# Trends in low birth weight: a comparison of two birth cohorts separated by a 15-year interval in Ribeirão Preto, Brazil

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*The incidence and some determinants of low birth weight (LBW) were studied in two population-based cohorts of singletons born live to families in Ribeirão Preto, São Paulo State, Brazil. The first cohort comprised infants born between June 1978 and May 1979 (6750 births — population survey) and the second, infants born between May and August 1994 (2990 births — sample survey). The incidence of LBW was 7.2% in 1978–79 and 10.6% in 1994. After adjustment for confounding factors, the following determinants remained significant in 1978–79: female sex, maternal age ⩾35 years, preterm delivery, < four antenatal health visits, maternal smoking, lower level of maternal education, and manual work/unemployment. In 1994, the significant determinants were preterm delivery, maternal smoking and caesarean section. The adjusted percentage population attributable risk (PAR%) fell for the majority of risk factors but increased for caesarean section, preterm birth, multiparity (⩾5), primiparity and non-cohabitation. The increase in the rate of LBW from 1978–79 to 1994 was higher for families with more qualified occupations, and occurred only for infants delivered at 36–40 weeks' gestational age and weighing 1500–2499 g, i.e. those most likely to be born by elective caesarean section. The caesarean section rate rose from 30.3% in 1978–79 to 51.1% in 1994. The increase in LBW was probably due to iatrogenic practices associated with elective caesarean section.*

## Introduction

Low birth weight (LBW) is an important determinant of both infant and neonatal mortality rates and is also an indicator of social and economic development (*1*, *2*). Patterns of LBW vary widely, being lower in the more developed countries (Denmark, 3.3% in 1984–87 (*3*); Spain, 4.9% in 1988 (*4*); USA, 7.1% in 1991 (*5*)); intermediate in some countries (Poland, 8.5% in 1985 (*6*); Puerto Rico, 9.1% in 1990 (*7*)); and higher in developing countries (Nigeria, 11.3% in 1980–85 (*8*); South Africa, 14.7% in 1989–91 (*9*)). In several countries, the rate of LBW is falling owing to economic development and the increasing well-being of populations (*10–12*). Nevertheless, there are remarkable differences between socioeconomic groups; the rate in the USA in 1991 was 5.8% for the white population but more than double (13.5) for the black population (*3*). Differences between urban and rural settings have also been documented in countries such as India, where in 1989–93 the rate was 15.9% in rural and 10.8% in urban areas (*11*).

Over the last few years, the rate of LBW has weakly declined, whereas the infant mortality and neonatal mortality rates have fallen more rapidly (*10*). In some instances the rate of LBW failed to decrease or even increased slightly, despite a sharp decline in the infant mortality rate (*3*, *6*). In Brazil, the rate varies widely; the lowest (5%) was in Florianópolis in 1987 (*13*) and the highest (13%) in Recife in 1978 (*14*). Other studies have shown intermediate rates: Pelotas, 8.1% in 1982 (*15*); Araraquara, 9.2% in 1986 (*16*); and Salvador, 12% in 1992 (*17*). In Ribeirão Preto in 1968–70, in the Interamerican Investigation of Mortality in Childhood (*18*), the rate of LBW was 8.7% and the infant mortality rate 52.6%.

In the present study, we discuss the trends of LBW in the municipality of Ribeirão Preto, São Paulo State, Brazil. By comparing two birth cohorts separated by a 15-year interval, we explore the paradox of the declining infant mortality rate and the rising rate of LBW in this city, at a time of improved social, educational, and economic indicators.

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## Methods

### Study area

Ribeirão Preto is located in the north-east of São Paulo State. Its population was 318 496 in 1978–79 and 461 427 in 1994, representing a 44.9% increase over the intervening period. The city has one of the highest per capita incomes in Brazil (ca. US$ 5800 per year) and 99% of households have piped water (*19*, *20*). The city is a regional and university centre, and the main economic activities are sugar cane production, commerce, finance and services. There were eight maternity hospitals in 1978–79 and ten in 1994.

### Study population

Surveys were carried out at all maternity hospitals in the city in both 1978–79 (*19*, *21*) and 1994. All live births of singletons to resident families were included in the analysis. In the first (population) survey, data were collected on 6750 deliveries in the 12 months from June 1978 to May 1979. Since there was no seasonality of births in 1978–79 (*19*), the second (sample) survey studied 2990 births during the 4 months from May to August 1994. Hospital deliveries accounted for at least 98% of all births (*22*). A standardized questionnaire was used and the mothers were interviewed soon after delivery. Birth weights were determined by trained personnel supervised by the research team. The infants were weighed naked using a calibrated scale with 10-g precision. The proportion of mothers discharged from hospital before they could be interviewed was 2.5% in the first survey and 3.2% in the second. In both surveys, fewer than 1% refused to be interviewed. The infant mortality rate was calculated for each cohort. When the mother was not interviewed, data were obtained from the medical records. Thus all births were included although some data, such as on newborn sex, maternal age, parity and type of delivery, were missing for some of them because the mother was not interviewed. In some cases, especially in 1994, the type of health insurance could not be determined because the mother was not sure if the prepaid health care plan covered hospitalization, the information was not in the medical records, and the same hospital admitted both private and public insurance patients. The methodology was the same in both surveys. Details of the methods have been published elsewhere (*19*).

### Specification of the determinants

The data included in the analysis covered birth weight (<2500 g, ≥2500 g), newborn sex, maternal age group (<20, 20–34, ≥35 years), marital status (cohabiting, non-cohabiting), maternal education level (<4, 4–11, ≥12 years), parity, including the current pregnancy (1, 2–4, ≥5), maternal smoking (yes/no), family income in multiples of the minimum Brazilian wage (<3, 3–10, >10), preterm birth (<37 weeks' gestation), gestational age (measured from the last menstruation), number of antenatal care visits (<4, ≥4), type of delivery (normal, caesarean section) and type of health insurance (public, private). Women covered by social security or attending free of charge at public institutions were considered to have public insurance, while those who had a private prepaid health care plan or one that paid directly for services were considered to have private insurance).

Occupational group was considered to be a marker of socioeconomic status and was divided into three categories. Group 1 included those with lower management, executive and academic jobs, including government or business management, administrators with an academic background, and employees in lower levels of management with intermediate vocational training or a lower level of education. Group 2 included skilled and semiskilled manual workers, and group 3 the unskilled or unemployed. This is an adaptation of the International Standard Classification of Occupations (*5*). In most cases, parental occupation was used for the coding of occupational groups. When parental occupation was not recorded, especially for non-cohabiting women, maternal occupation was used instead. The minimum Brazilian wage was equivalent to US$ 74 in 1978–79 and to US$ 65 in 1994.

### Statistical analysis

Populational parameters for the 1978–79 survey were obtained. Estimates and 95% confidence limits from the sample survey in 1994 were calculated.

The odds ratio was determined using logistic regression in a model that included all determinants under analysis except family income, for which there was a large percentage of missing values (19.5% in 1978–79 and 32.7% in 1994). Although gestational age also had a large percentage of missing data (24% in 1978–79 and 18.5% in 1994), it was included in the model because it was closely associated with the outcome. A model fitted without gestational age produced almost the same results. The group at lowest risk of LBW was kept as the reference category for each variable. Thus, the resulting odds ratio for each variable was adjusted to all others. All variables of known importance were included in the model, even if in an $r \times 2$ table they were not associated with LBW, in order to control their potential confounding

effects. Interaction terms were not added to the model, since our interest was to study only the main effect variables.

The prevalence of each risk factor within LBW babies, and the variation of the odds ratio for each of these variables over 15 years, were compared using adjusted percentage population attributable risk (PAR%) by means of Bruzzi's estimator (*23*) in order to identify the factors probably responsible for the trends over time. This estimator allows adjusted PAR% to be calculated from information on the prevalence of the risk factor in the affected population (cases) and the adjusted odds ratio obtained by logistic regression. We assumed that each risk factor exerted an independent effect. Thus, the sum of the PAR%s can be more than 100%.

## Results

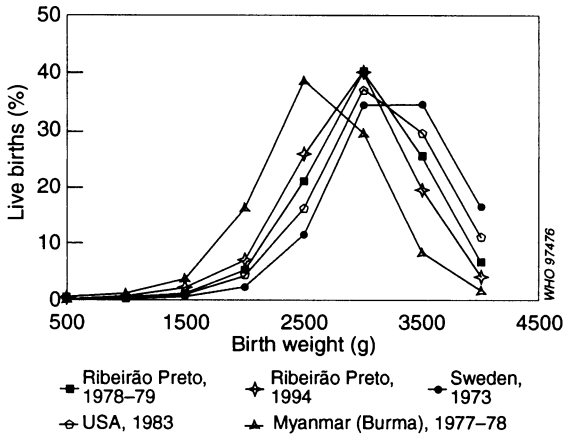
Low birth weight occurred in 7.2% of all singleton live births in 1978–79 and in 10.6% in 1994, an increase of 47.2%. The rise in the incidence of LBW was significant (Table 1). The incidence of very low birth weight (VLBW) also increased from 0.9% in 1978–79 to 1.2% in 1994, but the 95% confidence interval of the estimate in 1994 included the parameter of 1978–79. The distribution of birth weight among live births was better than in Myanmar in 1977–78 and worse than in Sweden in 1973 and in the USA in 1983 (*12*) (Fig. 1). Despite this increase in the rate of LBW, the infant mortality rate, comparing the two cohorts, dropped from 35.4 per 1000 in 1978–79 (*25*) to 16.1 per 1000 in 1994.

Table 1: **Distribution of birth weight in singleton live births in Ribeirão Preto, Brazil, 1978–79 and 1994**

| | 1978–79[a] | 1994 | |
|---|---|---|---|
| Birth weight (g) | No. of births | No. of births | |
| 500–999 | 22 (0.3)[b] | 11 (0.4) | *0.2–0.7*[c] |
| 1000–1499 | 39 (0.6) | 25 (0.8) | *0.6–1.3* |
| 1500–1999 | 70 (1.0) | 73 (2.4) | *1.9–3.1* |
| 2000–2499 | 354 (5.3) | 208 (7.0) | *6.1–8.0* |
| <2500 | 485 (7.2) | 317 (10.6) | *9.6–11.8* |
| 2500–2999 | 1404 (20.9) | 770 (25.8) | *24.3–27.4* |
| 3000–3499 | 2688 (40.0) | 1187 (39.8) | *38.1–41.6* |
| 3500–3999 | 1701 (25.3) | 582 (19.5) | *18.1–21.0* |
| ≥4000 | 443 (6.6) | 125 (4.2) | *3.5–5.0* |
| ≥2500 | 6236 (92.8) | 2664 (89.4) | *88.2–90.4* |
| Total | 6721 (100.0) | 2981 (100.0) | |

[a] Confidence limits were not calculated for 1978–79.
[b] Figures in parentheses are percentages.
[c] Figures in italics are 95% confidence intervals.

Fig. 1. **Birth weight distribution among live births, Ribeirão Preto, Brazil (1978–79 and 1994), Myanmar (Burma) (1977–78), Sweden (1973), and USA (1983). Data for Ribeirão Preto and Sweden are for singleton live births only.** (Source ref. *71*).




The incidence of preterm birth also increased, from 8.0% in 1978–79 to 14.8% in 1994. This rise was significant only among live births at 32–36 weeks' gestation; the percentage of mothers with below 32 weeks' gestation at delivery did not change over the period.

There was a significant increase over the period in the percentage of mothers aged <20 years, those ≥30 years, non-cohabiting women, primiparae, mothers having > three antenatal visits, private insurance, frequency of caesearean section (from 30.3% to 51.1%), maternal education ≥12 years, and family income of more than three times the minimum wage. There was a decrease in the percentage of mothers aged 20–29 years, mothers who smoked, parity ≥ five, maternal education <4 years, and family income less than four times the minimum wage. The percentage of heads of household engaged in management or academic occupations increased, and the percentage of heads of household working in manual jobs decreased during the period (Table 2).

Birth weight was missing for 29 cases (0.4%) in 1978–79 and for 9 live births (0.3%) in 1994. In 1978–79, there were only two infants with a birth weight <500g (350g and 430g), both of whom were excluded from the analysis. In 1994, no infant weighed <500g.

The mean and median birth weights decreased from 1978–79 to 1994 (Table 3). The difference in

median birth weight between babies born to those with intellectual/management jobs and those born to the unskilled/unemployed was 168 g in the first survey and 107 g in the second.

The determinants of LBW in 1978–79 and 1994 were compared in order to identify possible factors responsible for the increase in the rate. In 1978–79 the factors associated with LBW in the unadjusted analysis were as follows: giving birth to a female baby, maternal age <20 years or ⩾35 years, non-cohabitation, multiparity, preterm birth, < four antenatal visits, delivery in the public health system, maternal smoking, maternal education <12 years, family income of less than four times the minimum wage, skilled and semiskilled occupations, and unskilled/unemployed. After adjustment for

Table 2: **Trends in selected determinants of low birth weight in singleton live births, Ribeirão Preto, Brazil, 1978–79 and 1994**[a]

| | 1978–79[b] | 1994 | |
|---|---|---|---|
| | No. of births | No. of births | |
| *Sex of newborn* | | | |
| Male | 3470 (51.5)[c] | 1508 (50.8) | *48.9–52.6*[d] |
| Female | 3274 (48.5) | 1463 (49.2) | *47.4–51.1* |
| Missing | 6 (0.1)[e] | 19 (0.6)[e] | |
| *Maternal age (years)* | | | |
| <20 | 943 (14.1) | 517 (17.5) | *16.1–18.9* |
| 20–24 | 2206 (33.0) | 855 (28.9) | *27.3–30.6* |
| 25–29 | 1940 (29.0) | 785 (26.5) | *25.0–28.2* |
| 30–34 | 1030 (15.4) | 516 (17.4) | *16.1–18.9* |
| ⩾35 | 565 (8.5) | 285 (9.6) | *8.6–10.8* |
| Missing | 66 (1.0)[e] | 32 (1.1)[e] | |
| *Marital status* | | | |
| Cohabiting | 6215 (93.2) | 2380 (87.3) | *86.0–88.6* |
| Non-cohabiting | 456 (6.8) | 345 (12.7) | *11.4–14.0* |
| Missing | 79 (1.2)[e] | 265 (8.9)[e] | |
| *Parity* | | | |
| 1 | 2155 (32.9) | 1085 (36.9) | *35.1–38.7* |
| 2–4 | 3421 (52.3) | 1590 (54.1) | *52.2–55.9* |
| ⩾5 | 967 (14.8) | 266 (9.0) | *8.0–10.2* |
| Missing | 207 (3.1)[e] | 49 (1.6)[e] | |
| *Gestational age (months)* | | | |
| <22 | 4 (0.1) | 1 (0.0) | *0.0–0.3* |
| 22–27 | 20 (0.4) | 13 (0.5) | *0.3–0.9* |
| 28–31 | 38 (0.7) | 23 (0.9) | *0.6–1.4* |
| 32–36 | 347 (6.8) | 323 (13.2) | *11.9–14.7* |
| 37–41 | 4324 (84.3) | 1941 (79.6) | *77.9–81.2* |
| ⩾42 | 395 (7.7) | 137 (5.6) | *4.8–6.6* |
| Missing | 1622 (24.0)[e] | 552 (18.5)[e] | |
| *Preterm birth* | | | |
| No | 4719 (92.0) | 2078 (85.2) | *83.7–86.6* |
| Yes | 409 (8.0) | 360 (14.8) | *13.4–16.3* |
| *Prenatal visits* | | | |
| <4 | 1376 (23.4) | 234 (9.0) | *8.0–10.2* |
| ⩾4 | 4505 (76.6) | 2355 (91.0) | *89.9–92.0* |
| Missing | 869 (12.9)[e] | 401 (13.4)[e] | |
| *Type of delivery* | | | |
| Vaginal | 4700 (69.7) | 1449 (48.9) | *47.1–50.7* |
| Caesarean section | 2045 (30.3) | 1513 (51.1) | *49.3–52.9* |
| Missing | 5 (0.1)[e] | 28 (0.9)[e] | |
| *Mode of insurance* | | | |
| Private | 673 (10.0) | 1070 (39.5) | *37.6–41.3* |
| Public | 6027 (90.0) | 1642 (60.5) | *58.7–62.4* |
| Missing | 50 (0.7)[e] | 278 (9.3)[e] | |
| *Maternal smoking* | | | |
| No | 4608 (71.1) | 2153 (78.6) | *77.0–80.1* |
| Yes | 1872 (28.9) | 586 (21.4) | *19.9–23.0* |
| Missing | 270 (4.0)[e] | 251 (8.4)[e] | |

*(continued on p. 77)*

(Table 2, *continued*)

| | | | |
|---|---|---|---|
| *Maternal education (years)* | | | |
| <4 | 1 603 (24.5) | 393 (14.8) | *13.5–16.2* |
| 4–11 | 3 724 (56.9) | 1 492 (56.3) | *54.3–58.2* |
| ⩾12 | 1 215 (18.6) | 767 (28.9) | *27.2–30.7* |
| Missing | 208 (3.1)[e] | 338 (11.3)[e] | |
| *Family income*[f] | | | |
| <4 | 2 454 (45.1) | 641 (31.9) | *29.8–34.0* |
| 4–10 | 2 333 (42.9) | 940 (46.7) | *44.5–49.0* |
| ⩾10 | 649 (11.9) | 430 (21.4) | *19.6–23.3* |
| Missing | 1 314 (19.5)[e] | 979 (32.7)[e] | |
| *Occupational group* | | | |
| Lower managers, executives and academics | 1 077 (17.1) | 586 (21.7) | *20.2–23.3* |
| Skilled and semi-skilled | 3 844 (61.1) | 1 590 (58.9) | *57.0–60.7* |
| Unskilled/unemployed | 1 368 (21.8) | 524 (19.4) | *17.9–21.0* |
| Missing | 461 (6.8)[e] | 290 (9.7)[e] | |

[a] Percentages and confidence limits do not include missing data.
[b] Confidence limits were not calculated for 1978–79.
[c] Figures in parentheses are percentages.
[d] Figures in italics are 95% confidence intervals.
[e] Percentages of missing data calculated from the total.
[f] Expressed as multiples of the minimum wage.

all determinants shown in Table 4 (except family income), using multiple logistic regression, the following variables remained significant: female baby, maternal age ⩾35 years, preterm birth, < four antenatal visits, maternal smoking, lower maternal education and unskilled/unemployed (Table 4).

In 1994, the situation was markedly different. The factors associated with LBW were maternal age ⩾35 years, non-cohabitation, multiparity, preterm birth, < four antenatal visits, public insurance, maternal smoking, maternal education <12 years, family income of less than four times the minimum wage, and unskilled/unemployed. After adjustment for confounding variables, only three determinants remained associated: preterm birth, maternal smoking and delivery by caesarean section (caesarean section was not associated with LBW before adjustment for confounding factors (Table 5)).

A model fitted without gestational age gave the same result in 1978–79. For 1994, this model showed that delivery by caesarean section, preterm birth, maternal smoking, < four antenatal visits and maternal age ⩾35 years were associated with LBW.

The adjusted odds ratios comparing these two series decreased for female baby, maternal age <20 years or ⩾35 years, preterm birth, public insurance, lower maternal education and manual work, and increased for non-cohabitation, primiparity, multiparity, < four antenatal visits, caesarean section and maternal smoking.

The rate of LBW increased for all maternal age groups, especially those aged ⩾35 years, where it rose from 8.9% to 14.8% (a 66.3% increase). The rate increased for term births from 3.8% to 5.0% (a rise of 31.6%) and decreased for preterm births from 39.7% to 36.9% (a fall of 7.1%). The percentage increase in the rate of LBW was higher for caesarean section (86.4%) than for vaginal delivery (32.1%); higher for those with private insurance (167%) than

Table 3: **Mean and median birth weights of infants born to women from different occupational groups in Ribeirão Preto, Brazil, 1978–79 and 1994**

| | 1978–79 | | 1994 | |
|---|---|---|---|---|
| Occupational group | Mean weight (g) | Median weight (g) | Mean weight ± SD (g) | Median weight (g) |
| Lower managers, executives and academics | 3 344 | 3 335 | 3 169 ± 19.9 | 3 200 |
| Skilled and semi-skilled | 3 237 | 3 250 | 3 109 ± 41.1 | 3 150 |
| Unskilled/unemployed | 3 176 | 3 200 | 3 062 ± 27.5 | 3 100 |
| All groups | 3 234 | 3 250 | 3 115 ± 50.9 | 3 150 |

Table 4: **Frequency, percentage, and crude and adjusted odds ratios of selected determinants of low birth weight in Ribeirão Preto, Brazil, 1978–79**

| | No. with low birth weight | No. with favourable birth weight | Crude odds ratio | Adjusted odds ratio |
|---|---|---|---|---|
| *Sex of newborn* | | | | |
| Male | 219 (6.3)[a] | 3 233 (93.7) | | |
| Female | 266 (8.2) | 2 997 (91.8) | 1.31; *1.08–1.59*[b] | 1.59; *1.21–2.08* |
| *Maternal age (years)* | | | | |
| 20–34 | 334 (6.5) | 4 823 (93.5) | | |
| <20 | 98 (10.4) | 841 (89.6) | 1.68; *1.32–2.15* | 1.15; *0.78–1.68* |
| ⩾35 | 50 (8.9) | 512 (91.1) | 1.41; *1.02–1.95* | 1.91; *1.16–3.14* |
| *Marital status* | | | | |
| Cohabiting | 418 (6.8) | 5 773 (93.2) | | |
| Non-cohabiting | 61 (13.5) | 392 (86.5) | 2.15; *1.59–2.90* | 1.27; *0.70–2.30* |
| *Parity* | | | | |
| 2–4 | 218 (6.4) | 3 190 (93.6) | | |
| 1 | 158 (7.3) | 1 992 (92.7) | 1.16; *0.93–1.45* | 1.15; *0.84–1.59* |
| ⩾5 | 83 (8.6) | 878 (91.4) | 1.38; *1.05–1.82* | 0.67; *0.43–1.07* |
| *Preterm birth* | | | | |
| No | 177 (3.8) | 4 527 (96.2) | | |
| Yes | 161 (39.7) | 245 (60.3) | 16.81; *12.97–21.79* | 14.64; *10.97–19.53* |
| *Antenatal visits* | | | | |
| ⩾4 | 252 (5.6) | 4 237 (94.4) | | |
| <4 | 162 (11.8) | 1 211 (88.2) | 2.25; *1.81–2.79* | 1.39; *1.02–1.90* |
| *Type of delivery* | | | | |
| Vaginal | 366 (7.8) | 4 320 (92.2) | | |
| Caesarean section | 119 (5.9) | 1 915 (94.1) | 0.73; *0.59–0.92* | 0.98; *0.72–1.33* |
| *Mode of insurance* | | | | |
| Private | 22 (3.3) | 650 (96.7) | | |
| Public | 458 (7.6) | 5 545 (92.4) | 2.44; *1.55–3.89* | 1.04; *0.57–1.92* |
| *Maternal smoking* | | | | |
| No | 242 (5.3) | 4 352 (94.7) | | |
| Yes | 188 (10.1) | 1 678 (89.9) | 2.01; *1.64–2.47* | 1.80; *1.36–2.38* |
| *Maternal education (years)* | | | | |
| ⩾12 | 34 (2.8) | 1 181 (97.2) | | |
| 4–11 | 282 (7.6) | 3 423 (92.4) | 2.86; *1.96–4.20* | 1.83; *1.10–3.03* |
| <4 | 139 (8.7) | 1 458 (91.3) | 3.31; *2.22–4.97* | 1.77; *0.99–3.15* |
| *Family income*[c] | | | | |
| ⩾10 | 22 (3.4) | 627 (96.6) | | |
| 4–10 | 116 (5.0) | 2 209 (95.0) | 1.50; *0.92–2.46* | — |
| <4 | 210 (8.6) | 2 235 (91.4) | 2.68; *1.67–4.33* | — |
| *Occupational group* | | | | |
| Lower managers, executives and academics | 34 (3.2) | 1 042 (96.8) | | |
| Skilled and semi-skilled | 278 (7.3) | 3 549 (92.7) | 2.40; *1.64–3.52* | 1.75; *1.06–2.89* |
| Unskilled/unemployed | 121 (8.9) | 1 239 (91.1) | 2.99; *1.99–4.52* | 2.01; *1.15–3.53* |

[a] Figures in parentheses are percentages.
[b] Figures in italics are 95% confidence intervals.
[c] Expressed as multiples of the minimum wage. Family income was not significant in the model; it was excluded in the adjustment because of the large percentage of missing values.

for public health services (55%); and higher for lower-level managers, executives and academics (156.3%) than for manual workers and the unemployed (about 46%). Thus, the social differences in the rate of LBW fell owing to a higher proportional increase for those who worked in more qualified occupations. The mean and median birth weights decreased for all occupations, the rate being higher for those in executive and academic jobs. The difference in mean birth weight between 1978–79 and 1994 was 175 g for executives and academics, 128 g for skilled and semiskilled manual workers, and 114 g for unskilled workers and the unemployed.

For an improved understanding of the reasons for the increase in the rate of LBW, the adjusted PAR% was calculated for the determinants studied. The highest PAR%s in 1978–79 (>19%) were for

Table 5: **Frequency, percentage, and crude and adjusted odds ratios of selected determinants of low birth weight in Ribeirão Preto, Brazil, 1994**

| | No. with low birth weight | No. with favourable birth weight | Crude odds ratio | Adjusted odds ratio |
|---|---|---|---|---|
| *Sex of newborn* | | | | |
| Male | 148 (9.8)[a] | 1 356 (90.2) | | |
| Female | 168 (11.5) | 1 292 (88.5) | 1.19; *0.93–1.52*[b] | 1.31; *0.93–1.83* |
| *Maternal age (years)* | | | | |
| 20–34 | 211 (9.8) | 1 939 (80.6) | | |
| <20 | 61 (11.8) | 455 (88.2) | 1.23; *0.90–1.23* | 0.85; *0.51–1.41* |
| ⩾35 | 42 (14.8) | 241 (85.2) | 1.60; *1.10–2.33* | 1.54; *0.92–2.59* |
| *Marital status* | | | | |
| Cohabiting | 241 (10.2) | 2 132 (89.8) | | |
| Non-cohabiting | 51 (14.8) | 293 (85.2) | 1.54; *1.09–2.17* | 1.31; *0.79–2.16* |
| *Parity* | | | | |
| 2–4 | 153 (9.6) | 1 435 (90.4) | | |
| 1 | 111 (10.3) | 971 (89.7) | 1.07; *0.82–1.40* | 1.32; *0.90–1.95* |
| ⩾5 | 47 (17.9) | 216 (82.1) | 1.90; *1.29–2.81* | 1.34; *0.73–2.44* |
| *Preterm birth* | | | | |
| No | 104 (5.0) | 1 971 (95.0) | | |
| Yes | 132 (36.9) | 226 (63.1) | 11.07; *8.19–14.98* | 12.07; *8.60–16.94* |
| *Antenatal visits* | | | | |
| ⩾4 | 227 (9.7) | 2 124 (90.3) | | |
| <4 | 51 (22.0) | 181 (78.0) | 2.64; *1.84–3.76* | 1.73; *0.98–3.05* |
| *Type of delivery* | | | | |
| Vaginal | 148 (10.3) | 1 295 (89.7) | | |
| Caesarean section | 167 (11.0) | 1 345 (89.0) | 1.09; *0.85–1.39* | 1.61; *1.10–2.37* |
| *Mode of insurance* | | | | |
| Private | 94 (8.8) | 974 (91.2) | | |
| Public | 194 (11.8) | 1 444 (88.2) | 1.39; *1.06–1.82* | 1.02; *0.66–1.57* |
| *Maternal smoking* | | | | |
| No | 177 (8.2) | 1 972 (91.8) | | |
| Yes | 114 (19.6) | 469 (80.4) | 2.71; *2.07–3.54* | 1.98; *1.35–2.91* |
| *Maternal education (years)* | | | | |
| ⩾12 | 60 (7.8) | 706 (92.2) | | |
| 4–11 | 165 (11.1) | 1 322 (88.9) | 1.47; *1.06–2.03* | 1.18; *0.73–1.92* |
| <4 | 59 (15.0) | 334 (85.0) | 2.08; *1.39–3.11* | 1.38; *0.71–2.69* |
| *Family income*[c] | | | | |
| ⩾10 | 39 (9.1) | 390 (90.9) | | |
| 4–10 | 74 (7.9) | 864 (92.1) | 0.86; *0.56–1.32* | — |
| <4 | 88 (13.8) | 551 (86.2) | 1.60; *1.05–2.44* | — |
| *Occupational group* | | | | |
| Lower managers, executives and academics | 48 (8.2) | 537 (91.8) | | |
| Skilled and semi-skilled | 169 (10.7) | 1 416 (89.3) | 1.34; *0.94–1.89* | 1.05; *0.64–1.72* |
| Unskilled/unemployed | 68 (13.0) | 455 (87.0) | 1.67; *1.11–2.52* | 0.96; *0.50–1.85* |

[a] Figures in parentheses are percentages.
[b] Figures in italics are 95% confidence intervals.
[c] Expressed as multiples of the minimum wage. Family income was not significant in the model; it was excluded in the adjustment because of the large percentage of missing values.

preterm delivery, maternal education of 4–11 years' duration, skilled and unskilled manual workers, female baby and maternal smoking. In 1994, the highest PAR%s were for preterm delivery, caesarean section and maternal smoking. Although the majority of PAR%s decreased, the LBW rate increased. The PAR%s decreased between 1978–79 and 1994 for almost all determinants. The PAR%s increased for caesarean section, preterm delivery, parity ⩾ five, primiparity and non-cohabitation. The highest increase was for delivery by caesarean section (Table 6).

The rate of LBW decreased for preterm births <36 weeks and >40 weeks' gestational age and increased for those of 36–40 weeks' gestational age. Hence, the upward trend in the rate occurred only among infants of 36–40 weeks' gestational age. The percentage of live births occurring ⩽39 weeks' gesta-

Table 6: **Distribution of determinants of low birth weight (LBW) among LBW babies, adjusted odds ratios and adjusted PAR%s in Ribeirão Preto, Brazil, 1978–79 and 1994**

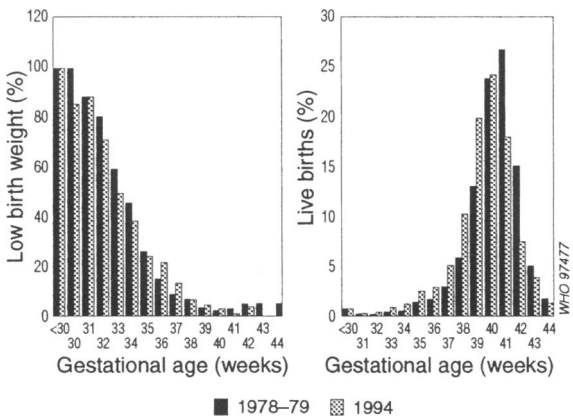
| | 1978–79 | | | 1994 | | | |
|---|---|---|---|---|---|---|---|
| Determinant | % LBW babies | Adjusted odds ratio | Adjusted PAR% | % LBW babies | Adjusted odds ratio | Adjusted PAR% | Difference in PAR%[a] |
| Female baby | 54.8 | 1.59 | 20.35 | 53.2 | 1.31 | 12.58 | −7.77 |
| Maternal age <20 years | 20.3 | 1.15 | 2.65 | 19.4 | 0.85 | −3.43 | −6.08 |
| Maternal age ≥35 years | 10.4 | 1.91 | 4.94 | 13.4 | 1.54 | 4.69 | −0.25 |
| Non-cohabitation | 12.7 | 1.27 | 2.71 | 17.5 | 1.31 | 4.13 | 1.43 |
| Primiparity | 34.4 | 1.15 | 4.49 | 35.7 | 1.32 | 8.65 | 4.16 |
| Deliveries ≥5 | 18.1 | 0.67 | −8.91 | 15.1 | 1.34 | 3.83 | 12.74 |
| Preterm birth | 47.6 | 14.64 | 44.38 | 55.9 | 12.07 | 51.30 | 6.92 |
| Antenatal visits <4 | 39.1 | 1.39 | 10.98 | 18.3 | 1.73 | 7.74 | −3.24 |
| Caesarean section | 24.5 | 0.98 | −0.50 | 53.0 | 1.61 | 20.09 | 20.59 |
| Public insurance | 95.4 | 1.04 | 3.67 | 67.4 | 1.02 | 1.32 | −2.35 |
| Maternal smoking | 43.7 | 1.80 | 19.43 | 39.2 | 1.98 | 19.39 | −0.04 |
| Maternal education 4–11 years | 62.0 | 1.83 | 28.11 | 58.1 | 1.18 | 8.86 | −19.25 |
| Maternal education <4 years | 30.5 | 1.77 | 13.29 | 20.8 | 1.38 | 5.72 | −7.57 |
| Skilled and semi-skilled workers | 64.2 | 1.75 | 27.52 | 59.3 | 1.05 | 2.82 | −24.69 |
| Unskilled/unemployed | 27.9 | 2.01 | 14.04 | 23.9 | 0.96 | −0.99 | −15.04 |

[a] PAR% (1978–79) – PAR% (1994).

tional age rose and that of births ≥ 40 weeks decreased (Fig. 2).

Analysis of the rate of caesarean section showed that in 1978–79 the rate increased with increasing gestational age. In 1994, however, the rate decreased up to 34 weeks' gestation, increased from 34 weeks to 38 weeks, and decreased thereafter. The peak rate was reached at 37–38 weeks' gestation (Fig. 3).

Fig. 2. **Trends in low birth weight and live births, by gestational age, Ribeirão Preto, Brazil, 1978–79 and 1994.**

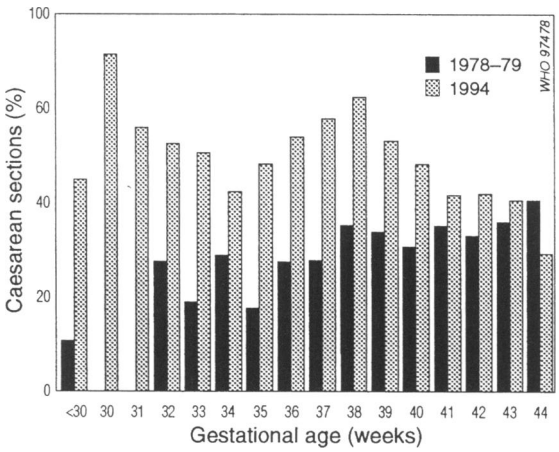



## Discussion

Maternal age had a U-shaped relationship with LBW in 1978–79 in the unadjusted analysis, while this relationship was absent in 1994. The relationship between younger maternal age and LBW was probably significantly affected by socioeconomic factors, an association that had disappeared by 1994. Although average maternal age fell over the period, the risk of young mothers having an LBW infant was reduced. Instead, the proportion of deliveries by older mothers increased. After adjustment, the risk of having an LBW infant was significant only for mothers aged ≥35 years and only in 1978–79.

Although the association between occupation and LBW was significant in 1978–79, adjustment tended to reduce it, confirming that socioeconomic differences are mediated by other variables. Mothers employed in less qualified occupations tended to be heavier smokers, to have fewer antenatal visits, to show a higher percentage of non-cohabitation, to be younger, to use public health services, and to have fewer years of education (*21*, *25*, *26*). The association between LBW and socioeconomic status was significant only in the first cohort and had disappeared in 1994. The same was the case with maternal education. Social differences in LBW disappeared in 1994 owing to a higher proportional increase in the rate of LBW among infants of mothers holding executive and academic jobs. In Sweden, a more equitable society than Brazil, social differences in the rate of LBW are still present though relatively small (*27*).

Fig. 3. **Trends in caesarean section, by gestational age, Ribeirão Preto, Brazil, 1978–79 and 1994.**




The sex of the infant was significant for LBW in 1978–79 but not in 1994. Preterm birth was associated with LBW in both cohorts; its odds ratio decreased, but the PAR% increased owing to the rise in the percentage of preterm deliveries from 1978–79 to 1994.

Maternal smoking was significant in both cohorts; its odds ratio increased and the PAR% was almost the same after 15 years. Type of delivery was not associated with LBW in the first cohort but was in the second.

In many countries, rates of LBW are decreasing owing to improvements in the quality and use of health services, to social changes and to shifts in demographic patterns. In Great Britain, for example, small and gradual annual increases in birth weight have been observed (*10*, *28*, *29*). Genetic factors are also related to these trends: intergenerational influence tends to promote secular increases in maternal weight, leading to an increase in birth weight (*30*).

In the USA, the rate of LBW declined steadily from 1970 to 1985 and thereafter increased slightly, from 6.7% in 1985 to 7.1% in 1991. This resulted from an increase in the proportion of preterm VLBW infants (*3*). The same occurred in England and Wales: a rise in the rate of VLBW from 0.84% in 1983 to 0.95% in 1987 was attributed to changes in perceptions of viability, with a consequent increase in assisted resuscitation and a rise in the registration of live births (*10*).

In Niamey, the capital of Niger, a rise in the rate of LBW was documented in a study performed in a representative sample of the population. The rate of 11.6% in 1980 fell to 8.7% in 1983, but increased again to 12.9% in 1985 owing to the Sahelian famine of 1984–85 (*9*). Data from the University of Nigeria Teaching Hospital (*31*) showed a rise from 7.3% in 1984 to 13.0% in 1989, attributed to economic recession and to the economic adjustment programme.

In Poland, the rate of LBW rose from 8.1% in 1985 to 8.4% in 1990. The highest proportional increase occurred among mothers from urban areas with fewer years of education. This increase was attributed to social problems and poor nutrition (*6*).

What factor or factors can explain the increase in LBW among the population of Ribeirão Preto over 15 years without a concomitant rise in infant mortality rate? A dissociation was observed between the increasing rate of LBW and decreasing infant mortality rate. There was no prolonged economic crisis or any situation of chronic famine to explain these trends. The rate of unemployment was very low in the cohorts studied, representing 0.5% in 1978–79 and 0.3% in 1994. The social indicators (maternal education and professional qualifications, measured by occupational group) improved during the period. The majority of risk factors showed a favourable development. Surprisingly, the proportional increase in LBW was higher for parents working in occupations that required more qualifications than for those in unskilled occupations. The situation deteriorated to such an extent that in 1994 the mean birth weight for infants of those with executive and academic jobs was lower than that for unskilled workers in 1978–79.

One possible explanation could be the increase in the incidence of preterm births, from 8.0% to 14.8% over the period. However, another factor responsible for the upward trends in LBW and preterm birth rates must also have been present. The incidence of preterm deliveries has remained relatively unchanged in many countries or has increased slightly in recent years (*32*), in contrast to the situation in Ribeirão Preto, where it rose markedly over the 15-year period. Although preterm birth rates rose, the percentage of infants with LBW among preterm births decreased. There was an increase in the number of births occurring up to the 39th week of gestation and a decrease in those after the 40th week. This shows a tendency to earlier deliveries in all gestational age groups, probably reflecting the effects of medical interventions such as elective caesarean section and induced labour.

The association between birth weight and type of delivery was studied in São Paulo in 1981. The incidence of caesarean sections increased with birth weight at two hospitals, and was attributed mainly to cephalopelvic disproportion (*33*). The same pattern

was detected in Ribeirão Preto in 1978–79: the rate of caesarean section tended to increase with birth weight, ranging from 10.5% for births occurring at 28–31 weeks' gestation to 24.5% for those at 32–36 weeks, 32.9% for those of 37–41 weeks and 33.9% for those at ≥42 weeks. The pattern changed in 1994, however: the highest rate of delivery by caesarean section occurred among infants born at term (54.6%), being 50.7% among preterm births and 35.3% among post-term children.

There was no increase in the rate of LBW among infants born up to the 35th week or after the 40th week of gestation. The increase occurred only among infants born at 36–40 weeks' gestation.

In the USA, there was a 32% increase in the rate of LBW among the black population from 1950 to 1967. A change of this magnitude also occurred during the Second World War in the Netherlands and Leningrad (St Petersburg), as a result of starvation. The rise in the American rate, however, was due largely to systematic underreporting of LBW, resulting from a shift to hospital deliveries among the black population (*34*). In the USA today, the rise in the rate of VLBW is attributed to an increase in registration of the condition, owing to changes in the perception of viability (*35*). The increase in the rates of VLBW in Scotland was attributed to an increase in the proportion of multiple births and to changes in the classification of non-registrable miscarriages or stillbirths to registered live births (*29*). In other countries, improvements in the registration of births have resulted in increased rates of LBW and VLBW (*36*, *37*). The criteria for assessing viability seem to vary among countries and are related to availability and access to neonatal care (*38*). In Ribeirão Preto between 1978–79 and 1994, the rate of LBW increased by 47.2%, a rise that could not be attributed to increasing registration or to starvation. As stated above, the increase in LBW occurred only among infants born between 36 weeks' and 40 weeks' gestation. Its is not probable that improved registration occurred only for births at these gestational ages. Similarly, there was no socioeconomic crisis to explain this upward trend. However, this study was restricted to singleton live births and thus an increase in triplet or other multiple births is not taken into account.

### *The role of caesarean section in LBW*

There are five lines of evidence indicating that delivery by caesarean section may be responsible for the upward trend in the rate of LBW. First, caesarean section was associated with LBW in 1994 after controlling for confounding variables. Second, the increase in LBW, comparing 1978–79 with 1994, was higher for families employed in occupations that required higher qualifications and the rate of delivery by caesarean section was also higher for this group. Third, the increase in LBW occurred only in deliveries at 36–40 weeks' gestation and among newborns weighing 1500–2499 g, i.e. those most likely to be born by elective caesarean section. Fourth, delivery by caesarean section showed the highest proportional increase in PAR% between 1978–79 and 1994. Finally, not only did an increase in the rate of LBW occur, but also a decrease in the mean and median birth weights of the entire newborn population, a phenomenon that cannot be attributed only to artefacts of registration. The increase in the rate of LBW was therefore probably due to iatrogenic practices related to elective caesarean section.

### *Consequences of increasing rates of LBW*

A rise in the rate of LBW generates unnecessary increases in medical care costs by lengthening the period of hospitalization. Although the increase in the rate in Ribeirão Preto did not lead to an increase in neonatal mortality rate (as also reported from the USA (*39*) where the lighter weights of infants born at term appeared not to affect perinatal survival) it must have augmented the levels of neonatal morbidity and suffering (*2*). The present results indicate the urgent need for a public health policy directed at reducing the rate of caesarean sections in Brazil, where it is probably the highest in the world.

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## Résumé

### Tendances du faible poids de naissance: comparaison de deux cohortes de naissance séparées par un intervalle de 15 ans, à Ribeirão Preto, Brésil

L'incidence et certains déterminants du faible poids de naissance ont été étudiés dans deux cohortes issues de la population dans la municipalité de Ribeirão Preto dans l'Etat de Sao Paulo, au Brésil.

Au cours de la première enquête (en population) réalisée de juin 1978 à mai 1979, la cohorte comportait 6750 naissances simples et vivantes dans des familles résidentes. La seconde enquête (sur un échantillon) incluait les 2990 naissances survenues de mai à août 1994. L'incidence du faible poids de naissance était de 7,2% en 1978–1979 et de 10,6% en 1994. Après ajustement sur les facteurs de confusion, les déterminants suivants sont restés significatifs en 1978–1979: sexe féminin, âge maternel ≥35 ans, prématurité, moins de 4 visites prénatales, tabagisme maternel, faible scolarisation de la mère et emploi manuel/mère sans emploi. En 1994, les déterminants significatifs étaient la prématurité, le tabagisme maternel, et l'accouchement par césarienne. Les odds ratios ajustés de ces deux séries diminuent pour le sexe féminin, l'âge maternel <20 ans ou ≥35 ans, la prématurité, la couverture par un système public d'assurances sociales, la faible scolarisation de la mère et un emploi manuel; ils augmentent pour la non-cohabitation, la primiparité, la multiparité, moins de 4 visites prénatales, l'accouchement par césarienne et le tabagisme maternel. Le risque attribuable en population (%) chute pour la majorité des facteurs de risque et augmente pour l'accouchement par césarienne, la prématurité, la multiparité (≥5), la primiparité et la non-cohabitation. L'augmentation de la fréquence du faible poids de naissance entre 1978–1979 et 1994 est plus grande dans les familles ayant un métier plus qualifié, et ne s'observe que pour les enfants nés à 36–40 semaines d'âge gestationnel et pesant 1500–2499 g, c'est-à-dire ceux pour lesquels la probabilité de naître par césarienne non indispensable est la plus forte. La fréquence des césariennes est passée de 30,3% en 1978–1979 à 51,1% en 1994. L'accouchement par césarienne est le facteur pour lequel le risque attribuable en population augmente le plus entre 1978–1979 et 1994. Les poids de naissance moyen et médian diminuent pour toute la population des nouveaunés pendant la période d'étude, phénomène qu'il est impossible d'attribuer à un artefact d'enregistrement. L'augmentation de la fréquence du faible poids de naissance est probablement due à des pratiques iatrogènes associées à la césarienne non indispensable.

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