IJE vol.33 no.4 © International Epidemiological Association 2004; all rights reserved. International Journal of Epidemiology 2004;33:821–828
Advance Access publication 20 May 2004 doi:10.1093/ije/dyh101

Can we explain why Brazilian babies are becoming lighter?

Antonio AM Silva,[1] Marco A Barbieri,[2] Heloisa Bettiol,[2] Marcelo Z Goldani[3] and Roberto J Rona[4]

Accepted 19 December 2003

Background We tried to explain why a marked decrease in birthweight of 122 g occurred over a 15-year period in Ribeirão Preto, Brazil.

Methods Factors reflecting biological, social, and health care characteristics (infant gender, parity, maternal age, marital status, type of hospital, maternal smoking, preterm birth, small for gestational age [SGA], and prenatal care) were assessed on 6711 newborns in 1978/1979 and 2838 in 1994 using multiple linear regressions.

Results The birthweight distribution shifted to the left and the residual distribution of small preterm babies increased from 1.9% to 3.4%. Only marital status and preterm delivery would have decreased the difference in birthweight over time, explaining for each of them around 30 g of the 122 g. Increasing levels of attendance at antenatal care over time might have decreased the birthweight difference by 40 g. Maternal age and SGA explained little of the decreasing trend. Reductions in maternal smoking would have increased mean birthweight slightly. In stratified analysis the downward trend was more marked among mothers with high education (−202 g) and those delivered by caesarean section (−194 g). After adjusting for all those significant variables mean birthweight was still 74 g (95% CI: −97, −50 g) lower in 1994 than in 1978/1979.

Conclusion The trend could be explained in part by factors related to marital status that might reflect dysfunctional families in the Brazilian context and the preterm increase that might be associated with advances in medical technology. The high attendance at antenatal clinics or factors associated with it might have prevented a further decrease in birthweight. Our results may be compatible with the high economic development of Ribeirão Preto within Brazil, together with factors associated with its unfavourable lifestyle.

Keywords Birthweight, caesarean section, trends, preterm birth, marital status

The birthweight distribution of a population is a sensitive indicator of biological and social conditions.[1] In most countries it has shifted to the right, resulting in bigger babies,[2–8] but there are indications that this trend is slowing down[9,10] or tapering off.[11] In some countries birthweight has even fallen.[12,13] It has been suggested that this diversity of trends may be related to biological changes or greater availability of perinatal technology and changing attitudes regarding foetal viability.[14]

In Ribeirão Preto, São Paulo, Brazil, two studies were carried out over an interval of 15 years, in 1978/1979 and in 1994. As the social indicators improved between the two periods[15] there was an expectation that mean birthweight would increase reflecting improvements in living standards and health care. However, a decline in mean birthweight and a shift to the left in the whole birthweight distribution was observed. The main objective of this analysis is to identify explanatory factors for this downward trend.

Material and Methods

Ribeirão Preto is a regional centre in the Northeastern region of the São Paulo state, Brazil. Its *per capita* income is one of the

[1] Department of Public Health, Federal University of Maranhão, Sao Luís, MA, Brazil.
[2] Department of Puericulture and Pediatrics, Faculty of Medicine of Ribeirão Preto, University of São Paulo, Ribeirão Preto, SP, Brazil.
[3] Department of Pediatrics and Puericulture, Faculty of Medicine, Federal University of Rio Grande do Sul, Porto Alegre, RS, Brazil.
[4] Department of Public Health Sciences, King's College London, UK.
Correspondence: Dr Heloisa Bettiol, Departamento de Puericultura e Pediatria, Faculdade de Medicina de Ribeirão Preto, Universidade de São Paulo, Avenida Bandeirantes 3900, 14049-900. Ribeirão Preto, São Paulo, Brazil. E-mail: hbettiol@fmrp.usp.br

highest in this country, about US$ 8200 a year in 1996. The main economic activities are the sugar cane industry, trading, services, and financing. Its population was 461 427 inhabitants in 1994, increasing by 45% over the period covered by this analysis.[15,16]

At least 98% of births have occurred in hospitals since 1978.[15] The two surveys were carried out in all these maternity hospitals in 1978/1979 and 1994. The 1978/1979 survey was carried out between June 1978 and May 1979 (6750 births). The 1994 survey included infants born from May to August (2846 births). Thirty-nine babies in 1978/1979 and eight in 1994 were excluded because information on birthweight was missing. This analysis was restricted to singleton live births from families residing in the municipality to avoid potential confounding due to multiple gestations. The mothers were interviewed soon after delivery using a standardized questionnaire after their consent to participate was obtained. Trained personnel weighed the naked newborns immediately after delivery using weekly-calibrated scales with 10 g precision. Non-response due both to early hospital discharge and refusal to participate was 3.5% and 4.2% in the first and second survey respectively. The methodology was the same in both surveys and details have been published elsewhere.[15,16]

The variables included in this analysis were: birthweight (continuous), maternal schooling in years (0–4, 5–8, 9–11, ⩾12), newborn gender, maternal age (<18, 18 and 19, 20–34, and ⩾ 35 years), marital status (married, cohabiting, non-cohabiting), parity, including the current one (1, 2–4, ⩾5), number of prenatal care visits (0, 1–3, 4–6, ⩾7), type of delivery (vaginal or caesarean), gestational age at delivery considering non-preterm (>36 weeks), moderately preterm birth (33–36 weeks) and very preterm birth (<33 weeks), maternal smoking (non-smokers, 1–10, 11–20 and ⩾20 cigarettes/day) and type of hospital (public teaching hospitals, private hospitals attending predominantly public insurance, and private hospitals attending predominantly private insurance). In some analyses maternal schooling was considered low (0–8 years), high (⩾9 years) and a missing category was included for most variables in the analysis. Gestational age was estimated according to the last normal menstrual period. A small number of newborns were excluded because their birthweight was above the 99th percentile for their gestational age, 32 cases in 1978/79 and 21 in 1994, according to British nomograms.[17] In some of the analysis we included, as an independent variable, small for gestational age (SGA) as babies below the 10th percentile according to published reference values.[18]

The Wilcox-Russell method was used to estimate the predominant normal birthweight distribution and to estimate the residual percentage of small preterm babies in both years.[19] The residual percentage provides an indication of the excess of preterm births in the distribution of birthweights. The predominant birthweight gives the mean birthweight and distribution excluding the excess residual percentage of small preterm births.

Changes in birthweight were evaluated with respect to biological, social, demographic, and health service factors. In a combined model including both years, coefficients were adjusted by multiple regression for all variables under analysis. The combined model included a variable for year of the survey (coded 0 for 1978/1979 and 1 for 1994) and interactions between year of survey and the variables that might be able to explain changes in mean birthweight were tested.

We also assessed, in a combined model including both years, changes in the coefficient of year of the survey effect by adding successively variables significantly associated with the outcome variable. The analysis is shown with the factors grouped according to their effect on the birthweight difference between surveys into factors that did not change the coefficient, factors that could have increased it, and those that could have decreased it in the fully adjusted model. Due to significant interactions with year of survey on their measurement effects on birthweight change, mode of delivery and maternal schooling were not included in this analysis but were stratified. As the distribution of birthweight was moderately left-skewed, we repeated the analysis using a square transformation.

Results

Mean birthweight was lower in 1994 (3113 g) than in 1978/1979 (3235 g) ($P < 0.001$) and the entire birthweight distribution shifted to the left. Using Wilcox and Russell's method, mean birthweight of the predominant Gaussian distribution decreased from 3293 g in 1978/1979 to 3185 g in 1994. There was also an increase in the residual percentage of small preterm babies from 1.9% to 3.4% (Figure 1).

Birthweight fell steeply in offsprings of multiparous, older, more highly educated, married women and heavy smokers in comparison to their counterparts in the unadjusted analysis. Mothers who underwent caesarean section, had their delivery in private hospitals, were predominantly privately insured, did not have an SGA baby, or had delivered a term or very preterm infant had a greater fall in mean birthweight of their newborns (Table 1).

In a combined model including the two surveys, newborn gender, parity, maternal age, marital status, maternal smoking, prenatal care, and type of hospital were all significantly associated with birthweight difference over time (Table 2). Two significant interactions were observed in the model, year of survey and maternal schooling ($P = 0.002$), and year of survey and mode of delivery ($P < 0.001$) on birthweight difference.

In sequential models, where a period effect was tested, mean birthweight was 122 g (95% CI: −146, −98 g) lower in 1994 than in 1978/1979. Parity, gender, and type of hospital did not change mean birthweight over time. Antenatal care increased the birthweight difference by 40 g, but maternal smoking only slightly increased the mean birthweight difference. Maternal age and SGA slightly decreased the difference. Marital status had the greatest effect in reducing the mean birthweight difference from 122 g to 91 g (25.4%), similar to the preterm effect from 122 g to 94 g (23%). After adjusting for all the variables in the model mean birthweight difference was reduced to −74 g (95% CI: −97, −50 g), but when preterm and SGA status were excluded the final mean birthweight difference was −126 g (95% CI: −154, −98 g) (Table 3). Thus most of the birthweight difference was not explained by the variables in the model.

We conducted the same analysis but stratified by mode of delivery and maternal schooling separately because of the interactions described above. The unadjusted decrease in mean birthweight was steeper among caesarean (−194 g) than among

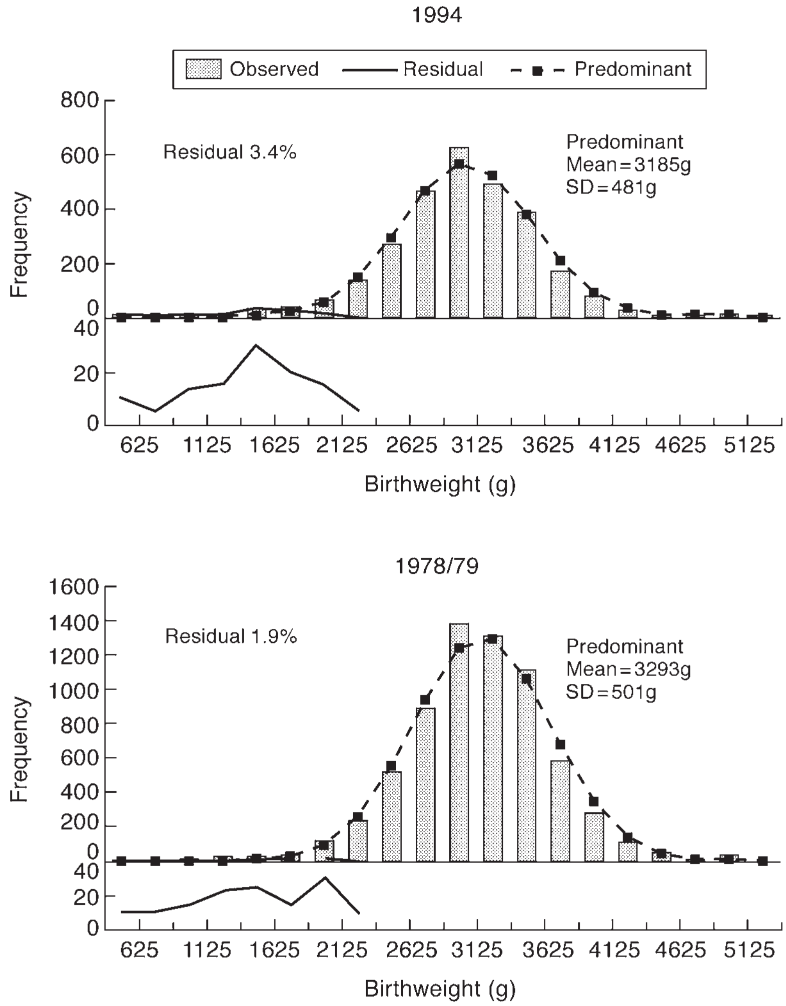

Figure 1 Birth weight distribution according to the method proposed by Wilcox and Russel, Ribeirão Preto, São Paulo, Brazil, 1978/79 and 1994.

vaginal deliveries (−101 g). It was also greater among highly (−202 g) than less educated mothers (−122 g). After adjusting for all factors, excluding preterm and SGA status, the decrease in birthweight differences were negligible, except for vaginal delivery. After adjusting also for preterm and SGA status birthweight differences decreased more markedly in all strata (Table 4). The main reason for a decrease was due to the preterm factor. After adjusting for year of survey, preterm birth, among vaginal deliveries the difference decreased from 101 g to 84 g (18.8%) and among caesarean sections from 194 g to 142 g (26.8%) (not shown). Marital status reduced the differences in birthweight from 101 g to 58 g (42.6%) among those delivered vaginally and from 194 g to 175 g (9.8%) among those delivered by caesarean section (not shown).

A square transformation almost completely normalized the birthweight distribution. The results using the square transformation were similar to those shown in the paper.

Discussion

In this study we have demonstrated a marked decrease in birthweight over a 15-year period. There was an increase in preterm birth rate and this factor explained 23% of the decrease in birthweight over the 15 years. Marital status also explained part of the decrease in birthweight. The decrease was greater among newborns delivered by caesarean section and mothers with more education. Changes in socio-demographic factors, lifestyle, medical organization, and health provision characteristics over the period explained little of the birthweight decrease.

The main strengths of our study are that the same methodology was used in the 1978/1979 and 1994 surveys, the participation rate was almost complete, and all maternity hospitals in Ribeirão Preto participated in the study. In our study, duration of gestation was based on last menstrual period in both surveys. It is possible that inadvertently in a few cases interviewers may have used ultrasound technology to estimate duration of gestation. This is a common problem in most secular trend studies; its effect would have been, at most, marginal in our study as the main outcome was birthweight. We have missing information for some variables, especially gestational age, that may have decreased the precision of some estimates.

The downward mean birthweight trend was unexpected as parents in the 1994 birth cohort had a higher proportion of

Table 1 Unadjusted mean birthweight according to socioeconomic, demographic, biological and health services variables. Ribeirão Preto, São Paulo, Brazil, 1978/1979 and 1994

Variables	1978 n	1978 %	1978 Mean (SD)[a]	1994 n	1994 %	1994 Mean (SD)[a]	Difference (95% CI)
Maternal schooling (years)							
0–4	3347	49.9	3196 (556)	631	22.2	3040 (620)	−156 (−205, −108)
5–8	1642	24.5	3237 (517)	1039	36.6	3116 (525)	−120 (−161, −80)
9–11	868	12.9	3312 (496)	609	21.5	3124 (558)	−188 (−242, −134)
⩾12	651	9.7	3382 (487)	368	13.0	3168 (528)	−215 (−279, −150)
Unknown	203	3.0	3066 (687)	191	6.7	3195 (490)	+129 (+10, +248)
Newborn gender							
Male	3448	51.4	3293 (541)	1443	50.8	3170 (579)	−123 (−156, −89)
Female	3263	48.6	3174 (535)	1395	49.2	3053 (521)	−121 (−154, −87)
Parity							
1	2359	35.2	3212 (536)	1154	40.7	3087 (545)	−126 (−164, −88)
2–4	3408	50.8	3259 (519)	1491	52.5	3137 (551)	−122 (−155, −90)
⩾5	735	11.0	3237 (601)	165	5.8	3054 (647)	−182 (−286, −79)
Unknown	209	3.1	3096 (678)	28	1.0	3259 (453)	−163 (−97, +423)
Maternal age							
<18	336	5.0	3017 (625)	211	7.4	2981 (628)	−36 (−144, +72)
18–19	601	9.0	3145 (482)	287	10.1	3111 (474)	−34 (−101, +34)
20–34	5151	76.8	3260 (531)	2064	72.7	3135 (552)	−125 (−152, −98)
⩾35	560	8.3	3234 (611)	269	9.5	3043 (576)	−191 (−278, −104)
Unknown	63	0.9	3272 (450)	7	0.2	3411 (500)	+139 (−222, +501)
Marital status							
Married	5522	82.3	3265 (526)	1674	59.0	3158 (534)	−108 (−137, −79)
Cohabiting	659	9.8	3110 (566)	700	24.7	3049 (583)	−62 (−123, −1)
Non-cohabiting	453	6.8	3050 (630)	346	12.2	3008 (597)	−42 (−128, +44)
Unknown	77	1.1	3226 (485)	118	4.2	3170 (451)	−55 (−190, +79)
No. of prenatal care visits							
0	488	7.3	3053 (620)	75	2.6	2834 (796)	−219 (−376, −61)
1–3	882	13.1	3130 (572)	159	5.6	2844 (645)	−286 (−385, −187)
4–6	1411	21.0	3231 (535)	330	11.6	3022 (636)	−209 (−276, −142)
⩾7	3072	45.8	3307 (493)	2026	71.5	3156 (515)	−151 (−179, −123)
Unknown	858	12.8	3195 (588)	248	8.7	3137 (513)	−58 (−139, +23)
Type of hospital							
Public teaching hospital	1051	15.7	3141 (584)	585	20.6	2966 (680)	−175 (−237, −112)
Private hospitals attending predominantly public insurance	5392	80.2	3247 (532)	1230	43.3	3171 (501)	−76 (−108, −43)
Private hospitals attending predominantly private insurance	266	4.0	3372 (501)	1023	36.1	3127 (520)	−245 (−315, −176)
Unknown	2	0.1					
Mode of delivery							
Vaginal	4678	69.7	3197 (544)	1393	49.1	3097 (542)	−101 (−133, −68)
Cesarean	2033	30.3	3322 (525)	1445	50.9	3129 (566)	−194 (−230, −157)
Maternal smoking (cigs/day)							
0	4615	68.8	3301 (510)	2157	76.0	3161 (534)	−140 (−167, −114)
1–10	1081	16.1	3128 (532)	294	10.4	2943 (576)	−185 (−255, −115)
11–20	653	9.7	3109 (522)	166	5.8	2848 (675)	−262 (−356, −167)
>20	81	1.2	3046 (580)	20	0.7	2839 (596)	−207 (−496, +82)
Unknown	281	4.2	2907 (797)	201	7.1	3089 (504)	182 (57, 307)
Small for gestational age							
No	4403	65.6	3350 (482)	1937	68.2	3213 (505)	−136 (−163, −111)
Yes	617	9.2	2558 (338)	306	10.8	2506 (377)	−52 (−100, −4)
Unknown	1691	25.2	3183 (558)	595	21.0	3098 (585)	−85 (−137, −32)
Gestational age							
Very preterm	76	1.1	1649 (625)	52	1.8	1548 (608)	−101 (−321, +120)
Moderately preterm	302	4.5	2779 (541)	251	8.8	2730 (523)	−49 (−138, +40)
Term	4642	69.2	3310 (473)	1940	68.4	3209 (454)	−101 (−126, −76)
Unknown	1691	25.2	3183 (558)	595	21.0	3098 (585)	−85 (−137, −32)
All	6711	100.0	3235 (541)	2838	100.0	3113 (554)	−122 (−146, −98)

[a] Standard deviation.

Table 2 Adjusted analysis of factors associated with birthweight, combined model (n = 9549), Ribeirão Preto, São Paulo, Brazil, 1978/79 and 1994

Variables[a]	Coefficient (95% CI)	*P*-value
Newborn gender		<0.001
Female	Ref.	
Male	116.47 (95.46, 137.48)	
Parity		<0.001
2–4	Ref.	
1	−46.26 (−70.90, −21.61)	
⩾5	38.47 (−2.09, 79.03)	
Maternal age (years)		<0.001
20–34	Ref.	
<18	−120.94 (−169.89, −71.99)	
18–19	−23.51 (−61.63, 14.60)	
⩾35	−71.69 (−112.22, −31.15)	
Marital status		<0.001
Married	Ref.	
Cohabiting	−32.94 (−67.30, 1.41)	
Non-cohabiting	−62.50 (−103.54, −21.45)	
Maternal smoking (cigs/day)		< 0.001
0	Ref.	
1–10	−148.86 (−179.75, −117.97)	
11–20	−185.34 (−223.82, −146.87)	
>20	−237.59 (−340.88, −134.31)	
Prenatal care		<0.001
0	Ref.	
1–3	2.42 (−31.77, 76.61)	
4–6	107.75 (56.66, 158.84)	
⩾7	166.44 (117.46, 215.42)	
Type of hospital		<0.001
Public teaching hospital	Ref.	
Private hospitals attending predominantly public insurance	86.23 (56.41, 116.04)	
Private hospitals attending predominantly private insurance	45.94 (−1.09, 92.98)	

[a] The categories representing missing values were not displayed on this Table. Two significant interactions between year and maternal schooling ($P = 0.002$) and year and mode of delivery ($P < 0.001$) have not been included.

occupations that attract higher income, more years of schooling, and more had private health insurance in comparison to those in the 1978/1979 cohort. In the 1994 birth cohort there were more women in gainful employment than in 1978/1979. The most surprising aspect of the downward trend in mean birthweight was the sheer magnitude of the preterm rate increase, from 7.6% to 13.6%.[20] Low birthweight rate increased from 7.2% to 10.6%[16] and SGA birth rate, from 11.1% to 12.8%. In spite of these worrying trends, the infant mortality rate dropped from 36 per 1000 to 17 per 1000 over the 15 years.[21]

Although the majority of the reports indicate that mean birthweight has increased,[2–8,22] a fall in mean birthweight has been reported in the Czech Republic, Samoa, and USA.[12,23,24] Preterm birth rates are increasing in many settings.[14,24–27] As there is a great diversity in the economic development of the countries in which a downward trend of mean birthweight or preterm rates have been reported, we suspect that economic background alone would not provide a full explanation for the increasing low birthweight and preterm rates.

Most individual factors in the main analysis explained only between 0 and 16 g of the 122 g mean birthweight difference between the 1978/1979 and the 1994 surveys. Marital status, antenatal care, and preterm trait were the only three factors explaining a greater percentage of the difference in mean birthweight. The decreasing trend in the mean birthweight was partially attributable to a rise in the preterm birth rate.[21] Several reports have shown that increasing obstetric interventions may explain the rising preterm births and/or low birthweight rates.[14,22,27–31] Even a mild decrease in the length of pregnancy is associated with increased neonatal morbidity[32]

Table 3 Factors associated with trends in birthweight, combined model (n = 9549), Ribeirão Preto, São Paulo, Brazil, 1978/79 and 1994

Variables[a]	Coefficient (95% CI)
Year effect	−122 (−146, −98)
Factors with no role	
Year plus newborn gender	−122 (−145, −98)
Year plus parity	−124 (−148, −100)
Year plus type of hospital	−122 (−148, −95)
Year plus newborn gender, parity and type of hospital	−123 (−150, −97)
Factors that could have increased mean birthweight	
Year plus antenatal care	−162 (−186, −138)
Year plus maternal smoking	−135 (−159, −111)
Year plus smoking and antenatal care	−165 (−190, −141)
Factors that decreased mean birthweight	
Year plus maternal age	−115 (−139, −92)
Year plus marital status	−91 (−116, −67)
Year plus preterm birth	−94 (−116, −72)
Year plus SGA[b] birth	−117 (−138, −95)
Year plus maternal age, marital status, preterm and SGA birth	−68 (−88, −48)
Year plus all factors without preterm and SGA birth	−126 (−154, −98)
Year plus all factors including preterm and SGA birth	−74 (−97, −50)

[a] Due to significant interactions with year, mode of delivery and maternal schooling have not been included in this analysis.

[b] Small for gestational age.

Table 4 Factors associated with trends in birthweight, combined models stratified separately by mode of delivery and maternal schooling. Ribeirão Preto, São Paulo, Brazil, 1978/1979 and 1994

Variables	Coefficient (95% CI)
Models stratified by mode of delivery	
Vaginal (n = 6071)	
Year effect	−101 (−133, −68)
Plus all factors without PTB[a] and SGA[b]	−78 (−114, −42)
Plus all factors	−47 (−77, −18)
Caesarean (n = 3478)	
Year effect	−194 (−230, −157)
Plus all factors without PTB[a] and SGA[b]	−218 (−264, −171)
Plus all factors	−127 (−165, −89)
Models stratified by maternal schooling (years)	
0–8 (n = 6659)	
Year effect	−122 (−153, −92)
Plus all factors without PTB[a] and SGA[b]	−112 (−147, −78)
Plus all factors	−64 (−93, −36)
⩾9 years (n = 2496)	
Year effect	−202 (−243, −160)
Plus all factors without PTB[a] and SGA[b]	−216 (−272, −159)
Plus all factors	−129 (−174, −85)

[a] Preterm birth.

[b] Small for gestational age.

and infant mortality.[33] The decrease in the difference in birthweight after adjustment for preterm level was similarly important in the total analysis and the stratified analysis. There was very little evidence that the preterm factor in respect to birthweight difference was more important in those delivered by caesarean section than in the rest.

Marital status was a strong factor in explaining a lower mean birthweight. A possible explanation for this finding is that cohabiting and one-parent families may represent, in Brazil, a more dysfunctional family and proportionally these two groups have greatly increased over the period. Another possibility is that it represents a poorer social group and this mechanism may explain its relevance in terms of birthweight difference. This interpretation of our results is less satisfactory because the decrease in mean birthweight was more marked in mothers with higher education.

In this study the increase in antenatal visits over time helped to prevent a more marked decrease in birthweight over the study period. The number of appropriate unplanned antenatal visits is unclear in the literature. There are those who believe that prenatal care may prevent preterm births.[34] However, a Cochrane systematic review concluded that the pattern of routine antenatal care might not be associated to any adverse outcome at delivery.[35]

There were two significant interactions in our analysis, maternal education and year of survey on mean birthweight difference, and mode of delivery and year of survey on mean birthweight difference. In these two interactions the differences were greater in those who were delivered by caesarean section and those with greater education. Differing declining trends in mean birthweight between high and low schooling mothers may reflect inequitable diffusion of medical technology in Ribeirão Preto.[21] Highly educated women are more likely to have access to medical care and have increasing medical interventions. They are also more likely to use infertility treatments.[29,36] It is probable that the greater decrease in birthweight over the period, experienced by those with higher education and caesarean delivery, may indicate that higher standard of living and easy access to medical services may have contributed to the decrease in birthweight. Caesarean section in Brazil is infrequently related to medical need and is mainly carried out for the convenience of the patient or the obstetrician.[37]

Even after accounting for all the studied factors approximately 50% of the birthweight difference was not explained. If we eliminate the preterm variable most of the birthweight differences were unexplained. Thus we have to speculate as to possible factors not included in our analysis for this decrease. A possible candidate in the search for an explanation is that a decrease in stillbirth rates associated with increasing obstetric interventions may have resulted in higher survival.[29,31] The stillbirth rate, defined as any fetus delivered from the 28 weeks of gestation that does not show any sign of life, in Ribeirão Preto decreased from 22.0% per 1000 in 1978/1979 to 9.6 per 1000 from 1978/1979 to 1994. Very small infants, who earlier would not have been considered viable, may now be reported as live births, producing a shift in classification from non-registrable miscarriages to registered births.[24,38] Changes in viability and the decrease in stillbirths would have had a marginal to moderate effect on the decrease of birthweight.

Increases in alcohol or illicit drug use may also have played a part. Daily illicit drug use (solvents, marihuana, cocaine, hallucinogens, and opiates) among under 20 year olds was 2.7% (1.9% solvents) in 1990.[39] Illicit drug use was more frequent among wealthier teenagers[40] who are less likely to become pregnant. We suspect that there has been an increase in substance abuse, but we do not have objective measures for assessing this trend.

Multiple births were excluded from our analysis and *in vitro* fertilizations were too few in the period (6) to have any impact on our results. Increasing use of ovulation inducing drugs[41,42] could also further explain part of the decrease in mean birthweight but data are unavailable.

An issue to consider is whether the results in Ribeirão Preto are relevant to Brazil. In Pelotas, the southernmost part of Brazil, a mean birthweight decrease of 33 g over a period of 11 years was shown.[43,44] In São Paulo there was no evidence of change in mean birthweight between 1993 and 1998.[36] Differing timing and patterns of diffusion of new perinatal technologies may explain differences in birthweight trends across geographical areas in the country. The results in Ribeirão Preto are important because this part of the country is the wealthiest and may have initiated a trend that will be replicated elsewhere.

We could not explore factors such as induction of labour caused by fetal distress, maternal stress, or urogenital infection. With the exception of induced labour these factors are more common in socially disadvantaged groups and could not have explained the steeper decrease in mean birthweight in the better educated mothers.

In conclusion we have only partially explained the reasons for the downward trend in birthweight. Marital status, antenatal care, and preterm delivery were the only factors having an impact in reducing the birthweight decrease. The effect of marital status may represent an unfavourable environment for the fetal growth. The preterm increase might be reflecting advances in medical technology rather than changes in socioeconomic or biological factors.[22,26] This may be compatible with the high economic development of Ribeirão Preto within Brazil.

Acknowledgements

We wish to express our thanks to CNPq (Brazilian Research Council) and FAPESP (São Paulo Research Council – grant 93/0525–0).

KEY MESSAGES

- Birthweight has increased over time in many countries, but not all.
- In the wealthiest city of Brazil a marked decrease in mean birthweight of 122 g occurred over a 15-year period.
- We attempted to explain this marked decrease in birthweight based on two surveys using the same method and a large array of independent variables.
- We explained only 40% of the decrease in birthweight and part of it, unsurprisingly, was due to increases in preterm rates. A more marked decrease was prevented by routine antenatal care, but we do not know what possible features of these clinics were effective.
- Only marital status explained a meaningful percentage of the decrease in birthweight and we speculate that it may be due to factors associated with unfavourable lifestyle.

References

1 Paneth NS. The problem of low birthweight. *Future Children* 1995;**5:**19–34.

2 David RJ, Siegel E. Decline in neonatal mortality, 1968 to 1977: better babies or better care? *Pediatrics* 1983;**71:**531–40.

3 Alberman E. Are our babies becoming bigger? *J R Soc Med* 1991;**84:**257–60.

4 Chike-Obi U, David RJ, Coutinho R, Wu SY. Birth weight has increased over a generation. *Am J Epidemiol* 1996;**144:**563–69.

5 Vagerö D, Koupilová I, Leon DA, Lithell UB. Social determinants of birthweight, ponderal index and gestational age in Sweden in the 1920s and the 1980s. *Acta Pædiatr* 1999;**88:** 445–53.

6 Kramer MS, Morin I, Yang H *et al*. Why are babies getting bigger? Temporal trends in fetal growth and its determinants. *J Pediatr* 2002;**141:**538–42.

7 Bonellie SR, Raab GM. Why are babies getting heavier? Comparison of Scottish births from 1980 to 1992. *BMJ* 1997;**315:**1205.

8 Ananth C, Wen SW. Trends in fetal growth among singleton gestations in the United States and Canada, 1985 through 1998. *Semin Perinatol* 2002;**26:**260–67.

9 Ericson A, Eriksson M, Källén B, Zetterstrom R. Secular trends in the effect of socio-economic factors on birth weight and infant survival in Sweden. *Scand J Soc Med* 1993;**21:**10–16.

10 Racine AD, Joyce TJ, Li W, Chiasson MA. Recent declines in New York City infant mortality rates. *Pediatrics* 1998;**101(4 Pt 1):**682–88.

11 Koupilová I, Bobák M, Holcik J, Pikhart H, Leon DA. Increasing social variation in birth outcomes in the Czech Republic after 1989. *Am J Public Health* 1998;**88:**1343–47.

12 Koupilová I, Vagero D, Leon DA *et al*. Social variation in size at birth and preterm delivery in the Czech Republic and Sweden, 1989–91. *Paediatr Perinat Epidemiol* 1998;**12:**7–24.

13 Margetts BM, Mohd Yusof S, Al Dallal Z, Jackson AA. Persistence of lower birth weight in second generation South Asian babies born in the United Kingdom. *J Epidemiol Community Health* 2002;**56:**684–87.

14 Kramer MS, Platt R, Yang H *et al*. Secular trends in preterm birth: a hospital-based cohort study. *JAMA* 1998;**21:**1849–54.

15 Bettiol H, Barbieri MA, Gomes UA, Andrea M, Goldani MZ, Ribeiro ERO. Saúde perinatal: metodologia e características da população estudada. *Rev Saúde Públ* 1998;**32:**18–28.

16 Silva AAM, Barbieri MA, Gomes UA, Bettiol H. Trends of low birth weight: a comparison of two birth cohorts separated by a 15 year interval in Ribeirão Preto, Brazil. *Bull World Health Organ* 1998;**76:**73–84.

17 Altman DG, Coles EG. Nomograms for precise determination of birthweight for dates. *Br J Obstet Gynecol* 1980;**87:**81–86.

18 Williams RL, Creasy RK, Cunningham GC, Hawes WE, Norris FD, Tashiro M. Fetal growth and perinatal viability in California. *Obstet Gynecol* 1982;**59:**624–32.

19 Wilcox AJ. On the importance—and the unimportance—of birthweight. *Int J Epidemiol* 2001;**30:**1233–41.

20 Bettiol H, Rona RJ, Chinn S, Goldani MZ, Barbieri MA. Factors associated with preterm births in Southeast Brazil: a comparison of two births cohorts born 15 years apart. *Paediatr Perinat Epidemiol* 2000;**14:**30–38.

21 Goldani MZ, Bettiol H, Barbieri MA, Tomkins A. Maternal age, social changes, and pregnancy outcome in Ribeirão Preto, southeast Brazil, in 1978/79 and 1994. *Cad Saúde Públ* 2000;**16:**1041–47.

22 Daltveit AK, Vollset SE, Skjærven R, Irgens LM. Impact of multiple births and elective deliveries on the trends in low birth weight in Norway, 1967–1995. *Am J Epidemiol* 1999;**149:**1128–33.

23 Baruffi G, Kieffer EC, Alexander GR, Mor JM. Changing pregnancy outcomes of Samoan women in Hawaii. *Paediatr Perinat Epidemiol* 1999;**13:**254–68.

24 Branum AM, Schoendorf KC. Changing patterns of low birthweight and preterm birth in the United States, 1981–98. *Paediatr Perinat Epidemiol* 2002;**16:**8–15.

25 Demissie K, Rhoads GG, Ananth CV *et al*. Trends in preterm birth and neonatal mortality among blacks and whites in the United States from 1989 to 1997. *Am J Epidemiol* 2001;**154:**307–15.

26 Joseph KS, Demissie K, Kramer MS. Obstetric intervention, stillbirth, and preterm birth. *Semin Perinatol* 2002;**26:**250–59.

27 Joseph KS, Kramer MS, Marcoux S *et al*. Determinants of preterm birth rates in Canada from 1981 through 1983 and from 1992 through 1994. *New Engl J Med* 1998;**339:**1434–39.

28 Slattery MM, Morrison JJ. Preterm delivery. *Lancet* 2002;**360:** 1489–97.

29 Joseph KS, Kramer MS. Recent versus historical trends in preterm birth in Canada. *CMAJ* 1999;**61:**1409.

30 Silva AAM, Lamy-Filho F, Alves MTSSB, Bettiol H, Barbieri MA. Risk factors for low birthweight in north-east Brazil: the role of caesarean section. *Paediatr Perinat Epidemiol* 2001;**15:**257–64.

31 Skjærven R, Gjessing HK, Bakketeig LS. Birthweight by gestational age in Norway. *Acta Obstet Gynecol* Scand 2000;**9:**440–49.

32 Seubert DE, Stetzer BP, Wolfe HM, Treadwell MC. Delivery of the marginally preterm infant: what are the minor morbidities? *Am J Obstet Gynecol* 1999;**181:**1087–91.

33 Kramer MS, Demissie K, Yang H, Platt RW, Sauve R, Liston R. The contribution of mild and moderate preterm birth to infant mortality. *JAMA* 2000;**284:**843–49.

34 Monteiro CA, Benicio MHD'A, Ortiz LP. Tendência secular do peso ao nascer na cidade de São Paulo (1976–1998). *Rev Saúde Públ* 2000;**34(Suppl.):**26–40.

35 Vintzileos AM, Ananth CV, Smulian JC, Scorza WE, Knuppel RA. The impact of prenatal care in the United States on preterm birth in presence and absence of antenatal high-risk conditions. *Am J Obstet Gynecol* 2002;**187:**1254–57.

36 Villar J, Carroli G, Khan-Neelofur D, Piaggio G, Gulmezoglu M. Patterns of routine antenatal care for low-risk pregnancy. *Cochrane Database Syst Rev* 2000;**4:**CD000934.

37 Gomes UA, Silva AAM, Bettiol H, Barbieri MA. Risk factors for the increasing caesarean section rate in the Southeast Brazil: a comparison of two birth cohorts, 1978–79 and 1994. *Int J Epidemiol* 1999;**28:**687–94.

38 Power C. National trends in birth weight: implications for future adult disease. *BMJ* 1994;**308:**1270–71.

39 Muza GM, Bettiol H, Muccillo G, Barbieri MA. Consumo de substâncias psicoativas por adolescentes escolares de Ribeirão Preto, SP (Brasil). I—Prevalência do consumo por sexo, idade e tipo de substância. *Rev Saúde Públ* 1997;**31:**21–29.

40 Muza GM, Bettiol H, Muccillo G, Barbieri MA. Consumo de substâncias psicoativas por adolescentes escolares de Ribeirão Preto, SP (Brasil). II—Distribuição do consumo por classes sociais. *Rev Saúde Públ* 1997;**31:**163–70.

41 Perri T, Chen R, Yoeli R *et al*. Are singleton assisted reproductive technology pregnancies at risk of prematurity? *J Assist Reprod Genet* 2001;**8:**245–49.

42 Tanbo T, Dale PO, Lunde O, Moe N, Abyholm T. Obstetric outcome in singleton pregnancies after assisted reproduction. *Obstet Gynecol* 1995;**86:**188–92.

43 Victora CG, Barros FC, Vaughan JP, Teixeira AM. Birthweight and infant mortality: a longitudinal study of 5914 Brazilian children. *Int J Epidemiol* 1987;**16:**239–45.

44 Victora CG, Barros FC, Halpern R *et al*. Estudo longitudinal da população materno-infantil da região urbana do Sul do Brasil, 1993: aspectos metodológicos e resultados preliminaries. *Rev Saúde Públ* 1996;**30:**34–45.