A feeling of well-being accompanied by a period of prosperity and birthweight in Chile: a possible link?

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Summary

The aims of the study were to describe the trend in birthweight from 1985 to 2000 in Chile and ascertain the possible factors that may explain the changes in birthweight during the period. We used time series of birthweight and length at birth of all live births ($n > 4\,000\,000$). Multivariable regression analyses were carried out to assess whether the gender of the newborn, maternal education, maternal age and marital status could explain the trend in the total time series and by period. Birthweight adjusted for gestational age was analysed in terms of grams and Z scores. There was an increase in birthweight of 100 g between 1989 and 1994 that coincided with the re-establishment of democracy and economic growth in Chile. The changes in birthweight were not explained by the available independent variables and trends of caesarean section, maternal obesity and post-mature deliveries over the period. The birthweight difference between mothers with university education and those with primary education was 0.2 Z scores (equivalent to 110 g) in 1985 and was greatly reduced by 2000 (equivalent to 40 g). A positive sense of social well-being and economic growth may have influenced an increase in birthweight between 1989 and 1994 as socio-economic growth preceded and continued after the period of increasing birthweight. Our study showed a remarkable decrease in the differences in birthweight by educational level not shown in other countries of similar wealth.

Introduction

An unprecedented sense of elation seized Chile between October 1988 and March 1990. In a plebiscite implemented by the government of General Pinochet, the majority voted against the *status quo* and 18 months later Patricio Aylwin took office as a democratically elected president. In an assessment of the birthweight trend over the 15 years from 1985 without an a priori hypothesis we found a marked increase in birthweight over the 5-year period from 1989. This period also coincided with an improvement in the standard of living as the Chilean Gross National Product increased at a rate of approximately 5.7% a year from 1986 to 1998, and started to slow down from 1998 onwards.[1] This increase was mirrored by a marked drop in the percentage of poverty from 40% to 17% by 1998.[1] Thus, over this period Chileans enjoyed a period of increasing prosperity accompanied by a sense of optimism that permeated most social layers of society, but the distribution of wealth remained unchanged.

There is a large body of research on the association between maternal stress and birth outcome;[2–4] many of these studies have shown negative findings, and in those that have shown an association the effect has been small.[5,6] Interventions designed to increase social support with the aim of reducing maternal distress have not shown effectiveness of the intervention.[7,8] As poverty may be an important factor related to maternal stress it is unsurprising that these intervention programmes were unsuccessful, as they may not have tackled one of the most important contributors accompanying psychological distress.[9]

There is less information on the possible effects of social health on birthweight. Positive social health can be perceived in terms of the degree to which people function adequately as members of a community.[10]

More recently this concept has been further elaborated within the framework of social capital.[11] A small study suggested that self-esteem and optimism were positively related to birthweight in a group of Hispanic and white women.[12] Social support at neighbourhood level influenced birthweight in a white sample, but not the African-American sample in a multilevel analysis.[13] We could not find in medical databases, studies assessing the effect on birthweight of change in type of government.

Our analysis is based on all births in Chile between 1985 and 2000. The aim was to assess the trend in birthweight and the possible factors that could have explained the shape of the curve over time. We did not have an a priori hypothesis; we observed the trends of birthweight in Chile and tried to find a *post hoc* explanation for this trend.

Methods

The Chilean National Institute of Statistics and Civil Registry gather information on births based on the birth certificates and information given by the person registering a newborn. Information is collected on weight and length at birth, gestational length of pregnancy, educational level of the mother and maternal parity. Our data set included only live births. The accuracy of stillbirths registration in Chile is uncertain; however, live births registration levels are excellent. There is a delay in the registration of births of approximately 5%. We do not know whether there have been differences in the registration of stillbirths and live births over time and thus we assessed the trend in the registration of live births of <28 weeks of gestation for clues. Trends of fertility rates in the 15- to 44-year-olds and caesarean sections over time were obtained, except for the years 1995, 1996 and 1998. Information on caesarean sections was provided separately from another data file. Thus, it could not be included in the overall analysis.

Weight and length at birth are measured by trained midwifes who have followed norms published by the Ministry of Health (1973).[14] The norms describe the equipment and advise staff to adjust for the weight of any garment put on the scales to protect the baby. The measurement techniques are illustrated, and summarily explained. We included length as supplementary information in our results to assess the accuracy of birthweight as the Pearson's correlation between these two anthropometric measurements is approximately 0.8. Gestational age is estimated from the first day of last normal menstruation period (LNMP) and ultrasound. Ultrasound for dating length of pregnancy was introduced in the late 1970s and its use has increased over the period. It is unknown which of the two methods used to estimate length of pregnancy prevailed when both were available. Relative to LNMP ultrasound underestimates length of pregnancy.[15] An increase in the use of ultrasound dating must have occurred between 1985 and 2000. Thus, trends in length of pregnancy of ≥41 and <28 weeks were used as a proxy measure to assess the possible contribution of change of method to assess length of gestation and changing patterns of induction of labour in Chile. Information on infant mortality was obtained from routinely published statistics and it is used in this report purely as a check of consistency in relation to anthropometric measurements at birth.[16]

We used maternal education at delivery of the baby as a proxy measure of socio-economic level divided into the groups: <9 years of full-time education (primary education), 9–12 years (secondary education) and >12 years of education (university education). We could not find the use of any measures on perception of well-being in the Chilean population during the period 1985–2000.

In some of the analysis birthweight was divided into four groups: <1500 g (VLBW), 1500–2499 g (LBW), 2500–2999 g and ≥3000 g. We also estimated Z scores as birthweight for gestational age for each birth using external data from a Canadian study of newborns.[17] Birthweight in Z scores was analysed by length of gestation divided into the groups: <33 weeks, 34–36 weeks and ≥37 weeks.

Two multivariable regression analyses were performed. In one analysis the dependent variable was birthweight assessed in grams and in the other, birthweight was expressed in Z scores adjusted for gestational age. The independent variables were: firstly, gender of the baby, maternal parity, and maternal age; secondly, maternal education (four levels) was added; finally, marital status was added. We used six levels of maternal parity as the relation between birth order and birthweight is not linear, the first livebirth is on average 100 g less than subsequent births and birthweight increases slightly from the second birth onwards. We also carried out the same multivariable regression analysis by period: 1985–89, 1990–94 and 1995–2000 using three linear splines[18] to adjust for all the dependent variables defined for the above periods.

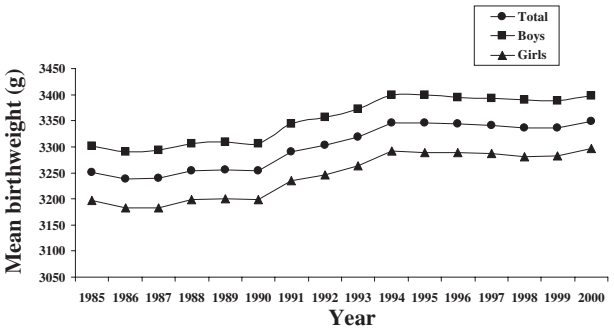

Figure 1. Birthweight by gender from 1985 to 2000 in Chile.

The first variable for the whole period took the value of 1 for the first year and in increments of 1 the following years until reaching the value of 16 for the last year. The second variable for the period 1990 onwards was zero for the first 5 years, 1 in the sixth year and, in increments of 1 a year, reaching a value of 11 for the last year. The third variable was zero for the first two periods, 1 for the eleventh year and, in increments of 1, 6 in the last year. The slope of the first 5 years corresponded to β of the first variable. The slopes of the second and third periods corresponded to the algebraic sum of the β of the first and second variables and the three variables respectively. In this analysis birthweight was expressed in Z scores of birthweight for gestational age. Although Table 1 provides the rate of multiple births, all the analyses were carried out in singletons.

Results

The annual number of births over the period was similar, but there was a small increase of births from 1985 to 1991 followed by a gentle decrease to pre-1988 levels (Table 1); the fertility rate in women in the age range 15 to 45-year-olds increased in up to 90 per 1000 in 1990 and decreased thereafter in a monotonic fashion to 70 per 1000 by the year 2000 (data not shown). The male/female ratio did not change systematically over the period. The percentage of births by gestational length decreased slightly in the groups 34–36 weeks and <34 weeks, reaching its nadir in the period 1993–94 and slightly increasing thereafter. In the group of ≥37 weeks, there was a slight increase until 1994 and a slight decrease thereafter. The percentage of multiple births and the age of the mother at delivery increased slightly, reflecting an increase in those aged 35 years or over from 9.5% in 1985 to 14.8% (not shown). Maternal education increased over the period so that by 2000 three-quarters of the mothers had reached at least secondary education whereas only slightly more than 50% reached that level in 1985. The percentage of single mothers increased markedly during the period. Parity defined as the number of previous viable pregnancies remained unchanged, except that the percentage of parity 5 or over decreased from 3.4% to 1.4% (not shown).

Figures 1 and 2 show the mean birthweight and length by gender over the period 1985–2000. There was a small increase in birthweight, approximately 20 g, between 1987 and 1989 in both sexes followed by a substantial increase, approximately 100 g, from 1989 to 1994. Mean birthweight plateaus from 1994 onwards with a small decrease in birthweight in 1995. Length at birth also increased from 1990 to 1994, followed thereafter by a moderate decrease between 1994 and 1997 and stabilisation. Adjustment for gender, maternal age, parity, education and marital status did not change the time trends with birthweight. Using three linear splines in terms of Z scores adjusted for gestational age, we found that the annual increment for the period 1990–94 was substantially greater than for the periods 1985–89 and 1995–2000 (Table 2). The slopes of annual increment for each period were hardly modified with adjustment for gender, maternal parity, educational level and marital status. We repeated the analysis using birthweight in grams. The annual increase in birthweight after adjustment was 3.3 g, 17.5 g and 1.8 g for the periods 1985–89, 1990–94 and 1995–2000, respectively.

Figure 3 shows the trends by birthweight categories. The percentage of those ≥3000 g increased from approximately 73–75% for the period 1985–89 to approximately 80% by 1994 and varying slightly for the period 1994–2000. The percentage of births with a weight between 2500 and 2999 g and of those between 1500 and 2499 g decreased between 1989 and 1994, but

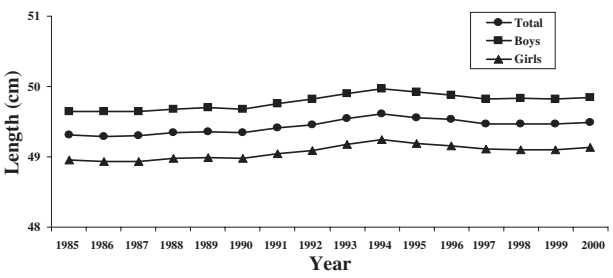

Figure 2. Length at birth by gender from 1985 to 2000 in Chile.

Table 1. Maternal and newborns socio-demographic characteristics from 1985 to 2000 in Chile

Year	Total births	Mother's age median (IQR) (years)	Male/female ×100	Multiple births %	Length of gestation weeks			Maternal education (%)					Single mothers %	First births %
					≤33	34–36	≥37	Univ.	Sec.	Prim.	None	N/K		
1985	248 879	25 (21–30)	103.8	1.5	1.3	4.4	94.3	7.8	46.4	43.3	1.7	0.7	31.8	40.0
1986	259 347	25 (21–30)	104.4	1.5	1.3	5.1	93.6	7.8	48.2	41.7	1.6	0.6	32.1	41.0
1987	265 774	25 (21–30)	105.2	1.6	1.3	5.0	93.7	8.4	50.3	39.3	1.4	0.6	32.8	41.2
1988	281 752	25 (21–30)	104.8	1.6	1.3	5.0	93.7	8.6	51.6	38.1	1.2	0.6	33.5	41.3
1989	288 608	25 (21–30)	105.1	1.6	1.2	5.1	93.6	9.1	52.8	36.6	1.1	0.5	33.6	41.2
1990	292 145	26 (22–30)	105.5	1.6	1.2	4.4	94.4	9.5	53.7	35.4	0.9	0.5	34.3	40.7
1991	284 483	26 (22–30)	104.9	1.6	1.2	4.4	94.5	9.9	54.5	34.2	0.9	0.4	35.4	39.9
1992	279 098	26 (22–31)	104.7	1.6	1.2	4.6	94.3	10.4	54.9	33.3	0.8	0.4	36.8	39.6
1993	275 916	26 (22–31)	105.0	1.6	1.1	4.1	94.8	11.2	55.4	32.3	0.7	0.4	38.1	40.0
1994	273 766	26 (22–31)	104.3	1.6	1.1	3.9	95.0	11.7	56.0	31.3	0.6	0.4	39.1	40.6
1995	265 932	26 (21–31)	104.6	1.7	1.1	4.1	94.8	12.3	56.6	30.2	0.5	0.4	40.5	41.1
1996	264 793	26 (21–31)	105.1	1.6	1.2	4.2	94.6	13.3	56.8	29.0	0.5	0.4	41.9	41.6
1997	259 959	26 (22–31)	105.4	1.7	1.1	4.2	94.7	14.3	56.5	28.4	0.5	0.3	43.6	41.8
1998	257 105	26 (22–31)	104.3	1.7	1.2	4.5	94.3	14.5	57.2	27.6	0.3	0.4	45.8	41.7
1999	250 674	26 (22–32)	104.8	1.7	1.3	4.6	94.1	15.1	57.7	26.5	0.4	0.3	47.1	41.5
2000	248 893	26 (22–32)	105.5	1.7	1.2	4.7	94.0	15.7	58.9	25.0	0.3	0.1	48.9	41.5

IQR, interquartile range; Univ., university education; Sec., secondary education; Prim., primary education; None, no formal education; N/K, not known.

Table 2. Annual increment in birthweight Z scores by period unadjusted and after adjustment for gender, parity, maternal age at delivery, maternal educational level and marital status

Period	Unadjusted model Mean [95%CI]	Adjusted model Mean [95%CI]
1985–89	0.014 [0.013, 0.015]	0.013 [0.012, 0.014]
1990–94	0.034 [0.032, 0.036]	0.033 [0.031, 0.035]
1995–2000	0.010 [0.008, 0.012]	0.012 [0.010, 0.015]

the percentages of those with a birthweight below 1500 g remained the same over the period.

A marked change has occurred in the stratification of birthweight using Z scores adjusted for gestational age and parity by maternal education (Fig. 4). In 1985 there was a Z score difference of 0.2, equivalent to 110 g, between babies born to mothers with university education and those with only primary education. Those with a secondary education had babies of intermediate birthweight in 1985. By 1994 those with a secondary education had caught up those with university degrees. By 2000 a small difference (0.07 Z scores equivalent to 40 g) in birthweight persisted between those with primary education and the other two groups. We repeated the analysis in those below 2500 g and found that a small difference between education groups remained between the three groups by 2000.

Figure 5 shows the birthweight for length of gestation in term of Z scores for the period. Weight of full-term newborns increased over the period by 0.31 units, the birthweight of those with a length of gestation between 34 and 36 weeks increased slightly up to 1995, and those <34 weeks decreased markedly from 1995. Those with length of gestation <34 weeks were heavier than equivalent Canadian babies while babies in the other two groups were lighter than the Canadian babies.

The percentage of singletons of ≥41 weeks gestation decreased in all maternal education groups, but the decrease was proportionally greater and started earlier in the university group (Fig. 6). The percentage of deliveries below 28 weeks remained the same over the 15 years of observation, varying from 0.23% in 1992 to 0.28% in 1985. The percentage of caesarean sections increased continuously from 1990 from slightly above 30% in 1990 to 40% in 2000 (Fig. 7). Infant mortality for the period under consideration decreased approximately 30% from 1989 to 1995 and 19.8% from 1995 to 2000 (Fig. 8).

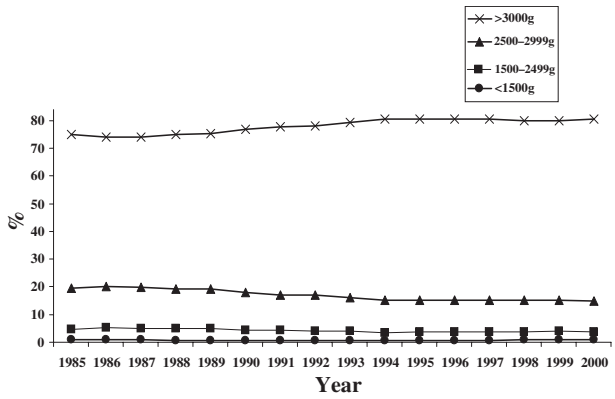

Figure 3. Percentage of newborns by birthweight group from 1985 to 2000 in Chile.

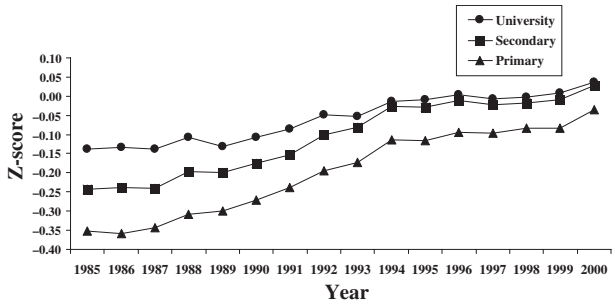

Figure 4. Birthweight Z scores adjusted for gestational age and parity by maternal educational level from 1985 to 2000 in Chile.

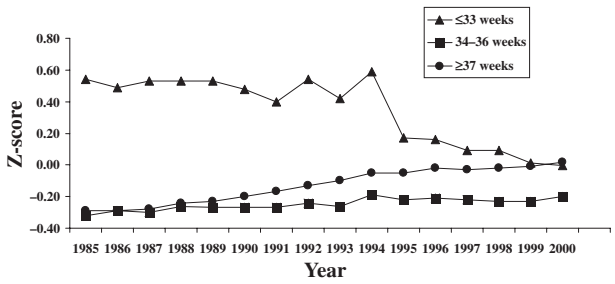

Figure 5. Birthweight Z scores by length of gestation between 1985 and 2000; based on Canadian reference value.

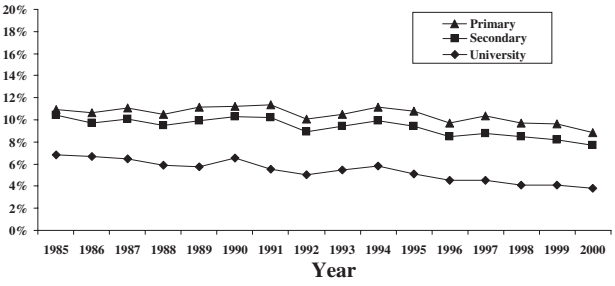

Figure 6. Trends in deliveries of pregnancies of more than 40 weeks by maternal educational level from 1985 to 2000.

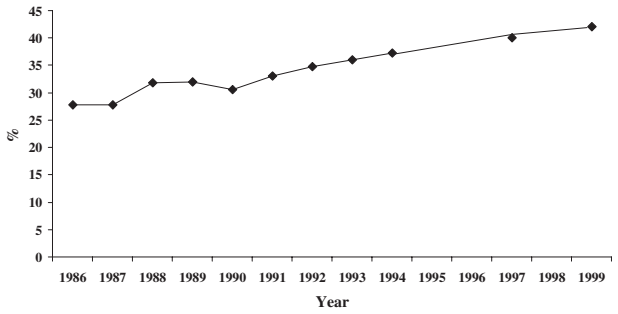

Figure 7. Trends in caesarean section rates from 1986 to 1999 in Chile (data for the years 1995, 1996 and 1998 were unavailable).

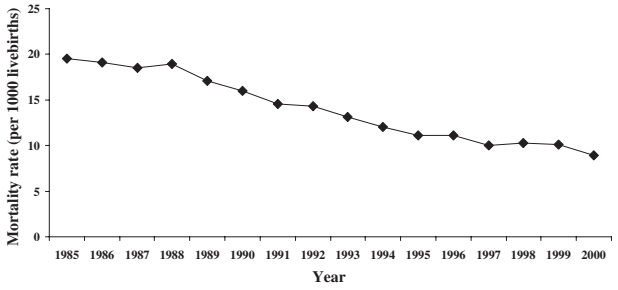

Figure 8. Trends in infant mortality from 1985 to 2000 in Chile.

Discussion

Birthweight increased markedly in the period 1989–94 in Chile. This increase was mainly the result of weight increases in full-term births. The stratification of birthweight by maternal education decreased over the 15-year period and disappeared by 2000 although a small difference by educational level still remained in those under 2500 g. This finding has so far not been reported in other countries with emerging economies,[19,20] and corresponds to some[21] but not all[13,22] highly evolved societies.

The strength of this study is that it included all registered live births. Almost all births took place in hospital, and weight and length at birth are included on the birth certificate. It is highly unlikely that our results can be explained by systematic measurement error, as the trends for weight and length at birth followed a similar pattern, although small differences between weight and length at birth were observed after 1996. The increase in weight and length at birth coincided with a marked decrease in infant mortality which was preceded and followed by short periods of a proportionally lower decrease in infant mortality. There were no changes in the measurement techniques of length and weight over the period of analysis. The norms give little information on measurement techniques, but this lack of detail may have contributed to random error only.

We included all births to avoid criticisms on data curtailment. We did not focus our analysis on preterm births because the period was transitional in the use of ultrasound technology for dating length of pregnancy and it would have been difficult to account for its influence in preterm rates in this study.[15] Thus we accept that the precision in estimating gestational age over the period may have changed with the increasing use of ultrasound as a dating method. We used information on trends of post-mature deliveries to check changes in frequency of deliveries that could have been due to technical changes in pregnancy dating. We also had measures of socio-economic status and educational level.

The main weakness of our study is that we did not have a measure of social well-being independent of socio-economic status for the period of analysis. We also did not have information on rates of induction over the period. Changes in viability based on the percentage of live births of <28 weeks of gestation remained similar over time.

Smoking, maternal age, height and pre-pregnancy weight, socio-economic level, parity, maternal blood pressure, ethnicity, multiple births are the main factors that are known to be associated with birthweight.[3] In our study, parity, maternal age at delivery, marital status and multiple births did not change the shape of the curve of birthweight over time. We could not adjust for smoking behaviour. In Chile smoking in 20- to 44-year-old females has consistently been very high, 40% and 55%.[23,24] Community studies on changes in the prevalence of smoking over time are available in schoolchildren only from 1994 to 2000 and this showed a small decrease from 46% in 1994 to 43% in 2000.[25] The recommendation to pregnant women to abstain from smoking may have become more widespread over the period, but there is no evaluation on the effectiveness of such a recommendation in Chile. Smoking cessation intervention during pregnancy has been shown to be ineffective or marginally effective in many studies[26,27] although there are some studies that have shown success.[28] Smoking prevalence is similar in all socio-economic groups in Chile.[24] In the unlikely event that unstructured advice was effective it would have had an impact mainly in the better-off social group who are more likely to respond to health edu-

cation advice, but this group had the smallest increase in birthweight.

Levels of obesity and the standard of living have increased in Chile during the period under consideration. The prevalence of obesity in pregnant women assessed before pregnancy started or early in the course of it has shown an increase from 12% in 1987, 25% in 1994 to 33% in 1999.[29] Pre-pregnancy adiposity is positively associated with birthweight so this may have influenced birthweight.[3] However, the trend in increasing obesity has not followed the trend in mean birthweight as obesity is still increasing, but mean birthweight stopped increasing in 1994. Kramer estimated[3] that an increase of 1 kg in pre-pregnancy weight could change birthweight by 9.5 g. It is difficult to imagine that the mean weight of women of reproductive age would have changed more than 2 kg from 1989 and 1994, so, at the most, it could be responsible for 20 g of the 100 g increase observed.

The decrease in poverty over the period studied provides a plausible explanation for our results, except that the increase in the standard of living started before 1989. Levels of education in Chile markedly increased over the period so that nowadays the majority of the population (59%) have access to secondary education, and 15.6% are admitted to university. In our analysis we used maternal education as proxy measure of socio-economic level as it is well known that it is strongly associated with wealth and we were certain of the accuracy of the information. Within-group variation may have hidden residual inequalities as most young mothers had secondary education in Chile. Small differences by educational level remained in the comparison restricted to those with babies <2500 g.

Social stratification in the frequency of caesarean section in Chile[30] does not explain the lack of difference in mean birthweight by educational level as we adjusted for gestational age. Without such adjustment, newborns of mothers with university education were the lightest group. A small difference between those with only primary education in comparison with the other educational groups persisted after adjusting for parity, indicating that a small difference in birthweight due to educational level still remains. Our results can be partially explained by the higher prevalence rate of obesity in poorer women. We also carried out the same analysis by borough stratified by poverty[31] and were able to confirm differences in birthweight for gestational age between boroughs classified by wealth disappeared by 1998.

For wealth alone to account for the change in birthweight in the period 1989–94 we would have to accept a lag time between the increase in the standard of living and its impact on birthweight, and that the increase of birthweight stopped well before the end of the faster economic growth period. The phenomenon was observed in our analyses in terms of birthweight and in Z scores adjusted for gestational age. Maternal weight cannot explain the increase trend because the steepest increase of maternal obesity occurred between 1995 and 1998 and has continued thereafter. If changes in smoking pattern have occurred they were very small and might have been affected by information bias, as the public is well aware of the detrimental effects of tobacco. The shift in the gestational distribution evidenced by the decrease in deliveries of >40 weeks occurred over the whole period and not only post-1995. Caesarean sections increased continuously from 1990 onwards; this should have had the same effect on birthweight over the whole period. A more marked decrease of infant mortality from 1989 to 1995 coincided with the birthweight increase.

The analysis of birthweight in terms of Z scores adjusted for gestational age based on the total sample hides differences in trends between gestational age groups. The trend in full-term babies increased over the whole period, but most markedly between 1989 and 1995. The increase was only slight in those with a gestational age between 34 and 36 weeks and did not follow a pattern by period; in those with a gestational age <33 weeks there was a sudden decrease from 1995 onwards. We do not believe that changes in fetal growth were due to changes in viability over time as the differences over the period were minimal. The increased frequency of caesarean sections affected all gestational length groups and was related mainly to changes of medical behaviour, especially in the private sector. It is possible that these changes reflect an excess proportion of full-term deliveries inappropriately classified as preterm delivery that may have decreased with the more frequent use of ultrasound in dating gestational age in the more recent period of our analysis.

We are well aware of the dangers of ecological fallacy in epidemiological studies. However, there are rare opportunities in which good-quality data on birthweight can be used to measure a unique event that permeated the greater part of society. For those who lived during the whole period from 1988 to 1994 or had the opportunity to visit Chile at the time there

was a distinct sense of optimism in which the return to democracy and an increase in economic wealth coincided. In this paper we speculate that a real increase in standard of living and a feeling of well-being in society together may have caused the sharp increase of birthweight in such a short period of time.

Unfortunately we do not have a measure of optimism in the Chilean population for the period considered in our study. If such an interpretation is appropriate, it is difficult to explain why, once the sense of optimism fizzled out by 1994, birthweight decreased very slightly and slightly more for length, but not for length adjusted for gestational age. A continuing increase in maternal adiposity during the period 1984–98 may have contributed to maintaining birthweight.[29] This type of study cannot be replicated in a randomised controlled trial as it would be almost impossible to reproduce a package of intervention mimicking the Chilean experience. We doubt that this can be achieved in a case–control or a cohort study as we cannot manipulate the events that occurred in Chile in the period described. Marmot has postulated[32] that a sense of self-esteem may have a positive effect on health. Our study indicates that self-esteem, if accompanied by an economic increase, could have an effect on birthweight. Many countries experienced a return to democracy in the last two decades, but the event was rarely accompanied by a marked economic increase. In those countries it would be important to assess whether birthweight changed similarly around the period of socio-political change.

This study showed that differences in birthweight due to socio-economic level decreased in a country with a per capita gross national product equivalent to a parity purchasing power of US$8400 per capita.[33] A strong welfare programme may have addressed in part the unequal distribution of wealth, maternal obesity is higher in poor groups of society, and some differences in birthweight due to social inequalities may remain within the large group of mothers with secondary education. Our study is thought provoking in proposing a possible link between a positive feeling of well-being and birthweight sustained by economic growth.

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