REGIONAL DIFFERENCES IN LOW BIRTH WEIGHT IN SPAIN: BIOLOGICAL, DEMOGRAPHIC AND SOCIOECONOMIC VARIABLES

VICENTE FUSTER, PILAR ZULUAGA, S. E. COLANTONIO and J. ROMÁN-BUSTO

Journal of Biosocial Science / Volume 47 / Issue 01 / January 2015, pp 90 - 104
DOI: 10.1017/S0021932014000030, Published online: 14 February 2014

J. Biosoc. Sci., (2015) **47**, 90–104, © Cambridge University Press, 2014
doi:10.1017/S0021932014000030 First published online 14 Feb 2014

REGIONAL DIFFERENCES IN LOW BIRTH WEIGHT IN SPAIN: BIOLOGICAL, DEMOGRAPHIC AND SOCIOECONOMIC VARIABLES

VICENTE FUSTER*[1], PILAR ZULUAGA†, S. E. COLANTONIO‡ AND J. ROMÁN-BUSTO*

**Department of Zoology and Physical Anthropology, Faculty of Biology, Complutense University of Madrid, Spain, †Department of Statistics and I.O., Faculty of Medicine, Complutense University of Madrid, Spain and ‡Anthropology Unit, Faculty of Mathematical, Physical and Natural Sciences, National University of Córdoba, Argentina*

Summary. The geographic and demographic dimensions of Spain, in terms of surface and number of inhabitants, and its heterogeneous socioeconomic development offer an adequate opportunity to study the provincial differences in birth weight from 1996 to 2010, focusing on possible factors determining the relative frequency of low birth weight. The study analysed geographic differences with regard to biological, demographic and socioeconomic factors that interfere with the female reproductive pattern. The variables considered here were: birth order, proportion of premature deliveries, mother's age, multiparity, mother's country of origin and professional qualifications. Two periods (1996–2000 and 2006–2010) were compared by means of principal components analysis. An increase in the relative frequency of deliveries weighing less than 2500 g occurred in most of the 52 geographic units studied, differences being significant in 42. Only in five cases was there a non-significant reduction in the proportion of low weight births. The first component after principal component analysis indicated that low birth weight was positively related to maternal age and to multiple deliveries, and negatively to the mother's low professional qualification. The second component related positively to the incidence of premature deliveries and to non-Spanish status and negatively in the case of primiparous mothers. The progressive increase in low birth weight incidence observed in Spain from 1996 onwards has occurred with considerable variation in each province. In part, this diversity can be attributed to the unequal reproductive patterns of immigrant mothers.

[1] Corresponding author. Email: vfuster@ucm.es

Introduction

Birth weight variation is caused by changes in physiological, nutritional and socio-cultural variables involved in the reproductive pattern of women (Wells, 2002; Kirchengast & Hartmann, 2003a, b). For each parity, the influence of maternal age on birth weight depends on the proportion of preterm or at-term low birth weight (LBW) deliveries (Ferraz *et al*., 1990; Kramer, 2003). Heterogeneity among some of these variables and in the proportion of multiple births, causing low weights at birth (Joseph *et al*., 1998; Moshin *et al*., 2003), is expected to be found regarding mother's origin (Bernis, 2006; Lim, 2011; Tsimbos & Verropoulou, 2011). Diverse associations of maternal origin with birth weight have been reported (Urquia *et al*., 2010). In some cases, the association was favourable (Kramer *et al*., 2000; Acevedo-García *et al*., 2007; Gagnon *et al*., 2009; Verropoulou & Tsimbos, 2013). In other studies, mothers with origins such as Africa and south Asia showed low birth weights (Wen *et al*., 1995; Bernis, 2006). In the USA it has been reported that mothers of foreign origin and recently immigrated tend to be more vulnerable to disease than native mothers (Reeske *et al*., 2011) of younger age at delivery, and are more often multiparous. They usually consist of mothers with low social status (Reeske *et al*., 2011), with varying levels of early schooling and engaged in manual jobs (García-Subirats *et al*., 2012).

Not all maternal characteristics influence LBW in the same way across ethnic groups. Access to maternal health care, health status and health behaviours have direct associations with LBW regardless of a family's financial status (Sparks, 2009). Equal access to adequate prenatal care – thus eliminating the disparities among these groups – may further reduce low birth weight variability (Sparks, 2009). Neighbourhoods with higher percentages of migrants from developing countries are also poorer, whereas neighbourhoods with less poverty are chosen by immigrants from developed countries. With regard to maternal origin, a migrant background might be determined by other underlying variables such as cultural factors, social deprivation and access barriers (Reeske *et al*., 2011). However, these variables could not be controlled in the present study. Some revealing evidence on the role of acculturation comes from studies conducted on Mexican-Americans in the USA. Inhabitants of localities grouping immigrants from the same origin are more likely to maintain cultural features that may protect against adverse birth outcomes than their counterparts from foreign localities (El-Sayed & Galea, 2010). According to English *et al.* (2003), communities that experience rapid change – including high population growth, population mobility, social discord and economic pressures – may have poorer reproductive results than stable neighbourhoods, due to an increase in stress and the collapse of personal support networks.

Significant changes in women's patterns of reproduction have been recently reported in Spain, influencing the number of births, birth weight and premature deliveries (Luque *et al*., 2011). Fuster *et al*. (2013) analysed the change of low birth weight (LWB) over time (1980–2010) considering the mother's age at reproduction, the predominance of primiparous maternities and the role played by non-Spanish women in the LWB variations. In that analysis a temporal variation in LWB was reported as a function of a varying reproductive pattern determined by women's geographical origin.

The results obtained by Fuster *et al*. (2010) on the temporal and territorial analysis of multiple deliveries in Spain indicated that geography was a valuable factor deserving

specific consideration in the study of birth weight. Spain is a country of sufficiently large territorial and demographic size to permit important socioeconomic heterogeneity which could, for example, condition access to reproductive treatment and therefore have an influence on multiple delivery rates, which in turn could affect the birth weight in each province in different ways.

The present study, in contrast to that of Fuster *et al.* (2013), analyses the influence of biological and socio-demographic variables on birth weight, considering both single and multiple deliveries, not for Spain as a whole, but separately for the existing 52 administrative units, each of them showing presumable socio-economic diversity and differential immigration rates.

In Spain control of the National Health Service corresponds to government of the seventeen autonomous communities or regions. These regions are composed of a variable number of provinces ranging from only 1, such as Madrid (code 28 in Fig. 2), to as many as 9 provinces in the Castile-León region (codes 5, 9, 24, 34, 37, 40, 42, 47 and 49). Although the Public Health Service provides universal coverage for pregnancy care, Cano-Serral *et al.* (2006) reported that women belonging to the manual labour class were less likely to attend obstetric clinics during pregnancy and more likely to ignore medical recommendations regarding the avoidance of social practices detrimental to health than were professional women. Mothers with low educational level, belonging to a low income class, were at a high risk of having low birth weight babies, premature or small in size for their gestational age (García-Subirats *et al.*, 2012).

The factors mentioned above may have varying influence on birth weight when small-scale geography is considered. For this reason, the present study focuses on the comparison of the proportion of LBW deliveries ($<$2500 g) among the Spanish provinces. Although the definition of LBW ($<$2500 g) has been described by Wilcox (2001) as arbitrary and the use of population-specific birth weight standards is recommended, LBW was preferred for this consideration of geographical influence because the proportion of LBW deliveries shows more geographic variation than the average birth weight. For the latter, geographic differences are balanced by the opposite change in the frequencies of newborns of low weight and overweight. Some researchers have recently treated separately the extreme categories of birth weight, distinguishing between very low birth weight (VLBW $<$1500 g) and LBW (1550–2500 g) (Chiavarini *et al.*, 2012; Verropulou & Basten, 2013). However, LBW is still considered the most prevalent and dominant risk factor for infant mortality and childhood development disorders, making it a serious problem worthy of efforts to solve it (Thompson *et al.*, 2005). Moreover, although costs per infant hospitalization are highest for extremely preterm infants, the larger number of moderately preterm and LBW infants is responsible for most these expenses (Russell *et al.*, 2007).

The geographic and demographic dimension of Spain in terms of surface and number of inhabitants and the existing provincial heterogeneity with regard to economic activity (some regions surpassing the European Union average and others falling far below it), as well as the diversity in international immigration and socio-cultural patterns, provide sufficient opportunity for studying the regional variations in the relative frequency of LBW. The objective of the present study was to determine the geographic extent of variation in low birth weight rates in the Spanish provinces from 1996 to 2010, and identify those regions with significantly high frequencies. In order to achieve this, the interactions

of individual maternal variables, as well as some socioeconomic factors, were studied. The research is not limited to single-year deliveries but groups them by periods, thus avoiding random deviation in the annual number of provincial deliveries. Since the aim was to determine whether some of the factors influencing birth weight modified with time (for instance as a consequence of fluctuating number of immigrants arriving), the analysis distinguished two periods of time (1996–2000 and 2006–2010). The average birth weight was discarded as the variable of interest; instead the study focused on the incidence of low weight births because LBW was considered a good indicator of inter-province diversity attributable to the possible diversity of the variables included in the study; moreover, LBW newborns are systematically receptors of specific postnatal hospital attention as imposed by the paediatric protocols.

Methods

Data source

Data were obtained from the Spanish National Institute for Statistics (INE) and consisted of records of live births in annual text format from 1996 to 2010. From this, a SPSS file was constructed containing 6,446,015 individual records of deliveries. The present analysis was carried out for 52 geographic units comprising the 50 provinces and the autonomous cities of Ceuta and Melilla (north Africa).

Case selection

Only live births were included, and still-births and birth weights below 400 g were discarded. The same selectivity has been applied by other authors (Moshin *et al.*, 2003). The shortest gestation age found in the database was 21 weeks; however, in Spain gestations shorter than 26 weeks are not necessarily registered by the INE. What may be considered an underestimation because of this difference in gestational ages is unimportant because of the selection criteria applied here. The result was a final sample of 5,331,855 valid birth records after the application of the following criteria for case selection:

a) Duration of gestation $\geq$21 weeks.
b) Birth weight $\geq$400 g.
c) Live birth.
d) Maternal residence in any of the 50 Spanish provinces plus Ceuta and Melilla.
e) Parity (number of live births, including the present delivery): 1–17.
f) Mother's age at delivery $<$55 years.

Variables

In the following analysis of possible regional patterns affecting the incidence of low birth weight in Spain, variables were defined as follows:

a) Sex of the newborn: males; females.
b) Multiparity: single; double, triple or quadruple.
c) Parity or birth order, grouped as: first delivery; second or subsequent children.

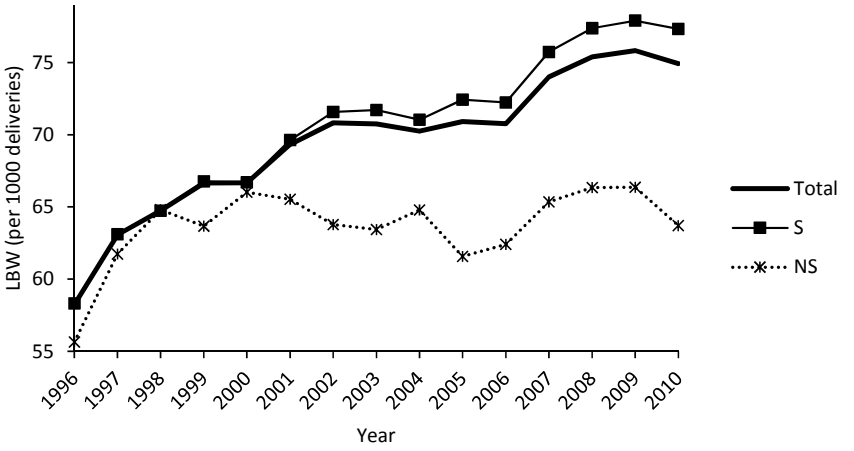

Fig. 1. Yearly relative frequency in Spain of low birth weight per 1000 deliveries. All deliveries (total), and according to mother's origin: Spanish (S) and non-Spanish (NS).

d) Four groups were established for duration of gestation: extreme premature ≤ 31 weeks; premature 32–36 weeks; normal 37–41 weeks; post-term ≥ 42 weeks.
e) Low birth weight: <2500 g.
f) Maternal age: ≥ 35 years.
g) Maternal origin was reduced to two categories: Spanish and foreign. Because the present study separates information into 52 geographic units, the total number of LBW deliveries from immigrants in each unit, with the exception of the most populated, was insufficient to permit an analysis based on particular maternal origins.
h) For the mother's type of employment, the thirteen original categories established by the INE were reduced to four groups: unremunerated, benefit recipients, etc.; low qualification; intermediate qualification; high qualification.

The mother's marital status was not included in the analysis because at present in Spain a large number of deliveries are to unmarried couples.

Statistical procedure

The percentages of LBW were obtained and compared based on maternal origin by means of a χ^2 test of homogeneity for each year. To reduce unwanted bias due to a limited yearly number of deliveries in certain smaller provinces, data were then merged into three consecutive periods (1996–2000, 2001–2005 and 2006–2010), taking into account the national temporal tendencies shown in Fig. 1. Variables included in the analysis were based on their percentages in each province. Differences between the periods 1996–2000 and 2006–2010 for the variables listed above were reduced by principal component (PC) analyses. The new variables created from PC analysis were related to differences in the percentage of LBW between periods in each province. Inter-period provincial variation in the incidence of LBW was correlated (Spearman's ρ) with provincial

indicators representative of each of the two periods considered: yearly income, percentage of women engaged in paid activity, percentage of individuals out of work and health variables such as total number of hospital beds and beds according to medical speciality.

Results and Discussion

The relative frequency of LBW increased in Spain from 1996 to 2010 (Fig. 1). Comparing the percentage of Spanish to non-Spanish LBW, significant differences can be observed since 2001, with higher values in the Spanish group (all p-values <0.006). From 2006 onwards, the two groups follow different patterns in their values, but with a roughly similar annual trend (Fig. 1). This trend differs from that reported by Martin *et al*. (2010) showing for the USA a reversal in 2006 of the earlier tendency of the increase in the relative frequency of premature births. This rise was caused by demographic changes and other factors such as more frequent multiple births, induced labour and Caesarean delivery. Simo & Méndez (2013) indicated that the factors associated with fertility structure must be controlled when trying to relate birth weight differences between ethnic groups to socioeconomic factors.

To highlight more clearly the temporal evolution of LBW in each Spanish province with regard to the variables that may be significant, the following analysis compares only two periods separated over time: Period 1 (1996–2000) and Period 2 (2006–2010). Between one period and the other, the overall percentage of LBW increased from 6.4 to 7.4%. Minor differences in percentages can be observed between native and non-native mothers in the first period, becoming greater in the second. A similar tendency was reported in a study on Hong Kong births (Verropoulou & Basten, 2013), in which the chances for LBW showed a yearly increase of about 2%.

The variables that might influence LBW (Mariotoni & Barros Filho, 2000; Kramer *et al*., 2002; Kirchengast & Hartmann, 2003a; Moshin *et al*., 2003; Wardlaw *et al*., 2004; Acevedo-Garcia *et al*., 2007; Tsimbos & Verropoulu, 2011) have evolved from the first to the second period as follows:

- Multiple deliveries increased from 1.4 to 2.1%.
- The percentage of first deliveries rose from 52.0 to 53.5%.
- Premature newborns increased from 6.8 to 7.1%.
- The initial percentage of mothers aged 35 and older (20.3%) climbed to 29.4%.
- Percentages of mothers with low professional and job qualifications were elevated from 14.1 to 23.4%.

The variation of the above factors can be considered unfavourable regarding LBW. Table 1 shows the inter-period differences for each province (2006–2010 minus 1996–2000) in the percentage of LBW and their corresponding statistical significance according to the χ^2 test. Only five provinces (Alava, Balearic Islands, Guipúzcoa, Lérida and Vizcaya) had no increase in the percentage of LBW, but a decrease that did not attain a level of significance (see the p-value column in Table 1). The same table shows the inter-period differences (see the Gr column in Table 1) in the following categories: 1: negative but not significant; and 2: positive but not significant. Groups 3 and 4 are

Table 1. Inter-period provincial differences in low birth weight percentages and principal components, Spain 1996–2000 and 2006–2010

		Period 2 – Period 1			Principal component				Period 2 – Period 1			Principal component	
Province	Code	Diff.	Gr	*p*-value	First	Second	Province	Code	Diff.	Gr	*p*-value	First	Second
Álava	1	−3.130	1	0.152	1.174	1.040	Lugo	27	17.774	4	***	1.512	−0.281
Albacete	2	18.260	4	***	0.213	0.058	Madrid	28	6.377	3	***	1.035	0.267
Alicante	3	12.835	4	***	0.072	0.944	Málaga	29	15.219	4	***	−0.198	−0.544
Almería	4	6.078	3	0.004	−1.432	−0.226	Murcia	30	12.420	4	***	−0.784	0.382
Ávila	5	4.844	2	0.220	−0.825	−0.828	Navarra	31	11.302	3	***	0.132	1.524
Badajoz	6	6.608	3	0.003	−0.228	−1.940	Orense	32	9.385	3	0.011	2.025	0.046
Baleares	7	−0.361	1	0.417	−0.121	0.771	Asturias	33	12.553	3	***	0.340	0.005
Barcelona	8	6.575	3	***	1.029	1.325	Palencia	34	6.951	2	0.076	−0.028	−0.269
Burgos	9	10.354	3	0.001	0.860	0.645	Palmas	35	5.207	3	0.003	0.278	−0.271
Cáceres	10	14.403	4	***	0.647	−0.224	Pontevedra	36	12.824	4	***	1.214	−1.165
Cádiz	11	17.400	4	***	−0.443	−1.925	Salamanca	37	6.987	3	0.035	0.366	−0.315
Castellón	12	18.327	4	***	−1.423	1.686	Tenerife	38	14.709	4	***	0.221	−0.482
Ciudad Real	13	25.819	4	***	−1.113	0.292	Cantabria	39	8.843	3	0.001	0.081	−0.256
Córdoba	14	12.669	4	***	−0.850	−1.398	Segovia	40	13.569	4	0.003	−0.417	0.048
Coruña	15	17.925	4	***	1.360	−1.225	Sevilla	41	16.100	4	***	0.788	−1.243
Cuenca	16	27.330	4	***	−0.219	1.187	Soria	42	21.955	4	***	0.483	1.587
Girona	17	2.242	2	0.194	−0.117	0.770	Tarragona	43	8.183	3	***	−0.821	−0.299
Granada	18	13.062	4	***	−0.582	−1.418	Teruel	44	7.604	2	0.064	−1.167	0.125
Guadalajara	19	10.073	3	0.009	−0.886	0.662	Toledo	45	24.593	4	***	−1.250	1.452
Guipuzcoa	20	−0.468	1	0.407	1.631	0.416	Valencia	46	11.268	3	0.000	0.341	0.894
Huelva	21	17.707	4	***	0.409	−0.937	Valladolid	47	13.509	4	***	0.938	−0.787
Huesca	22	8.064	3	0.030	−1.151	0.241	Vizcaya	48	−1.943	1	0.114	1.861	0.359
Jaén	23	15.712	4	***	−1.228	−2.396	Zamora	49	11.217	3	0.014	−0.831	−1.569
León	24	18.830	4	***	1.220	−0.903	Zaragoza	50	10.210	3	***	0.789	0.881
Lérida	25	−0.162	1	0.491	−0.904	0.763	Ceuta	51	3.492	2	0.238	−2.831	0.179
Rioja	26	14.746	4	***	−0.227	1.501	Melilla	52	15.367	4	0.002	−0.945	0.847

Period 1: 1996–2000; Period 2: 2006–2010; Diff.: provincial differences between periods (Period 2 − Period 1) for low birth weight percentages. Gr: categorical group of inter-period differences in percentages according to the magnitude of the difference (1: negative and non-significant; 2: positive and non-significant; 3: ≤median; 4: >median), the median value being = 11.8611.
***$p < 0.001$.

defined based on their median value from the significant inter-period differences (median = 11.8611): 3 ≤ median; 4 > median (see footnote to Table 1).

Figure 2 shows the geographic distribution of differences in the incidence of LBW corresponding to the values reported in Table 1, column Gr. A degree of geographic heterogeneity can be deduced from this map, with more frequent LBW in recent years affecting mainly the western provinces, and extending to central and southern Spain.

By means of multidimensional logistic regressions and considering only single births, Verropoulou & Basten (2013) reported that the relative risks for low birth weight were significant for both LBW and VLBW. By contrast, female newborns or those corresponding to parity 1 showed a significantly higher chance of LBW while not for VLBW. Although in this analysis the consideration of more than one category of birth

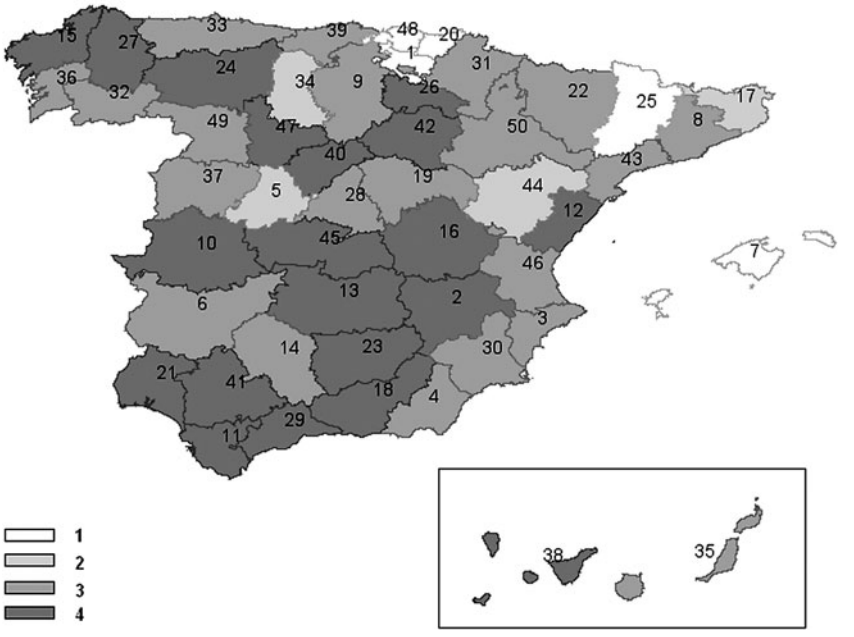

Fig. 2. Inter-period differences (2006–2010 minus 1996–2000) in percentage of LBW for the 50 Spanish provinces (Ceuta and Melilla are not represented). 1: negative and non-significant; 2: positive and non-significant; 3: ≤median; 4: >median. Provincial codes are indicated in Table 1.

weight would have been an alternative analysis, the reduced total number of deliveries in several provinces of small census size and demographically aged would have complicated the statistical analysis.

Based on the differences in the relative frequency of LBW in each province (values for period 2006–2010 minus 1996–2000) shown in Table 1, the principal components (PC) analysis was applied to the following variables: mothers aged 35 and older; multiple, first and premature deliveries; percentage of non-Spanish mothers; and low professional and job qualification (Fig. 3). The two principal components explain 57.323% of the total variability in LBW (31.676 PC1 and 25.647 PC2).

The correlation between the original variables and the PC is shown in Table 2. The first component is positively correlated with the difference in multiple deliveries ($R = 0.567$) and mothers aged 35 or older ($R = 0.810$). Conversely, the correlation is negative with regard to the difference in percentage of mothers with low levels of professional or job qualification ($R = -0.819$). The interaction between older mothers and the incidence of multiple deliveries may be due to both delayed maternity and assisted reproduction treatments. The association between delayed maternity and access to these treatments has the secondary effect of larger numbers of multiple deliveries, a situation that is more applicable to Spanish than to non-Spanish mothers (Fuster *et al.*, 2008). Machado (2005) and Torres-Arreola *et al.* (2005) also evidenced the negative relationship between maternal age over 35 and LBW.

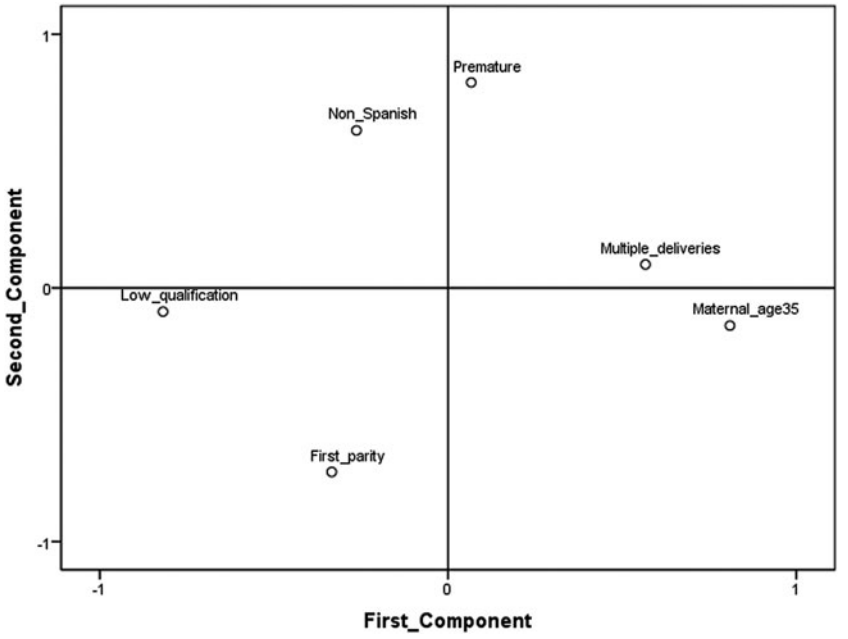

Fig. 3. Principal components bi-plot representing the difference in percentages between the periods 2006–2010 and 1996–2000 for: mother's low qualification; multiple deliveries; first deliveries; maternal age ≥ 35; premature deliveries and non-Spanish mothers.

Table 2. Two-dimensional principal components analysis

Period 2 − Period 1 differences (%)	Principal component	
	First	Second
Low qualification	−0.819	−0.094
Multiple deliveries	0.567	0.092
First deliveries	−0.334	−0.725
Mother's age over 35	0.810	−0.148
Premature deliveries	0.066	0.810
Non-Spanish mothers	−0.263	0.621

Correlation among the variables (left column) and the first and second components. Period 1: 1996–2000, Period 2: 2006–2010.

The second component is correlated negatively with the inter-period difference in the relative frequency of first deliveries ($R = -0.725$), and positively with the variation in premature births ($R = 0.810$) and non-Spanish mothers ($R = 0.621$). Thus in the second period, parities of two or more predominate among non-Spanish mothers (NS). This result is not unexpected as many of the NS mothers – despite having resided a considerable time in Spain – may have retained the traditional reproductive pattern of greater fertility prevalent in their countries of origin, and give birth more frequently

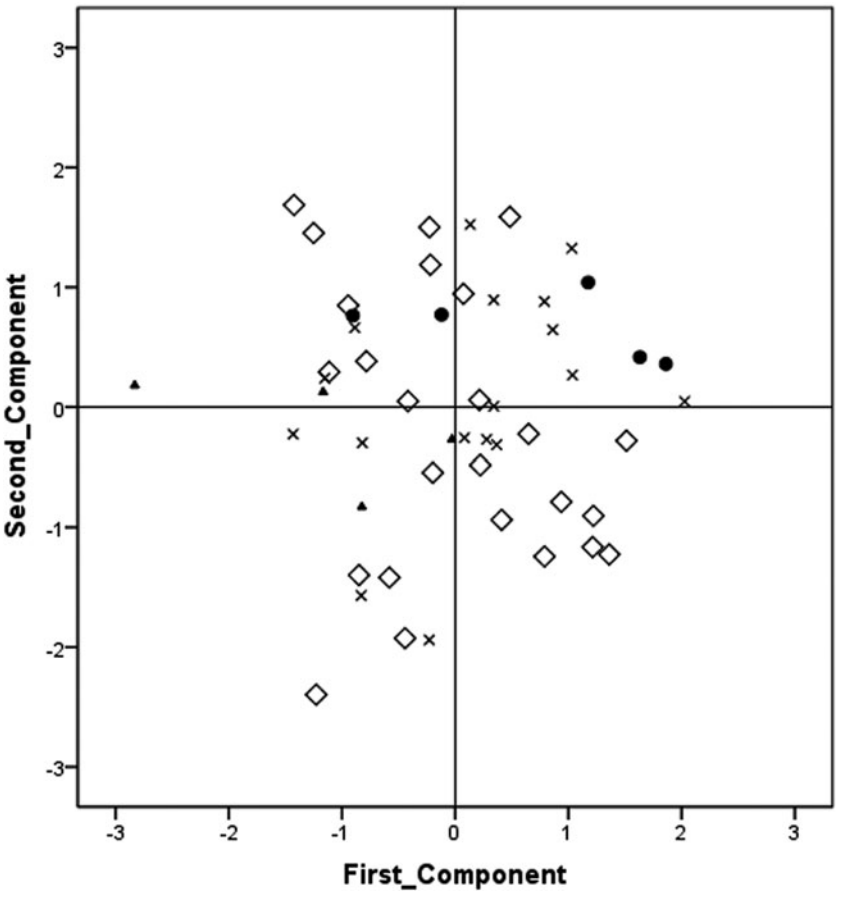

Fig. 4. Principal components bi-plot representing the difference in percentages between the periods 2006–2010 minus 1996–2000 by province according to values in Table 1 (first/second component column). Circles: negative and non-significant differences; triangles: positive and non-significant differences; crosses: ≤median; diamonds: >median.

to premature children, perhaps also due to late maternity. According to Castro-Martín & Rosero-Bixby (2011), 41% of non-Spanish women had initiated their reproductive activity prior to immigration, which could also have contributed to differences in parity.

It is worth noting the determination of the values for each province according to the two principal components (PC1, PC2) shown in Fig. 3. The two new variables have a mean equal to 0 and a standard deviation equal to 1; therefore, they can be interpreted as representing typified values. The scores of each province corresponding to the two PCs are shown in Table 1 under the column 'Principal component'. A zero value indicates that the score for that component is equal to the mean for that component; a positive value indicates that it is above the mean; and negative, below.

In Fig. 4, provinces are represented according to their principal component values (first and second component columns in Table 1) among their inter-period

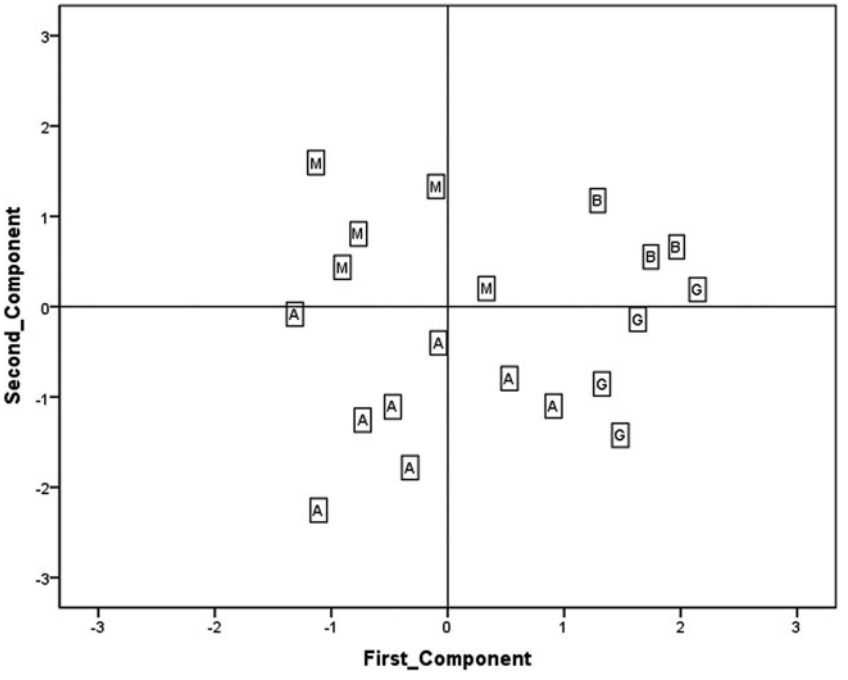

Fig. 5. Principal components bi-plot representing the difference in percentages between the periods 2006–2010 minus 1996–2000. Provinces in some of the autonomous regions are shown: Basque Country (B: Álava, Guipúzcoa, Vizcaya); Castile-La Mancha (M: Albacete, Ciudad Real, Cuenca, Guadalajara, Toledo); Galicia (G: Coruña, Lugo, Orense, Pontevedra); Andalusia (A: Almería, Malaga, Huelva, Granada, Seville, Cordoba, Cadiz, Jaén).

LBW difference (column Gr in Table 1). The provinces appearing in the first quadrant (top right) have high values for both components (older mothers, more premature and more multiple deliveries). In the second quadrant (top left) the value for the first component is low (more mothers with low qualifications) and high for the second (more non-Spanish mothers and premature deliveries). In the third quadrant (bottom left), values are low for both the first and second components (more mothers with low qualifications and more first deliveries). In the fourth, values are high for the first component and low for the second (older mothers, more multiple deliveries and first deliveries). It can be seen that the majority of provinces in which differences in the relative frequency of LBW were not significant (circles and triangles) have positive values for the second component.

Figure 5 shows provinces belonging to a selection of autonomous regions (the Basque Country, Castile-La Mancha, Galicia and Andalusia), based on the variation in the percentage of LBW reported in column Gr in Table 1. In general the results obtained for provinces tend to group them by autonomous regions (see caption to Fig. 5). Those in the Basque Country (B) are closely grouped in the first quadrant. Andalusian provinces (A) are low with regard to the second component thus grouping in the third quadrant.

On the other hand, values for this component are high for Castile-La Mancha (M) provinces, which appear in the second quadrant, while Galician provinces (G) are represented in the fourth quadrant.

A comparison of Figs 3 and 5 indicates that the Basque provinces reveal a high proportion of older maternities and multiple deliveries (PC1), Andalusia has more first deliveries (PC2), and Galicia has higher maternity ages of primiparous mothers. Most of the provinces for which the variation in the relative frequency of LBW was not significant appear in the scatter plot in the area defined by more immigration and prematurity, reflecting a particular predominance of industrial economic activity – as in the Basque Country – which may have promoted rapid demographic changes. In other regions such as Andalusia and Castile-La Mancha, there is a greater prevalence of agriculture, causing a slower demographic evolution.

The above results may be compared with those of Thompson *et al*. (2005), who reported that in 1998 LBW rates varied threefold across regions in the USA. These regional differences are not easily explained but are linked to place of maternal residence as well as to perinatal health care. A possible explanation of these differences in LBW is that a region's social and medical systems respond differently to the biological and social status of its population. It is worth noting that there are many regions in close proximity – even within states – that have low frequencies of LBW and yet are adjacent to regions with high LBW rates. The fluctuations in these areas may be particularly useful for studies to evaluate the health care facilities provided to women of childbearing age. Goodman *et al.* (2001) reported a slight association between US regional variation in the availability of neonatologists and low birth rates. Thus the two most significant preventable birth outcomes – that is, LBW and prematurity – are not affected by neonatal intensive care.

The negative relationship found in the present analysis between provincial income per individual (differences between periods) and low inter-period variation in the relative frequency of LBW can be seen as a consequence of better investment in prenatal care. However, this result considers the relative income variation from one period to the other rather than its absolute value. For this reason, some high-income provinces such as Madrid and Barcelona may show a significant increase in LBW, while others (Alava, Guipúzcoa and Vizcaya) do not. García-Subirats *et al*. (2012) found in an urban Spanish neighbourhood that the prevalence of LBW was lower in births to women residing in areas with the highest socioeconomic level. This result is consistent with the findings of Thompson *et al.* (2005): mothers who reside in US counties with a household income below the median are more likely to deliver a LBW infant. With regard to other European countries, Astolfi & Zonta (1999), Kirchengast & Hartmann (2003b) and Tsimbos & Verropoulou (2011) indicated an association between birth order and LBW. Chiavarini *et al*. (2012) reported for an Italian region that mothers aged 30–39, with lower education, not married, and those of non-European origin were more likely to have single births of VLBW ($<$1500 g). Assisted reproduction also had a significant effect on this category of weight; and Fujii *et al*. (2010) found in Japan a relationship between VLBW and preterm delivery.

A tentative analysis was performed based on a set of provincial indicators representing each of the two periods considered. These indicators include the following: yearly income (Euros/inhabitant), percentage of women engaged in paid activity, percentage of

individuals out of work and health variables such as total number of hospital beds and beds by medical speciality. Only income correlated negatively with the inter-period provincial variation in the incidence of LBW (Spearman's $\rho = -0.510$, $p < 0.001$). Income also correlated positively with the rate of obstetric beds ($\rho = 0.452$, $p = 0.001$).

A certain similarity can be established between Korea and Spain for maternal reproductive patterns. According to Lim (2011), in Korea the average maternal age at first delivery rose from 27.6 years in 1993 to 31.3 in 2010. As the number of births has decreased (total fertility rate equal to 1.15 children per woman in 2009), so has the average birth weight, and the percentage of LWB increased from 2.63% in 1993 to 5.02% in 2010. The rate of preterm births underwent a similar variation. Moreover, multiple birth rates (per 1000 deliveries) rose steadily from 1.13 to 2.76. Lim (2011) found that birth weights under 1500 g had increased at twofold the rate of those under 2500 g. This suggests that advances in neonatal care, as would occur in cases of very small weights or extremely low gestational age, may have caused the reporting of live births to increase.

Conclusions

The results of this paper point to the conclusion that from 1996 to 2010 there was a decrease in the average weight of newborns, in parallel with an increase in the relative frequency of LBW affecting the majority of Spanish provinces. This variation was accompanied by a progressive delay in mother's age at delivery and more frequent multiple births in primiparous women. The geographic pattern expressed as a provincial variation is explained by differences in the relative frequency of the variables considered in the principal components analysis: provinces in areas where first deliveries predominate and the increase of LBW was notable tend to group together (i.e. region of Andalusia), but so do other provinces with a predominantly higher proportion of immigrant mothers and lower professional qualification (i.e. Galicia). In contrast, provinces with minor (non-significant) variations are distributed mostly in the north-west regions of Spain (i.e. the Basque Country), where premature multiple deliveries by older mothers are more frequent. The heterogeneity of the variables characterizing reproducing females residing in each province suggests that the global temporal change occurring in Spain with regard to birth weight is the accumulative result of biological, demographic and socioeconomic variables, which may provide an interpretation for this diversity.

Acknowledgments

This work was supported by the Spanish Ministry of Science and Innovation (project reference CGL2008-03737). Thanks are given to Erik Lundin for revising the manuscript.

References

Acevedo-García, D., Soobader, M. J. & Berkman, L. F. (2007) Low birthweight among US Hispanic/Latino subgroups: the effect of maternal foreign-born status and education. *Social Science & Medicine* **65**, 2503–2516.

Astolfi, P. & Zonta, L. A. (1999) Risks of preterm delivery and association with maternal age, birth order and fetal gender. *Human Reproduction* **14**, 2891–2894.

Bernis, C. (2006) Aspects biosociaux de l'immigration en Espagne: facteurs de variabilité du poids à la naissance. *Antropo* **11**, 29–140.

Cano-Serral, G., Rodríguez-Sanz, M., Borell, C., Pérez, M. M. & Salvador, J. (2006) Socio-economic inequalities in the provision and uptake of prenatal care. *Gaceta Sanitaria* **20**, 25–30.

Castro-Martín, T. & Rosero-Bixby, L. (2011) Maternidades y fronteras. La fecundidad de las mujeres inmigrantes en España. Monográfico 1: La inmigración en España: perspectivas innovadoras. *Revista Internacional de Sociología* **Monograph 1**, 105–137.

Chiavarini, M., Bartolucci, F., Gili, A., Pieroni, L. & Minelli, L. (2012) Effects of individual and social factors on preterm birth and low birth weight: empirical evidence from regional data in Italy. *International Journal of Public Health* **57**, 261–268.

English, P. B., Kharrazi, M., Davies, S., Scalf, R., Waller, L. & Neutra, R. (2003) Changes in the spatial pattern of low birth weight in southern California county: the role of individual and neighborhood level factors. *Social Science & Medicine* **56**, 2073–2088.

El-Sayed, A. M. & Galea, S. (2010) Community context, acculturation and low-birth-weight risk among Arab Americans: evidence from the Arab-American birth-outcomes study. *Journal of Epidemiology & Community Health* **64**, 155–160.

Ferraz, E. M., Gray, R. H. & Cunha, T. M. (1990) Determinants of preterm delivery and intrauterine growth retardation in north-east Brazil. *International Journal of Epidemiology* **19**, 101–108.

Fujii, M, Matsuoka, R., Bergel, E., van der Poel, S. & Okai, T. (2010) Perinatal risk in singleton pregnancies after in vitro fertilization. *Fertility and Sterility* **94**, 2113–2117.

Fuster, V., Zuluaga, P, Colantonio, S. & de Blas, C. (2008) Factors associated with recent increase of multiple births in Spain. *Twin Research and Human Genetics* **11**, 70–76.

Fuster, V., Zuluaga, P., Colantonio, S. & Román-Busto, J. (2010) Temporal and territorial analysis of multiple deliveries in Spain (1900–2006). *Twin Research and Human Genetics* **13**, 207–216.

Fuster, V., Zuluaga, P., Colantonio, S. E. & Román-Busto, J. (2013) Factors determining the variation in birth weight in Spain (1980–2010). *Annals of Human Biology* **40**, 266–275.

Gagnon, A. J., Zimbeck, M., Zeitlin, J. & The ROAM Collaboration (2009) Migration to western industrialised countries and perinatal health: a systematic review. *Social Science & Medicine* **69**, 934–946

García-Subirats, I., Pérez, G., Rodríguez-Sanz, M., Ruiz Muñoz, D. & Salvador, J. (2012) Neighborhood inequalities in adverse pregnancy outcomes in an urban setting in Spain: a multilevel approach. *Journal of Urban Health* **89**, 447–463.

Goodman, D. C., Fisher, E. S., Little, G. A., Stukel, T. A. & Chang, C. (2001) Are neonatal intensive care resources located according to need? Regional variation in neonatologists beds, and low birth weight newborns. *Pediatrics* **108**, 426–431.

Joseph, K. S., Kramer, M. S., Marcoux, L. S., Ohlsson, A., Wen, S. W., Allen, A. C. & Platt, R. (1998) Determinants of secular trends in preterm births in Canada. *New England Journal of Medicine* **339**, 1434–1439.

Kirchengast, S. & Hartmann, B. (2003a) Advanced maternal age is not only associated with newborn somatometrics but also with mode of delivery. *Annals of Human Biology* **30**, 1–12.

Kirchengast, S. & Hartmann, B. (2003b) Impact of maternal age and maternal somatic characteristics on newborn size. *American Journal of Human Biology* **15**, 220–228.

Kramer, M. S. (2003) The epidemiology of adverse pregnancy outcomes: an overview. *Journal of Nutrition* **133**, 1592–1596S.

Kramer, M. S., Morin, I., Yang, H., Platt, R. W., Usher, R., McNamara, H. *et al.* (2002) Why are babies getting bigger? Temporal trends in fetal growth and its determinants. *Journal of Pediatrics* **141**, 538–542.

Kramer, M. S., Séguin, L., Lydon, J. & Goulet, L. (2000) Socio-economic disparities in pregnancy outcome. Why do the poor fare so poorly? *Paediatric & Perinatal Epidemiology* **14**, 194–210.

Lim, J. W. (2011) The changing trends in live birth statistics in Korea, 1970 to 2010. *Korean Journal of Pediatrics* **54**, 429–435.

Luque, M. A., Bueno, A. & de Mateo, S. (2011) Differences in the reproductive pattern of low birthweight by maternal country of origin in Spain, 1996–2006. *European Journal of Public Health* **31**, 104–108.

Machado, C. J. (2005) Impact of maternal age on birth outcomes: a population-based study of primiparous Brazilian women in the City of Sao Paulo. *Journal of Biosocial Science* **38**, 523–535.

Mariotoni, G. G. B. & Barros Filho, A. A. (2000) Birth weight and maternal characteristics at the Maternity of Campinas along 25 years. *Journal of Pediatrics* **76**, 55–64.

Martin, J. A., Osterman, M. J. K. & Sutton, P. D. (2010) Are preterm births on the decline in the United States? Recent data from the National Vital Statistics System. *NCHS Data Brief*, 39. National Center for Health Statistics, Hyattsville, MD.

Moshin, M., Wong, F., Bauman, A. & Bai, J. (2003) Maternal and neonatal factors influencing premature birth and low birth weight in Australia. *Journal of Biosocial Science* **35**, 161–174.

Reeske, A., Kutschmann, M., Razum, O. & Spallek, J. (2011) Stillbirth differences according to regions of origin: an analysis of the German perinatal data base, 2004–2007. *BMC Pregnancy & Childbirth* **11**, 63–72.

Russell, R. B., Green, N. S., Steiner, C. A., Meikle, S., Howse, J. L., Poschman, K. *et al.* (2007) Cost of hospitalization for preterm and low birth weight infants in the United States. *Pediatrics* **120**, e1 doi: 10.1542/peds.2006-2386

Simo, C. & Méndez, S. (2013) Testing the effect of the epidemiologic paradox: birth weight of newborns of immigrant and non-immigrant mothers in the region of Valencia, Spain. *Journal of Biosocial Science* doi:10.1017/S0021932013000539

Sparks, P. J. (2009) One size does not fit all: an examination of low birthweight disparities among diverse set of racial/ethnic groups. *Maternal and Child Health Journal* **13**, 769–779.

Thompson, L. A., Goodman, D. C., Chang, C. H. & Stukel, T. A. (2005) Regional variation in rates of low birth weight. *Pediatrics* **115**, 114–1121.

Torres-Arreola, L. P., Constantino-Casas, P., Flores-Hernández, S., Villa-Barragán, J. P. & Rendón-Macías, E. (2005) Socioeconomic factors and low birth weight in Mexico. *BMC Public Health* **5**, 20 doi:10.1186/1471-2458-5-20

Tsimbos, C. & Verropoulou, V. (2011) Demographic and socioeconomic determinants of low birth weight and preterm births among natives and immigrants in Greece: an analysis using nationwide vital registration micro-data. *Journal of Biosocial Science* **43**, 271–283.

Urquia, M. L., Glazier, R. H., Blondel, B., Zeitlin, J., Gissler, M., Macfarlane, A. *et al.* (2010) International migration and adverse birth outcomes: role of ethnicity, region of origin and destination. *Journal of Epidemiology and Community Health* **64**, 243–251.

Verropoulou, G. & Basten, S. (2013) Very low, low and heavy weight births in Hong Kong SAR: how important is socioeconomic and migrant status? *Journal of Biosocial Science* doi:10.1017/S0021932013000321

Verropoulou, G. & Tsimbos, C. (2013) Modelling the effects of maternal socio-demographic characteristics on the preterm and term birth weight distributions in Greece using quantile regression. *Journal of Biosocial Science* **45**, 375–390.

Wardlaw, T., Blanc, A., Zupan, J. & Ahman, A. (2004) *Low birth weight: Country, regional and global estimates*. United Nations Children's Fund (UNICEF), New York, and WHO, Geneva.

Wells, J. C. K. (2002) Thermal environment and human birth weight. *Journal of Theoretical Biology* **214**, 413–425.

Wen, S. W., Kramer, M. S. & Usher, R.H. (1995) Comparison of birth weight distributions between Chinese and Caucasian infants. *American Journal of Epidemiology* **141**, 1177–1187.

Wilcox, A. (2001) On the importance – and the unimportance – of birthweight. *International Journal of Epidemiology* **30**, 1233–1241.