft report. The findings were also shared with the National Immunisation Committee, Communicable Diseases Network Australia, and the Australian Technical Advisory Group for Immunisation.

The study was conducted by NCIRS as part of its national immunisation program evaluation role and using de-identified aggregated data; ethics committee approval was not required.

Results

Document review

Guidance on the use of BCG vaccine in Australia is provided in both *The Australian Immunisation Handbook*[7] and the NTAC guidelines *The BCG vaccine: information and recommendations for use in Australia*.[9] We also identified jurisdiction-specific BCG immunisation policies or guidelines from all states and territories of Australia except for the Australian Capital Territory and Tasmania. Recommendations in current national and jurisdictional guidelines are compared in Table 3. There are minor differences between the 2 national guidelines, and more substantial differences between some of the jurisdictional guidelines.[6,7,19–25]

Key stakeholder interviews and associated data analysis

Twelve key stakeholders from across 5 stakeholder groups (Appendix), including representatives from 7 jurisdictions (New South Wales, the Northern Territory, Queensland, Tasmania, South Australia, Victoria and Western Australia, completed a semi-structured questionnaire covering program implementation issues across the following areas.

Vaccine administration

Availability of bacille Calmette-Guérin vaccine for providers

Participants stated that BCG vaccine is purchased through different routes, either via: their jurisdictional Department of Health Immunisation Branch (South Australia, Victoria and Western Australia); hospitals (New South Wales, Northern Territory); or central pharmacy (Queensland).

Demand for BCG vaccine at the state or territory level was reported to be measured variably. It is estimated from the previous year's usage in New South Wales, the Northern Territory and Queensland. In Western Australia, usage is monitored regularly by the central clinic. In Victoria, measurement was reported to have recently changed from estimation using the previous year's usage to a more detailed picture of actual and projected demand including: the number of children on the waiting list by month; mean or median waiting time from referral to administration of BCG; and the number of children vaccinated by month, age and gender and country of origin of parents.

All stakeholders, except one, stated that the recurrent shortages of BCG vaccine and uncertainty of supply had significantly impacted on BCG vaccine availability in their jurisdiction in the past 3 years.

Consumer access to bacille Calmette-Guérin vaccination

Consumer access to BCG vaccination varied between jurisdictions. New South Wales, Queensland, Western Australia and the Northern Territory provide access at regional and remote locations while South Australia and Victoria provide access only in central major city locations. Moreover, vaccine is not provided by general practitioners and only provided by travel medicine clinics (n=4) in one jurisdiction (Table 4).

Table 3: Recommendations in national and jurisdictional guidance documents on bacille Calmette-Guérin immunisation, with comparison to National Tuberculosis Advisory Committee guidelines*

NTAC guidelines[7]	Immunisation handbook[6]	NSW[19,20]	NT[21]	Qld[22]	SA[23]	Vic.[24]	WA[25]
Bacille Calmette-Guérin vaccination recommended for							
1. Indigenous neonates in communities with a high incidence of TB.	✓	–	✓	✓	✓	✓†	–
2. Neonates and children aged ≤5 years who will be travelling or living in countries or areas with a high prevalence of TB for extended periods	✓ (specifies 'young children, particularly those aged <5 years', country with incidence of >40 per 100,000)	✓ (specifies children aged <5 years and ≥3 months in country with incidence of ≥40 per 100,000)	✓ (specifies aged <5 years who have high probability of travelling to countries of high TB incidence for extended period)	✓ (specifies ≥3 months of age in country with incidence of ≥40 per 100,000)	✓ (specifies ≥3 months of age)	✓ (Depends on age and duration e.g. all children aged <5 years going to country with incidence of > 100 per 100,000 for children aged ≥4 weeks (<4 weeks for children aged <1 year); all aged <1 years going to country with incidence of >40 per 100,000 for ≥4 weeks)	✓ (specifies 'could be vaccinated' if aged >6 months in area with incidence of >50 per 100,000)
3. Neonates born to parents with leprosy or a family history of leprosy	✓	✓	✓	✓ (specifies parent with leprosy only)	✓	✓	✓ (specifies 'could' be vaccinated')
						Children aged <5 years who live in household that includes immigrants or unscreened visitors, recently arrived from countries of high TB incidence (>40 per 100,000)	

Table 3 *continued*: Recommendations in national and jurisdictional guidance documents on bacille Calmette-Guérin immunisation, with comparison to National Tuberculosis Advisory Committee guidelines*

NTAC guidelines[7]	Immunisation handbook[6]	NSW[19,20]	NT[21]	Qld[22]	SA[23]	Vic.[24]	WA[25]
Bacille Calmette-Guérin vaccination should be considered for							
1. Children aged >5 years who will be travelling or living in countries or areas with a high prevalence of TB for extended periods	✓	–	✓	–	–	✓ (specifies >2–3 months, also young adults)	–
2. Health care workers who may be at high risk of exposure to drug resistant TB	✓	–	✓	–	✓	✓	✓
			Children aged <5 years who will be living in Northern Territory Indigenous communities			Children, adolescents and young adults exposed to index active MDR TB case Persons over the age of 5 years through to young adulthood living or travelling for extended periods in countries of high TB prevalence	New-born children of migrants who have arrived from countries with high incidence of TB in last 5 years, or who have household contact with people who have arrived from a high incidence country in last 5 years. Children <6 years who are household contacts of newly diagnosed leprosy case.

* No guidance documents identified for Tasmania or the Australian Capital Territory; stakeholders from those jurisdictions advised that they follow national guidelines.

† No communities meet this criterion (personal communication)

Table 4: Bacille Calmette-Guérin vaccine provision, Australia, by type of provider, state or territory and sub-region location

	Major cities	Regional	Remote
NSW	TB/chest clinic (onsite)	TB/chest clinic (onsite)	TB/chest clinic (onsite)
NT	TB/chest clinic (onsite) Maternity ward	TB/chest clinic (onsite) Maternity ward	TB/chest clinic (onsite) TB/chest clinic (outreach)
Qld	TB/chest clinic (onsite)	TB/chest clinic (onsite) TB/chest clinic (outreach) Maternity ward	TB/chest clinic (onsite) TB/chest clinic (outreach) Maternity ward
SA	TB/chest clinic (onsite)	Not available	Not available
Tas.	TB/chest clinic (onsite)	TB/chest clinic (onsite)	Not available
Vic.	Royal Children's Hospital and Monash Medical Centre. Four private travel health clinics also give bacille Calmette-Guérin vaccine.	Service provided through St John of God Hospital in Geelong	Not available
WA	TB/chest clinic (onsite)	Regional public health units – very occasional usage	Remote public health units – very occasional usage

One stakeholder suggested that BCG vaccination services could be improved if the vaccine could be provided in a single dose vial.

"Provide vaccine in a single dose cost-effective vial so that BCG could be given at any clinic. Currently clients need to fit in with the allocated days for BCG clinics, and then book into the appointment system e.g. one BCG clinic per month with 30 max neonates to be booked."

Access to BCG vaccine in rural and remote areas was a common concern identified in the key stakeholder surveys, and several stakeholders suggested increasing the number of vaccination sites regionally and/or in additional locations in major cities. Moreover, maintaining an adequate number of appropriately trained and accredited staff, particularly in areas with low demand and/or high staff turnover, was identified as a common challenge.

All participating key stakeholders stated that in their state or territory eligible individuals are referred to BCG immunisation providers through both general practitioner (GP) referral and patient self-referral. In Queensland and Western Australia, eligible individuals are also referred by travel medicine clinics, child health clinics and community health nurses. The average waiting time for consumers to access BCG vaccine, as reported by stakeholders, varied by jurisdiction and remoteness of location (Table 5).

Communication strategies and resources to promote awareness

Communication strategies varied between jurisdictions. Most commonly BCG immunisation guidelines and consumer information were disseminated through health department web sites, online learning packages, media releases, brochures and face-to-face education for providers.

Most of the key stakeholders identified GPs, antenatal clinics and child health clinics as potential groups among which greater promotion of BCG vaccination for eligible individuals could occur, with particular focus suggested in areas where parents who are likely to be taking young children to live overseas.

The recurrent shortages of BCG vaccine were reported to have been a considerable barrier in promoting the vaccine and public awareness.

"We have been told that there may not be supplies of BCG after December 2015 so are not promoting the vaccine at present."

Reporting of vaccination coverage and adverse events

When asked how likely it is that BCG vaccination information will be entered into the ACIR, key stakeholder responses varied widely by jurisdiction and in the case of Queensland, where stakeholders from different settings were interviewed, within the jurisdiction. Stakeholders from the Northern Territory and Queensland reported that BCG vaccination information is 'always' entered into the ACIR and one stakeholder from

Table 5: Reported waiting times and/or frequency of bacille Calmette-Guérin clinic services for access to bacille Calmette-Guérin vaccination

Waiting time for BCG vaccination	Major cities	Regional	Remote
NSW	≥2 weeks	Data not provided	Data not provided
NT	<1 week	Regional and remote area are dependent on scheduled visits by accredited vaccine providers	Regional and remote area are dependent on scheduled visits by accredited vaccine providers
Qld	Data not provided	Data not provided Regional clinics are organised every 3–4 weeks.	Remote outreach clinics are organised usually every 6 months.
SA	1–<2 weeks	Need to come to Adelaide	Need to come to Adelaide
Tas.	≥2 weeks	Data not provided	Data not provided
Vic.	≥2 weeks	≥2 weeks	≥2 weeks
WA	1–<2 weeks	Data not provided	Data not provided

Victoria stated that it is done 'most of the times'. For the rest of the stakeholders (Queensland, Victoria, New South Wales, Western Australia, South Australia and Tasmania) responses ranged from 'sometimes' to 'never'.

One key stakeholder identified IT system barriers to the transfer of data from the jurisdictional immunisation register to the ACIR. Another respondent highlighted the need for a *"great deal of encouragement to chest clinic staff to use ACIR"*.

BCG vaccine-related AEFI are reported to the TGA, as with other vaccines. Stakeholders did not spontaneously report any particular issues with these arrangements.

Strengths and challenges

Key stakeholders' opinions about the strengths and challenges of their BCG immunisation programs are summarised in Table 6.

Analysis of Australian Childhood Immunisation Register and adverse events following immunisation data

Australian Childhood Immunisation Register data

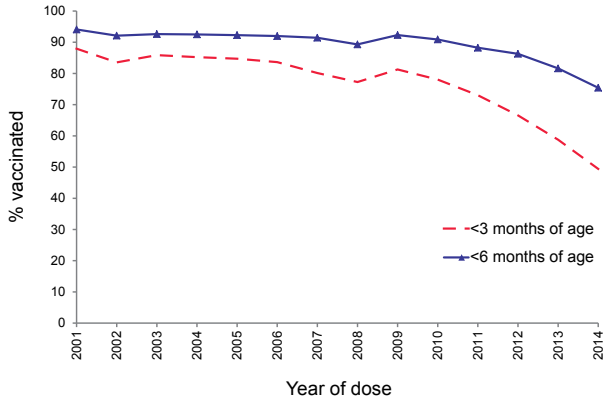
Table 7 shows the number of BCG vaccine doses recorded in the ACIR as administered between 2001 and 2014, by age group. The total number of doses recorded as administered varied by year with the highest number in 2010 and the lowest in 2014. The age distribution of recorded doses changed over time. In 2001, 94.1% of BCG vaccine doses were recorded as administered to infants aged less than 6 months, compared with 75.4% in 2014 (Figure).

Table 8 shows the number of BCG doses recorded on the ACIR and the percentage vaccinated by state or territory and Indigenous status for 12-month wide birth cohorts between 2012 and 2014. Substantial differences in the vaccination rate between jurisdictions and between Indigenous and non-Indigenous children are observed. The

Table 6: Summary of bacille Calmette-Guérin immunisation program strengths and challenges identified by key stakeholders

Strengths	Challenges
TB clinics provide good advisory service to travel vaccine services, GPs and patients	Availability of vaccine
Remote and outreach clinics to Indigenous communities in some jurisdictions	High demand for BCG vaccine in some metropolitan areas
Incorporated within routine childhood immunisation program (NT only)	Increasing access in rural and regional areas
Routine administration of bacille Calmette-Guérin (BCG) vaccine to Aboriginal neonates (NT only)	Maintaining adequate number of appropriately trained and accredited staff, particularly in areas with low demand and/or high staff turnover
Dual vaccination strategy by TB Control Units and maternity units to capture infants at birth in high risk areas (NT only)	Wastage, especially in regional area clinics due to multi-dose vials and product life following reconstitution
	Informing at-risk groups of the availability of the vaccine
	Providing routine clinic times for vaccine administration
	Ability to catch up following periods of shortage and rationing, due to the need for Mantoux tuberculin skin test in children >6 months

Figure: Percentage of bacille Calmette-Guérin vaccinated children vaccinated at less than 3 months of age and less than 6 months of age, Australia, 2001 to 2014



Source: Australian Childhood Immunisation Register

Northern Territory and Queensland had the highest proportion of both Indigenous and non-Indigenous children vaccinated with BCG. However, in 2014 there was a substantial reduction in the proportion of the birth cohort recorded as having BCG vaccine in all states and territories.

Adverse events following immunisation data

According to ADRS data, the overall rate of reported BCG vaccine-related AEFI among children aged less than 7 years was 89.8 per 100,000 doses administered, and the rate of serious AEFI was 11.9 per 100,000 doses (Table 9). Reporting rates appear to be increasing from 2011 onwards. The number and rate of reported serious AEFI did not show any pattern over time.

Discussion

This is the first national level evaluation of BCG immunisation programs in Australia. We identified only minor differences between the two national guidelines (the NTAC guidelines and *The Australian Immunisation Handbook*), but more substantial differences in some of the jurisdictional-specific guidelines. For example, the Victorian guidelines recommend BCG vaccination for children aged less than 5 years living in a household that includes immigrants or visitors recently arrived from countries of high TB incidence, and the Western Australia guidelines state vaccination should be considered for neonates in such households. Further discussion in national forums such as NTAC may be useful to explore the reasons for such discrepancies, and to determine whether greater national consistency can be achieved.

Table 7: Bacille Calmette-Guérin vaccine doses administered to children aged less than 7 years, Australia, 2001 to 2014, by age group

	Bacille Calmette-Guérin vaccine doses administered													
Age (months)	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
<3	7,687	7589	8,634	9,575	10,054	10,430	9,976	8,902	11,168	11,114	9,652	7418	6,502	4,189
3–5	537	779	679	819	896	1,042	1,407	1,390	1,517	1,828	2,011	2,200	2,526	2,203
6–8	100	191	187	211	222	276	254	302	278	379	463	546	735	652
9–11	69	90	103	118	125	124	160	173	90	196	241	269	356	388
≥ 12	347	435	452	513	569	598	650	758	688	723	849	712	944	1,044
Total	8,740	9,084	10,055	11,236	11,866	12,470	12,447	11,525	13,741	14,240	13,216	11,145	11,063	8,476

Source: Australian Childhood Immunisation Register

Table 8: Number of bacille Calmette-Guérin doses administered and proportion of birth cohort vaccinated, Australia, 2012 to 2014, by state or territory and Indigenous status

Year	Indigenous status	ACT	NSW	NT*	Qld*	SA*	Tas.	Vic.	WA	Aust.
2012	Indigenous	2	8	767	1,548	17	0	12	29	2,383
	birth cohort	129	4,895	1,336	5,130	755	454	1,063	2,036	15,798
	% vaccinated	1.6	0.2	57.4	30.2	2.3	0.0	1.1	1.4	15.1
	Non-Indigenous	126	1,589	216	3,951	245	38	2,496	541	9,202
	birth cohort	5,473	97,920	2,294	59,255	19,663	5,475	77,089	32,678	299,847
	% vaccinated	2.3	1.6	9.4	6.7	1.3	0.7	3.2	1.7	3.1
	Total	128	1,597	983	5,499	262	38	2,508	570	11,585
	birth cohort	5,602	102,815	3,630	64,385	20,418	5,929	78,152	34,714	315,645
	% vaccinated	2.3	1.6	27.1	8.5	1.3	0.6	3.2	1.6	3.7
2013	Indigenous	0	12	530	1,667	8	1	13	21	2,252
	birth cohort	134	4,884	1,234	4,905	804	409	1,159	1,991	15,520
	% vaccinated	0.0	0.3	43.0	34.0	1.0	0.2	1.1	1.1	14.5
	Non-Indigenous	77	1,092	215	3,579	162	24	2,381	394	7,924
	birth cohort	5,428	93,934	2,312	56,967	18,881	5,532	75,132	31,835	290,021
	% vaccinated	1.4	1.2	9.3	6.3	0.9	0.4	3.2	1.2	2.7
	Total	77	1,104	745	5,246	170	25	2,394	415	10,176
	birth cohort	5,562	98,818	3,546	61,872	19,685	5,941	76,291	33,826	305,541
	% vaccinated	1.4	1.1	21.0	8.5	0.9	0.4	3.1	1.2	3.3
2014	Indigenous	0	5	453	1,424	5	0	8	17	1,912
	birth cohort	133	5,032	1,338	5,252	826	432	1,266	2,066	16,345
	% vaccinated	0.0	0.1	33.9	27.1	0.6	0.0	0.6	0.8	11.7
	Non-Indigenous	51	664	127	1,992	75	8	2,068	180	5,165
	birth cohort	5,505	93,649	2,339	57,334	19,360	5,401	75,474	32,316	291,378
	% vaccinated	0.9	0.7	5.4	3.5	0.4	0.2	2.7	0.6	1.8
	Total	51	669	580	3,416	80	8	2,076	197	7,077
	birth cohort	5,638	98,681	3,677	62,586	20,186	5,833	76,740	34,382	307,723
	% vaccinated	0.9	0.7	15.8	5.5	0.4	0.1	2.7	0.6	2.3

* Bacille Calmette-Guérin vaccination is recommended in Indigenous neonates in communities with a high incidence of tuberculosis

Source: Australian Childhood Immunisation Register

Reliable supply of BCG is a major challenge, along with access issues related to the availability of vaccine in multi-dose formulations only, and the additional training required in BCG vaccination and pre-vaccination screening. If cost-effective single dose vials could be sourced (currently not available from any manufacturer globally to our knowledge), this could facilitate wider provision of BCG vaccination, but would also require an increased pool of appropriately trained service providers. BCG is currently provided in general practices and maternity wards in the Northern Territory and Queensland in areas with a high proportion of Indigenous population. This practice may be an appropriate option for consideration in high use areas within other states and territories.

The total number of BCG vaccine doses recorded as administered in the ACIR varied by year. Despite the increase in population and no significant changes in national guideline recommendations over the study period, the number of doses recorded as administered in 2014 was less than that in 2001. The age distribution also changed over time, with 94% of BCG vaccine doses recorded as administered to infants aged less than 6 months in 2001, compared with 75% in 2014. However, it is unclear to what extent the ACIR data on the number of doses and age distribution reflect real (e.g. supply-related) issues or data quality issues. There was considerable variation between jurisdictions in the reported likelihood of entry of BCG vaccination data into the ACIR. Analysis of ACIR data also showed a wide variation between

Table 9: Adverse events following bacille Calmette-Guérin immunisation among children aged less than 7 years, Australia, 2001 to 2014

Year	Number of adverse events		Vaccine doses*	Rate per 100,000 doses			
				All		Serious	
	All	Serious		n	95% CI†	n	95% CI†
2001	2	0	8,740	22.9	0–54.6	0.0	
2002	1	0	9,084	11.0	0–32.6	0.0	
2003	0	0	10,055	0.0		0.0	
2004	2	0	11,236	17.8	0–42.5	0.0	
2005	5	4	11,866	42.1	0–79.1	33.7	0–66.7
2006	12	4	12,470	96.2	41.8–150.7	32.1	0–63.5
2007	5	2	12,447	40.2	0–75.4	16.1	0–38.3
2008	6	0	11,525	52.1	0–93.7	0.0	
2009	12	2	13,741	87.3	37.9–136.7	14.6	0–34.7
2010	17	2	14,240	119.4	62.7–176.1	14.0	0–33.5
2011	21	2	13,216	158.9	91.1–226.8	15.1	0–36.1
2012	20	0	11,145	179.5	100.9–258.0	0.0	
2013	23	2	11,063	207.9	123.0–292.8	18.1	0–43.1
2014	17	1	8,476	200.6	105.3–295.8	11.8	0–34.9
Total	143	19	159,304	89.8	75.1–104.5	11.9	0–17.3

* Bacille Calmette-Guérin vaccine doses recorded in Australian Childhood Immunisation Register.

† Rate of adverse events reported in Australian Adverse Drug Reactions System, per 100,000 administered doses.

jurisdictions in the proportion of non-Indigenous infants reported as receiving BCG, suggesting significant differences in vaccine delivery between states and territories and/or significant under-reporting to the ACIR. The main two jurisdictions with Indigenous programs (Northern Territory and Queensland) have a substantially higher proportion of non-Indigenous children reported as vaccinated compared with other states, suggesting differing implementation of the non-Indigenous program and/or better reporting, in the Northern Territory and Queensland.

The absence of any state or territory or nationally based requirements for transparent reporting on BCG vaccine coverage, as well as any provider and parental incentives to record data, may contribute to under-reporting to the ACIR. In the case of NIP vaccines, for which such requirements and incentives exist, under-reporting has relatively little impact with coverage rates routinely over 90%.[17] BCG vaccine is also not on the NIP and is often administered by specialist providers in chest clinics, rather than GPs who routinely utilise ACIR for NIP vaccines. Data on the number of BCG vaccine doses administered to older children and adults is not readily available, although this may change with the extension of the ACIR to a whole of life register.

Analysis of the TGA ADRS database showed an apparent increase in the rate of BCG vaccine related adverse events notification since 2011. However, BCG vaccine related AEFI data need to be interpreted with caution due to the small numbers involved, likely under-reporting of both numerator (AEFI) and denominator (vaccine doses administered) data, delayed reporting of some AEFI and the general increase in reporting of AEFI related to other vaccines in children over this period.[26] More detailed analysis of BCG related AEFI data reported between 2009 and 2014 has been reported in a separate publication.[27]

In addition to limitations related to data quality issues, this evaluation was of limited scope and did not assess a range of relevant issues including resourcing and cost of jurisdictional programs, whether any costs are charged to consumers, and whether jurisdictions conduct any formal follow-up of BCG-vaccinated individuals in relation to AEFI. The sample size of key stakeholders interviewed for the evaluation was also relatively small, particularly in relation to the number of BCG immunisation providers interviewed. Therefore, the views provided by participants may not necessarily represent those of stakeholders more broadly. No consumers were interviewed. Further study could be undertaken to build on existing evidence regarding poor awareness of BCG vaccine and

programs in parents of children in the target population [28] and to explore some of the information and issues reported by stakeholders in this evaluation, such as waiting times for BCG vaccination.

Concerns have been raised regarding low awareness of current BCG immunisation guidelines among both parents and providers.[28,29] Communication strategies and resources could be developed to target GPs, antenatal clinics and child health clinics, particularly in areas where parents are likely to be taking young children overseas to TB endemic countries. However, the potential effectiveness of such measures is difficult to quantify, as the size of the eligible target population is not known. Available sources suggest the target population is vastly greater than that being currently provided BCG. Further work should be undertaken to define the eligible target population size and distribution, for example using data on departures from Australia for overseas travel to TB endemic countries for young children.[28,29]

It is also difficult to quantify the number of cases potentially preventable by promoting greater awareness of and uptake of BCG vaccination in accordance with current guidelines. The TB notification rates in children are much higher among overseas-born compared with Australia-born children (9.6 (n = 294) vs. 0.6 (n = 230) cases per 100,000 children aged less than 15 years between 2003 and 2012).[30] Limited data are available on the mode of disease acquisition in Australian-born children (e.g. whether via travel to a TB endemic country or via family member contact in Australia), eligibility for vaccination according to current national guidelines, and vaccination status. A review of 2003 to 2012 TB notification data found 42% (226/538) had a history of travel to or through, or residence in, a high-risk country, but did not present any further breakdown of these figures.[30] A hospital audit of all children (< 18 years of age) treated for TB at the Children's Hospital at Westmead between January 2008 and December 2011 found that among 22 TB cases, 21 had a history of immigration or travel to a TB endemic country and 4 of known TB contact within Australia.[31] More comprehensive information on mode of disease acquisition would help inform steps to secure supply of BCG vaccine and/or implement TB screening programs and pre-emptive latent tuberculosis infection treatment in returned travellers.

Conclusions

BCG immunisation programs in Australia are considered important for preventing severe forms of TB in infants and young children who live in or travel to high burden settings. The increasing rate of drug resistant TB globally generates additional importance in terms of the need to provide individual protection. The NTAC plays a key coordinating role in promoting consistency of program delivery, as do recommendations in *The Australian Immunisation Handbook*. However, inconsistent vaccine supply and different state-based procurement processes are major current challenges that are contributing to low, variable and inequitable vaccine delivery. It is important that BCG vaccine-related AEFI data are monitored closely given the adverse event profile of this live attenuated vaccine and particularly in light of the continuing need to use unregistered BCG vaccines. Improved data quality in relation to reporting of BCG vaccination uptake and AEFI is required for more accurate monitoring of both program delivery and vaccine safety. Improvements in access to BCG vaccine and communication strategies are suggested to optimise equity for at-risk children Australia-wide. There could be potential for greater centralisation of some aspects of vaccine procurement and program delivery, for example through inclusion of BCG vaccine on the NIP, to help facilitate such improvements. We hope that publication of this evaluation report promotes further discussion on improving BCG immunisation program delivery across Australia.

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Appendix: Key stakeholder survey questions

1.0 Your role in the BCG vaccination program			
1.1	Job title		
1.2	Department/Section		
1.3	Professional background		
1.4	What is your role in the BCG vaccination program?		
2.0 Program Implementation: Availability (for providers) of BCG vaccine			
2.1	Which area/s of your state/territory government is/are responsible for purchase of BCG vaccine?		
2.2	How is the demand for BCG vaccine in your state/ territory estimated?		
2.3	Please describe any issues which impacted BCG vaccine availability in your state/ territory in the last 3 years (i.e. since the National Tuberculosis Advisory Committee Update in October 2012)		
2.4	Based on your experiences, do you have any recommendations to improve BCG vaccine availability?		
3.0 Program Implementation: Access (for consumers) to BCG vaccine			
3.1	What are the current modes of service for providing BCG vaccine in your state/ territory/area?	Location	Type of Services (please tick ✓)
		Major Cities	☐ TB/Chest Clinic (onsite) ☐ TB/Chest Clinic (outreach) ☐ Other (specify) ……
		Regional	☐ TB/Chest Clinic (onsite) ☐ TB/Chest Clinic (outreach) ☐ Other (specify) ……
		Remote	☐ TB/Chest Clinic (onsite) ☐ TB/Chest Clinic (outreach) ☐ Other (specify) …….
3.2	How eligible individuals are referred to BCG immunisation providers in your state/territory/area?	(✓ tick all that apply) ☐ GP referral ☐ Patient self-referral ☐ Other (Specify) ……	
3.3	How long is the average waiting time for patients to access BCG vaccine?	Location	Average waiting time (please tick ✓)
		Major Cities	☐ <1 week ☐ 1–<2 weeks ☐ >=2week ☐ Other (specify) ……
		Regional	☐ <1 week ☐ 1–<2 weeks ☐ >=2week ☐ Other (specify) ……
		Remote	☐ <1 week ☐ 1–<2 weeks ☐ >=2week ☐ Other (specify) ……
3.4	Does waiting time vary by location?	☐ Yes If Yes, specify …… ☐ No	
3.5	Please describe any issues which impacted consumer's access to BCG vaccine in your state/ territory/area in the last 3 years?		
3.6	Based on your experiences, do you have any recommendations to improve consumer's access to BCG vaccine?		

4.0 Communication strategies & resources: Awareness			
4.1	Does your jurisdiction have specific state/territory policies/guidelines for BCG vaccination?	☐ Yes If Yes, specify …… ☐ No	
4.2	How are these guidelines promoted? (if answered Yes to 4.1)		
4.3	Since 2012, what provider/community groups/ organisations have been targeted to inform about the BCG vaccination program?		
4.4	Since 2012, were any state/territory/jurisdictional resources (in addition to guidelines) developed for the program?	☐ Yes If Yes, specify …… ☐ No	
4.5	What methods have been used to advise relevant target groups about the BCG vaccination program?	Target group	Method (✓ tick all that apply)
		Providers (e.g. GP, travel medicine clinic)	☐ Media ☐ Brochures ☐ Webpage/online ☐ Letters ☐ Other (specify) …… ☐ None
		Migrants	☐ Media (mainstream) ☐ Media (ethnic) ☐ Brochures ☐ Webpage/online ☐ Other (specify) …… ☐ None
		Indigenous communities	☐ Media (mainstream) ☐ Media (ethnic) ☐ Brochures ☐ Webpage/online ☐ Other (specify) …… ☐ None
		Travellers	☐ Media (mainstream) ☐ Media (ethnic) ☐ Brochures ☐ Webpage/online ☐ Other (specify) …… ☐ None
		Other	☐ Media (mainstream) ☐ Media (ethnic) ☐ Brochures ☐ Webpage/online ☐ Other (specify) …… ☐ None
4.6	Please describe any issues which impacted public/provider awareness of BCG immunisation recommendations in your state/territory/area in the last 3 years?		
4.7	Based on your experiences, do you have any recommendations to improve public/provider awareness of BCG immunisation recommendations?		

5.0 Data					
5.1	How do you collect records of BCG vaccine in your state/territory/area?	(✓ tick all that apply) ☐ Electronic register ☐ Database of BCG vaccinations only ☐ Paper-based records only ☐ Other (Specify) …. ☐ None			
5.2	How many doses of BCG vaccines were administered in your state/territory/area in the last three years? (Please give total number of doses administered in each year)	Jurisdiction/Year	2012	2013	2014
		State/Territory/Area			
		No.			
5.3	How many doses of BCG vaccines were wasted in your state/territory/area in last there year? (Please give total number of doses wasted in each year)	Jurisdiction/Year	2012	2013	2014
		State/Territory/Area			
		No.			
5.4	How likely is BCG vaccination information to be entered into ACIR in your state/territory/area?	(please tick ✓) ☐ Never ☐ Rarely ☐ Sometimes ☐ Most of the times ☐ Always			
5.5	Do you have any recommendations to improve ACIR reporting of BCG vaccines in your state/territory/ area?				
5.6	How are adverse events following BCG immunisation reported in your state/territory/area?	(✓ tick all that apply) ☐ To TGA ☐ To state or territory health department ☐ Other (Specify) ……			
5.7	How likely are adverse events following BCG immunisation to be reported in your state/territory/ area?	(please tick ✓) ☐ Never ☐ Rarely ☐ Sometimes ☐ Most of the times ☐ Always			
5.8	Do you have any recommendations to improve the level of reporting adverse events following BCG immunisation in your state/territory/area?				
5.9	Has your jurisdiction undertaken any internal evaluation/s specific to the BCG vaccination program?				
5.10	Are there any other data collected or available on BCG vaccination from your jurisdiction which has not been previously mentioned?				
6.0 Program strengths and challenges **From your perspective and compared with other vaccination programs**					
6.1	What, if any, are the strengths of the BCG vaccination program in your state/territory and/or area?				
6.2	What, if any, are the challenges facing the BCG vaccination program in your state/territory and/or area?				
6.3	What, if any, are the issues/problems which you have encountered with implementing the BCG vaccination program in your state/territory and/or area?				
6.4	Based on your experiences, do you have any additional recommendations for improving BCG vaccination uptake in your state/territory and/or area?				
6.5	Do you have any further comments?				

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