

Birthweight Centile Charts from Rural Community-based Data from Southern India

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Objective: The objectives of the study were to estimate gestational age specific birthweight centiles from healthy pregnancies in a defined rural block and compare the under-two month mortality rates in those belonging to the lowest and highest centile groups.

Design: Retrospective chart review.

Setting: Routine data collected regarding all pregnancies, births and deaths occurring in Kaniyambadi, a rural block in Southern India, between 2003 to 2012.

Subjects: All singleton live newborns of women without known major antenatal risk factors.

Main outcome measures: Gestational age- and sex-specific birthweight centile curves were created using the LMS method. Mortality rates for the first two months of life were calculated for

those in various centile groups.

Results: The median birthweight at term was lower for the study subjects as compared to the median birth weights in the WHO child growth standards 2006, the US and the UK standards. Mortality rates for those with birthweights both below the 3rd centile as well as above the 97th centile higher than for those between 3rd and 97th centiles.

Conclusions: While absolute values of birthweights were lower than the WHO 2006 child growth standards there was a J shaped curve of birthweight and mortality. This suggests that in a given population, mortality increases at extremes of birthweights, even if some of these birthweights may be considered normal by other standards.

Keywords: Birthweight, India, Mortality, Outcome, Rural.

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Birth weight centiles are available for developed countries [1,2] but are not easily available in developing countries although the importance of ethnic-specific standards has been acknowledged [3]. Sex- and parity-specific birthweight charts for gestational age have been published based on births in tertiary hospitals but community-based birth weight centile charts representing all births in a population are not available [4,5]. An earlier comparison of birth weights in rural south India against an Indian standard showed that the Indian standard was descriptive rather than normative as the proportion small-for-gestation (SGA, below the 10th percentile) was much lower than the proportion who were low birth weight (below 2500g), while comparison with a Canadian standard showed a high rate of SGA [6].

The primary objective of this study was to construct birthweight centiles for children born to healthy mothers in a rural block in southern India between 2003-2012 and to compare with the birth weights of developed countries as well as the WHO child growth standards. The secondary objective was to compare mortality rates

within two months of birth, for children with birth weights below the 3rd centile and above the 97th centile to those with birthweights between the 3rd and 97th centiles.

METHODS

The study was carried out in a rural block of 110 000 population and 82 villages in southern India, which is the service area of the Community Health and Development (CHAD) program linked to the community health department of a large tertiary hospital. The primary care activities of the program are supported by a 140-bedded secondary hospital. Information regarding pregnancies, births and deaths in this area is collected and maintained in a computerised database by female health workers as described in an earlier study [6]. The prevalence of low birth weight (below 2500 g) and preterm births (<37 weeks) in this area was 17% and 5.5%, respectively while proportion of women receiving any antenatal care was 99% in 2005 [6].

The data on births occurring in the block was obtained from the computerised database maintained by

the health information system of the secondary hospital [6]. Only births with recorded birth weights and gestational age at the time of delivery (determined by either the date of the last menstrual period or ultrasound scans) were included in the final database. Tukey's method was followed to exclude extreme values/outliers of birthweights, which revealed seven outliers [7]. The upper limit (Tukey's outer fence) was taken as the third quartile value plus 3 times the interquartile range while the lower limit of normal (Tukey's inner fence) was taken as the first quartile minus three times the interquartile range.

As the birthweight centiles were meant to be descriptive of healthy pregnancies, mothers diagnosed with medical conditions known to have an effect on birthweight, including gestational diabetes, pregnancy induced hypertension, maternal heart disease, short stature (taken as maternal height less than 140 cm), and hemoglobin less than 10 g/dL were excluded [8].

The data were used to compute smoothed centile charts, based on the LMS method [9,10] using the software LMS Chartmaker, according to sex of the child and parity of the mother. This method uses the Box-Cox Power transformation to make the distribution normally distributed and produces curves of L (Box-Cox power parameter), M (median) and S (coefficient of variation) plotted against age. The centiles drawn were 3rd, 10th, 25th, 50th, 75th, 90th and 97th and spread sheets with L, M, S values and centile values were also created. For each child, the Z score was computed using the previously described formula [11].

Although most infant deaths occur in the first month of life, we used under-two month mortality rates as a means of validation of the birth weight centile groupings, in order to account for all deaths may be associated with low birth weight. The mortality rates were computed using available mortality data for children born to permanent residents of the study area, as follow up was done mainly for these children and not for mothers who were temporary residents (mothers who had only come for antenatal care/delivery to their maternal homes). The number of deaths in various centile groups among the children included in the birth weight centile data were used for obtaining these rates, thus giving under two month mortality rates for singleton live born children born to mothers without the antenatal high risk factors mentioned earlier.

RESULTS

The total number of births in Kaniyambadi block between 2003-2012 was 21 726, which included 356 stillbirths

and 337 twins. The number of singleton live births between 2003 to 2012 was 21 054. During this period there was a 2.7 % increase in mean (SD) birth weight from 2.799 (0.464) kg in 2003 to 2.904 (0.471) kg in 2012 with an increase in hospital deliveries from 84% in 2003 to 99.4% in 2012, with an overall rate of 95% hospital deliveries.

Of the 21054 singleton live births, gestational age was unknown for 712 and birth weight was unknown for 692. The number of singleton live births of 28 weeks or more, with known gestational ages and birth weight was 19692. However, as the number of births according to gender was small between 28 and 31 weeks, birth weight centiles were only computed for the singleton live births between 32 and 42 completed weeks. The number of singleton live births between 32 and 42 completed weeks with known gestational ages and birth weights was 19545 and after excluding outliers there were 19538 singleton live births. Birthweight centiles were finally computed using gestational ages and birth weights of 15994 singleton live births, after omitting women with complications such as pregnancy induced hypertension (291, 1.5%), gestational diabetes (23, 0.1%), haemoglobin below 10 g% (2039, 10.9%), maternal heart disease (68, 0.3%), short stature (58, 1.1%) and missing values for hemoglobin (859, 4.4%) or height (631, 3.2%). The number of males and females born to nulliparous mothers was 4122 and 3894, respectively; while males and females born to multiparous women were 4189 and 3789, respectively. The average height of the mothers of the selected 15994 children was 155 cm (SD 6.7 cm).

Birth weight centile charts for both sexes were created by the LMS software and the corresponding values of L, M, S and centile values obtained. Birth weight centiles for males and females are depicted in **Table I-II**, and **Fig. 1,2**. The normality of Z scores calculated using the L, M and S values for each gestational age was confirmed by Normal Q-Q plots for both genders and gestational age categories within each gender.

While the low birth weight proportion was 14%, the proportion of small for gestational age was 8.1%. The median birth weights of the study population were compared to the median birth weights of US whites as well as UK white and Asian newborns (**Web Fig. I**) [12,13].

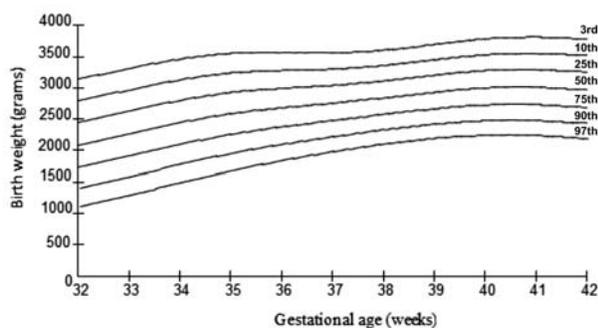
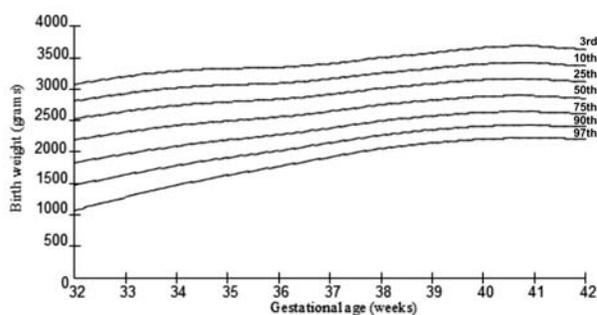
Mortality: Mortality data analyzed for the years 2003 to 2012 for children for whom follow up data was available showed that there were 207 deaths within the first two months among 14557 live born singleton births, giving an under-two month mortality rate of 14/1000 live births.

TABLE I CENTILE VALUES FOR MALES (N=8311)

Age in weeks	N	Centile values*						
		3 rd	10 th	25 th	50 th	75 th	90 th	97 th
32	53	1125.384	1418.11	1727.398	2084.334	2453.804	2796.073	3142.263
33	79	1307.635	1601.246	1909.976	2264.929	2631.248	2969.843	3311.737
34	120	1503.045	1793.081	2096.685	2444.482	2802.354	3132.4	3465.081
35	218	1691.319	1969.419	2259.296	2590.198	2929.677	3242.041	3556.329
36	361	1852.737	2110.664	2378.467	2683.149	2994.827	3280.956	3568.32
37	707	1994.273	2232.185	2478.42	2757.777	3042.841	3304.013	3565.884
38	1473	2117.048	2343.623	2577.654	2842.682	3112.685	3359.728	3607.16
39	1967	2205.521	2432.892	2667.591	2933.219	3203.687	3451.045	3698.701
40	1911	2254.88	2488.435	2729.537	3002.431	3280.316	3534.471	3788.945
41	1134	2251.521	2489.452	2735.158	3013.352	3296.714	3555.942	3815.545
42	288	2200.339	2441.596	2690.899	2973.335	3261.173	3524.612	3788.529

TABLE II CENTILE VALUES FOR FEMALES (N=7683)

Age in weeks	N	Centile values						
		3 rd	10 th	25 th	50 th	75 th	90 th	97 th
32	27	1071.636	1475.614	1835.385	2198.258	2533.816	2818.151	3085.657
33	54	1282.052	1637.941	1971.751	2320.082	2650.357	2935.297	3207.051
34	102	1471.989	1788.05	2095.316	2424.744	2743.945	3023.918	3294.427
35	174	1633.286	1913.546	2193.013	2499.096	2801.184	3070.089	3333.063
36	271	1774.326	2024.39	2278.336	2561.137	2844.551	3100.108	3352.778
37	535	1919.274	2148.231	2383.89	2649.787	2919.664	3165.744	3411.443
38	1163	2057.021	2273.012	2497.713	2754.026	3017.052	3259.297	3503.364
39	1892	2147.135	2355.66	2574.738	2827.229	3089.107	3332.698	3580.371
40	27	2206.053	2412.441	2631.489	2886.691	3154.404	3406.103	3664.593
41	1207	2227.793	2428.827	2644.25	2897.872	3166.935	3422.661	3688.011
42	299	2212.253	2403.482	2610.16	2855.84	3119.26	3372.265	3637.491

**FIG. 1** Birth weight centiles for males - 3rd, 10th, 25th, 50th, 75th, 90th, 97th**FIG. 2** Birth weight centiles for females - 3rd, 10th, 25th, 50th, 75th, 90th, 97th

Of these 207 deaths, 146 (70%) occurred among the children born to women without risk factors as included in the current study. A comparison of mortality rates between children with lower birth weight centiles and those in higher birth weight centile groups (*Web Table I*) showed higher mortality at extremes of birth weight.

DISCUSSION

Previous Indian growth charts have been from tertiary centres [4,5], which are often referral centres for those with antenatal complications. However, the WHO growth standards provides median birth weights for both sexes, for children born at term to healthy non-smoking mothers [14], which can be taken as possibly representing ideal birthweights.

The sex-specific growth charts produced by the present study are descriptive of singleton live births of rural antenatal women with no major antenatal risk factors, good antenatal care, a high rate of institutional deliveries and a low birth weight rate of 15% similar to the rest of Tamil Nadu (17.2%), but lower than that of the entire country (22%). However, these growth charts are not suitable as standards as the population is not the ideal one required for the creation of standards.

Compared to the median birth weight for boys of 3.3 kg (3rd centile 2.1 kg, 97th centile 5 kg) in the WHO Child Growth Standards 2006 [14], where healthy, socioeconomically well off mothers were included, in our study males born at 40 weeks had a lower median birth weight of 3 kg (3rd centile 2.25 kg, 97th centile 3.8 kg). Similarly the median birth weight of females in the WHO Growth standards was 3.2 kg (3rd centile 2 kg, 97th centile 4.8 kg) which was higher than that of females in our study (median 2.9 kg, 3rd centile 2.2 kg, 97th centile 3.6 kg). Comparison with birth weight centiles of the US and the UK showed that while the weights of preterms were comparable to US births, there was obvious faltering of the current study's birth weights at term, as compared to US whites, UK whites as well as south Asians in the UK. A recent study from a tertiary centre in Andhra Pradesh also showed lower birth weights as compared to international standards [5].

Although data regarding nutritional status by daily caloric intake of this population was not recorded over the years, while a previous survey from Tamil Nadu [15] showed that the median intake of daily calories by pregnant women was below the recommended allowance. The average height of the study women of 155 cm [6] was higher than the national average of 152 cm, [16] but lower than that of developed countries [17]. The shorter stature of Indian women while partly

explained by genetic variation, may also be due to under nutrition, as even in developed countries, 20% of the variation in height is thought to be due to environmental factors, with this proportion expected to be higher for less developed countries [18].

The difference between the birth weights in the WHO growth standards and our data illustrates that rural antenatal women even without major antenatal risk factors had children with lower birth weights. While major risk factors for low birth weight have been excluded, low caloric intake remains a possibility which needs to be further studied.

The mortality data highlighted the predictive value of the birthweight centiles showing a much higher mortality among children with birth weights below the 3rd centile as well as above the 97th. This was interesting considering that the 97th centile value in our data for *e.g.* 3.8 kg for males was below the 85th centile of the WHO growth standards, weight for age for boys of 3.9 kg. Thus the mortality experience of our neonates increases from birth weight centiles far below the 97th centile of the WHO growth standards (4.3 kg for boys), at weights which would be considered normal by the WHO growth standards. This pattern of a J shaped mortality curve with higher mortality at extremes of birth weight [20] which is an established phenomenon was also reflected in this study population although the absolute values for birth weight seem to be situated to the left of the widely accepted WHO growth standards.

A limitation of the data was that gestational age was based mostly on last menstrual period, as performing ultrasound scans for dating has not been a routine practice in rural areas. However, we have attempted to reduce the error by removing birth weight outliers (abnormally high/low birth weights for a gestation) and restricting to an upper gestation of 42 weeks. Although we excluded mothers with known antenatal risk factors affecting birth weight, it is possible that undiagnosed risk factors for *e.g.* undiagnosed gestational diabetes could have contributed to mortality among those with high birth weights. Children with anomalies were also not excluded as this information was not available.

The study findings raise the possibility that increase in birthweights to match the WHO standards alone may not reduce infant mortality in rural India as birthweights seem to be following a different norm. While increase in birth weights would be of use in preventing deaths in those in the lowest birth weight categories it may not be necessary or even be harmful beyond a certain limit in its effect on neonatal mortality. Comprehensive measures are needed to address both outcomes for children with

WHAT IS ALREADY KNOWN?

- Birth weight centile charts from tertiary centers in India are available.

WHAT THIS STUDY ADDS?

- Birth weight centile curves based on healthy pregnancies in a defined geographical region according to sex.
- Under two month mortality rates of children with birth weights both below the 3rd centile and above the 97th centile were higher than those with normal birth weights (between 3rd and 97th centiles) although the median birth weights were lower than international standards.

higher but so-called normal birth weights, along with attempts to decrease low birth weights.

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