Anthropological Review • Vol. 76 (2), 129–150 (2013)
Available online at: https://doi.org/10.2478/anre-2013-0006

Pregnancy outcome and delivery in Spanish and migrant women: an ecological approach

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Abstract: For most of our history as a species, maternal constraint was the main environmental factor affecting biological status at birth. However, the great increase in medical intervention in the20th Century coincided first with an extraordinary reduction in perinatal mortality and later with an increase in preterm and low birth-weight babies. Herein, we analyze these temporary trends in neonate biology in Spain, according to early viability (1980–2010) and ethnic variability (1996–2010). The aim of this study is to evaluate the interaction between maternal and medical environmental constraints affecting the biology of birth and to understand the observed ethnic differences and secular trends. All single births in Spain between 1980 and 2010 are included. Following descriptive analysis, logistic regression analysis was applied to evaluate the effect of secular trends, mode of delivery and mother's origin on birth outcome after adjustment for other maternal bio-cultural factors. Results highlighted that mean birth weight decreased and prematurity increased in still births, live births and deaths before one day. In regard to ethnic differences, while there were no secular trends in weight by gestational age in the Spanish newborns, there was an increase among the newborns of foreign mothers. Spanish mothers experienced an increasing and higher frequency of low birth weight, while foreigners had an increasing and higher frequency of prematurity. Both groups, however, shared temporal reduction in gestational age, and although this was less marked in foreigners, it suggests a common trend related to medical care and increasing obstetric interventions.

Key words: weight by gestational age, distribution of gestational age, perinatal health, obstetric intervention

Introduction

Human reproduction is the result of the interaction between biological processes, which have hardly changed since they were fixed in our philogenesis at least 200.000 years ago (Trevathan 1987; Rosenberg and Trevathan 2002; Glukman and Hanson 2004), and cultural processes, which are inherent to the human ecosystem and which, in addition to presenting a wide population variability, have recently undergone an intense temporary transformation (Bernis 2003). Biological Anthropology and Huma Ecology offer the conceptual and methodological basis for evaluating this interaction and the bi-

Original Article: Received September 19, 2013; Accepted for publication October 22, 2013
DOI: 10.2478/anre-2013-0006

ological consequences of the changes for our cultural environment (Stinson et al. 2000; Thomas 2001; Goodman and Letherman 2001; Bernis 2003; Dufur 2006). As Wolánski and Siniarska (2005) point out, the only objective method for recording the effect of the environment on our species is to evaluate the biological state of its members, including development, nutrition and reproduction characteristics, and the presence of diseases.

Being born in optimal biological conditions is a passport to health for life, therefore is essential that national health systems proritize its evaluation, recording population data on normal foetal development over time, including the information on the so called "maternal system" (WHO 2006). Maternal system represents the combination of environmental, biological, psycho-social, behavioural and socio-sanitary factors which contribute to the production and care of descendants in the pre and early post-natal stages (WHO 2006).

For most of the 20th Century, medical intervention in perinatal health was very successfully directed towards reducing mother and infant mortality, achieving very low rates of foetal and perinatal deaths without any important changes (at least, not detected originally) in birth weight or gestational age (EURO-PERISTAT Project with SCPE and EUROCAT 2013). From 1990, population trends pointed to an increase in prematurity and low birth weight in most studies undertaken, including European populations with a high economic level (EURO-PERISTAT Project with SCPE and EUROCAT 2013; WHO 2012), which has generated great interest in establishing causes and consequences. The variability detected in birth weight and prematurity is a result of the interaction between genetic, epigenetic and environmental factors, with partially different consequences: low birth weight is linked to an increased risk of suffering cardiovascular and metabolic diseases in old age (Barker et al. 1989; Barker 1999; Rich-Edwards et al. 1999; Singhal et al. 2003; Gluckman et al. 2007) and also at younger ages (Ibáñez et al. 2006), while prematurity increases impaired motor and cognitive development (March of Dimes, PMNCH, Save the Children, WHO 2012); both indicators show a high rate of perinatal mortality and morbility.

In these populations with highly controlled infant mortality where an increase in prematurity and low birth weight has been detected, perinatal intervention should be aimed at improving functionality in neonates which, as WHO (2006: 14) states means achieving from a public health perspective an "(…) optimal fetal development (…) defined as that state at birth in which the neonate is most likely to survive and thrive through the neonatal transition and infancy, and to be prepared such that early developmental effects do not impact negatively on the individual's life-course." Optimal foetal development requires mothers with a good biological and emotional state, and medical attention in observance of current WHO directives on gender equality. Evaluating the biological state of the neonate must take into account the enormous perinatal heterogeneity in the figures for premature births (Villar et al. 2004). It must also acknowledge that the connection between health problems, gestational age and birth weight is continuous (WHO 2002), which implies that environmental change affects such distributions beyond those cut-off points established as risk (McIntire et al. 1999) and that these circumstances

should be taken into account in the design of prevention programmes to reduce these problems. Therefore, international organisations (EURO-PERISTAT Project with SCPE and EUROCAT 2013; March of Dimes, PMNCH, Save the Children, WHO 2012) recommend the publication of national data on weight distribution and gestational age and weight by gestational age as offered herein. Figure 1 illustrates this approach, showing the five basic foetal factors which define the biological state and health of neonates (sex, viability, multiplicity, maturity and anthropometry) and also indicators for the maternal system, divided into two large groups: those which typify women's biological, socioeconomic and psycho-social state, and those which define the socio-sanitary assistance received, and which generate diversity in perinatal health and biology.

The determinants of a mother's biological state are closely linked to the circumstances in which her life cycle takes place, especially to her nutritional state before and during pregnancy (EURO-PERISTAT Project with SCPE and EUROCAT 2013; Bernis 2009), to her age of maternity, to her previous reproductive life, and to certain habits such as smoking or drinking alcohol (Abrams and Selvin 1995; Bernis 2009). Mother's emotional state determinants are linked to inequalities which generate psycho-social stress: economic inequality, gender inequality and, in multiethnic societies, ethnic inequality (Dole el at 2003; Mustillo et at. 2004). Different evidence suggests that wide social networks

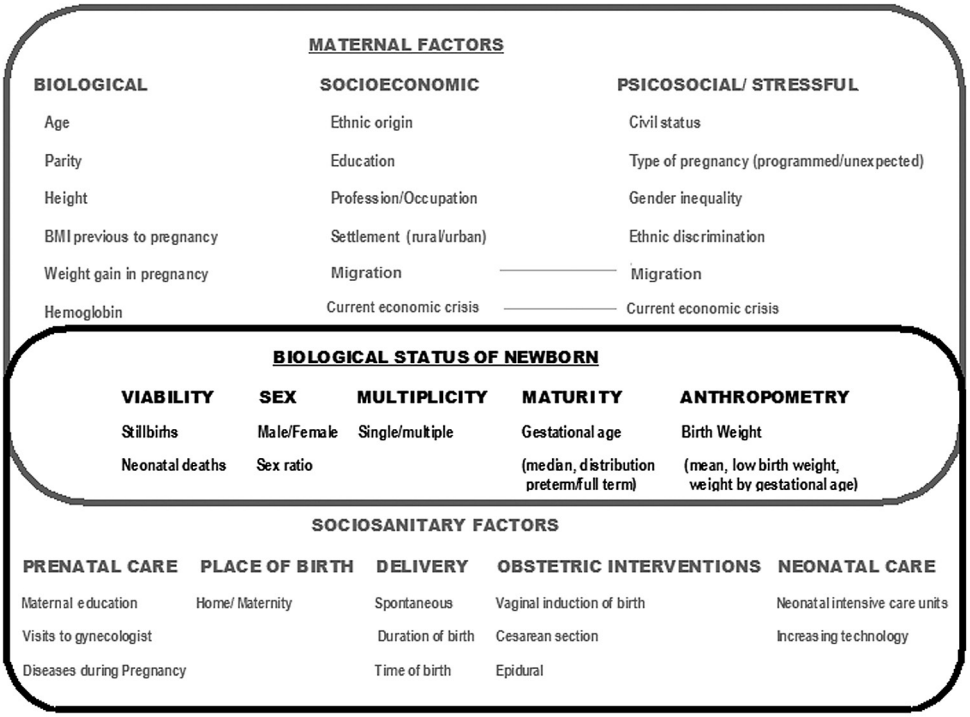

Fig. 1. Main factors related to neonatal biological and health status and the maternal system

are linked to good results in more vulnerable women (Krieger et al. 2005). The fact that social support can improve the negative impact of psycho-social stress in more vulnerable women suggests that many long-lasting effects found in their children (Pike 2005) can also be reduced by interventions such as those similar to the ones used to prevent the effects of nutritional stress, smoking and infection.

There is a wide consensus based on evidences establishing which indicators should be used to evaluate the mother's physical state and which interventions are needed for optimal foetal development (WHO 2006). However, it is harder to agree on useful indicators for evaluating psycho-social stress and its effects on foetal development, although the role of class, ethnicity, and gender is important, especially in countries which – like Spain – have recently registered important changes in these categories. Birth weight is the most used anthropometric indicator for evaluating the optimality of foetal development through three basic estimates which offer different but complementary information: a) mean birth weight, which is useful for comparing changes over time in foetal growth and population diversity (WHO 2006); b) the incidence of low birth weight, which is the indicator with most information in most countries and is useful for evaluating the population's health, as well as variability and temporary trends (WHO/Unicef 2004; Wardrow et al. 2004); and c) weight depending on gestational age, which is the most complete indicator both from a public health and a bio-anthropological point of view, as it allows an evaluation of the dynamics of foetal development and temporary changes, and the preparation of population reference tables (Lubchenco el at. 1963; Overpeck el at, 1999; Terán 2013). But it is not only maturity which is important. Gestational age and its distribution are an essential indicators of perinatal health, strongly recommended by international organisations (EURO-PERISTAT Project with SCPE and EUROCAT 2013; March of Dimes, PMNCH, Save the Children, WHO 2006; WHO 2012). Despite this information is still scarcely recorded in international databases, recent results have shown differences in the distribution of gestational ages between populations, sexes and ethnic groups (Gage 2000; Zeitlin el at. 2002; EURO-PERISTAT Project with SCPE and EUROCAT 2008; 2013).

In Spain, trends in perinatal biology and health occurring after 1995 show a great reduccion in late foetal and very early infant deaths (less than 24 hours), and an increasing rate in preterm and low birth weight babies for single births (Bernis 2010). In addition, multiplicity has increased substantially since the 1990's as a result of changes in the age of maternity and assisted reproduction (Varea et al. 2012). To analize this and other questions, our group started a research project in 2005 on the impact of migration on mother-infant health in Spain (*Plan Nacional de I+D+I 2004-2007, Exp. 06/31*), with special focus on birth outcomes of immigrant mothers in order to analyze these and other questions. Our preliminary results focused on recent secular trends in birth outcomes linked to ethnic variability (Bernis 2005; Bernis and Varea 2006, Bernis 2009; Varea 2010; Varea et al. 2010; Bernis and Varea 2012, Varea et al. 2012; Bernis et al. 2013), and have demonstrated ethnic differences in maternal and newborn characteristics, coinciding with other authors (Pérez-Cuadrado et al. 2004;

Alonso et al. 2005; Alonso 2008; Cabrera 2007). Spanish mothers are older, more often primiparous, and have higher rates of multiple births compared with immigrants, whereas Spanish babies presented lower mean weight and higher frequency of low birth weight than those of migrant mothers, but similar rates of prematurity (Bernis 2005; Acevedo 2005; Bernis and Varea, 2006, Bernis 2009; Acevedo et al. 2009; Bernis 2010; Varea et al. 2012; Terán 2013). However, the different trends followed by foreign mothers compared with those of Spanish mothers present a more complicated picture for interpretation.

Starting with these previous results and with the aim of evaluating possible consequences of the current economic crisis, this study investigates the temporal trends in the biology of neonates in Spain. First, we present the information for the population as a whole from 1980 to 2010, the frame needed to understand variability in neonates depending on maternal origin, which is restricted to the period 1996–2010. During this latter period, there are important changes in reproductive behaviour, in women's bio-psycho-social characteristics (including a large increase of foreign mothers), increased medical control of pregnancy and neonatal care, and an extreme rate of intervention during delivery, all of which may well be affected by the economic crisis. Using such considerations as a starting point, our general aim is to show the usefulness of analysing neonatal biology as an indicator of environmental quality, covering the following specific objectives:

(1) document recent temporal changes in neonatal biology (viability, maturity and birth weight) in Spain between 1980 and 2010;
(2) evaluate variability in neonatal biology and is temporal trend between 1996 and 2010, according to maternal origin;
(3) identify variables in the maternal and socio-sanitary systems which help to explain temporal changes and ethnic differences.in neonatal biology

Materials and methods

This work is based on all single births in Spain between 1980 and 2010 (N= 11,794,153). The data are provided by the *Boletín Estadístico de Parto* (Statistical Bulletin of Childbirth, SBC), a register of all births in the country whatever the nationality or legal status of residence of the parents, which is used to prepare national vital statistics on birth. Vital statistical data for each population clearly reflect their socioeconomic, demographic and sanitary characteristics, and allow us to simultaneously evaluate temporary tendencies for foetal viability, prematurity and birth weight (Alberman 1991; Kramer et al. 2001; Fenton 2003; Wen et al. 2004), as well as the maternal and socio-sanitary factors under consideration. Furthermore, their numeric volume means we can simultaneously stratify analysis by sex and maternal origin, and prepare national growth reference charts (Terán 2013). The information included in the second European Report on Perinatal Health (EURO-PERISTAT Project with SCPE and EUROCAT 2013) about birth weight and gestational age mainly emanates from national vital statistic records, including Spain. In their analysis of the validity of the data collected from birth certificates compared with hospital records, Di Giuseppe et al. (2002) found high levels of coincidence for pregnancy outcome variables analysed in this study,

specifically birth weight and gestational age. On the other hand, foetal ultrasound measurements are not considered very reliable and accurate in predicting the foetal weight.

A single database for the period concerned was created from the original annual archives of microdata in ASCII and analysed using the SPSS-19 statistics program. This included 98 variables on the parents, type of birth and the newborn for each birth. From 2007, information on birth type (Caesarean section or vaginal) was included in the SBC. Maternal, socio-sanitary and newborn characteristics were compared between Spanish and the three predominant groups of immigrant mothers in Spain: South Americans, Maghrebians, and Eastern Europeans. In this paper, the term *foreign* refers to non-native women who gave birth in Spain, immigrants without Spanish nationality, regardless of their legal residential status in the country. Foreign mothers had increased sevenfold over the previous 15 years, from 3.3% in 1996 to 20.8% in 2010 (with a 2008 maximum of 21.0%) (Table 1). The contribution of Maghrebian mothers to migrant births remain the highest and most stable over the period considered (from 23.8% in 1996 to 29.4% in 2010), South Americans have doubled their contribution (15.7% in 1996, 27.0% in 2010), and Eastern Europeans increased almost five-fold (from 3.8% to 19.3%). Moroccan, Romanian (overtaking Polish women from 2000 onwards) and Ecuadorian (since 1998) women are predominates within the three established groups of foreign mothers.

Because the rates of preterm, low birth weight and Caesarean sections area significantly higher in multiple births, and multiple birth rates are much higher in Spanish mothers, only single births are included in our analysis. Firstly, the secular trends in weight, maturity and sex ratio of all single births between 1980 and 2010 were evaluated by sex and early viability. Then the variability in neonatal biology according to maternal origin from 1996 to 2010 and its temporal trends were analysed. Finally, a multiple regression analysis on low birth weight in single births was performed to evaluate the influence of maternal, biological and socio-economic factors, adjusted for sex and maturity. This regression was performed for the economic crisis period (2007–2010).

Table 1. Temporal change in the distribution of Spanish foreign mothers (all births, Spain selected years)

Year of birth	Origin % (n)				
	Spain	South America	Maghreb	East Europe	Other areas
1996	96.7 (347,553)	0.5 (1,854)	0.8 (2,798)	0.1 (446)	1.9 (6,658)
2003	87.7 (381,662)	4.9 (21451)	2.6 (11,287)	1.7 (7,264)	3.1 (13,597)
2010	79.2 (378,912)	5.5 (26,268)	6.0 (28,620)	4.0 (18,835)	4.9 (23,483)
Total 1996–2010	87.3 (5,640,510)	4.1 (267,199)	3.1 (202863)	2.0 (121,684)	3.4 (220,691)

($\chi 2$=258,215.061, df=56, p=.000)

Results

Secular trend in the biology (weight, sex ratio, maturity) of newborns in Spain 1980–2010 by sex and early viability

Figure 2 shows secular trend in mean birth weight in all single births according to viability and sex. It reveals a temporal decrease in mean live birth weight for the entire study period, while late foetal deaths and deaths of newborns less than 24 hours old share a slight tendency to decrease birth weight until the mid-1990's. The three groups differ in mean birth weight and sex differences. Thus, mean birth weight for stillborns and live-birth deaths less than 24 hours was much lower than that for live births surviving more than one day over the entire period. The mean birth weight for stillborns between 1980 and 1996 was always less than 2,500g, but still almost 500g more than for those who died in less than 24 hours, which mean approximately 2,000g. Weights for both groups converged at approximately 2,000g from 1996, with a reduction in birth weight for deaths in less than 24 hours from 2004, especially in males. Neither group of early deaths displayed sex differences.

Figure 3 shows secular trend in the rate of prematurity in all single births, which increased in live births surviving more than 24 hours, live birth deaths before 24 hours and in stillbirths. The prematurity rate in live births surviving more than 24 hours remained much lower than for the other two groups, although it almost tripled between 1980 and 2010. The rate for late foetal deaths and deaths within 24 hours was much higher than that for live births, affecting

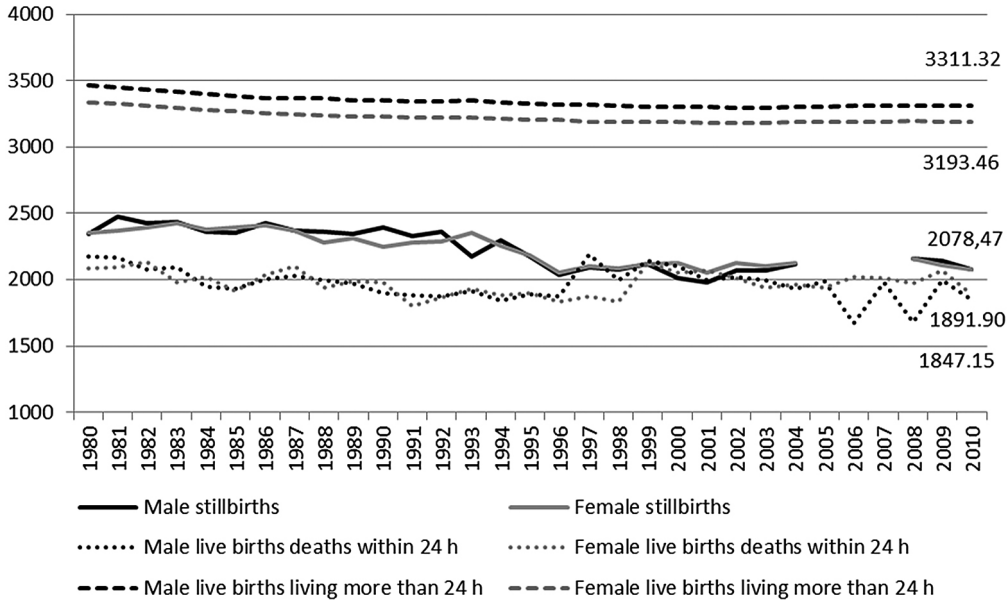

Fig. 2. Secular trend in birth weight according to sex and viability (single births, Spain 1980–2010)

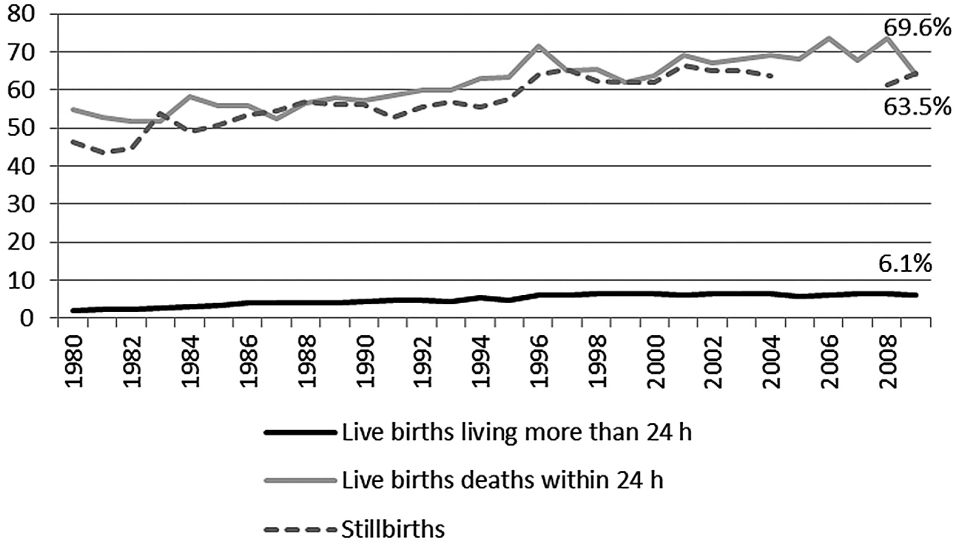

Fig. 3. Temporal trends in the rate of prematurity according to viability (single births, both sexes, Spain 1980–2010)

more than half the births at the start of this period and almost 70% at the end.

Figure 4 depicts the sex ratio and its secular trend in live births, stillbirths, deaths within 24 hours and deaths in less than one year. All groups recorded a more or less constant value in the study period. The secondary sex ratio was

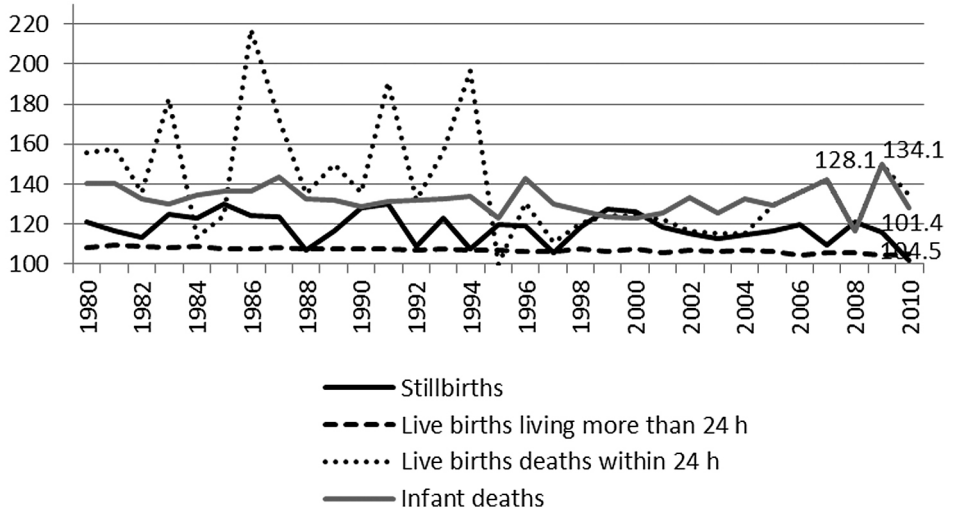

Fig. 4. Sex ratio of live births, stillbirths, deaths before 1 year and infant deaths (single births, both sexes, Spain 1980–2010)

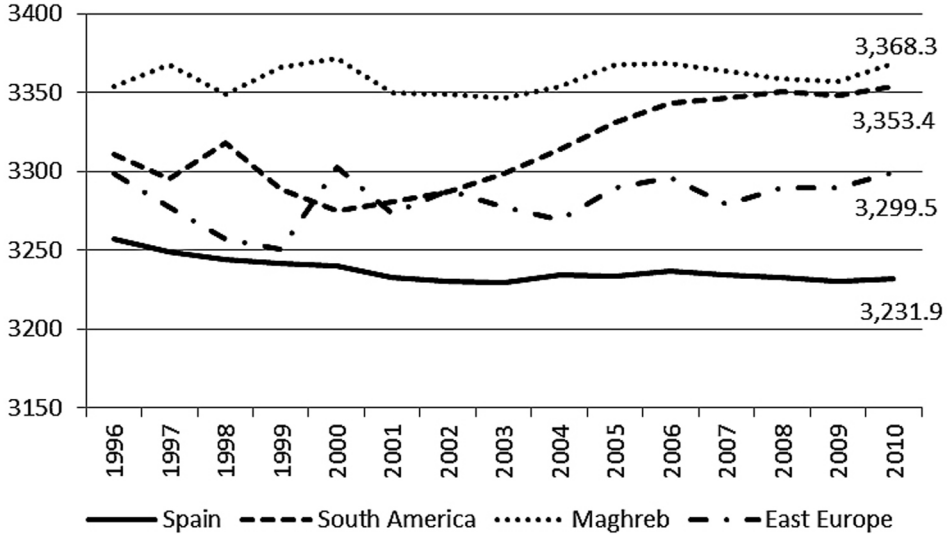

Fig. 5. Temporal change in mean birth weight according to mother's origin (single births, both sexes, Spain 1996–2010)
(Between groups variability 2010: F=960.52, df=3, $p<.001$. Within groups variability 1996-2010: Spain, F=85.234, df=14, $p<.001$; South America, F=39.82, df=14, $p<.001$.; Maghreb, F=2.311, df=14, $p<.01$; East Europe, F=2.667, df=14, $p<.01$).

much higher in live birth deaths within 24 hours and for infant deaths in general, whereas in stillborns it was closer to that for live births surviving more than 24 hours and decreased to 101.4% in the last year examined.

Secular trend in biology (weight, gestational age and weight at gestational age) of newborns from 1996–2010 by maternal origin

Figure 5 shows ethnic differences and its secular trends in mean birth weight in live single births. Newborns of Spanish mothers had lower birth weight for the entire period showing a slightly tendency to reduction. Maghrebian live births had the highest mean birth weight, virtually constant throughout the period. The mean birth weight for newborns of Eastern European mothers also remained relatively constant, with values significantly higher than those for Spanish mothers but lower than in Maghrebian mothers. Finally, the South American newborn weights were also significantly higher than those for Spaniards, with a significant increase from 2001 to almost equal Maghrebian newborns at the end of this period.

The incidence of low birth weight and its secular by ethnicity are compared in Figure 6. East European and Spanish mothers had the highest rates of low birth weight, which increased slightly between 1996 and 2008 in both groups and among Spaniards until the end of the study period. In contrast, Maghrebian and South American neonates had the lowest rates and more constant trends in the incidence of low birth weight.

Figure 7 shows the incidence of prematurity and its secular trend by maternal origin. East European and South American mothers present the highest

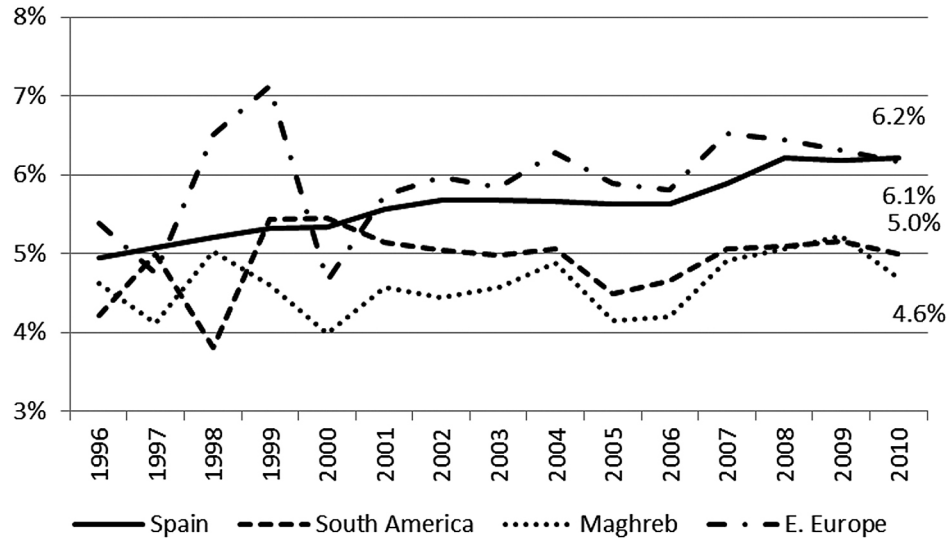

Fig. 6. Temporal change in the rate of low birth weight according to mother's origin (single births, both sexes, Spain 1996–2010)
(Between groups variability 2010: χ^2=141.965, df=3, p <.001. Within groups variability 1996-2010: Spain: χ^2=1433.02, df=14, p <.001; South America: χ^2=35.031, df=14, p <.001; Maghreb: χ^2=52.569, df=14, p <.001; East Europe: χ^2=24.201, df=14, p <.05).

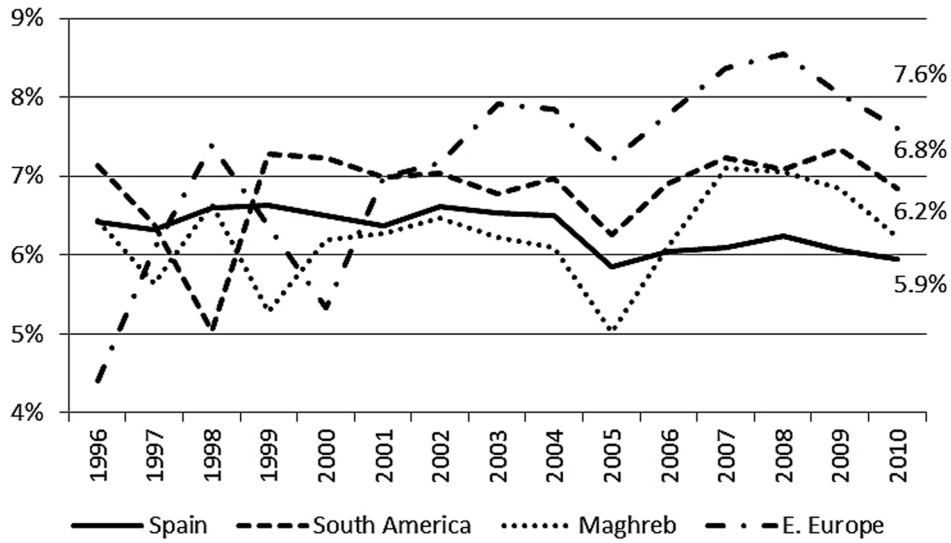

Fig. 7. Temporal change in the rate of prematurity according to mother's origin (single births, both sexes, Spain 1996–2010)
(Between groups variability 2010: χ^2=89.898, df=3, p <.001. Within groups variability 1996-2010: Spain, χ^2=509.905, df=14, p <.001; South America: (χ^2=42.149, df=14, p <.001; Maghreb: χ^2=80.068, df=14, p <.001; East Europe: χ^2=53.488, df=14, p <.001).

Table 2. Temporal change in the distribution of gestational age according to mother's origin (single births, Spain 1996–2010)

Gestational age	Spanish mothers		Foreign mothers	
	1996 % (n)	2010 % (n)	1996 % (n)	2010 % (n)
<=33 weeks	1.5 (4.215)	1.4 (4.436)	2.0 (79)	2.0 (1.039)
34–36 weeks	5.0 (14.155)	4.5 (14.189)	4.5 (182)	4.9 (2.582)
37–38 weeks	17.5 (50.151)	22.5 (70.253)	15.8 (635)	22.1 (11.696)
39–41 weeks	70.8 (202.300)	68.8 (215.162)	71.5 (2.868)	67.6 (35.737)
>=42 weeks	5.3 (15.062)	2.8 (8.756)	6.1 (245)	3.4 (1.796)

Spanish mothers,1996–2010: χ^2=17,380.129, df=56, p=.000; Foreign mothers, 1996–2010: χ^2=2,121.140, df=56, p=.000).

rates along the analyzed period contrasting with Maghrebians, who present the lowest until 2005, when it increases approaching the values of the other two foreign groups. In contrast, Spanish mothers maintain a low incidence along the period. All groups experience a decrease in the last 2 o 3 years of the analyzed period.

Table 2 and Figure 8 show the temporal change in the distribution of gestational ages for Spanish and foreign mothers. Both groups share the reduction of pregnancies after 38 weeks, and the increase of those between 37 and 38. However, they differ in the tendencies relative to the so called "late preterms" (34–36

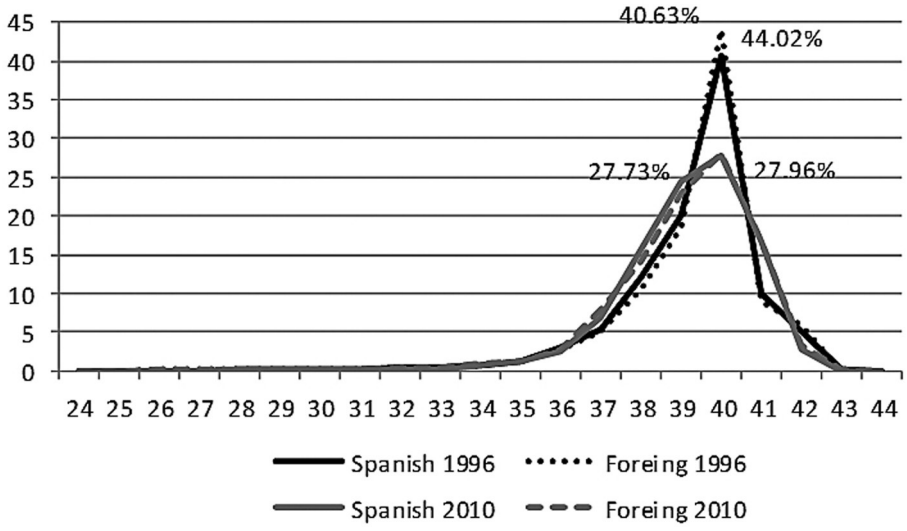

Fig. 8. Temporal change in the distribution of gestational age according to mother's origin (single births, both sexes, Spain 1996 and 2010)

weeks), slightly reduced in the Spaniards and increased for the foreigners. As a result of this shift to the left in the distribution, the median gestational ages for Spanish and foreign newborns are reduced from 40 weeks to 39 after 2003.

Finally, weights by gestational age for Spanish and foreigner foetus in 1996 and 2000 were compared to evaluate the dynamics of foetal growth by sex (Figures 9 and 10). Male newborns of foreign mothers had in 1996 lower weights

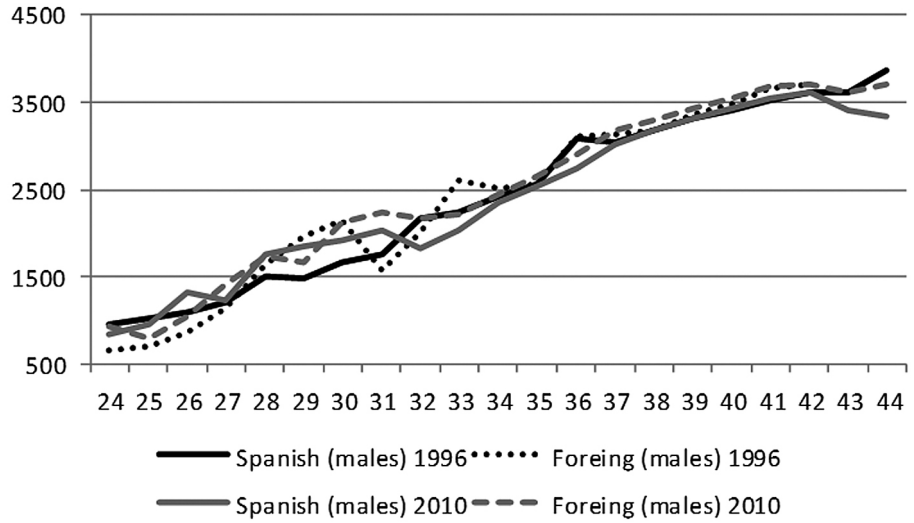

Fig. 9. Temporal change in weight for gestational age according to mother's origin (males, single births, Spain 1996 and 2010)

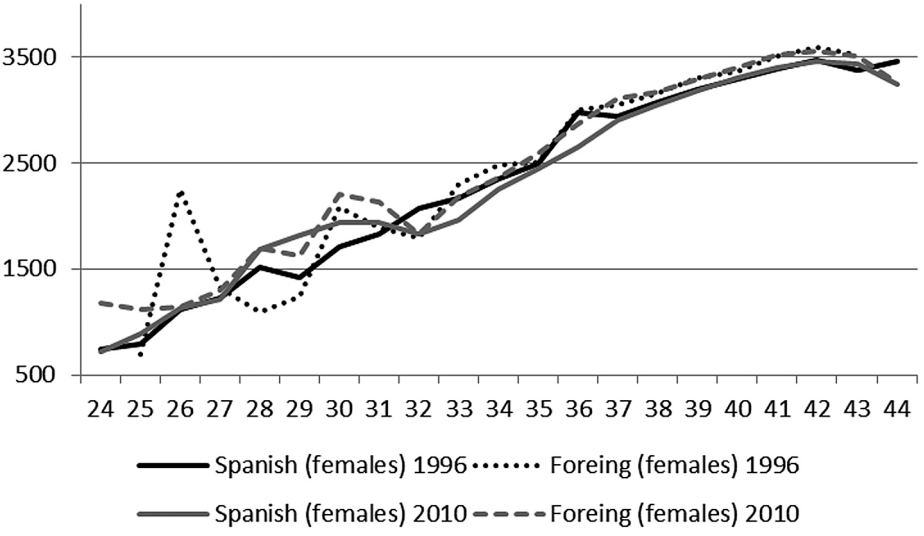

Fig. 10. Temporal change in weight for gestational age according to mother's origin (females, single births, Spain 1996 and 2010)

than their Spanish counterparts for all gestational ages (Figure 9); no secular change between 1996 and 2010 have been detected for Spanish full term newborns, whereas birth weight for foreign newborns increased significantly between 1996 and 2010 overtaking that of the Spaniards. In contrast with male foetus, the birth weight of foreign newborn females in 1996 did not differ to their Spanish counterparts (Figure10). However, as was the case for males, the weight by gestational age for Spanish female foetuses did not change significantly between 1996 and 2010, while foreign female foetuses increased their weight by gestational age during this period. A surprising increase in weight at gestational age between weeks 27 and 33 was detected for both newborns

Table 3. Results of logistic regression analysis for the relative effect of maternal and birth variables on low birth weight (single births, Spain 2007–2010)

Newborn, labor and maternal characteristics (reference category)	Low birth weight (<2,500 g) 2007–2010		
		95% CI	
	Exp (B)	Lower limit	Upper limit
Year of birth (2007)			
2008	1.090***	1.066	1.116
2009	1.100***	1.075	1.125
2010	1.068***	1.044	1.092
Occupation (Professionals)			
Skilled workers	1.106***	1.079	1.134
Primary and tertiary sectors, and non-skilled workers	1.296***	1.264	1.329
Housewifes and students	1.375***	1.338	1.413
Origin (Spain)			
South America	.653***	.629	.677
Maghreb	.657***	.627	.688
East Europe	.797***	.763	.832
Maternal age (>34 y)			
<20 y	NS	.995	1.099
20–27 y	.923***	.900	.946
28–34 y	.896***	.880	.913
Parity (Primiparous)			
Multiparous	.696***	.685	.708
Sex (Male)			
Female	1.440***	1.418	1.463
Maturity (Full term)			
Preterm	28.893***	28.413	29.381
Caesarean section (No)			
Yes	1.573***	1.546	1.600
Constant	.025***		

(N=1,355,990; χ^2=229,950.18, df=17, p=.000; percentage correct=94,04%).

of Spanish and foreign mothers and for both sexes.

Evaluation of the contribution of socio-maternal factors on varying birth weight (adjusted for foetal characteristic, 2007–2010)

Table 3 summarizes logistic regression analysis performed to explain the contribution of maternal origin and medical intervention (Caesarean section yes/no), after adjustment for the year of birth, maternal, social and reproductive characteristics, and maturity. The model explains 38.1% of variability in birth weight, and low birth weight outcome (yes/no) was significantly associated with all independent variables. There was a significant increase in the risk of low weight for the three years following the 2007 reference year. Compared with the oldest maternal age group (>34), the risk of having low birth weight babies significantly reduced for mothers aged 20–27 and 28–34, while adolescent mothers (<20) had no significant differences to the reference age group. Compared with professional and with better off women, other occupational groups had significantly increased risk of low birth weight babies. Primiparous women had significantly higher risk of having low birth weight babies compared to their multiparous counterparts. Compared with Spanish women, all three immigrant mother groups had significantly lower risk of having low birth weight babies. Finally, Caesarean section interventions significantly increased the risk of having low birth weight babies.

Discussion

In Spain, as in other Western populations, the change in the environmental conditions affecting pregnancy and birth outcome has been remarkable from the beginning of the 20th Century, affecting the maternal system determinants (Bernis 2009; Varea, 2009; Varea et al. 2012), the socio-sanitary system (Bernis and Varea 2012; Bernis et al. 2013; Varea et al. 2012) and different aspects of neonatal biology, which are jointly examined in this study (sex ratio, mortality rate, weight, gestational age and sex differences). Sex differences show that males present higher birth weight, lower gestational age and a greater contribution to live births and early infant deaths. Thus, from 1980 to 2010, (a) the sex ratio for births remains constant at around 105 males to 100 females, and (b) the sex ratio for stillbirths remains at around 115 (except during the last year analyzed), while for deaths within 24 hours and for all infant deaths the male contribution is much higher (around 145 and 125 respectively). Over this period, mean birth weight reduces both for live births surviving more than 24 hours (also showing significant sex differences) and for stillbirths and live births deaths within 24 hours (were sex differences disapear). These latter two groups show much lower mean values than live births and until 1996 the weight of those who died within 24 hours remains significantly lower than that of stillbirths. Prematurity increases in the three birth outcome groups, almost tripling (from 2.1 in 1980 to 6.1 in 2010) among live births surviving more than one day. From 1980 there is a constant reduction in mortality for all ages, especially pronounced for those diying before 24 hours, who at the beginning of the period presented the highest contribution to infant deaths (followed by age group 28–364 days: Bernis et al. 2010) and since 1996 the lowest.

As regards sex differences in weight and its secular trend, it is important to highlight that mean birth weight decreased in live births in both sexes over the entire period, while it decreased in stillbirths only until 1996 and then increased and remained at a similar value as that for deaths within 24 hours. Prematurity also increased for all births in Spain between 1980 and 2010, both for live births surviving more than 24 hours and stillbirths, and for live births deaths within 24 hours. In conjunction with the marked reduction in foetal deaths and deaths within 24 hours, these results stressed the role played both by progress in neonatal assistance and by increasingly interventionist delivery protocol.

From 1996 not only is there an increase in the contribution of foreign mothers to births in Spain (as indicated, from 3.3% in 1996 to 20.8% in 2010), but also important aspects of the maternal system are changing in the Spanish women (later age of first birth, increased primiparity and reduced birth interval, and an increase in the number of professional women who keep working during and after maternity) (Varea 2009; Varea et al. 2012). According to Gluckman and Handson (2004) maternal system is the major non-genetic factor determining the size of the foetus at term, and some mechanisms of action have been suggested. For example, primiparity limits the capacity for vascular dilation in the uterine vasculature, reducing the physiological possibilities for foetal nutrition (Naeye 1983), and late age of first maternity is associated with preterm births, partly because of greater recourse to assisted reproduction with an increase in multiple births, and also because they are more often treated with obstetric interventions which bring forward births that could have taken place at the end of pregnancy (Joseph et al. 2002).

The results of the regression analysis show how primiparity and maternity ages of over 30 increase the risk of low birth weight. It is also interesting that a greater risk of low weight in births by Caesarean section has been found. The regression also shows that newborns of women with a greater socio-economic level are protected from the risk of low birth weight compared to all the other levels. This is particularly interesting when we observe that newborns of foreign mothers, whose socioeconomic level is much lower than for Spanish women, nevertheless show higher mean birth weight and a lower risk of low birth weight (aspects which we will look at later).

As for ethnic differences detected in the biology of neonates, the fact that newborn of Spanish mothers present lower mean birth weight during all analyzed period as well as higher incidence of low birth weight than the offspring of all the immigrant groups is quite remarkable, especially if we take into account that among Spanish neonates there is no significant increase in prematurity over this period, whereas there is for those of East European, South American and even Maghrebian mothers. The increase in mean birth weigth among neonates from South American women is accompained by an increase in their weight by gestational age between 1996 and 2010. All immigrant groups share with Spanish mothers a reduction in longer gestations in favour of a 37 and 38 weeks of gestation. In the case of newborn from South American mothers, their temporal increase in weight by gestational age may be linked to changes in dietary patterns, especially to an increased intake

of energy (as consequence specially of the consumption of fats), which has also been detected in their developing countries of origin (Popkin 2001). The risk of these neonates to develop later metabolic and cardiovascular diseases needs to be evaluated. It is interesting to point out that this increase in birth weight is significantly greater in males, whose biological characteristics determine their increased rate of early death, premature birth and distocic births (Bernis 2010), and their greater sensitivity to environmental factors (James 2000; Zeitling et al. 2002; Catalano and Bruckner 2006), both for good and for bad environmental conditions. Maghrebian and East European descendants maintain higher mean birth weight for all the period than their Spanish counterparts. This situation, in which immigrant groups in worse social conditions delivered higher birth weight babies than the national hosts, was previously found in the USA, especially among Mexicans (Buekens et al. 1998; Cervantes et al. 1999; Gould et al. 2003), and also among Maghrebians in several European countries including Spain (Acevedo 2004; Prado et al. 2004; Vahratian et al. 2004; Bernis and Varea 2006; Bernis 2010; Varea 2009). However, the incidence of prematurity inverts, being higher among immigrant groups and showing a marked increase until 2008 not shared by Spanish mothers. Previous results comparing Maghrebian and Spanish women who gave birth in a large maternity hospital in Madrid (Bernis 2009) indicated that the Maghrebian group showed the worst socioeconomic indicators, the worst pregnancy control, and significantly higher frequencies of nausea and foetal distress, although the weight of their newborns remained significantly higher. Maghrebian mothers are characterized by the highest frequency of housewives, lowest rates of smokers, and high BMI values, circumstances explaining their higher birth weights and that could increase their risk for metabolic disorders (Roville-Sause and Prado 2004; Guihard-Costa and Papiernik 2004; Bernis 2009; Acevedo et al. 2010). Important differences in the mode of delivery were also detected, with fewer epidural and Caesarean sections than in Spanish and the other foreign groups, whereas they show significantly more episiotomies and instrumental births (Bernis et al. 2013).

Analysis of weight by gestational age shows that among offspring of Spanish mothers there was no change for weeks 34 to 42 between 1996 and 2010, while there was an increase for neonates of foreign mothers, especially males. This fact implies that the decrease in mean birth weight in descendants of Spanish mothers between 1996 and 2010 is not due to the increase in prematurity, but is rather a consequence of the change described in the distribution in the gestational age: a decrease in those born with 39 or more weeks and an increase in the ones born with 37 and 38 weeks, which are full term pregnancies but whose mean weight is significantly lower than those who reach week 39 or more. This fact coincides with what is happening in the USA, where the median age of gestation in single births has fallen from week 40 to 39 (Daviddof et al. 2006), a fact linked to a change in behaviour regarding moment of birth, highlighting an increase in births at less than 39 weeks due to maternal or medical decisions. Recent findings (Hoffmire et al. 2011) show that full term children born before week 39 (either vaginally or by Caesarean section) as a result of maternal or medical decision need to be send to ne-

onatal intensive care units more frequently than children born naturally at the same gestational age. Linking these results with those of the logistic regression for the period 2007–2010, which show that migrant mothers are at a significantly lower risk of having low birth weight neonates compared with the Spanish, allows us to conclude that immigrant mothers have not been contributing to the increase of low birth weight in Spain (Varea et al 2012; Terán 2013) despite having higher rates of preterm deliveries throughout the analyzed period. In Spain the reduction in median gestational age shared by both Spanish and immigrant mothers may be linked to the increase in induced deliveries (González-González 2009), but we need to explain why prematurity increases only in immigrant mothers (especially from 2007) while mean birth weight is not affected or even increases (as is the case among South American mothers). Previous studies (Bernis 2009) which examine stress situations and neonatal biology in Spain showed that unwanted pregnancies, the presence or lack of a partner, and maternal origin are significantly linked to the increase in prematurity, and that the proportion of unwanted pregnancies among Spanish women is much less than among immigrants (10% for Spanish, 12% for East Europeans, 25% for Maghrebians and 33.5% for South Americans). The increased risk of prematurity among unplanned, unwanted, and mistimed pregnancies has been pointed out by others (Shah et al. 2011; Orr et al. 200), and shows that increased stress, psycho-social problems, economic disadvantages and lack of prenatal care may explain the discrepancies found in the outcome of unplanned pregnancies (March of Dimes, PMNCH, Save the Children, WHO 2012).

Conclusions

1. Secular trends observed in the biology of new born are excellent indicators of environmental change. Its evaluation as continuous traits – beyond the cut-off points established for neonatal risk – will contribute positively to outline prevention programmes of perinatal health, and to improve the interpretation of their results.
2. In general, the biological state of newborns in Spain between 1980 and 2010 is good. However, together with positive changes (such as a decrease in foetal and perinatal deaths, and the decrease in male contribution to perinatal deaths and infant mortality as a whole), negative aspects were also detected, specifically a decrease in mean birth weight, and an increase in low birth weight and prematurity.
3. The observed decrease in male contribution to live births (and especially to perinatal and infant mortality) is modifying an important demographic aspect: the age at which sex ratio is 1:1, which in Spain before 1950 was 16 years, in the seventies was 25 years, and nowadays is 41.
4. Changes in maternal biosocial characteristics (delayed maternity, small families, higher education, stressful situations associated to difficulties in conciliate familiar and working responsibilities, etc.) are directly associated with increased risk of preterm, low birth weight and other negative biological aspects of new born, but also indirectly to finish pregnancies before full time, as they are significant factors responsible of the increasing number of medical decisions.

5. Significant ethnic differences exist both in the indicators (birth weight, maturity and weight by gestational age) and in their secular trends. On the whole, we can assert that mean values and trends for mean weight and low weight are worse for Spanish newborns than for immigrants, although the latter show a higher rate of prematurity.
6. Among migrant mothers weight by gestational age increased between 1996 and 2010 (especially in South Americans) coinciding with an increase in mean birth weight, despite they also present a similar tendency in the median and the distribution of gestational age. The findings on birth weight suggest an improvement in nutrition and living conditions as compared to their country of origin (although is important to remember that the country of origin of the South American and East European mothers has changed during the analysed period). The findings on the shift to left of the gestational age distribution suggest that medical decisions on obstetric interventions are similar in Spanish and foreign mothers.
7. Migrant mothers have not been contributing to the observed reduction in mean birth weight and increase in low birth weight in Spain between 1996 and 2010.
8. Obesity prevention programmes directed towards the population of Spain, which currently consider nutritional prevention, should take into account the evidence that stressing situations during foetal development, associated with low birth weight, lead to an increase in central obesity. The development of overweight and obesity among the offspring of foreign women needs to be evaluated and prevented.

Final reflection

Tracking the hallmark of adaptive responses incorporated in the biology of contemporary populations is of value to medical sciences (Wells et al. 2012), contributing for instance to clarify whether the current excess in medical intervention during labor is negatively affecting the natural basis for human reproduction (Martin 2007; Varea and Bernis, 2013).

Acknowledgements

This paper has been written as a part of the research project *The impact of migration on maternal-infant health from a gender perspective*, funded by I+D+I National Plan (2006-2008), Exp. 06/31, Ministerio de Sanidad y Política Social (Spain).

Author contribution

Both authors equally contributed to this paper.

Conflict of interests

The authors declare that there is no conflict of interests.

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