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ORIGINAL ARTICLE

Effects of individual and social factors on preterm birth and low birth weight: empirical evidence from regional data in Italy

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Abstract
Objectives We examine the effects of mother's characteristics and socioeconomic condition on weight at birth and preterm delivery in an Italian region (Umbria).
Methods The study concerns all live-born singleton infants in 2007 with at least a gestational age of 22 weeks. Information derived from the Standard Certificate of Live Birth was linked to information from census statistics, so as to obtain a deprivation index.
Results On the basis of the fitting of two separate logistic regression models, we conclude that all individual socioeconomic factors are strongly associated with the outcomes at birth, apart from the deprivation index. Older and less educated mothers, and those with lower occupational level, have a higher probability to run into preterm delivery with respect to the other mothers. The relative risk ratios for low birth weight are significantly higher for older mothers, non-European, and not married. Lower weight rates are found in infants from complicated pregnancy and non-spontaneous conception.
Conclusions Effects of mother's characteristics on weight at birth and weeks of gestation are confirmed. The deprivation index does not affect these outcomes, showing the proper implementation of the Health System.

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Keywords Individual risk factors · Deprivation index · Socioeconomic status · Standard Certificate of Live Birth

Introduction

Low birth weight, less than 2,500 g (World Health Organization 1975), and preterm birth, before the 37th gestational week (Società Italiana di Pediatria 1987), are used as indicators to monitor adverse perinatal outcomes (Greene 2002). In particular, the medical literature has largely found that birth weight and gestational age are the main determinants of neonatal and infant death (McCormick 1985). On the other hand, some studies have stressed the importance of socioeconomic conditions affecting the perinatal period in adverse medical outcomes at birth. The association between women who work during pregnancy and outcomes, in terms of birth weight, have been described by several authors (see, among others, Teitelman et al. 1990; Peoples-Sheps et al. 1991; Draper et al. 1999; Horbar et al. 2002). Evidence shows that rates of low birth weight are higher among manual workers than non-manual workers. Furthermore, some papers have focused on parental occupation to derive indirect factors that explain the association with adverse perinatal outcomes (Savitz et al. 1989).

Some studies are focused on other specific maternal factors that affect neonatal birth results. According to these studies, maternal age, marital status, height, and parity are significantly associated with birth results in Europe and in the United States (Ludwig et al. 2006; Allen et al. 2006; Maher and Macfarlane 2004; Macfarlane et al. 2004; Shouls et al. 1999; Kramer et al. 2000; Gissler et al. 2003; Bai et al. 2002). The phenomenon has become complex and has been subjected to changes over the past 20 years (Fairley 2005). Although mothers with adverse perinatal

outcomes are more likely to be young, single, shorter, and of high parity, these results do not seem to currently reflect the effect of the inequality in socioeconomic conditions, irrespective of the increase in the proportion of older, single, and taller mothers, and of mothers with undetermined social class (this group includes individuals with inadequate job description, who never worked, housewives, and students). We also have to consider that these results are different from country to country, reflecting the relationship between socioeconomic conditions and specific maternal factors in affecting inequalities in the delivery outcomes. This justifies specific investigation for Italy (Cardano and Marinacci 2004).

The purpose of the present study is to examine the effects of maternal and environmental characteristics on the weight at birth and preterm delivery in a population of contemporary Italian women in the Umbria region. This is a Region of around 900,000 inhabitants, situated in the middle of Italy, where the number of births per year is around 8,000. Birth-rate and fertility indexes have constantly increased and have moved close to the national average (birth-rate 2007: Italy 9.5‰, Umbria 8.9‰; fertility index 2007: Italy 1.40, Umbria 1.38). These data also reflect a low birth-rate which characterizes Italy in comparison to other European countries.

The proposed analysis is carried out by re-examining the information available from the Standard Certificate of Live Birth (SCLB), where the richness of the administrative data enables us to link birth registrations with the mother's characteristics and documentations regarding pregnant assistance. In the present study we specify, among the contextual variables, a deprivation index to measure conditions of the woman's household. This multidimensional index is built on the basis of a large set of socioeconomic and demographic variables and, to classify municipalities, scores for these areas are summarised in a discrete ranking. This approach generates confounding problems that might arise from the interactions between individual and contextual variables. For these reasons, when appropriate, we test the determinants of inequality conditions at birth time by a multilevel analysis. Mother's education is an important factor, which is significantly associated with low neonatal weight, preterm birth, and perinatal mortality, but also internationally recognized as a prevalent condition in families with lower economic and social conditions (Gnavi and Costa 2002; Luo et al. 2006; Fairley and Leyland 2006).

Methods

Data source and study population

The study is based on data obtained from the SCLB of the Umbria region (Italy) in 2007, which provides information on the birth population. In Italy, the state law requires birth certificates to be completed for all births. These certificates provide information on health, epidemiological, and socio-demographic characteristics of the mother through the registration of birth events, including causes of mortality and possible malformations of the newborn. To ensure a uniform methodology of the regional surveys, so as to obtain datasets containing comparable indicators, each participating region was required to use the same questionnaire.

The SCLB is filled in within 10 days after the delivery by the midwife who attends the birth or the doctor responsible of the operational unit. In particular, it contains epidemiological information about risk factors in the pregnancy, obstetric procedures, characteristics and methods of delivery, and abnormal conditions and congenital anomalies of the newborn. For details see Decree No. 349 of Italian Ministry of Health (Minelli et al. 2009).

We used population data from 7,068 live singleton hospital births in Umbria. About the mother's nationality, 77.42% of the mothers are Italian, whereas foreign mothers that come from other European countries and extra-European countries are, respectively, the 13.26 and the 9.32%.

Variables of interest

Gestational age and birth weight are the most widely used health outcome measures, which are recommended by the World Health Organization. These are comprehensive measures that incorporate several dimensions on health and are highly associated with child mortality. In particular, gestational age at birth was defined as the number of complete gestational weeks after the first day of last menstruation.

We considered two categorical response variables:

(i) *gestational weeks*, with categories: PTB, preterm birth (below 37 weeks) and SB, standard birth (at least 37 weeks); the last one was taken as the reference category;
(ii) *weight at birth*, with categories: VLBW, very low birth weight (below 1,500 g), LBW, low birth weight (between 1,500 and 2,500 g), and NBW, normal birth weight (above 2,500 g); the last one was taken as the reference category.

We also considered a full range of individual and social control variables of the mother:

(i) *age*, with four categories: <20, 20–29, 30–39, >39; the reference category is 20–29;
(ii) *citizenship*, with three categories: Italy, EU-27, extra-Europe; Italy is the reference category;
(iii) *marital status*, with two categories: married, unmarried; married is the reference category.

Furthermore, since differences in socioeconomic status are likely to play an important role in accounting for disparities in health, we included *educational level* among the controlling variables. The first is represented by the self-reported highest level of education. In particular, we recoded the education level following the International Standard Classification of Education (ISCED) classification as: low (no more than 8 years of education), medium (from 9 to 13 years of education), and high (more than 13 years of education); the last was used as the reference category. We also examined differences in the occupational status of the mothers. In particular, the typology of occupation was classified in three categories: family business and white collar, blue collars, and home maker; we took the first as the reference category.

We also examined the impact of pregnancy factors on preterm birth by including *parity* (with categories: 0 or 1+; the latter is the reference category), and *intrauterine growth* (with categories: restriction and standard; the latter is the reference category). Furthermore, we included complicated *pregnancy* as a measure differentiated with respect to normal pregnancy of the impact on outcomes. Finally, we added a variable related to treatments of *assisted reproduction* to account for the heterogeneous effects with respect to spontaneous conception on low birth weight and preterm delivery.

To assess the effect of health inequality conditions on the outcomes for the Umbria region, we used a measure of socioeconomic disadvantage (SED). In particular, we estimated, on the basis of household surveys matched with the 2001 census data of the National Statistical Institute, a deprivation index for the 92 municipalities of the region. A large number of indicators were summarised in five macro-variables, which were suitably standardized. The final index is based on the sum of the standardized scores and, successively, categorized on the basis of the quartiles of the observed statistical distribution. We used as reference category that below the first quartile (idcat1), whereas the other categories indicate growing levels of deprivation (idcat2, idcat3, idcat4).

Statistical methods

The relation between individual and environmental characteristics and preterm birth was firstly estimated by a logistic regression model. Secondly, we extended the analysis to study the influence of territorial socioeconomic disadvantages on the gestational outcome by a multilevel version of this model. The latter is a version of the logistic regression model that, further to the same predictors as the initial model (with the exception of the deprivation index), includes a two-level random-effects structure: one level is for the subject and the other for the municipality. Thus, while the first logit model analysis provides odds-ratios which compare increasing levels of socioeconomic deprivation, the multilevel model aims at identifying the existence of geographical inequalities affecting preterm delivery.

In order to monitor adverse perinatal outcomes based on the low birth weight outcome, we estimated a multinomial logit model. As for the logit model above, the estimated odds-ratios we obtained measure the impact of individual differences and aggregate socioeconomic variables on the delivery weight.

Results

Descriptive statistics for the dataset we analyzed are reported in Table 1. This table summarises the distribution of the characteristics of the mother for each type of perinatal outcome we considered. Note that, due to missing data, the overall frequency is not the same for each distribution.

We observe that, in terms of gestational weeks, women having a preterm delivery tend to be older and less educated with respect to women having a standard birth. Moreover, they are more frequently non-Italian citizens, blue-collars, unmarried, and living in a municipality with high deprivation index. Finally, among preterm deliveries, we observe a higher frequency, with respect to other deliveries, of complicated pregnancies, restrictions in the foetal growths, and nulliparous.

A similar pattern as above is observed with reference to weight at birth. In particular, women having a newborn in category VLBW or LBW are older, less educated, and less frequently married and employed as white collars, with respect to women having a newborn in category NBW. We also note a higher frequency in the birth weight critical categories of nulliparous and of complicated pregnancies.

The parameter estimates obtained under the logistic regression model, adopted to study the relationship between weeks of gestation and the key predictor variables of interest, are reported in Table 2. In particular, the estimates under the fixed-effects logit model, which includes the deprivation index among the covariates, are reported in the penultimate column, whereas those obtained under its random-effects version, which does not include this covariate, are reported in the last column.

We are particularly interested in testing how the deprivation index affects preterm delivery conditional on the individual characteristics. Although the estimate of the odds-ratio for the 4th quartile is higher than the estimates for the other quartiles, the effect of the deprivation index on gestational weeks is not significant. In fact, the likelihood ratio test statistic between the logit model that includes the

Table 1 Frequency distributions of the mother's characteristics for each perinatal outcome (Umbria study on birth, Italy, 2007)

Variable	Category	Gestational weeks				Weight at birth					
		<37 (PTB)		≥37 (SB)		<1,500 g (VLBW)		1,500–2,500 g (LBW)		≥2,500 g (NBW)	
		n	%	*n*	%	*n*	%	*n*	%	*n*	%
Maternal age	<20	9	2.64	124	1.86	0	0.00	10	3.52	123	1.84
	20–29	88	25.81	2,042	30.56	10	21.74	71	25.00	2,049	30.61
	30–39	214	62.76	4,121	61.67	34	73.91	184	64.79	4,117	61.51
	≥40	30	8.80	395	5.91	2	4.35	19	6.69	404	6.04
	Total	341	100.00	6,682	100.00	46	100.00	284	100.00	6,693	100.00
Maternal citizenship	Italy	221	74.66	4,606	77.69	27	61.36	191	78.93	4,609	77.61
	Ue-27	42	14.19	780	13.16	7	15.91	30	12.40	785	13.22
	Extra-Europe	33	11.15	543	9.16	10	22.73	21	8.68	545	9.18
	Total	296	100.00	5,929	100.00	44	100.00	242	100.00	5,939	100.00
Maternal education	Low	99	29.20	1,559	23.47	15	32.61	75	26.60	1,568	23.57
	Medium	171	50.44	3,433	51.69	23	50.00	147	52.13	3,434	51.62
	High	69	20.35	1,650	24.84	8	17.39	60	21.28	1,651	24.82
	Total	339	100.00	6,642	100.00	46	100.00	282	100.00	6,653	100.00
Maternal occupation	Family business and white collar	118	39.86	2,808	49.60	15	37.50	111	46.64	2,800	49.39
	Blue collar	79	26.69	1,173	20.72	9	22.50	54	22.69	1,189	20.97
	Home maker	89	30.07	1,680	29.68	16	40.00	73	30.67	1,680	29.63
	Total	296	100.00	5,661	100.00	40	100.00	238	100.00	5,669	100.00
Marital status	Married	251	74.04	5,314	79.75	31	67.39	211	74.82	5,323	79.76
	Unmarried	88	25.96	1,349	20.25	15	32.61	71	25.18	1,351	20.24
	Total	339	100.00	6,663	100.00	46	100.00	282	100.00	6,674	100.00
Deprivation index	Quartile 1	61	17.89	1,389	20.78	–	–	–	–	–	–
	Quartile 2	131	38.42	2,544	38.07	–	–	–	–	–	–
	Quartile 3	76	22.29	1,579	23.63	–	–	–	–	–	–
	Quartile 4	73	21.41	1,171	17.52	–	–	–	–	–	–
	Total	341	100.00	6,683	100.00	–	–	–	–	–	–
Pregnancy	Normal	244	70.11	6,438	96.45	17	36.96	212	74.65	6,446	96.31
	Complicated	104	29.89	237	3.55	29	63.04	72	25.35	247	3.69
	Total	348	100.00	6,675	100.00	46	100.00	284	100.00	6,693	100.00
Reproduction	Spontaneous conception	329	97.34	6,534	98.81	42	91.30	278	98.93	6,543	98.78
	Assisted reproduction	9	2.66	79	1.19	4	8.70	3	1.07	81	1.22
	Total	338	100.00	6,613	100.00	46	100.00	281	100.00	6,624	100.00

Table 1 continued

Variable	Category	Gestational weeks				Weight at birth					
		<37 (PTB)		≥37 (SB)		<1,500 g (VLBW)		1,500–2,500 g (LBW)		≥2,500 g (NBW)	
		n	%	*n*	%	*n*	%	*n*	%	*n*	%
Foetal growth	Standard	306	90.00	6,465	97.61	–		–		–	
	Restriction	34	10.00	158	2.39	–		–		–	
	Total	340	100.00	6,623	100.00	–		–		–	
Parity	0	185	59.11	3,249	53.83	32	69.57	167	61.62	3,235	53.63
	1+	128	40.89	2,787	46.17	14	30.43	104	38.38	2,797	46.37
	Total	313	100.00	6,036	100.00	46	100.00	271	100.00	6,032	100.00

PTB preterm birth, *SB* standard birth, *VLBW* very low birth weight, *LBW* low birth weight, *NBW* normal birth weight

Table 2 Estimates under the Binary logistic regression models for the gestational weeks in terms of odds ratios for preterm birth against (PB) and against standard birth (SB); (Umbria study on birth, Italy, 2007)

Explanatory variable	Category	Fixed-effects model	Random-effects model
Maternal age	<20	1.656	1.624
	20–29 (ref)	–	–
	30–39	1.247	1.275
	≥40	1.822**	1.830**
Maternal citizenship	Italy (ref)	–	–
	Ue-27	1.301	1.289
	Extra-Europe	1.043	1.002
Maternal education	Low	1.764**	1.782**
	Medium	1.348	1.368
	High (ref)	–	–
Maternal occupation	Family business and white collar (ref)	–	–
	Blue collar	1.519**	1.543**
	Home maker	1.074	1.135
Marital status	Married (ref)	–	–
	Unmarried	1.114	1.125
Deprivation index	Quartile 1—less deprivate (ref)	–	–
	Quartile 2	0.863	–
	Quartile 3	0.932	–
	Quartile 4	1.336	–
Pregnancy	Normal (ref)	–	–
	Complicated	10.499***	10.259***
Reproduction	Spontaneous conception (ref)	–	–
	Assisted reproduction	1.767**	1.799**
Foetal growth	Standard (ref)	–	–
	Restriction	2.005***	2.031***
Parity	0	1.199	1.194
	1+	–	–

*** p values below 0.01

** p values below 0.05

* p values below 0.1

categories of deprivation index and the restricted one, in which this variable is omitted, is equal to 5.09, corresponding to a p value of 0.165 computed on the basis of a Chi-squared distribution with 3 degrees of freedom. Then, we conclude that the socioeconomic condition of the municipality where the mother lives has not a significant influence on the number of gestational weeks. This is confirmed by the fact that the parameter estimates under the random intercept model are very close to those obtained under the fixed-effects model, although the first model does not include the deprivation index among the covariates.

From the results in Table 2, we conclude that women in the older classes are more likely than those in the other classes to have a preterm delivery. Indeed, we found that the age class ≥40 has higher odds of about 80% to run into preterm delivery with respect to the reference age class (20–29). A relationship between maternal education and preterm delivery is also observed. Women with no more than 8 years of education have a nearly 76% excess odds of preterm delivery, compared to women with high educational level.

Similar patterns of association between maternal typology of occupation and preterm delivery were noted for blue collars (about 52% higher), but the effect sizes is smaller and not significant for home makers with respect to the reference category (family business and white collars). On the contrary, the inclusion of maternal citizenship and married couple status in the model with preterm delivery response do not seem to affect the perinatal outcome.

The results showed that maternal clinical characteristics are highly associated with preterm birth. As expected, complicated pregnancy very frequently induces a reduction of the gestational period. A similar result holds for the foetal growth, where the presence of an intrauterine growth restriction leads to doubling the odds to anticipate the birth.

Table 3 reports the estimates obtained under the multinomial logistic model for the categories of weight at birth. We observe that mothers aged 30–39, non-European, with lower education, and those not married more likely give birth to infants with VLBW. Very low weight birth rates are found in infants whose mothers are primiparas, had a complicated pregnancy or did not have a spontaneous conception.

About the category LBW, we note that mothers with age less than 20 have an odds to have infants with LBW that is more than the double that of the reference age class. We also estimated a large risk on LBW of complicated pregnancy with respect to normal pregnancy. The remaining explanatory variables have not a significant effect on LBW.

Discussion

The estimates confirm that inequalities in adverse perinatal outcomes depend on maternal characteristics. Older mothers and mothers with a lower educational level, unmarried, and nulliparous have a greater probability of a preterm delivery and/or a delivery with low birth rate.

It is worth noting that, although young maternal age is itself a risk factor for preterm delivery (see, for example, Olausson et al. 2001), we do not find strong evidence of this. Thus, we can suppose that in our case study the worse mother's perinatal outcomes registered for younger with respect to older mothers are more affected by the lack of prenatal care rather than lower social conditions.

Women with a lower level of schooling and a low social level are generally found to be able to forecast investments in health care. These women have a lower propensity to undergo more checks in pregnancy that induces a risk reduction of a preterm delivery or a low birth weight.

As already found (Waite and Gallagher 2000), a positive effect of maternal child health conditions on birth weight is indirectly confirmed by the large and significant effect of being married with respect to being unmarried. This result may reflect selection into marriage, where sick women tend to be excluded from marriage, or are less likely to stay in a couple or to remarry after the first marriage.

The estimation results also indicate differences in outcomes due to maternal citizenship. We refer to the literature of birth weight reference curves to explain our findings. It is known that birth weight is governed by two major processes: duration of gestation and intrauterine growth rate; real genetic differences exist in intrauterine growth or gestational duration among different racial or ethnic groups (Ego et al. 2006). Women from outside Europe, particularly those from a developing country, show an increase in intrauterine growth, justifying a significant higher probability of VLBW greater than Europeans. One of the relevant research questions is whether socioeconomic deprivation affects preterm birth (Galobardes et al. 2007; Fairley and Leyland 2006; Craig et al. 2002). The results confirm that the deprivation index does not affect the outcome. Therefore, for the Umbria region, the implementation of an efficient Health System seems to have eliminated territorial differences among mothers.

An association between the mother's job, particularly permanent jobs, and the rate of preterm births has been found in several studies. According to the specific literature (Mamele et al. 1984; Saurel-Cubizolles et al. 2004; Joseph et al. 2007), more job hours per day is considered as one of the indicators which contribute to increase the risk of preterm delivery. The estimates indicate that blue collar mothers are 50% more likely to have a preterm birth, in line with the findings of the literature (Berkowitz and Papiernik 1993). We follow the usual explanation according to which working 40 or more hours per week, which normally should be added to housework, may also reflect elements of psychological and physical stress. Moreover, we find an association between assisted reproduction and preterm delivery; see Fujii et al. (2010). Women who get pregnant after undergoing assisted reproduction have an increased risk of premature birth, which persists after the risk for multiple pregnancies has been accounted for. The same authors argued that the significant association can be explained by the frequent coexistence in these women of

Table 3 Estimates under the multinomial logistic regression model for the weight at birth in terms of odds ratios of between very low birth weight (VLBW) and low birth weight (LBW) against normal birth weight (NBW); (Umbria study on birth, Italy, 2007)

Response category	Explanatory variable	Category	Fixed-effects model
<1,500 g	Maternal age	<20	–
		20–29 (ref)	–
		30–39	4.551***
		≥40	2.246
	Maternal citizenship	Italy (ref)	–
		Ue-27	2.016
		Extra-Europe	2.759**
	Maternal education	Low	2.725*
		Medium	1.640
		High (ref)	–
	Maternal occupation	Family business and white collar (ref)	–
		Blue collar	0.985
		Home maker	1.728
	Marital status	Married (ref)	–
		Unmarried	2.567**
	Pregnancy	Normal (ref)	–
		Complicated	36.018***
	Reproduction	Spontaneous conception (ref)	–
		Assisted reproduction	4.841**
	Parity	0	2.056*
		1+	
1,500–2,500 g	Maternal age	<20	2.591*
		20–29 (ref)	
		30–39	1.206
		≥40	0.848
	Maternal citizenship	Italy (ref)	
		Ue-27	1.012
		Rest of the world	0.969
	Maternal education	High (ref)	–
		Medium	1.197
		Low	1.253
	Maternal occupation	Family business and white collar (ref)	–
		Blue collar	1.200
		Home maker	1.045
	Marital status	Married (ref)	–
		Unmarried	1.027
	Pregnancy	Normal (ref)	–
		Complicated	8.906***
	Reproduction	Spontaneous conception (ref)	–
		Assisted reproduction	0.489
	Parity	0	1.302
		1+	–

*** p values below 0.01

** p values below 0.05

* p values below 0.1

infertility uterine malformations, history of pelvic infections, and recurrent use of invasive procedures involving the uterine cervix.

To summarise, these findings highlight potential gaps in health information and in social support for socioeconomically vulnerable mothers and families in the year after birth. While our investigation accounts for the vast majority of preterm births in Umbria using singleton live births, there will also be a contribution from multiple births, which has grown due to modern infertility treatments. Multiple births also have a higher risk of preterm delivery than singletons. Future research on this cohort

(and others) could quantify how much of the increase in preterm birth rates in Umbria can be accounted for by multiple births.

Understanding the mechanisms of preterm birth has made significant strides; the assessment of primary risk factors, in particular socioeconomic and psychosocial factors, is a key step in defining women at risk. Thus, improvement of social and educational conditions, with the development of information campaigns and therapeutic approaches to the main psychological distresses represent important steps in preventing preterm delivery.

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