

Brief original article

Revisiting the ‘Low BirthWeight paradox’ using a model-based definition

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ABSTRACT

Introduction: Immigrant mothers in Spain have a lower risk of delivering Low BirthWeight (LBW) babies in comparison to Spaniards (LBW paradox). This study aimed at revisiting this finding by applying a model-based threshold as an alternative to the conventional definition of LBW.

Methods: Vital information data from Madrid was used (2005–2006). LBW was defined in two ways (less than 2500 g and Wilcox’s proposal). Logistic and linear regression models were run.

Results: According to common definition of LBW (less than 2500 g) there is evidence to support the LBW paradox in Spain. Nevertheless, when an alternative model-based definition of LBW is used, the paradox is only clearly present in mothers from the rest of Southern America, suggesting a possible methodological bias effect.

Conclusion: In the future, any examination of the existence of the LBW paradox should incorporate model-based definitions of LBW in order to avoid methodological bias.

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Revisando la “paradoja del bajo peso” utilizando una definición basada en modelos

RESUMEN

Introducción: Estudios previos señalan que las madres inmigrantes residentes en España tienen menos probabilidades de dar a luz niños con bajo peso que las autóctonas (paradoja del bajo peso). Este estudio evalúa si este resultado se mantiene al utilizar un umbral alternativo que tiene en cuenta las distribuciones de peso en los diferentes colectivos.

Métodos: Se utilizaron las estadísticas vitales de Madrid (2005–2006). Se definió bajo peso al nacer como menos de 2.500 g y siguiendo la propuesta de Wilcox. Se utilizaron regresiones logísticas y lineales.

Resultados: Utilizando el umbral convencional confirmamos la existencia de la paradoja del peso al nacer. Sin embargo, con el umbral alternativo sólo las madres del resto de América del sur muestran una menor probabilidad de bajo peso.

Conclusión: Futuras investigaciones tienen que incorporar definiciones de bajo peso que tengan en cuenta las distribuciones específicas según el origen de la madre para evitar sesgos metodológicos.

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Introduction

The importance of birthweight as an indicator of health is well established in the literature. Low BirthWeight (LBW) is linked to neonatal and infant mortality¹ and, later in life, to specific diseases and causes of death.^{2–4} Systematic evidence shows that immigrant mothers coming from lower socioeconomic contexts, and experiencing social disadvantages in the host country, have a lower probability of delivering low birthweight babies in comparison to natives mothers (i.e., the ‘Low BirthWeight paradox’ – LBW paradox).^{5–8} Many hypotheses have been formulated to explain this phenomenon, although they all focus on general mechanisms (i.e., selection in origin),⁹ unobserved confounders (i.e., smoking or

diabetes),¹⁰ or cultural aspects (i.e., values, lifestyles)¹¹ without contemplating the possibility of it being an artificial effect connected to the conceptualization of LBW.

The definition of LBW commonly refers to babies weighing less than 2500 g. Although accepted in the literature, there is no ‘gold standard’ to define LBW and this threshold is problematic when used comparatively.

This paper aims at testing whether immigrants have a lower probability of being LBW compared to Spaniards using both the conventional definition (less than 2500 g) and a model-based threshold (OTP), which avoids an *ad hoc* threshold to define LBW/normal-weight babies.

Methods

We used vital information data on births in Madrid provided by the Madrid Statistical Institute for the years 2005 and

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2006 ($n = 144,616$ babies). We selected living singleton babies. We excluded observations without information on weight and with absurd weight values for their gestational age, based on the limits published about different populations.

The final sample size was 128,591. Migration status was classified according to the mother's nationality into the following groups: (a) the European Union and other rich countries, (b) North Africa, (c) Sub-Saharan Africa, (d) Mexico and Central America, (e) Southern America – Argentina, Chile, Brazil and Uruguay, (f) the rest of Southern America, (g) Asia and Oceania, and (h) other non-EU27 European countries.

We defined LBW using 2500 g and the model-based Wilcox threshold, which estimates the optimal truncation point (OTP-threshold) applying Maximum Likelihood Estimation to determine the specific point where the two distributions (residual and normal) converge. For further details about this estimation see Wilcox.^{12,13}

We ran logistic and linear regressions to model the odds of delivering LBW babies and to assess mean differences.

Results

Babies born to foreign mothers are on average 85 g heavier than Spanish mothers (Table 1). Immigrants as a whole and babies born to North African, Asian and Oceanian, and 'other

Southern American' mothers have lower LBW prevalence than Spaniards according to less than 2500 g. In contrast, using the OTP-threshold, there are no statistical differences compared to Spaniards.

Table 2 shows the main results. The adjusted logistic regression using <2500 g as a threshold shows that the odds of having LBW babies are 35% lower among immigrant mothers than Spanish mothers ($OR_{2500} = 0.65$) while 17% higher when the OTP-threshold is used ($OR_{OTP} = 1.17$). Immigrant mothers have babies 109 g on average heavier when compared to Spanish mothers.

The odds of having LBW is lower for babies born to 'other Southern American' mothers ($OR_{2500} = 0.52$; $OR_{OTP} = 0.60$) and they also show a higher probability of having, on average, heavier babies ($\beta_g = 138$). Babies born to Mexican and Central American, as well as Sub-Saharan African mothers do not show statistically significant differences from either threshold ($OR_{2500} = 0.82$, $OR_{OTP} = 1.17$, and $OR_{2500} = 0.82$, $OR_{OTP} = 1.23$, respectively), but they are on average heavier than Spanish ones ($\beta_g = 89$ and $\beta_g = 51$, respectively).

Newborns from the rest of nationalities show contradictory effects between the thresholds. Thus, being a newborn to a non-EU27, EU27, or any other rich country mother increases the likelihood of having LBW babies ($OR_{OTP} = 2.37$ and 2.89, respectively), while mothers from Asia and Oceania, North Africa, and Southern America lose their statistically

Table 1
Birthweight mean and the percentages below the thresholds and 95% confidence intervals by nationality.

Maternal nationality	N (%)	Mean birthweight (CI-95%)	% <2500 g (CI-95%)	OTP ^a	% <OTP (CI-95%)
Spaniard	101,994 (79.3)	3199 (3196–3201)	5.56 (5.42–5.7)	2250	2.46 (2.4–2.6)
Immigrants	26,597 (20.7)	3284 (3278–3290)	4.79 (4.53–5.0)	2250	2.53 (2.3–2.7)
Non-EU27 European	5171 (4.0)	3253 (3239–3267)	6.05 (5.4–6.7)	2500	6.05 (5.4–6.7)
North African	2881 (2.2)	3341 (3323–3359)	3.92 (3.2–4.7)	2250	2.36 (1.8–2.9)
Sub-Saharan African	1123 (0.9)	3251 (3221–3280)	5.70 (4.3–7.1)	2250	3.47 (2.4–4.6)
Mexican and Central American	1356 (1.0)	3217 (3190–3242)	5.97 (4.7–7.3)	2250	3.47 (2.5–4.5)
Southern American	1398 (1.1)	3277 (3252–3302)	4.86 (3.7–6.0)	2250	2.50 (1.6–3.6)
Other Southern American	11,111 (8.6)	3305 (3296–3314)	4.28 (3.9–4.7)	2250	2.18 (1.9–2.4)
Asian and Oceanian	1750 (1.3)	3250 (3228–3272)	4.16 (3.2–5.1)	2250	1.88 (1.2–2.5)
EU27 and other rich countries	1852 (1.4)	3259 (3259–3280)	4.70 (3.7–5.7)	2500	4.70 (3.7–5.7)

Note: CI-95% = 95% confidence interval; OTP = optimal truncation point.

^a The specific optimal truncation point (OTP-threshold) estimated for each population.

Table 2
Multivariate regression modeling low birthweight and birthweight mean; adjusted parameters 95% confidence intervals by maternal nationality.^a

Maternal nationality	Logistic regression		Logistic regression		Linear regression	
	<2500	<OTP	<2500	<OTP	Mean diff.	
	OR	(CI-95%)	OR	(CI-95%)	β	(CI-95%)
Spaniard						
Immigrants	0.65	(0.60–0.70)	1.17	(1.05–1.30)	109	(103–115)
Spaniard						
European non-EU27	0.74	(0.64–0.86)	2.37	(2.01–2.78)	96	(84–108)
North African	0.62	(0.50–0.77)	0.97	(0.73–1.30)	148	(132–164)
Sub-Saharan African	0.82	(0.60–1.11)	1.23	(0.83–1.84)	80	(56–104)
Mexico and Central America	0.82	(0.63–1.07)	1.17	(0.82–1.67)	51	(29–73)
Southern American	0.74	(0.55–0.98)	0.94	(0.64–1.39)	89	(67–111)
Rest of Southern America	0.52	(0.63–0.58)	0.6	(0.51–0.71)	138	(129–147)
Asia and Oceania	0.74	(0.57–0.97)	0.88	(0.56–1.25)	54	(35–74)
EU27 and other rich countries	0.85	(0.66–1.08)	2.89	(2.21–3.78)	54	(35–74)
Number of observations	12,8591		12,859		12,859	

Note: CI-95% = 95% confidence interval; OTP = optimal truncation point; OR: odd ratio; β = beta coefficient.

^a Models are adjusted for: gestational age, marital status, maternal age, mother's and father's occupation, birth order, newborn gender.

significant advantages (CI-95% 0.56–1.25, 0.73–1.30, and 0.64–1.39, respectively). All immigrant babies are heavier on average than Spanish ones ($\beta_g = 96$ for non-EU17; $\beta_g = 128$ for North Africa; $\beta_g = 89$ for Southern America; $\beta_g = 54$ for Asia and Oceanic; $\beta_g = 54$ for EU-27 and other rich countries).

Discussion

Our results confirm previous findings observed in Spain and other developed countries,^{7,8,11} which suggests the existence of better (or equal) outcomes at birth in immigrants when compared with natives. This finding is observed both in the mean differences in birthweight as well as in LBW defined by less than 2500 g.

The lack of an absolute standard to define LBW not only neglects the accepted variability of birthweight distributions across populations, as well as the historical improvement around the biological viability threshold (nowadays placed at 22 gestational weeks and 500 g), but certainly affects the comparison between groups. We found that, when comparing babies born to immigrants rather than Spaniards, the presence of the paradox depends on the approach used to conceptualise LBW. Using a model-based approach, the positive outcome disappears for newborns to non-EU27, EU27 and other rich country mothers. However, the LBW-paradox persists in other populations no matter how LBW is conceptualized. We included all the other immigrants in the advantaged group since 'the paradox' lies in the existence of *equal* or *better* health outcomes.

The fact that for some specific nationality groups, the LBW paradox seems an artificial effect poses an important research question. Following Wilcox's explanation, the less than 2500 g does not capture properly the population at risk (LBW) but is biased by the average birthweight.¹³

As it is well established in the literature, the distribution of birthweight is characterized by a mix of two distributions^{12,14,15}: the 'Gaussian distribution' (i.e., normal birthweight) and the 'residual distribution' (i.e., the LBW population). This feature is what would enable us to identify, from a continuous anthropometrical measurement, a dichotomous health indicator at birth (LBW vs. normal birthweight). The existence of two distributions with different characteristics and associated risk factors implies that they are mathematically independent. In this regard, it is necessary to focus on the specific intersection between the two distributions as the exact point where they split up (OTP). This optimal truncation point should be the threshold which captures the LBW population (residual distribution). Any point placed above this optimal point will induce a bias in the identification of the LBW population insofar as it will capture the parameters of the main distribution (basically mean differences). This bias is what occurs in our data when using the 2500 g as the estimation to capture the mean differences, where immigrants are actually heavier than natives, rather than the compromise LBW babies. A model-based threshold is, by definition, valid only for the migration classification use and for the period under study, since it may change as the population changes. A model-based threshold can be derived from any social group with associated socioeconomic and risk factors (i.e., a target for public health intervention, not a genetically homogenous group). This condition can be questioned in some of our categories, which may be very heterogeneous.

In summary, our study discusses the implications of using the conventional definition of LBW based on less than 2500 when comparing populations with different birthweight distributions. Using a model-based definition of LBW, we found that for some groups of nationalities the previous advantage reported in the literature might be due to an artificial advantage.

What is known about the topic?

Systematic evidence shows that immigrant mothers are at lower risk of delivering Low BirthWeight (LBW paradox) babies than those of the host population. This finding is mainly explained as the result of a selection in origin and less attention has been paid to whether it is an artificial effect.

What this study adds to the literature?

This study tests whether the LBW paradox is a methodological artefact based on the definition of LBW used (<2500 g) which ignores the fact that different populations have different birthweight distributions.

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Contributors

Juárez had the original idea and Juárez and Ploubidis contributed to the design of the study; Juárez performed the analyses. Juárez wrote the first draft of the manuscript, and all authors made substantial contributions to the interpretation of the results and manuscript revision. All authors approved the final version of the manuscript.

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Conflicts of interest

The authors have no conflicts of interest to disclose.

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