# Indigenous and non-Indigenous Australian children hospitalised for burn injuries: a population data linkage study

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**The known** Rates of burn injuries are higher for Indigenous children than for non-Indigenous Australian children.

**The new** Among Indigenous children admitted to hospital for burns, the proportion presenting with burns affecting more than 10% TBSA was greater than for non-Indigenous children, and their mean stay in hospital was longer. A smaller proportion of Indigenous children with burns were treated in a hospital with a paediatric tertiary burn unit.

**The implications** Indigenous children with burns may require more intensive and specialised treatment and longer rehabilitation periods than non-Indigenous children because they more frequently present with burns affecting larger proportions of TBSA.


## Abstract

**Objective:** To investigate differences in the characteristics of burn injuries leading to hospitalisation of Indigenous Australian and non-Indigenous children in New South Wales.

**Design, setting:** Population-based cohort analysis of linked hospital and mortality data for 2000–2014.

**Participants:** 35 749 Indigenous and 1 088 938 non-Indigenous children aged 0–13 years.

**Main outcome measures:** The external cause of the injury, its anatomic location, total body surface area affected (%TBSA), burn depth, length of hospital stay (LOS).

**Results:** 4246 non-Indigenous and 323 Indigenous children were hospitalised for a first burn injury during 2000–2014. A higher proportion of Indigenous than non-Indigenous children were admitted with burns affecting more than 10% TBSA (17% *v* 12%) and a lower proportion of Indigenous children than of non-Indigenous children were treated at a hospital with a paediatric tertiary referral burn unit (40% *v* 50%; $P < 0.001$). The mean LOS during the index admission was almost 3 days longer for Indigenous children than for non-Indigenous children (6.1 days [95% CI, 4.8–7.4 days] *v* 3.4 days [95% CI, 3.2–3.7 days]; $P < 0.001$); the difference in LOS was still statistically significant after adjusting for characteristics of the burn and residential location.

**Conclusion:** The proportion of Indigenous children with burns who presented with burn injuries affecting more than 10% TBSA was greater than for non-Indigenous children. Their mean LOS was also longer; the difference remained statistically significant after adjusting for characteristics of the burn and of residential location.


Burns are a major cause of injury for children in Australia.[1] Indigenous Australian children are disproportionally affected: they are more than twice as likely to be hospitalised for a burn injury as non-Indigenous children, and mortality is five times as high.[2-4] Despite this high burden, little is known about the characteristics of burn injuries to Indigenous children or whether they differ from those to non-Indigenous children.[5]

A study in Western Australia[4] found that a larger proportion of Indigenous than of non-Indigenous children admitted to hospital for burns presented with flame burns, and Indigenous children were more likely to sustain severe burns than their non-Indigenous counterparts.[6] Similarly, a recent study in New South Wales and the Australian Capital Territory found that children from rural areas more frequently presented with flame burns and burns affecting more than 10% of total body surface area (TBSA) than children from urban areas, and that they have longer hospital stays and higher rates of re-admission after burn injury.[7] However, this study did not disaggregate children by Indigenous status, and differences between urban and remote areas may reflect differences in the respective populations, as a higher proportion of Indigenous Australian children (5.1%) than of non-Indigenous children (0.5%) live in remote areas of NSW.[8]

Although there are differences in burn characteristics at initial presentation, a study in WA found that, once they entered the hospital system, Indigenous people with major burns (50% TBSA) experienced levels of service and had outcomes comparable with those of non-Indigenous patients.[9] However, it is not known whether there are differences for patients with less severe burns, or, in particular, for children.

The aim of our study was to explore differences in the characteristics of burn injuries leading to hospitalisation, and in their treatment and outcomes, for Indigenous Australian and non-Indigenous children in NSW.

## Methods

### Setting

The estimated population of NSW is 6.8 million, 1.3 million of whom are aged 0–14 years.[8] At the 2006 census (midpoint of our study), 2.2% of NSW residents identified as Aboriginal and/or Torres Strait Islander (Indigenous Australians), including 7.0% of children aged 0–14 years. Aboriginal people are the original inhabitants of NSW; Torres Strait Islander people comprise 0.1% of the NSW population.[8]

### Study design and data sources

This study was a population-based cohort analysis of linked hospital and mortality data. We used hospital data from the NSW Admitted Patient Data Collection (APDC) linked with mortality

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▪ doi: 10.5694/mja16.00213 ▪ See Editorial, p. 389

data from the NSW Register of Births, Deaths and Marriages (RBDM). The APDC includes records for all separations from NSW public and private sector hospitals and day procedure centres. Patient demographic data, diagnoses and procedures are recorded for each separation and coded according to the Australian modification of the International Statistical Classification of Diseases and Related Problems, tenth revision (ICD-10-AM).[10] The RBDM captures details of all deaths registered in NSW. Probabilistic linkage of the datasets was performed by the NSW Centre for Health Record Linkage (http://www.cherel.org.au); de-identified datasets of linked APDC and RBDM data from July 2000 to March 2014 were supplied to the researchers for analysis.

### Participants and analysis

The linked data were used to define a cohort of children for the analysis, details of which have been described elsewhere.[2] In brief, we selected all children resident in NSW and born in a NSW hospital between 1 July 2000 and 31 December 2012. We then identified children in this cohort who were admitted to a NSW hospital for a first burn injury. Based on the findings of a previous study of the impact of case selection criteria on the identification of patients hospitalised for burn injuries,[11] the index burn admission was defined by a primary diagnosis of injury (ICD-10-AM codes, S00–T75, or T79) and an external cause code of exposure to smoke, fire and flames (ICD-10-AM, X00–X09) or contact with heat and hot substances (ICD-10-AM, X10–X19); or by a primary diagnosis of burns (ICD-10-AM, T20–T32). Repeat admissions for the same injury were identified as admissions with either the same primary diagnosis or the same external cause code and primary diagnosis of burn injury as the index admission.

Information about the external cause of the injury (smoke, fire and flames: ICD-10-AM, X00–X09; scalds: ICD-10-AM, X10–X14; contact burns: ICD-10-AM, X15–X19), the body part affected, %TBSA, depth of burn injury, treatment at a hospital with a paediatric tertiary referral burn unit (the Children's Hospital at Westmead), and inhalation injury (ICD-10-AM, T27, T28.0, T58, T59) were derived from the index admission. Severe burns were defined as partial or full thickness burns affecting more than 10% TBSA.[12] Length of stay (LOS) for the index admission was defined as the difference in days between the final discharge day and the date of admission for the index episode of care. Hospitalisations consisting of several continuous episodes of care for the same injury were counted as one hospital stay. The total LOS was defined as the LOS for all admissions related to the index admission. The type of care provided to the child was determined for all burn-related admissions.

### Statistical analysis

The proportions of Indigenous and non-Indigenous children with specific burn characteristics were compared in $\chi^2$ tests. The influence of these characteristics on differences between Indigenous and non-Indigenous children in LOS was analysed by Cox regression analysis, adjusted for individual (Indigenous status, sex, age), burn (inhalation injury, %TBSA) and area (disadvantage, remoteness) characteristics. Geographic remoteness was defined according to the Accessibility/Remoteness Index of Australia (ARIA+)[13] and area-level socio-economic status according to the Australian Bureau of Statistics' Socio-Economic Index for Areas (SEIFA) Index of Relative Social Advantage and Disadvantage.[14] Indigenous status was derived from the child's birth record in the hospital data. Data were prepared for analysis with SAS 9.3 (SAS Institute) and analysed in Stata 12 (StataCorp).

### Ethics approval

Ethics approval for the study was granted by the Population Health Services Research Ethics Committee (reference, HREC/09/CIPHS/18), the Aboriginal Health and Medical Research Council Ethics Committee (reference, 684/09), and the University of Western Sydney Ethics Committee (reference, CI2009/03/141).

## Results

### Cohort characteristics

A total of 1 124 717 children were included in the cohort, of whom 35 749 (3.1%) were Indigenous Australians. The proportion of Indigenous children living in remote areas (9%; 3312 children) was higher than that for non-Indigenous children (1%; 7574 children). During 2000–2014, 323 Indigenous and 4246 non-Indigenous children were hospitalised for a first burn injury; including repeat admissions, these burns accounted for 5829 hospitalisations of non-Indigenous children and 464 of Indigenous children. The proportions of Indigenous children admitted for a burn injury who lived in remote (15%; 48 children) or disadvantaged areas (76%; 245 children) were higher than for non-Indigenous children (1%; 45 children, and 46%; 1955 children respectively; Box 1).

### Burn injury characteristics and outcomes

Scalds were the leading cause of burn injury to both Indigenous (47%) and non-Indigenous children (62%). A larger proportion of Indigenous (18%) than non-Indigenous patients (8%) were admitted for flame burns (Box 2).

The body regions most often injured were different for the two groups of children ($P = 0.005$). A smaller proportion of Indigenous children presented with burns to the hand or wrist (17%) and a higher proportion with burns to the ankle or foot (12%) than non-Indigenous children (23% and 8% respectively). When stratified by area of residence, the proportion of Indigenous children with burns to the foot and ankle was greater among those living in metropolitan and inner regional areas (14%, 24 children; online Appendix).

A greater proportion of Indigenous than of non-Indigenous patients sustained full thickness burns (16% *v* 14%) or burns affecting more than 20% TBSA (6% *v* 2%; Box 2). When stratified by area of residence, the proportion of Indigenous children with burns affecting more than 10% TBSA was greater for those living in outer regional and remote areas (21%, 29 children; online Appendix).

The proportions of Indigenous children with severe burn injuries (17%) or inhalation injuries (4%) were similar to those for non-Indigenous children (12% and 3% respectively; Box 2).

A smaller proportion of Indigenous patients than of non-Indigenous patients were treated at a hospital with a paediatric tertiary burns unit (40% *v* 50%; $P < 0.001$); of children with severe burn injuries, 59% of Indigenous and 56% of non-Indigenous children were admitted to a hospital with a paediatric tertiary burns unit ($P = 0.69$; Box 2).

A larger proportion of Indigenous than of non-Indigenous children with severe burn injuries living in major cities and inner regional areas (63% *v* 58%) and a higher proportion of those living in outer regional and remote areas (56% *v* 43%) were treated at a hospital with a specialist burns unit (online Appendix).

Most Indigenous (85%) and non-Indigenous children (84%) were hospitalised once for their burn injury; there was no significant

**1 Characteristics of children admitted to hospital for a first burn injury, New South Wales, 2000–2014**

| | All children | Non-Indigenous children | Indigenous children | *P* |
|---|---|---|---|---|
| Total number of children | 1 124 717 | 1 088 968 | 35 749 | |
| Children admitted to hospital for a first burn injury (% of cohort) | 4569 (0.41%) | 4246 (0.39%) | 323 (0.90%) | |
| Age | | | | 0.03 |
| < 1 year | 798 (17.5%) | 745 (17.5%) | 53 (16%) | |
| 1–4 years | 3057 (66.9%) | 2854 (67.2%) | 203 (63%) | |
| 4–13 years | 714 (15.6%) | 647 (15.2%) | 67 (21%) | |
| Sex | | | | 0.86 |
| Girls | 1902 (41.6%) | 1769 (41.7%) | 133 (41%) | |
| Boys | 2667 (58.4%) | 2477 (58.3%) | 190 (59%) | |
| Area-level disadvantage | | | | < 0.001 |
| First tertile (most disadvantaged) | 2200 (48.2%) | 1955 (46.0%) | 245 (76%) | |
| Second tertile | 1453 (31.8%) | 1383 (32.6%) | 70 (22%) | |
| Third tertile (least disadvantaged) | 916 (20.0%) | 908 (21.4%) | 8 (2%) | |
| Geographic remoteness | | | | < 0.001 |
| Major cities | 2716 (59.4%) | 2649 (62.4%) | 67 (21%) | |
| Inner regional | 1163 (25.5%) | 1054 (24.8%) | 109 (34%) | |
| Outer regional | 597 (13.1%) | 498 (11.7%) | 99 (31%) | |
| Remote/very remote | 93 (2.0%) | 45 (1.1%) | 48 (15%) | |
| Number of hospitalisations | 5829 | 6293 | 464 | |

difference in the overall pattern of re-admissions ($P = 0.19$; Box 2). There were, however, differences in the care received: a lower proportion of Indigenous children underwent surgery (20% *v* 25% of non-Indigenous children; $P = 0.025$), and a higher proportion received physical and occupational therapy (13% *v* 9%; $P = 0.015$) (Box 3).

A smaller proportion of Indigenous children with burn injuries were treated as day-only patients (31% *v* 41% of non-Indigenous patients), and a larger proportion stayed in hospital for more than one week (32% *v* 17%; Box 2).

The mean LOS during the index admission (excluding day patients) for Indigenous children (6.1 days; 95% CI, 4.8–7.4 days) was almost 3 days longer than for non-Indigenous children (3.4 days; 95% CI, 3.2–3.7; $P < 0.001$). The median LOS for each group of children was one day (Box 4). After adjusting for sex, age, inhalation injury, %TBSA, depth of burn, geographic remoteness, and area disadvantage, LOS was still significantly longer for Indigenous than for non-Indigenous children ($P = 0.002$). %TBSA, depth of burn, and geographic remoteness were each significantly associated with increased LOS (Box 5).

## Discussion

In this data linkage cohort study, we found that a higher of proportion of burn injuries to Indigenous than to non-Indigenous children were caused by flame burns, that their burns more often affected a larger %TBSA, and that they stayed in hospital longer.

The higher proportion of flame burns among Indigenous children admitted to hospital for burn injuries might partially be explained by the higher proportion of Indigenous children living in rural and remote areas, where the incidence of flame burns is higher,[7,15] perhaps because there are more outdoor fires in rural areas or because rural children more frequently engage in risky behaviour than those in urban areas.[7]

A recent study similarly found that a higher proportion of children from rural areas presented to a specialist burn unit with burns affecting more than 10% TBSA;[7] however, this analysis did not analyse cases by Indigenous status. Our results suggest that this difference could be partly explained by the higher proportion of Indigenous children living in remote areas.

The mean LOS for a burn injury was almost 3 days longer for Indigenous than for non-Indigenous children. This difference is similar to the reported difference in LOS between children living in remote and urban areas.[7] After adjusting for burn injury characteristics, geographic remoteness, and area-level disadvantage, the difference in LOS between Indigenous and non-Indigenous children was still statistically significant, indicating that other factors also influence LOS.

A smaller proportion of Indigenous children than of non-Indigenous children were treated at a hospital with a paediatric tertiary referral burn unit. One explanation could be that a larger proportion of non-Indigenous children live near this hospital, located in western Sydney, so that it is their first point of contact. Inequities in access to medical services experienced by Indigenous Australians and people living in remote areas are recognised.[16-18] In contrast, we found that a higher proportion of Indigenous than of non-Indigenous children presenting with a severe burn and living in remote areas were treated at a hospital with a tertiary burns unit. About 40% of Indigenous and non-Indigenous children with severe burns were not admitted to a hospital with a tertiary burns unit, but our data did not allow further investigation of the underlying reasons. However,

**2 Characteristics of burn injury, treatment and outcome for children admitted to hospital for a first burn injury, New South Wales, 2000–2014**

| | All children | Non-Indigenous children | Indigenous children | *P* |
|---|---|---|---|---|
| Number of children | 4569 | 4246 | 323 | |
| External cause of injury | | | | < 0.001 |
| Smoke, fire and flame | 407 (8.9%) | 348 (8.2%) | 59 (18%) | |
| Scalds | 2794 (61.2%) | 2641 (62.2%) | 153 (47%) | |
| Contact burns | 910 (19.9%) | 835 (19.7%) | 75 (23%) | |
| Other | 458 (10.0%) | 422 (9.9%) | 36 (11%) | |
| Anatomic location | | | | 0.005 |
| Head/neck | 874 (19.1%) | 806 (19.0%) | 68 (21%) | |
| Trunk | 962 (21.1%) | 896 (21.1%) | 66 (20%) | |
| Shoulder/upper limb | 604 (13.2%) | 569 (13.4%) | 35 (11%) | |
| Wrist/hand | 1027 (22.5%) | 973 (22.9%) | 54 (17%) | |
| Hip/lower limb | 505 (11.1%) | 466 (11.0%) | 39 (12%) | |
| Ankle/foot | 384 (8.4%) | 347 (8.2%) | 37 (12%) | |
| Other/unspecified | 213 (4.7%) | 189 (4.5%) | 24 (7.4%) | |
| Total body surface area (%TBSA) injured* | | | | 0.002 |
| < 10% | 3796 (83.1%) | 3546 (83.5%) | 250 (77%) | |
| 10–19% | 462 (10.1%) | 426 (10.0%) | 36 (11%) | |
| ≥ 20% | 122 (2.7%) | 104 (2.4%) | 18 (6%) | |
| Depth of injury† | | | | < 0.001 |
| Superficial | 324 (7.1%) | 297 (7.0%) | 27 (8.4%) | |
| Partial | 3309 (72.4%) | 3105 (73.1%) | 204 (63%) | |
| Full thickness | 645 (14.1%) | 593 (14.0%) | 52 (16%) | |
| Inhalation injury | 133 (2.9%) | 120 (2.8%) | 13 (4.0%) | 0.22 |
| Severe burn‡,§ | 533 (11.7%) | 487 (12.4%) | 46 (17%) | 0.14 |
| Treated at hospital with tertiary referral burn unit | 2260 (49.5%) | 2132 (50.2%) | 128 (40%) | < 0.001 |
| Severe burn treated at hospital with tertiary referral burn unit | 298 (55.9%) | 271 (55.6%) | 27 (59%) | 0.69 |
| Number of re-admissions | | | | 0.19 |
| 0 | 3825 (83.7%) | 3550 (83.6%) | 275 (85%) | |
| 1 | 608 (13.3%) | 570 (13.4%) | 38 (12%) | |
| 2 | 115 (2.5%) | 109 (2.6%) | 6 (2%) | |
| > 2 | 21 (0.5%) | 17 (0.4%) | 4 (1%) | |
| Length of stay | | | | < 0.001 |
| < 1 day | 1841 (40.3%) | 1742 (41.0%) | 99 (30.7%) | |
| 1–7 days | 1917 (42.0%) | 1795 (42.3%) | 122 (37.8%) | |
| 8–28 days | 510 (11.1%) | 454 (10.7%) | 56 (17.3%) | |
| > 28 days | 301 (6.6%) | 255 (6.0%) | 46 (14.2%) | |

* Missing data: 170 non-Indigenous and 19 Indigenous children. † Missing data: 251 non-Indigenous and 40 Indigenous children. ‡ Missing data: 311 non-Indigenous and 45 Indigenous children. § Defined as partial or full thickness burn and > 10% TBSA. ◆

separation from family and community are likely to influence decisions by physicians and families about transferring children from remote areas to specialist burn units, typically located in metropolitan areas.[19] Moreover, the introduction of telehealth procedures has facilitated care of patients in remote areas, so that fewer children need to be transferred to a hospital with a specialist burn unit.[20]

A lower proportion of Indigenous than of non-Indigenous patients underwent surgery, but a higher proportion of Indigenous children received in-hospital physical and occupational therapy, probably because a larger proportion of their injuries were severe burns.

This is the first data linkage cohort study of the characteristics of burn injuries to Indigenous and non-Indigenous children in Australia. However, it was subject to limitations that are inherent to the use of routinely collected hospital data. Our study was restricted to injuries that resulted in a hospitalisation; hospital admission and access may vary between population groups and regions; and higher admission rates in remote areas may reflect

**3 Treatment of children admitted to hospital for a first burn injury, New South Wales, 2000–2014**

| | All children | Non-Indigenous children | Indigenous children | *P* |
|---|---|---|---|---|
| Total number of hospitalisations | 6293 | 5829 | 464 | |
| Mechanical ventilation | 75 (1%) | 65 (1%) | 10 (2%) | 0.047 |
| Surgical intervention | 1547 (25%) | 1453 (25%) | 94 (20%) | 0.025 |
| Physical/occupational therapy | 612 (10%) | 552 (9%) | 60 (13%) | 0.015 |
| Other allied health* | 1207 (19%) | 1100 (19%) | 107 (23%) | 0.027 |

* Includes nutrition and dietetics, social work, speech pathology, pharmacy, pastoral care, play therapy and social work. ◆

differences in access to other health care providers and services.[21] Children living in rural and remote areas are more likely to be treated as inpatients because their travelling distances to hospital are longer, making it more difficult to return as day patients.[22]

There is currently no source of data on injuries incurred in the community and treated in the primary care setting in Australia, and we did not capture presentations at outpatient burn clinics or to Indigenous community-controlled health services.

Inaccuracies in the coding of external cause are possible, as well as in the coding of %TBSA in hospital data.[23-25] It has been reported that %TBSA is likely to be overestimated by referring hospitals when compared with assessments in specialist burn units.[23,24] We may have underestimated the burden of burn injury hospitalisation in our cohort, as some repeat admissions might have been missed because of differences in external or primary diagnosis coding, and because we restricted our analysis to the first burn injury.

In view of the fact that patients admitted to hospital with a tertiary burns unit are reviewed by a physiotherapist, the proportion of children recorded as having received physical and occupational therapy was surprisingly low; the recording of such therapy in the hospital data may have been incomplete.

Anatomic location was not included as a factor in our statistical modelling of LOS because of the small numbers of cases in individual categories.

**4 Length of hospital stay for children admitted to hospital for a first burn injury (excluding day patients), New South Wales, 2000–2014**

| | Non-Indigenous children | Indigenous children | *P* |
|---|---|---|---|
| Number of children | 2504 | 224 | |
| Length of stay, first admission (days) | | | |
| Median (IQR) | 1 (1–3) | 1 (1–6) | < 0.001 |
| Mean (95% CI) | 3.4 (3.2–3.7) | 6.1 (4.8–7.4) | < 0.001 |
| Range | 1–61 | 1–77 | |
| Length of stay, total (days) | | | |
| Median (IQR) | 2 (1–4) | 3 (1–7) | < 0.001 |
| Mean (95% CI) | 4.1 (3.8–4.3) | 7.1 (5.6–8.5) | < 0.001 |
| Range | 1–61 | 1–79 | |

**5 Effects of individual and area-level characteristics on differences in hospital length of stay for Indigenous and non-Indigenous children admitted to hospital for a first burn injury, New South Wales, 2000–2014**

| Characteristic | Hazard ratios* (95% CI) | *P* |
|---|---|---|
| Indigenous status | | |
| Non-Indigenous | Reference | |
| Indigenous | 0.78 (0.66–0.92) | < 0.002 |
| Sex | | |
| Girls | Reference | |
| Boys | 1.00 (0.92–1.09) | 0.98 |
| Age | | |
| 0–4 years | Reference | |
| 5–13 years | 0.98 (0.86–1.12) | 0.82 |
| Inhalation injury | | |
| No | Reference | |
| Yes | 0.80 (0.52–1.23) | 0.30 |
| Depth of injury | | |
| Superficial | Reference | |
| Partial | 0.72 (0.60–0.85) | < 0.001 |
| Full thickness | 0.45 (0.36–0.55) | < 0.001 |
| Total body surface area (%TBSA) injured | | |
| < 10% | Reference | |
| 10–19% | 0.53 (0.47–0.60) | < 0.001 |
| ≥ 20% | 0.23 (0.17–0.29) | < 0.001 |
| Geographic remoteness | | |
| Major cities | Reference | |
| Inner regional | 0.88 (0.80–0.97) | 0.01 |
| Outer regional | 0.82 (0.72–0.94) | < 0.001 |
| Remote/very remote | 1.00 (0.75–1.33) | 1.0 |
| Area-level disadvantage | | |
| First tertile (most disadvantaged) | Reference | |
| Second tertile | 1.05 (0.95–1.16) | 0.34 |
| Third tertile (least disadvantaged) | 1.05 (0.93–1.17) | 0.45 |

* Adjusted for all other variables in table. ◆

Further, underreporting of Indigenous status in routinely collected data is a recognised problem that can lead to underestimation of the number of Indigenous children hospitalised for injuries.[26] We used Indigenous status as recorded in birth records to minimise the effect of differential misclassification bias, whereby the opportunity to be recorded as Indigenous rises with the number of times a child is admitted to hospital. However, applying different algorithms to identify Indigenous children on the basis of linked hospital data has been shown to increase both their identification and the sizes of differences between Indigenous and non-Indigenous children.[2,27] Our estimates of differences between Indigenous and non-Indigenous children may therefore be conservative.

## Conclusion

We found that the proportion of burns affecting more than 10% TBSA was higher for Indigenous than for non-Indigenous

children, and that, after adjusting for the characteristics of the burn and residential location, Indigenous children spend more time in hospital.

**Acknowledgements:** Holger Möller and Kathleen Falster were supported by a National Health and Medical Research Council (NHMRC) capacity-building grant (573122). Kathleen Falster was also supported by an NHMRC Early Career Fellowship grant (1016475). Rebecca Ivers was supported by an NHMRC fellowship (APP1031781). We thank Sanja Lujic for statistical advice, and Deborah Randall (both of the University of New South Wales) for cleaning and editing the linked data.

We thank John Harvey for his comments on the revised manuscript. We acknowledge the NSW Ministry of Health and the NSW Registry of Births, Deaths, and Marriages for allowing access to the data, and the NSW Centre for Health Record Linkage for conducting the probabilistic linkage of records.

**Competing interests:** No relevant disclosures.

Received 25 Feb 2016, accepted 8 Nov 2016. ■



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