Australian national birthweight percentiles by gestational age

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Abstract

Objective: To develop national birthweight percentiles by gestational age for male and female singleton infants born in Australia, and to compare the birthweight percentiles of Indigenous and non-Indigenous infants.

Design and setting: Cross-sectional study of singleton live births to Australian-born mothers from 1991 to 1994.

Main outcome measures: Birthweight percentiles by gestational age.

Results: During 1991–1994 Australian-born women gave birth to 769 077 live singleton infants. Of these, 28 230 (3.7%) were reported as births to Aboriginal or Torres Strait Islander women. Birthweight was missing for 581 (0.1%) births and gestational age was missing for 3014 (0.4%). An additional 3283 (0.4%) births were excluded because the recorded birthweights were extreme outliers for their recorded gestational ages. Indigenous women were more likely to be recorded as giving birth preterm (< 37 weeks' gestation) than non-Indigenous women (11.6% v. 5.4%) and were more likely to give birth to small-for-gestational-age infants at term. After 34 weeks' gestation, the median birthweights of Indigenous infants were consistently lower than those of non-Indigenous infants. At 40 weeks' gestation the difference in the median birthweights between these two groups was 160 g for males and 130 g for females.

Conclusions: We present recent birthweight percentiles by gestational age based on national data in Australia. These percentiles provide current Australian norms for clinicians and researchers, and can provide a baseline for monitoring Indigenous perinatal outcomes.

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Birthweight is one of the strongest indicators of the risk of perinatal mortality and morbidity.[1,2] However, classifying infants by birthweight alone does not allow differentiation of the role of growth status (size for age) and maturity (gestational age).[3,4] Birthweight percentiles (tables or graphs that demonstrate the distribution of birthweights at each gestational age) may aid clinicians in identifying infants who require observation, special care, additional feeding, or who are at risk of a poor outcome.

Comparing any infant with a population norm may be important in monitoring growth through infancy and childhood. In epidemiological studies, birthweight percentiles are used to define small-for-gestational-age (SGA) and large-for-gestational-age (LGA) infants so that risk factors for such births can be identified. Other applications include determining risks of perinatal mortality, examining determinants of growth and development, comparing size at birth between populations, and monitoring changes within populations over time.

Importantly, because birthweight percentiles represent cross-sectional measurement of birthweight at birth, they do not necessarily represent fetal growth standards.[2,5]

To date, there have been no Australian birthweight percentiles published using national data. Charts based on infants born in Melbourne in the 1970s are still widely used.[6,7] These percentiles, based on small numbers, are not differentiated by infant sex and are hospital-based rather than population-based. Guaran et al also developed hospital-based percentiles from births in a Melbourne hospital from 1980 to 1989.[8] Population-based percentiles were developed for Western Australia based on births in the early 1980s, and more recently for New South Wales,[9-11] but these still have relatively small numbers of births for subgroups that have different risks for mortality or morbidity, such as very preterm infants (< 28 weeks' gestation).

Our aim was to develop national birthweight percentiles for male and female singleton infants born in Australia, and then to compare birthweight distributions by gestational age for Indigenous and non-Indigenous infants.

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Methods

Birth data

We analysed data on singleton live infants delivered by Australian-born mothers from 1991 to 1994. Births were restricted to Australian-born women to reduce the potential influences of environmental factors.

The data (derived from State and Territory perinatal data collections) were obtained from the computerised birth files of the Australian Institute of Health and Welfare National Perinatal Statistics Unit (NPSU). Notification forms are completed for all births of at least 20 weeks' gestation or 400 g birthweight, usually by midwives but sometimes by medical practitioners.

We use the term *Indigenous* to refer to infants whose mothers were recorded as of Aboriginal or Torres Strait Islander descent. Gestational age is reported in completed weeks of gestation, calcu-

lated from the first day of the last menstrual period (LMP) or estimated by prenatal and/or postnatal assessment if the LMP date was missing. Birthweight is reported to the nearest five grams. Births were stratified by infant sex and by Indigenous status (Indigenous and non-Indigenous).

Exclusion of outliers: For some births, reported gestational age and birthweight combinations were implausible. This occurred more often at earlier gestational ages, for which some very high birthweights were recorded. For each infant sex/Indigenous status stratum, we excluded outlying birthweights at each gestational age, using a method described previously.[5] Briefly, for births outside the interquartile range we determined a value that was a function of the interquartile range. The further the birthweight from the interquartile range the greater the value. We then excluded birthweights where this value exceeded 2.0.

Analysis

We tabulated exact percentiles for each gestational age by infant sex and Indigenous status. Percentiles were not plotted if there were too few births. We arbitrarily selected a minimum of 100 births in a gestational age stratum to plot the third percentile and 50 births to plot the tenth percentile.

All analyses were carried out using SAS for Windows.[12] The univariate procedure was used to examine the birthweight distributions and to determine the interquartile range for each gestational age. After removing outliers, this procedure was used to determine the exact birthweight percentile values for each gestational age.

Results

During 1991–1994 the NPSU recorded 769 077 singleton live births among Australian-born women (Table 1). A total of 3855 (0.5%) births were missing one or more key variables and were excluded, as were 37 births for which the infant's sex was recorded as indeterminate. There were 28 230 (3.7%) births reported for Indigenous women. Of these, 3262 (11.6%) were recorded as preterm (< 37 weeks' gestation), compared with only 5.4% of non-Indigenous births. Indigenous status was not recorded for 9144 (1.2%) births; these were included as non-Indigenous births.

Of the 765 185 births for which the infant's sex, birthweight and gestational age were available, 3283 (0.4%) were removed as outliers, leaving 761 902 births in the analysis (27 757 Indigenous, 734 145 non-Indigenous). For instance, infants with a gestational age less than 30 weeks and birthweight greater than 3000 g were excluded. The removal of outliers had a small effect on the mean birthweight (⩽ 6 g) within strata for infant sex and Indigenous status. A decrease occurred in the 90th percentile of preterm births, with noticeable smoothing of the extremely high values that had been noted initially. However, there was little effect on the 10th percentile, median or interquartile range. Only seven births ⩽ 28 weeks' gestation were removed for outlying low birthweight (< 300 g). After removal of outliers, the mean birthweights (± standard deviation) were 3476 ± 550 g for male non-Indigenous infants, 3345 ± 516 g for female non-Indigenous infants, 3246 ± 632 g for male Indigenous infants, and 3128 ± 595 g for female Indigenous infants.

Median birthweights were lower for females than males at all gestational ages. Indigenous and non-Indigenous median birthweights were similar at gestational ages up to 34 weeks, but thereafter the median birthweight for Indigenous infants was lower, particularly for term births (37–41 weeks' gestation). At 40 weeks, the median birthweight for Indigenous male infants was 160 g below that of non-Indigenous male infants, and for Indigenous female infants was 130 g below that

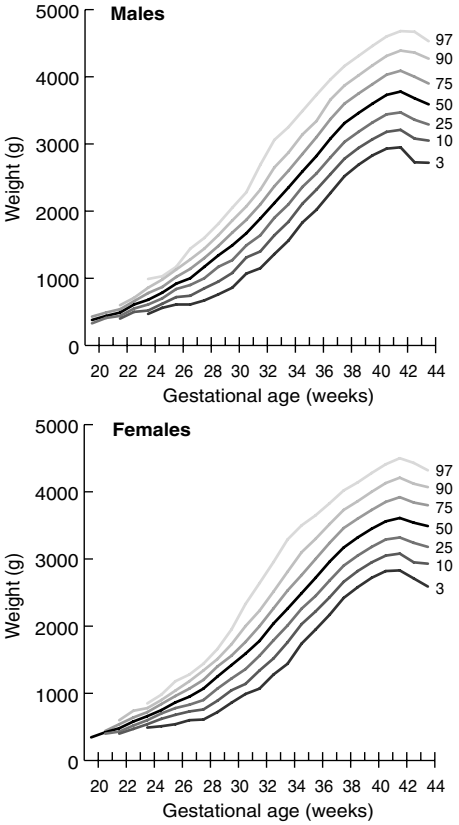
1: Live singleton births to Australian-born women, Australia 1991–1994

	Indigenous* (*n* = 28 230)	Non-Indigenous (*n* = 740 847)	Total (*n* = 769 077)
Infant sex			
Male	14 540 (51.5%)	381 489 (51.5%)	396 029 (51.5%)
Female	13 682 (48.5%)	358 989 (48.5%)	372 671 (48.5%)
Indeterminate	1	36	37
Missing	7	333	340
Birthweight			
< 1500 g	514 (1.8%)	5 222 (0.7%)	5 736 (0.7%)
1500–2499 g	2 489 (8.8%)	27 352 (3.7%)	29 841 (3.9%)
2500–4499 g	24 840 (88.0%)	694 334 (93.7%)	719 174 (93.5%)
⩾ 4500 g	355 (1.3%)	13 390 (1.8%)	13 745 (1.8%)
Missing	32 (0.1%)	549 (0.1%)	581 (0.1%)
Gestational age			
20–31 weeks	597 (2.1%)	6 027 (0.8%)	6 624 (0.9%)
32–36 weeks	2 665 (9.4%)	33 622 (4.5%)	36 287 (4.7%)
37–41 weeks	23 809 (84.3%)	666 855 (90.0%)	690 664 (89.8%)
42–44 weeks	884 (3.1%)	31 604 (4.3%)	32 488 (4.2%)
Missing	275 (1.0%)	2 739 (0.4%)	3 014 (0.4%)
Outliers†	164 (0.6%)	3 119 (0.4%)	3 283 (0.4%)

* Mothers reported as Aboriginal or Torres Strait Islander.
† Births for which the gestational age and birthweight combination was an outlier.

2: Number (%) of Indigenous infants classified as small-for-gestational-age (SGA)

	Indigenous male infants		Indigenous female infants	
Gestational age	SGA	All	SGA	All
20–27 weeks	9 (6.7%)	134	19 (19.6%)	97
28–31 weeks	17 (10.2%)	167	14 (8.9%)	158
32–36 weeks	195 (15.0%)	1 303	158 (11.8%)	1 336
37–41 weeks	2 321 (19.0%)	12 213	2 032 (17.7%)	11 466
42–44 weeks	89 (18.0%)	494	65 (16.7%)	389
All	**2 631 (18.4%)**	**14 311**	**2 288 (17.0%)**	**13 446**



Birthweight percentiles for live singleton births. Values derived from infants born to non-Indigenous Australian-born women in Australia from 1991 to 1994.

of non-Indigenous female infants. As gestational age increased, the proportion of SGA Indigenous infants (< 10th percentile on the non-Indigenous percentiles) also increased (Table 2). More than 17% of Indigenous infants born at term were classified as SGA, instead of the expected 10%.

The Figure shows birthweight percentiles by gestational ages for male and female infants of non-Indigenous mothers. The exact values are shown in Tables 3 and 4.

To assess consistency of recording, we compared the mean and standard deviation for gestational age and birthweight by State and Territory. As the patterns were similar by the infant's sex, we have presented the findings by Indigenous status alone (Table 5). For non-Indigenous infants, mean gestational age is very similar by State and Territory. With the exception of the Northern Territory, which has a lower mean birthweight, the mean birthweights of non-Indigenous infants are also tightly clustered. However, there is much greater variability in the results for Indigenous infants, with a greater spread of both mean gestational ages and birthweights across States and Territories.

Discussion

Our birthweight percentiles provide a population norm for infants born in Australia. They use data from an entire population and provide a more valid standard than those based on data from single or selected hospitals, or from very different populations. Unlike previous Australian percentiles, ours have a relatively large number of preterm births. Smoothing of the percentiles at early gestational ages was not required. Further, our data were selected from a relatively short time period (four years) and are thus less susceptible to variations due to secular trends.[5]

Many factors, including maternal race/ethnicity, parity, maternal age, height, weight, previous obstetric experience, nutrition and smoking behaviour, may affect birthweight.[13] The current consensus is that genetic influences are relatively unimportant in explaining birthweight variation,[14] but are probably more important in developed countries. In developing countries they may be obscured by environmental influences such as maternal undernutrition.[14,15] Mothers born in developing countries (and Aboriginal mothers) have rela-

3: Birthweight percentile values (g) for live singleton males born to non-Indigenous Australian-born women, 1991–1994

Gestational age (weeks)	Number of births	Mean birthweight ± SD (g)	Birthweight percentile (g)										
			1st	3rd	5th	10th	25th	50th	75th	90th	95th	97th	99th
20	27	385 ± 76	—	—	—	—	330	380	430	—	—	—	—
21	43	447 ± 66	—	—	—	—	410	440	490	—	—	—	—
22	74	495 ± 80	—	—	—	400	440	490	540	600	—	—	—
23	95	607 ± 92	—	—	470	500	550	610	660	710	780	—	—
24	135	690 ± 129	—	470	480	520	610	680	780	860	930	990	—
25	180	791 ± 132	—	560	580	620	700	785	870	980	1000	1030	—
26	235	921 ± 158	—	610	620	720	840	920	1020	1130	1160	1170	—
27	284	1017 ± 209	—	610	650	740	900	1000	1140	1280	1350	1440	—
28	361	1157 ± 240	570	670	720	850	1000	1170	1300	1440	1550	1600	1790
29	397	1316 ± 261	670	760	840	950	1170	1340	1480	1640	1740	1810	1900
30	571	1477 ± 313	730	860	960	1080	1270	1490	1680	1860	1950	2050	2270
31	743	1682 ± 311	910	1070	1130	1310	1490	1670	1870	2070	2170	2280	2450
32	1 117	1875 ± 378	1020	1150	1230	1400	1640	1890	2100	2320	2470	2690	2980
33	1 471	2142 ± 415	1210	1360	1450	1640	1900	2120	2370	2650	2920	3060	3300
34	2 657	2358 ± 418	1310	1560	1670	1840	2100	2350	2600	2870	3080	3250	3530
35	4 092	2610 ± 413	1600	1830	1960	2110	2360	2590	2850	3140	3330	3490	3770
36	8 788	2835 ± 432	1780	2020	2150	2320	2560	2820	3100	3380	3570	3730	3960
37	18 660	3089 ± 442	2030	2270	2380	2550	2800	3080	3370	3660	3840	3960	4200
38	51 404	3317 ± 431	2310	2520	2620	2780	3030	3310	3600	3870	4050	4160	4390
39	72 871	3471 ± 426	2500	2690	2790	2940	3180	3460	3750	4020	4200	4310	4520
40	141 553	3610 ± 432	2630	2830	2920	3070	3320	3600	3890	4170	4340	4460	4680
41	55 946	3739 ± 443	2730	2930	3030	3180	3440	3730	4030	4310	4490	4600	4820
42	14 781	3787 ± 463	2730	2950	3040	3210	3470	3780	4090	4390	4570	4680	4910
43	1 267	3698 ± 501	2510	2770	2910	3080	3360	3680	4000	4360	4580	4670	4970
44	409	3612 ± 474	2620	2720	2850	3050	3290	3590	3900	4270	4440	4530	4790

4: Birthweight percentile values (g) for live singleton females born to non-Indigenous Australian-born women, 1991–1994

Gestational age (weeks)	Number of births	Mean birthweight ± SD (g)	Birthweight percentile (g)										
			1st	3rd	5th	10th	25th	50th	75th	90th	95th	97th	99th
20	12	418 ± 184	—	—	—	—	—	345	—	—	—	—	—
21	25	414 ± 55	—	—	—	—	400	420	440	—	—	—	—
22	71	485 ± 85	—	—	—	400	430	480	540	600	—	—	—
23	79	591 ± 103	—	—	—	470	520	580	640	740	—	—	—
24	115	661 ± 95	—	490	500	540	600	660	720	780	830	850	—
25	136	760 ± 116	—	510	560	620	700	750	840	900	960	980	—
26	188	865 ± 158	—	540	550	680	780	865	960	1040	1130	1180	—
27	231	944 ± 183	—	600	620	730	830	950	1070	1180	1250	1280	—
28	287	1060 ± 228	—	610	700	760	900	1070	1200	1340	1400	1440	—
29	325	1233 ± 247	630	720	810	890	1070	1250	1400	1510	1580	1660	1820
30	440	1403 ± 275	740	860	945	1045	1220	1420	1560	1730	1885	1950	2100
31	548	1581 ± 336	800	990	1050	1140	1360	1590	1765	2000	2130	2330	2560
32	877	1797 ± 383	920	1070	1170	1340	1560	1780	2000	2230	2470	2640	2970
33	1200	2038 ± 403	1135	1280	1385	1520	1790	2040	2265	2515	2755	2955	3150
34	2086	2282 ± 439	1260	1440	1570	1760	2010	2260	2530	2810	3090	3290	3510
35	3418	2523 ± 433	1520	1740	1840	2030	2260	2490	2760	3100	3340	3500	3710
36	7320	2738 ± 433	1740	1950	2060	2220	2450	2720	3000	3300	3505	3650	3860
37	16105	2967 ± 432	1940	2170	2280	2430	2680	2960	3240	3520	3700	3830	4050
38	47809	3187 ± 419	2220	2420	2520	2660	2900	3170	3460	3730	3900	4020	4220
39	68846	3329 ± 412	2390	2580	2670	2820	3050	3320	3600	3860	4030	4140	4340
40	137570	3463 ± 414	2530	2720	2810	2950	3180	3450	3730	4000	4170	4280	4490
41	53260	3577 ± 421	2630	2820	2910	3050	3290	3560	3850	4130	4300	4410	4620
42	13318	3627 ± 442	2630	2830	2930	3080	3320	3610	3920	4210	4370	4500	4700
43	1285	3539 ± 463	2460	2710	2770	2950	3240	3540	3840	4120	4320	4430	4620
44	433	3490 ± 448	2420	2590	2720	2930	3180	3490	3800	4070	4230	4320	4470

tively higher rates of growth-retarded fetuses.[15-17] Full fetal growth potential may require one or more generations with improved socioeconomic circumstances.[14,15]

Our data indicate that birthweight distributions differ by Indigenous status at gestational ages of more than 34 weeks. These differences may be due to adverse environmental influences for Indigenous mothers, such as smoking, poor nutrition or poor access to health services. We also found Indigenous birthweight distributions vary substantially among the States and Territories; this may result from a heterogeneous population that includes both Aboriginal and Torres Strait Islander mothers living in traditional and urban communities. Ancestry may also be influential. Among Aboriginal women delivering at the Royal Darwin Hospital, babies without a non-Aboriginal ancestor were smaller at birth than babies with a non-Aboriginal ancestor.[17] Until the effect of such population and environmental influences is ascertained, we believe it would be unwise to publish percentiles that imply a separate population norm for Indigenous infants — to do so might lead clinicians or researchers to accept that Indigenous infants are genetically smaller, whereas the clinical characteristics suggest otherwise. Instead, regular updating of these percentiles will allow monitoring of trends in birthweight.

The only previously published birthweight percentiles for Aboriginal infants were based on Western Australian births from 1980 to 1986.[10] Comparison with these data did not prove fruitful because of differing methods. In particular, outliers were not removed from the WA data, which may have contributed to the noticeably higher median birthweights

5: Mean gestational age and birthweight by State/Territory for non-Indigenous and Indigenous singletons, 1991–1994*

	Non-Indigenous infants			Indigenous infants		
	Number of births	Gestational age (mean ± SD)	Birthweight (mean ± SD)	Number of births	Gestational age (mean ± SD)	Birthweight (mean ± SD)
New South Wales	243422	39.3 ± 1.8	3418 ± 535	5617	39.0 ± 2.2	3223 ± 596
Victoria	185175	39.4 ± 1.9	3418 ± 535	1648	39.1 ± 2.0	3317 ± 563
Queensland	141010	39.3 ± 1.9	3409 ± 547	8744	38.7 ± 2.4	3217 ± 623
Western Australia	60449	39.2 ± 1.9	3409 ± 525	5453	38.5 ± 2.6	3162 ± 609
South Australia	60612	39.3 ± 1.8	3393 ± 544	1550	38.5 ± 2.8	3147 ± 698
Tasmania	23565	39.5 ± 1.8	3412 ± 543	19	39.6 ± 1.2	3268 ± 484
Australian Capital Territory	13199	39.3 ± 1.9	3424 ± 534	111	39.0 ± 2.1	3312 ± 556
Northern Territory	6713	39.3 ± 1.9	3333 ± 537	4615	38.6 ± 2.5	3091 ± 616

*After removal of extreme outlying birthweight/gestational age combinations.

for Indigenous infants < 38 weeks' gestation. However, at term, where outliers are rare, comparison suggests there has been little change in birthweight distributions for Indigenous infants over the past 10 years.

For any large database, issues of data quality and incomplete records are important.[5,18] In our data, birthweight was missing or considered outlying in only 0.5% of records. Outliers are likely to result from incorrectly reported gestational age.[5] Because preterm births are relatively uncommon (< 7%), the distribution of birthweights for preterm infants could be skewed towards higher values if even a few term births were incorrectly recorded as preterm births. However, this would have less effect on the 3rd and 10th birthweight percentiles.

The validity of data may differ by State and Territory. However, the overall distributions for non-Indigenous infants by State/Territory were very close, with the exception of the Northern Territory. This similarity suggests that recording methods are consistent throughout Australia. For Indigenous births there is greater variation. Fewer Indigenous births at each gestational age probably also influence these comparisons. This leaves open to question how much these variations result from differences in recording for Indigenous births.

Of greater concern is misclassification of gestational age, especially the possibility of differential misclassification by Indigenous status.[19] Not all States and Territories report LMP date; some provide estimates of gestational age based on prenatal or postnatal assessment. The difficulties in obtaining accurate gestational ages for Indigenous infants have been previously emphasised.[19] However, simulation models suggested that gestational age misclassification was an unlikely explanation for the divergence of median birthweights at each week of gestation for Indigenous and non-Indigenous infants in Queensland.[20]

Finally, the reporting of Indigenous status must be considered. Only maternal Indigenous status is recorded. This is based on self-identification, but midwives may not always ask women if they are Aboriginal or Torres Strait Islanders, and some Indigenous women may be reluctant to identify themselves to midwives.[21] This would result in some infants being misclassified as non-Indigenous. However, a validation study of the WA Midwives' Notification System in 1992 found maternal Indigenous status incorrectly reported on only 2% of the forms.[22] Encouragingly, although the proportion of mothers reported as Indigenous remained steady at 3.8% over the four years of our study, records missing Indigenous status declined from 2.9% in 1991 to 0.2% in 1994.

In conclusion, we present birthweight percentiles by gestational age based on national data in Australia. They provide current population norms for Australian clinicians and researchers. Indigenous infants have an increased risk of preterm delivery and are more likely than non-Indigenous infants to be defined as SGA. These percentiles can provide a baseline for monitoring progress in Indigenous perinatal outcomes.

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