

Discordant time trends in maternal body size and offspring birthweight of term deliveries in France between 1972 and 2003: data from the French National Perinatal Surveys.

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Summary

We investigated time trends in maternal weight before and during pregnancy and in infant birthweight in France, from 1972 to 2003, in data on singleton live term births from the representative National Perinatal Surveys in 1972, 1981, 1995, 1998 and 2003 (N=8 664, 4 494, 11 445, 12 006, 12 692 respectively). Mothers were interviewed a few days after delivery and data on delivery and the newborn were extracted from hospital records. Maternal prepregnancy weight, height, body mass index and pregnancy weight gain all increased from 1972 to 2003, however birthweight did not show a parallel evolution. After taking into account gestational age, maternal age, parity, country of origin, newborn gender and maternal smoking during pregnancy, mean birthweight increased between 1972 and 1995 but decreased thereafter, and consistently, there was an increase in small for gestational age and a decrease in large for gestational age newborns. Further adjustment for induced delivery, an indicator of obstetric practices, did not change the results. A similar trend has been very recently observed in the United States and in Germany. Further research is needed to identify the factors responsible for these discordant changes and especially the factors responsible for the recent increase in SGA, a condition shown to be associated with poorer health in later life.

Keywords: Time trends, maternal body size, birthweight

Introduction

An increase in the prevalence of obesity since the 1990's has been well documented in France.^{1,2} French women of childbearing age have not been spared; Blondel et al. highlighted an increase in prepregnancy body mass index (BMI) between 1998 and 2003.³ Birthweight is strongly and positively related with maternal preconception weight,^{4,5} as well as with weight gain during pregnancy.^{6,7} Therefore, it would be expected that this increase in maternal weight before pregnancy, and weight gain during pregnancy, would be associated with an increase in birthweight at the population level.⁵ For example, in Sweden, an increasing trend in Large for Gestational Age (LGA) babies has been observed between 1992 and 2003, that was explained mainly by an increasing trend in maternal BMI.⁸ An upward trend in birthweight parallel to an increase in maternal anthropometry has been reported in several other countries,^{5,8-10} however two recent studies reported a decrease in mean birthweight: in the United States between 1990 and 2005 and in Bavaria (Germany) between 2000 and 2007.^{11,12} High prepregnancy weight and high pregnancy weight gain are also associated with several perinatal adverse outcomes such as brachial palsy, clavicle fracture, shoulder dystocia, meconium aspiration and low Apgar score.¹³ In the last decades, changes in obstetric practices have aimed to prevent these complications, among which induction of labour and caesarean section before labour.^{14,15} These changes in obstetric practices, in addition to changes in other factors such as maternal age, gestational age, parity, prepregnancy weight, maternal country of origin, and smoking status, may also have impacted on the time trend in birthweight.

The aim of this study was to investigate time trends in birthweight in relation with maternal prepregnancy anthropometry and pregnancy weight gain, in France, from 1972 to 2003, taking into account potential confounders.

Methods

We used data from the French National Perinatal Surveys in 1972, 1981, 1995, 1998, and 2003.^{3, 16, 17} For the 1972 survey, France was divided into 12 geographic areas and the survey was conducted in a different area each month. A two-stage sampling procedure was used to select births: first, a random sample of maternity units was selected, after stratification for geographic area, hospital status (private or public) and size (annual number of deliveries); second, a random sample of ¼ of births was chosen from the deliveries register of the maternity units selected. The 1981 survey differed from the 1972 survey by the sample size (a sampling fraction of 1/8). In 1995, 1998 and 2003, the study population included all births during one full week. The surveys were approved by the French “*Comité du label des enquêtes statistiques*” and the “*Commission Nationale de l’Informatique et des Libertés*” (CNIL).

The inclusion criteria in this analysis were: singleton live births at term, 37 complete weeks of amenorrhea or more. However, we also display descriptive data for preterm births as there were changes in obstetric practices and preterm management that impacted the profiles of preterm deliveries over the study years.

For all surveys, maternal characteristics (age, parity, cigarette use, height, prepregnancy weight) were obtained by interview in the postpartum period, and medical data on the pregnancy, delivery and the infant’s health were extracted from hospital records (induction of labour, caesarean section before labour, maternal weight at delivery, gestational age, birth weight and newborn gender). In France gestational age was estimated using the date of the last menstrual period from the 1970’s to the 1980’s, whereas in the following decades, the last menstrual period method was routinely combined with early ultrasound for assessment of gestational age.

The mother's prepregnancy BMI was calculated as the reported prepregnancy weight (kg) divided by reported height (m) squared. Pregnancy weight gain was calculated as weight at the end of pregnancy (extracted from hospital records) minus prepregnancy weight. Maternal country of origin was categorised in four classes (France, Other European countries, North Africa and Other Countries). Induced delivery was defined as induction of labour or caesarean section before labour, as both interventions have the same impact on the length of gestation. Cigarette smoking during the third trimester of pregnancy was categorized into three groups (no smoking, fewer than 10 cigarettes per day and 10 cigarettes or more per day). LGA and Small for Gestational Age (SGA) births were defined respectively, as birthweight over the 90th percentile and below the 10th percentile of French gestational age and gender specific reference curves.¹⁸ Post maturity was defined as a birth at the 42nd week of gestation or later.

Numbers and infant birthweight (mean \pm standard deviation) in the populations selected or not for the analysis in each survey year (1972, 1981, 1995, 1998 and 2003) are described.

Maternal age, parity, country of origin, smoking during pregnancy, type of delivery (induced or not), anthropometry (height, prepregnancy weight and BMI, weight at delivery), and infant gestational age and birthweight were described in each survey year, by means \pm standard deviations or percentages (numbers). The effect of the survey year was tested by analysis of variance for quantitative traits or by χ^2 test for percentages.

In order to evaluate the time trend in birthweight, after taking into account possible confounders, we assessed adjusted mean birthweight in each survey year, after adjustment for gestational age, maternal age, parity, country of origin, newborn gender and maternal smoking during pregnancy, in multiple linear regression analyses. We also estimated odds ratios for SGA and LGA births for each survey year, with 1995 as reference year, in logistic

regression models, where we adjusted for maternal age, parity, country of origin and maternal smoking during pregnancy.

To investigate the relation between maternal anthropometry and birthweight and their joint evolution over time, we used the standardized beta coefficients from a linear regression model predicting birthweight, (adjusted for gestational age) from each maternal anthropometric variable, survey year and the interaction between these two variables.

The percentage of induced deliveries and the mean pregnancy weight gain (adjusted for gestational age) were compared between the different categories of prepregnancy BMI (thin: BMI $\leq 18.5 \text{ kg/m}^2$, normal weight: $18.5\text{--}24.9 \text{ kg/m}^2$, overweight: $25\text{--}29.9 \text{ kg/m}^2$ and obese: 30 kg/m^2 or more) for each study year.

In order to test specifically whether the evolution in obstetric practices could have impacted on the observed trend, we further adjusted birthweight and the Odds Ratios (OR) for LGA and SGA, for weight gain in pregnancy and induced delivery.

For sensitivity analyses, we described the birthweight trend including infants without data for gestational age. We also analysed the birthweight trend after removing post-term births from analysis. Finally the trend in mean birthweight was analysed separately in strata of maternal BMI (adjusted for maternal age, country of origin, height, pregnancy weight gain, smoking status during pregnancy, induced delivery and gestational age).

Analyses used Statistical Analysis Software (SAS) version 9.

Results

Before data selection, the surveys included 10 871 singleton births in 1972, 5 395 in 1981, 12 869 in 1995, 13 076 in 1998 and 14 039 in 2003 (**Table 1**). The percentage of missing values for gestational age decreased over the study period, from 10% in 1972, 7% in 1981 to below 1% afterwards. In 1972 there were 6.8% preterm births, and this remained around 5%

between 1981 and 2003. Mean birthweight in preterm births increased from 1972 to 1981 (2 725g to 2 745g) and decreased from 1981 to 2003 (2 745g to 2 305g). After exclusion of preterm births, missing data for gestational age, maternal weight or birthweight, there were 8 684 mother-infant pairs with term births in 1972, 4 494 in 1981, 11 445 in 1995, 12 006 in 1998 and 12 692 in 2003.

Over the years, the percentage of younger mothers (< 25 years) declined from 50% in 1972 to 19% in 2003 and the percentage of older mothers (\geq 35 years) increased (**Table 2**). The proportion of mothers with parity two or more decreased slightly (25% in 1972 and 21% in 2003). There were more mothers smoking while pregnant in 1998 than in 1972 (25% vs 10%) but a slight decrease was observed in 2003 (22%). The rate of induced deliveries (inductions of labour and caesarean sections before labour) increased sharply from 12% in 1972 to 31% in 2003.

From 1972 to 2003, all maternal anthropometric characteristics (height, prepregnancy weight, prepregnancy BMI, weight at delivery and pregnancy weight gain) showed an upward trend (**Table 2**).

Infant birthweight did not increase over time. The unadjusted mean birthweight in infants born at term increased significantly between 1972 and 1981 ($p = 0.02$), then decreased significantly between 1981 and 1995 ($p = 0.04$) and remained constant thereafter. The percent of infants who were SGA decreased between 1972 and 1995 (10.6% to 7.5%), increased thereafter and reached 8.7% in 2003. The percentage of LGA births remained around 11% until 1998, then decreased slightly to 9.9% in 2003.

After adjusting for gestational age, maternal age, parity, country of origin, newborn gender and maternal smoking during pregnancy, the mean birthweight in term births increased between 1972 and 1995 ($47.8\text{g} \pm 5.9$ $p = <0.0001$) and decreased between 1998 and 2003 (-50.9g (5.2) between 1995 and 2003 $p = <0.0001$) (**Figure 1**). Changes in the risk of

LGA and of SGA births, adjusted for maternal age, parity, country of origin and maternal smoking during pregnancy, were consistent with this trend in mean birthweight (**Figure 1**). Indeed, there was a strong decrease in SGA between 1972 and 1995, whereas between 1995 and 2003, an increase in SGA and a decrease in LGA were observed.

The association between maternal prepregnancy BMI and birthweight was stronger in 1972 than in 2003 (standardized beta coefficients: 0.20 in 1972, and 0.18 from 1981 to 2003, $p < 0.0001$ for interaction between prepregnancy BMI and survey year). Similarly, the strength of the relation between maternal pregnancy weight gain and birthweight decreased significantly between 1972 and 2003 (standardized beta coefficients of 0.17 and 0.14 respectively, $p < 0.0001$ for interaction). The relation between maternal height and birthweight also seemed to be stronger in 1972 than in 2003 (standardized beta coefficients of 0.19 and 0.17 respectively), even if the test of interaction between maternal height and survey year on birthweight was not significant. The strength of the relation between birthweight and maternal anthropometric characteristics decreased more sharply between 1972 and 1981; there were fewer changes from 1981 onwards.

Whatever the prepregnancy BMI, pregnancy weight gain increased between 1972 and 2003 (**Figure 2**). However the increase over time was smaller in obese women (from 7.6 kg [95% Confident Interval (CI) 6.9, 8.4] in 1972 to 8.3 kg [CI 95% 7.4, 9.3] in 2003, $p < 0.0001$) than in thin women (from 11.0 kg [CI 95% 10.8, 11.3] to 13.7 kg [CI 95% 13.5, 14.0], $p < 0.0001$). When mean birthweight was estimated with further adjustment for the mother's weight gain during pregnancy, birthweight was stable between 1972 and 1981 ($3\,375\text{g} \pm 4.7$ to $3\,371\text{g} \pm 6.0$) and decreased between 1981 and 2003 ($3\,298\text{g} \pm 4.1$ in 2003, $p < 0.0001$). Data on weight gain during pregnancy were not available in 1995 and 1998.

From 1972 to 2003, the percentage of induced deliveries increased from 12% to 25% in thin women and from 15% to 40% in obese women (**Figure 3**). Induced deliveries

increased for all categories of birthweight between 1972 and 2003, but more sharply for LGA births between 1981 and 1995 (results not shown). It is of note that there were no significant changes in the percentages of induced deliveries between 1995 and 2003.

The trend in adjusted birthweight was unchanged after additional adjustment for induced deliveries (data not shown).

The observed trends in mean birthweight were unchanged in the sensitivity analyses: combining infants with and without gestational age available in the same model, removing post-term births from the analysis and in an analysis stratified by categories of maternal BMI (results not shown).

Discussion

Although the maternal anthropometric characteristics positively associated with birthweight increased from 1972 to 2003, birthweight did not show the expected upward trend over these years. When possible known confounders were taken into account, birthweight showed an increasing trend from 1972 to 1995 but a decrease from 1995 onwards. Over the period 1972-2003, weight gain monitoring and management at the end of pregnancy improved in France, resulting in less weight gain in obese women and more induced deliveries (caesarean sections before labour and inductions of labour). However, taking into account the percentage of induced deliveries and weight gain during pregnancy, the trend in birthweight was not explained.

Our study is the first to report the time trends in maternal prepregnancy anthropometry, pregnancy weight gain and infant birthweight and their relation in France, and a strength of this study is that data are based on large, national, representative samples of births.

Data on maternal prepregnancy anthropometry are based on self-reported weight and height and this could induce bias in our results. Self-reported body weight may underestimate the true weight, especially among overweight women.^{19, 20} However, as our data on prepregnancy weight are based on mothers self-report in all survey years, the effect of under-reporting of prepregnancy weight on the change in maternal prepregnancy weight and its relation with birthweight over time may be limited. In our data, in spite of a possible under-reporting of weight, women's weight increased for all BMI categories but birth weight did not increase accordingly. It has been recently shown that an under-reporting of body weight would lead to an overestimation of the statistical relation between maternal weight and birth weight.²¹ A second possible source of bias was the changes in the methods of estimation of gestational age between 1972 and 2003. Indeed, in the 1970's, gestational age was estimated

only from the last declared menstrual period, whereas the 1980's have seen the generalisation of ultrasound in combination with the last menstrual period for assessing gestational age. This could explain why missing values for gestational age were more frequent in 1972 and 1981 than later (below 1% between 1995 and 2003) and also partly explains the much higher percentages of preterm and post term infants in 1972 than in 2003, that could be more likely attributed to misclassification. The trend in mean birthweight was unchanged when estimated on all births, including those without documented gestational age, suggesting that the observed trend in mean birthweight is not biased by missing data on gestational age. The fact that we selected term deliveries only, may have led to a selection bias since lean and morbidly obese women are more at risk of preterm delivery, and they may have been underrepresented in our study sample. However this selection was probably similar from 1995 to 2003 and therefore has less affected the trend in mean birthweight over this period than in previous years. Gestational age was reported in weeks and this can be a limit for our study, as a decrease of only a few days in gestational age can impact birth weight. However gestational age was reported in weeks in all 5 surveys and should affect birth weight in the same way from 1972 to 2003. We selected only term births for this study because of the frank decrease in mean birth weight in preterm births between 1981 and 1995. This decrease may be due to changes in gestational age estimations after the 1980's and also to changes in neonatal care with the growing ability to maintain alive preterm babies, with a very low birthweight.

Previous studies have investigated time trends in mothers' anthropometry and pregnancy weight gain in relation with birthweight in countries comparable to France.^{5, 7-10} In contrast to our results, the increase in maternal anthropometry was generally accompanied with an increase in mean birthweight and in the proportion of LGA births. A study on all Illinois births between 1950 and 1990 demonstrated an overall increase in birthweight and an increase according to generations within families.⁹ A study from Canada between 1978 and

1996 highlighted an increase over time in maternal anthropometry (weight and height before conception), an increase in mean birthweight and LGA births and a decrease in SGA births.⁵ A Finnish study showed an increase in maternal height, prepregnancy weight and BMI in three cohorts in the area of Helsinki (1954-1963, 1985-1986 and 2000-2001).⁷ They also highlighted an increase in pregnancy weight gain between the first and the second cohort but not between the latter two cohorts. In parallel, the mean birthweight and the proportion of LGA births increased between the first and the second cohorts and were stable thereafter. A Swedish study showed an increase in the percentage of overweight and obese women between 1992 and 2001, an increase in mean birthweight and in the prevalence of LGA births before adjustment for maternal and pregnancy characteristics.⁸ The increase in the prevalence of LGA births disappeared after adjustment for maternal BMI and maternal smoking. A study from Switzerland reported that all maternal anthropometric characteristics increased between 1986 and 2004, as well as mean birthweight.¹⁰

Only two recent studies have shown results comparable to ours. A Bavarian study reported an increase in maternal pregnancy weight gain and a decrease in birthweight in singleton term births after accounting for potential confounders.¹² In the United States, the mean weight of singleton term births has very recently been shown to decrease from 1990 to 2005, and especially after 1999.¹¹ This decline was not explained by maternal and neonatal characteristics or by trends in obstetric practices. Data on maternal prepregnancy BMI or gestational weight gain were not available in this study, as acknowledged by the authors, but accounting for the increasing trend in maternal BMI in the US would have adjusted fetal growth estimates further downwards. It is noteworthy that similar to our study, the decrease in mean birthweight was reflected in both an increase in SGA and a decrease in LGA prevalences.

The relation between maternal prepregnancy anthropometry, pregnancy weight gain and birthweight is well known. Many studies have reported that maternal weight and height before conception are related to birthweight, including studies from Denmark,¹³ Switzerland⁸ and the United Kingdom.²² Among these maternal anthropometric factors related to birthweight, prepregnancy weight, which is a combination of lean and fat mass, appears to be important.²³ However, as shown by the decrease in standardized regression coefficients of maternal variables on birthweight, the relation between maternal anthropometry and birthweight has declined over time in France. It suggests the growing impact of other factors, which progressively obscure the relation between maternal and infant anthropometries. Among them, we explored the role of pregnancy weight gain and induced delivery, which reflect changes in obstetric practices.

Mean pregnancy weight gain increased significantly between 1972 and 2003 for all maternal BMI categories, except for obese women between 1981 and 2003. The trend in pregnancy weight gain in obese women could have limited the proportion of LGA births in these women. However, the decrease in LGA births over time was observed in all women, despite a frank increase in mean pregnancy weight gain, indicating that this is unlikely to be the main explanation. Induced deliveries (induction of labour and caesarean sections before labour) increased with time in all women, but more sharply in the overweight and the obese. The increased rates of induced deliveries especially for LGA births from 1972 to 1995 reflect changes in obstetric practice. These practices may have some impact on overall birthweight but less on birthweight for a given gestational age. Induced deliveries in post-term pregnancies and the increase in induced deliveries in LGA births could have modified the natural range of birthweight in France toward lower values. However there were no significant changes in the percentage of induced deliveries between 1995 and 2003. We did not have information on gestational diabetes in this study. Gestational diabetes are more

intensively diagnosed and treated and thus could have participated in the reduction of LGA births.

We have been unable to explain the negative trend in mean birthweight since 1995, but the combination of many factors, each with a small effect on birthweight, might be involved in this trend. As examples, infertility treatments including *in vitro* fertilisation, working conditions during pregnancy, environmental exposures or stress,^{11, 24, 25} could have been involved, but we could not investigate these hypotheses as these factors were not measured in the French perinatal surveys.

In conclusion, we could show that in France, although maternal prepregnancy BMI and weight gain during pregnancy increased from 1972 to 2003, birthweight tended to decrease from 1995 onwards, and the factors measured in our study did not provide an explanation for this trend. Low birthweight is associated with long-term health disorders and chronic diseases. In this respect, the increasing prevalence of SGA in France, but also in other countries such as the United States, should draw research efforts towards a better understanding of the causes of this time trend.

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Conflict of interest

No potential conflict of interest relevant to this publication.

REFERENCES

1. Charles MA, Eschwege E, Basdevant A. Monitoring the Obesity Epidemic in France: The Obepi Surveys 1997-2006. *Obesity (Silver Spring)*. 2008 May 29. [Epub ahead of print].
2. Czernichow S, Maillard-Teyssier L, Vergnaud AC, Peneau S, Bertrais S, Mejean C, et al. Trends in the prevalence of obesity in employed adults in central-western France: A population-based study, 1995-2005. *Preventive Medicine* 2008.
3. Blondel B, Supernant K, Du Mazaubrun C, Breart G. [Trends in perinatal health in metropolitan France between 1995 and 2003: results from the National Perinatal Surveys]. *Journal de Gynécologie Obstétrique et Biologie de la Reproduction (Paris)* 2006; 35:373-387.
4. Galtier-Dereure F, Boegner C, Bringer J. Obesity and pregnancy: complications and cost. *American Journal of Clinical Nutrition* 2000; 71:1242S-1248S.
5. Kramer MS, Morin I, Yang H, Platt RW, Usher R, McNamara H, et al. Why are babies getting bigger? Temporal trends in fetal growth and its determinants. *The Journal of Pediatrics* 2002; 141:538-542.
6. Kari YL, Stephan Rössner, Martin Neovius. Maternal predictors of birthweight : the importance of weight gain during pregnancy. *Obesity Research & Clinical Practice*. 2007; 1:243-252.
7. Kinnunen TI, Luoto R, Gissler M, Hemminki E. Pregnancy weight gain from 1960s to 2000 in Finland. *International Journal of Obesity and Related Metabolic Disorders* 2003; 27:1572-1577.
8. Surkan PJ, Hsieh CC, Johansson AL, Dickman PW, Cnattingius S. Reasons for increasing trends in large for gestational age births. *Obstetrics & Gynecology* 2004; 104:720-726.
9. Chike-Obi U, David RJ, Coutinho R, Wu SY. Birth weight has increased over a generation. *American Journal of Epidemiology* 1996; 144:563-569.
10. Frischknecht F, Bruhwiler H, Raio L, Luscher KP. Changes in pre-pregnancy weight and weight gain during pregnancy: retrospective comparison between 1986 and 2004. *Swiss Medical Weekly* 2009; 139:52-55.
11. Donahue SM, Kleinman KP, Gillman MW, Oken E. Trends in birth weight and gestational length among singleton term births in the United States: 1990-2005. *Obstetrics & Gynecology* 115:357-364.
12. Schiessl B, Beyerlein A, Lack N, von Kries R. Temporal trends in pregnancy weight gain and birth weight in Bavaria 2000-2007: slightly decreasing birth weight with increasing weight gain in pregnancy. *Journal of Perinatal Medicine* 2009; 37:374-379.
13. Orskou J, Henriksen TB, Kesmodel U, Secher NJ. Maternal characteristics and lifestyle factors and the risk of delivering high birth weight infants. *Obstetrics & Gynecology* 2003; 102:115-120.

14. Liston WA. Rising caesarean section rates: can evolution and ecology explain some of the difficulties of modern childbirth? *Journal of the Royal Society of Medicine* 2003; 96:559-561.
15. Vahratian A, Siega-Riz AM, Savitz DA, Zhang J. Maternal pre-pregnancy overweight and obesity and the risk of cesarean delivery in nulliparous women. *Annals of Epidemiology* 2005; 15:467-474.
16. Blondel B, Breart G, du Mazaubrun C, Badeyan G, Wcislo M, Lordier A, et al. [The perinatal situation in France. Trends between 1981 and 1995]. *Journal de Gynécologie Obstétrique et Biologie de la Reproduction (Paris)* 1997; 26:770-780.
17. Carayol M, Blondel B, Zeitlin J, Breart G, Goffinet F. Changes in the rates of caesarean delivery before labour for breech presentation at term in France: 1972-2003. *European Journal of Obstetrics, Gynecology, and Reproductive Biologie* 2007; 132:20-26.
18. Mamelle N, Munoz F, Grandjean H. [Fetal growth from the AUDIPOG study. I. Establishment of reference curves]. *Journal de Gynécologie Obstétrique et Biologie de la Reproduction (Paris)* 1996; 25:61-70.
19. Bostrom G, Diderichsen F. Socioeconomic differentials in misclassification of height, weight and body mass index based on questionnaire data. *International Journal of Epidemiology* 1997; 26:860-866.
20. Jalkanen L, Tuomilehto J, Tanskanen A, Puska P. Accuracy of self-reported body weight compared to measured body weight. A population survey. *Scandinavian Journal of Sococial Medicine* 1987; 15:191-198.
21. Bodnar LM, Siega-Riz AM, Simhan HN, Diesel JC, Abrams B. The Impact of Exposure Misclassification on Associations Between Prepregnancy BMI and Adverse Pregnancy Outcomes. *Obesity (Silver Spring)*.
22. Griffiths LJ, Dezateux C, Cole TJ. Differential parental weight and height contributions to offspring birthweight and weight gain in infancy. *International Journal of Epidemiology* 2007; 36:104-107.
23. Frederick IO, Williams MA, Sales AE, Martin DP, Killien M. Pre-pregnancy Body Mass Index, Gestational Weight Gain, and Other Maternal Characteristics in Relation to Infant Birth Weight. *Maternal and Child Health Journal* 2008; 12:557-567.
24. Niedhammer I, O'Mahony D, Daly S, Morrison JJ, Kelleher CC. Occupational predictors of pregnancy outcomes in Irish working women in the Lifeways cohort. *Bjog: an international of obstetrics and gynaecology* 2009; 116:943-952.
25. Tough SC, Greene CA, Svenson LW, Belik J. Effects of in vitro fertilization on low birth weight, preterm delivery, and multiple birth. *The Journal of Pediatrics* 2000; 136:618-622.

Table 1 Number of infants and mean birthweight \pm standard deviation, in each study year among different study subgroups. The French National Perinatal Surveys.

		1972	1981	1995	1998	2003
Total singleton births	N	10 871	5 395	12 869	13 076	14 039
	birthweight (g)	3 286 \pm 506	3 326 \pm 482	3 294 \pm 502	3 291 \pm 503	3 281 \pm 519
Missing gestational age	% (n)	9.7 (1056)	7.2 (386)	0.78 (101)	0.38 (50)	0.43 (60)
	birthweight (g)	3 245 \pm 530	3 285 \pm 500	3 241 \pm 438	3 316 \pm 480	3 131 \pm 554
Preterm births	% (n)	6.8 (734)	4.6 (253)	4.5 (574)	4.6 (604)	4.9 (692)
	birthweight (g)	2 725 \pm 681	2 745 \pm 620	2 364 \pm 671	2 379 \pm 648	2 305 \pm 696
Term births \geq 37 weeks	N	9,081	4 756	12 194	12,422	13 287
	birthweight (g)	3 336 \pm 455	3 361 \pm 451	3 338 \pm 448	3 336 \pm 450	3 333 \pm 454
Term births, with data on	N	8 684	4 494	11 445	12 006	12 692

maternal weight, gestational

age and birthweight available birthweight (g) 3 337 ± 451 3 361 ± 448 3 339 ± 446 3 335 ± 449 3 332 ± 453

Table 2: Trends in maternal and infant characteristics in singleton live births ≥ 37 weeks of gestation, mean \pm SD for crude variables, mean \pm SEM for adjusted birthweight and % (n) for qualitative variables. The French National Perinatal Surveys.

	1972	1981	1995	1998	2003
N	8 684	4 494	11 445	12 006	12 692
Maternal age (% (n))					
<25 years	49.7 (4 320)	37.8 (1 697)	21.2 (2 436)	17.6 (2 117)	18.7 (2 370)
25 to 29 years	29.4 (2 549)	37.2 (1 671)	38.8 (4 440)	38.0 (4 557)	33.3 (4 226)
30 to 34 years	12.4 (1 079)	19.5 (877)	27.9 (3 194)	30.1 (3 612)	32.4 (4 112)
≥ 35 years	8.5 (736)	5.5 (249)	12.0 (1 375)	14.3 (1 720)	15.6 (1 984)
Parity (% (n))					
0	45.1 (3 912)	42.6 (1 910)	41.6 (4 748)	43.3 (5 170)	43.3 (5 428)
1	29.7 (2 570)	34.3 (1 536)	35.2 (4 022)	33.6 (4 010)	35.7 (4 467)
≥ 2	25.2 (2 188)	23.1 (1 036)	23.2 (2 643)	23.1 (2 760)	21.0 (2 632)

Maternal Origin (% (n))

France	93.8 (8 103)	91.6 (4 105)	90.0 (10 281)	90.3 (10 822)	89.4 (11 324)
Other European countries	4.5 (389)	3.1 (137)	3.1 (357)	3.0 (362)	2.5 (315)
North Africa	1.3 (110)	3.8 (172)	4.4 (500)	3.9 (465)	4.1 (517)
Other Countries	0.4 (36)	1.5 (66)	2.5 (285)	2.8 (339)	4.1 (515)

Smoking during third trimester (% (n))

non-smoker	90.3 (7 768)	85.3 (3 753)	75.2 (8 502)	75.2 (8 898)	79.3 (9 557)
<10 cigarettes/day	6.2 (534)	9.3 (407)	14.2 (1 610)	14.9 (1 767)	12.7 (1 534)
≥10 cigarettes/day	3.5 (301)	5.4 (239)	10.6 (1 197)	9.9 (1 173)	7.9 (954)

***Induced delivery (% (n))** 12.0 (1 040) 16.5 (742) 28.3 (3 229) 28.5 (3 414) 31.0 (3 901)

Maternal anthropometry

Height (cm)	160.8 ± 6.0	161.7 ± 6.0	.	163.7 ± 6.2	164.0 ± 6.3
Prepregnancy weight (kg)	55.3 ± 8.7	56.0 ± 8.7	58.9 ± 10.5	60.1 ± 11.6	61.6 ± 12.5
Prepregnancy BMI (kg/m ²)	21.3 ± 3.1	21.4 ± 3.1	.	22.4 ± 4.1	22.9 ± 4.4

Weight at delivery (kg)	65.6 ± 9.2	67.5 ± 9.1	.	.	74.6 ± 12.6
Pregnancy weight gain (kg)	10.3 ± 3.8	11.6 ± 3.8	.	.	13.0 ± 5.2
Gestational age (weeks)	39.9 ± 1.5	39.9 ± 1.4	39.4 ± 1.2	39.3 ± 1.2	39.5 ± 1.2
Infant's characteristics					
Birthweight (g)	3 337 ± 451	3 361 ± 448	3 339 ± 446	3 335 ± 449	3 332 ± 453
SGA births (% (n))	10.6 (919)	9.2 (410)	7.5 (863)	7.9 (951)	8.7 (1 101)
LGA births (% (n))	11.1 (961)	11.5 (511)	10.8 (1 234)	10.7 (1 286)	9.9 (1 254)
Post maturity (% (n))	12.3 (1 070)	11.4 (511)	1.6 (185)	1.2 (146)	1.1 (140)
Female infants (% (n))	48 (4 131)	48 (2 130)	49 (5 605)	49 (5 890)	49 (6 194)

* Induction of labour or caesarean section before labour

All characteristics were significantly different between study years with $p < 0.0001$ (ANOVA test of 4 df) except for crude birthweight ($p = 0.003$); percent of female infants and gestational age (not significantly different).