Original Article

New evidence on the effects of international migration on the risk of low birthweight in Mexico

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Abstract

The purpose of this article is to provide new empirical evidence linking migration of Mexican households to the USA with infant health outcomes. By using new data for Mexico, the Encuesta Nacional de la Dinamica Demografica 2006, this research focuses on the effect of migration on birth weight. Multivariate logistic regression methods are used to model low birth weight (LBW) as a function of a set of proximate, intermediate and socioeconomic determinants. In analyzing the channels through which migration affects birth outcomes, the findings provide no conclusive evidence for remittances as the only mechanism associated with lowering the odds of LBW. Given the limitations of the data, the study results showed new empirical evidence explaining the significance of both financial and social remittances associated with international migration and infant health outcomes in Mexico.

Keywords: low birthweight, migration, remittance, health, Mexico.

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Introduction

Mexico is considered the second largest recipient of financial remittances (the income migrants send home) in the world (Newland & Patrick 2004). According to official estimates from the Mexican Government, approximately 11 million Mexican-born people are living in the USA [National Population Council (CONAPO) 2002]. Although estimates differ, given different methodologies and sources of information, in general, the annual influx of Mexicans that have migrated to the USA has been estimated to range between 300 000 and 450 000 people between 1990 and 2000 (Hill & Wong

2005). A decade ago, the total Mexican population in the USA accounted for approximately one-eighth of Mexico's labour force (Escobar-Latapi 2008), and current estimates are likely to show an even more dramatic increase. The most common means by which international migration directly impacts sending countries is through financial remittances, also referred to herein as *migradollars*, or the flow of money that enters Mexico as a result of migration to the USA (Durand *et al.* 1996a,b). In the case of Mexico, remittances have steadily increased over the last two decades. Financial remittances from the USA to Mexico have increased from approximately \$2 billion in the 1990s (Massey & Parrado 1994) to

\$23.1 billion in 2006 (Canas *et al.* 2006), and this is roughly equivalent to 2.5% of the gross domestic product of Mexico (IMF 2006).

When investigating the effects of migration, it is important to consider other potential consequences of people's movements between sending and receiving destinations. In receiving locations, migration may have immediate effects on local labour markets as well as may increase the demand for basic services such as housing and health care. Analyzing the impact of migration on sending locations leads to a more complex problem. On one hand, losing part of the population among the working ages negatively affects the local economy as productivity for these age groups is diminished. Additionally, at the household level, out-migration may lead to some instability in family formation or growth given that, in many cases, it is the head of the family or household who migrates (Massey & Parrado 1994). On the other hand, once migrants start remitting money to their families in the sending location, the families may experience financial benefits as economic resources increase. This increased economic support may in turn lead to increases in consumption expenditures and savings. These effects have been shown to be more important in rural communities with a long history of sending migrants, particularly in certain central and southern states of Mexico, including Jalisco, Michoacan, Zacatecas, Durango and Oaxaca (Unger 2005). The income received by families in the sending location from family members in the USA results in improved and sustained living standards and helps to promote local economies (Canas *et al.* 2006).

While the implication is that the migratory process is likely to have direct effects on the total amount of financial remittances generated, the migratory

process may also impact the household and community indirectly. These other channels are related to the level of attachment or exposure of migrants to the US practices, the transfer of which may be thought of as social remittances. Specifically, migration may also have an impact on health outcomes through non-monetary channels, such as the transfer of health information (Hildebrandt & McKenzie 2005). Through exposure to the US practices, migrants may gain health knowledge resulting in higher health attainment. Hildebrandt & McKenzie (2005) provide evidence that mothers in migrant families are found to have higher levels of health knowledge, which in turn results in health knowledge spillovers to mothers in non-migrant households.

Thus, the purpose of this paper is to provide empirical evidence linking infant health outcomes with Mexican households' migration to the USA. In particular, this research focuses on the effects of migration on low birthweight (LBW) in Mexico. A review of relevant literature on the mechanisms through which international migration experiences in households and communities may impact infant health outcomes is detailed below.

Literature review

The most direct pathway through which migration has the potential to influence local economic development in Mexico is through remittances. In this sense, there are several venues by which remittances can impact the broader socio-economic development of communities. One of the topics that has received much attention among scholars is how remittances modify both household's expenditure behaviours and potential associations with infant health outcomes (Durand *et al.* 1996a,b, 2001; Massey & Parrado 1997;

Key messages

- Although the migrant households in Mexico seem to have lower odds of low birthweight children, the mechanisms through which migration affects birth outcomes are not clear.
- The strong and robust association between migrant households and low birthweight may provide new insights about the possibility that households may be benefitting from international migration indirectly.
- In-depth analysis directed specifically at the effects of migration on health outcomes must include factors measuring both economic and social remittances.

Kanaiaupuni & Donato 1999; Amuedo-Dorantes & Pozo 2006).

As explained by Hildebrandt (2005), sending migrants abroad generates a flow of remittances to sending communities with subsequent short- and long-term effects. For example, at the individual level, remittances can be seen as increasing households' disposable incomes, which finances increased consumption, housing expenditures or the education costs of children still living at home. Recent research has provided empirical evidence to support this argument (Frank 2005; Hamilton *et al.* 2008). Amuedo-Dorantes *et al.* (2006) further find that migrant households dedicate a considerable proportion of total remittance earnings to healthcare expenditures. Their study reports that the single largest category for the use of remittances is the one related to health expenses. Based on data from the Mexican Migration Project, 46% of remitters declare health expenses as the primary purpose for their remittances. In a related study, Amuedo-Dorantes & Pozo (2006) assess the relationship between remittances and healthcare access of the Mexican population in sending communities. Through the estimation of the elasticity of health care, their findings indicate that healthcare expenditures rise in response to the receipt of remittances. Primary expenditures are also significantly higher among households with higher remittance inflows, where spending accounts for between 5% and 9% of remittance receipts for primary healthcare services.

Research on the impact of migration on health outcomes of Mexicans, particularly on infant health outcomes, has attracted the attention of scholars from different disciplines. One of the first studies analyzing the effect of international migration on infant health in Mexico comes from Kanaiaupuni & Donato (1999). This piece of work is one of the most influential and frequently cited studies in this area. Their study explores whether children of international migrants experience lower rates of mortality than non-migrants. By applying multilevel statistical methods, these authors were able to examine how migration patterns in communities affect infant survival in Mexico. They hypothesized that migration effects are not linear; instead, migration results in a cumulative process with varying health effects at dif-

ferent stages. Their argument first states that at initial stages of migration, communities may suffer some instability because of the absence of heads of families. The absence of the head of the family may negatively affect the primary source of economic and social support in the household. In this sense, migration may worsen health outcomes in the short term, as families may have less money to spend on consumption needs and medical care. However, once migration becomes institutionalized as a part of local life in communities, migration may positively affect the standard of living and infant survival probabilities. Over the long term, their study found that communities in Mexico with more than 20 years of exposure to migration rates of at least a 25% threshold had much lower odds of infant deaths. This effect appeared to be attributed, in large part, to high annual remittances, or *migradollars*, to the communities. In a related study, Frank & Hummer (2002) examined the relationship between the US migration experience and the risk of LBW in Mexico using data from the 1997 Encuesta Nacional de la Dinamica Demografica (ENADID 1997). In this study, the authors hypothesized that at the household level, the migration process would negatively affect the risk of LBW among Mexican infants. They concluded that infants born in migrant households in Mexico were less likely to be of LBW when compared with infants born in non-migrant households. A key result from this study found that the risk of LBW was reduced for pregnant women living in Mexican households that received remittances from abroad.

It has been long documented that LBW is strongly associated with neonatal mortality and developmental problems in childhood through adulthood. Birthweight is considered a good predictor of immediate and future health standards of a newborn; more specifically, LBW is directly associated with infant morbidity and neonatal mortality (Wilcox 2001). Empirical evidence has also shown that LBW infants have higher probabilities of infection, handicapped conditions during childhood, mental deficiencies and problems related to cognitive development, as well as susceptibility to chronic diseases such as hypertension later in life (Barker 1994).

Studies analyzing the implications of LBW in the economic literature have shown that there is a direct

effect on human capital accumulation in infants with adverse birth outcomes. A recent study by Behrman & Rosenzweig (2004) found evidence that differences in birthweights have direct implications on educational attainment, adult height and labour market payoffs. Hence, the study of the risk factors associated with LBW is important for its effects on total productivity and, consequently, on the overall economy in the long term (Hildebrandt & McKenzie 2005).

It is also well known that LBW is partially a consequence of the conditions faced by the mother during pregnancy. Among the main non-genetic factors attributed to LBW are gestational age, prenatal care, maternal health behaviours (alcohol consumption and smoking) and maternal stress (Chevalier & O'Sullivan 2007). A variable that it is highly correlated with and that can potentially affect all these variables is maternal education. Mothers who have lower levels of education are less likely to provide resources dedicated to medical care, nutrition, sanitary facilities and water supply to their infants (Behrman *et al.* 1989). Maternal marital status may also influence birth outcomes and infant mortality rates (Sussman *et al.* 1999). Past studies have shown that unmarried mothers have higher odds of infant mortality (Bird *et al.* 2000). Additionally, the quality of housing can have a strong influence on infant health. For example, access to water and lack of adequate sanitation facilities expose a child's health to the effects of environmental contaminants. Conversely, higher-quality sanitary facilities and improved water supply are directly associated with better health outcomes. The access to resources such as health care is often cited as a factor explaining why health differences in urban areas are generally better than in rural areas. Women living in rural areas may experience limited access to health care as well as lower educational levels, fewer employment opportunities and, in general, higher rates of poverty (Hillemeier *et al.* 2007). All these factors indeed may influence infant and child health conditions.

An additional factor most consistently associated with LBW and other birth outcomes is the gestational age of the infant. Some authors have argued that gestational age is a better predictor of neonatal survival than birthweight alone (Varloove-Vanhorick *et al.* 1986). The incidence of LBW is correlated with two

pathologic conditions and one normal condition. The pathologic conditions include preterm delivery and intrauterine growth retardation (Vandenbosche & Kirchner 1998). The normal condition refers to births resulting in a healthy but constitutionally small baby. Recent evidence suggests that in developing countries, preterm births account for almost two-thirds of all LBW, while the opposite holds true in developed countries (Hosain *et al.* 2005).

Finally, regional differences may also influence infant health conditions and, in general, survival chances of children. One of the reasons is that accessibility to services is inequitably distributed across a country. It also may be the case that one area of the country has higher prevalence for some diseases compared with other areas (Frank & Hummer 2002). In the case of Mexico, regional differences in health are influenced by geographic disparities in levels of accessibility and utilization of health services (Bobadilla & Langer 1990).

This paper contributes to the existing literature in this area by providing new evidence on factors associated with LBW using the most recent data available for Mexico, the ENADID 2006. This analysis allows for testing the possible association of international migration experiences of households on birth outcomes, the latter concept operationalized as LBW. The goal is to provide an analysis allowing for the identification of channels, other than solely remittances, that associate migration with LBW. Particular attention is given to maternal health conditions and gestational age as biological determinants of LBW. The mother's socio-economic conditions as influencing birth outcomes are considered as well. Therefore, this study seeks to test two main hypotheses: (1) the odds on the incidence of LBW will be lower for infants born in households engaged in international migration compared to households with no migration experience; (2) the positive effect of household migration on birth outcomes remains robust after including a separate set of different explanatory variables.

Data and methods

Data used in this study come from the ENADID 2006 (National Survey of Demographic Dynamics). The

2006 survey updates information and issues that were addressed in the immediately preceding ENADID survey administered in 1997. Institutions such as the Secretaria de Salud (Ministry of Health) and the Consejo Nacional de Poblacion (National Council of Population) participated in the conceptual and methodological design of the survey. The sampling frame for the survey was built using the cartographic and demographic information from the 2000 General Census of Population and Housing (INEGI, 2000). The ENADID 2006 is a nationally representative survey, which collects information from each of the 32 Mexican states, making a total sample of 41 926 households. The survey was conducted in the last quarter of 2006 and provides information related to fertility, infant and maternal health, infant and general mortality, national and international migration experiences and contraceptive practices. The total sample included in the analysis corresponds to 39 449 infants, in which 2489 are reported to be LBW (<2500 g) and 36 960 are reported to be normal weight (≥ 2500 g). The sample for this analysis only includes single births, as it has long been established that LBWs are highly correlated with multiple births (Khader & Ta'ani 2005).

The data are well suited for this research for two reasons. First, the survey contains retrospective information about birth outcomes and maternal health for the last pregnancy for women between the ages of 15 and 54 years. Second, a module of questions related to international migration is also included in the survey, which contains information on whether a member of a particular household has emigrated to the USA either in search of a job or for other reasons. This allows maternal and infant health characteristics to be combined with international migration information at the household level.

The analysis includes a variable that incorporates the migration experience of the household. This variable is utilized in order to identify the effect of international migration on LBW. This is obtained from the question that asks whether household members have ever been in the USA searching for work. This question is asked to all household members who normally live in the household. In this study, the migrant household variable is operationalized as a

binary variable with value 1 if any member of the household at least 15 years of age or older had migrated to the USA since January 2001; a value 0, if otherwise. In order to provide more reliable estimates on the relationship between household migration experience and LBW, only those infants born after the migratory trip occurred are included.

Maternal education was categorized in order to distinguish between women who had received no formal education, those who have had less than a primary school education (1–5 years) and had not graduated from elementary school and those who had completed primary school or more (≥ 6 years). This categorization of maternal education has been strongly associated with infant health outcomes (Frank & Hummer 2002). In order to examine the possible existence of a gradient effect of household's income upon birthweight outcomes, the total household income is also included and coded in four quartiles. This categorization suggests that the fourth quartile represents the highest income group, while the first quartile represents the lower income group.

Maternal age is also a potential confounder in perinatal studies, where the risk of neonatal death or poor birth outcomes is higher for mothers under 18 or over 40 years of age (Rothman *et al.* 2008). In order to capture the possible effects of maternal age, three different age groups – <20, 20–34 and ≥ 35 years – were included in the analysis. Parity was operationalized using the Kleinman & Kessel (1987) Parity Index, in which variables detailing birth order and maternal age were combined to create three different parity categories, including (a) first birth; (b) low parity (second-order births to women 18 and older, third-order births to women 25 and older) and (c) high parity (second- or higher-order births to women under 18, third- or higher-order births to women under 25 and fourth- and higher-order births to women 25 and older). Dichotomous variables were created for each of these three categories. Marital status was then categorized as a dummy variable with value 1 if the mother was married at the time of the infant's birth and a value 0 if otherwise.

The survey also includes information about antenatal health care as well as the presence of maternal health problems during pregnancy. A binary variable was created to indicate whether or not the mother received prenatal care (yes = 1 and no = 0). Problems during pregnancy (such as vaginal bleeding, urinary tract infection, diabetes, hypertension, high fever) and other type of problems (such as abdominal pain, tiredness, backache, swollen ankles, feet and legs) were also categorized into a single dichotomous variable with value 1 if women responded to have had any of these problems during their pregnancies and with value 0 if they did not. Gestational age is reported in the survey as the length of pregnancy in months. This variable is then converted to weeks and coded as a dummy variable for pre-term births with value of 1 for those infants born at less than 37 completed weeks of gestation and a value of 0 if otherwise. This variable is included in all the models in order to control for its biologically significant association with birth outcomes. This allows the examination of whether the positive effect of migrant households is attributed to lowering the odds of LBW, or if it is the prematurity indicator that is the variable capturing the effect on LBW.

Lastly, the analysis accounts for differences in urban–rural birth outcomes as an important factor for assessing the type of health problems in communities with different levels of urbanization. Hence, two dummy variables were created in order to categorize large metropolitan areas ($\geq 100\,000$ inhabitants) and non-metropolitan areas ($< 100\,000$ inhabitants). Following Frank & Hummer (2002), in order to characterize infant's housing conditions, several variables, such as the availability of indoor water facilities, sanitary drainage and electricity, are used. A variable called poor infrastructure is created to indicate if a household reported to have any of the following: dirt floors, lack of indoor sanitation or water facilities and lack of electricity. The possible effects of regional differences on infant birth outcomes are also included through a set of regional dummy variables. Included with these was an additional dummy variable, commonly operationalized in past studies representing the historic migrant sending region (Massey & Parrado 1994; Hamilton *et al.* 2008). These regions are

classified according to mother's residence: Border, Capital, Center, Southeastern and Historic¹.

Multivariate logistic regression is used to model LBW as a function of a set of proximate determinants (length of gestation period), intermediate determinants (maternal age, pregnancy problems, prenatal care) and socio-economic determinants (mother's education, income level, housing infrastructure).

Results

Given that the main interest of this study is to examine possible differences in the distributions of characteristics between households experiencing migration to the USA vs. those who do not, the percentage distribution of variables included in the analysis is provided in Table 1.

Column 1 presents the distribution of characteristics for all households. Column 2 presents the distribution of characteristics included in this analysis for infants born in households with migration experience, while column 3 presents the distributions of households without migration experience. Chi-squared test values are provided in the last column. Approximately 6% of the births in the sample were LBW, and about 13% of infants were reported to be premature. Migrant households account for approximately 7% of the sample. These percentage values are similar to the previous estimates using ENADID 1997 (Frank & Hummer 2002; Hildebrandt & McKenzie 2005).

Variables used to capture the mother's demographic profile in the complete sample indicate that more than two-thirds of mothers were between the ages of 20 and 34 years, mostly married, living predominantly in metropolitan areas with more than 100 000 inhabitants, did not report having problems during pregnancy, received some kind of prenatal care

¹The regions were classified as follows: Border: Baja California, Baja California Sur, Chihuahua, Coahuila, Nuevo Leon, Sinaloa, Sonora, Tamaulipas; Center: Colima, Guerrero, Guanajuato, Michoacan, Morelos, Nayarit, Oaxaca, Puebla, Queretaro, Tlaxcala; Southeastern: Campeche, Chiapas, Quintana Roo, Tabasco, Veracruz, Yucatán; Capital: Distrito Federal, Estado de Mexico; and Historic: Aguascalientes, Durango, Guanajuato, Jalisco, Michoacán, San Luis Potosí, and Zacatecas.

Table 1. Percentage distribution of variables

	Column 1		Column 2	Column 3	Column 4
	N size (unweighted)	Total	Migrant	Non-migrant	Chi-squared test
Member of migrant household					
Yes	2 649	6.71	100.00	0.00	
No	3 800	93.29	0.00	100.00	
Low birthweight					
Yes	2 489	6.31	5.61	6.34	2.51*
No	36 960	93.69	94.39	93.66	
Maternal age (years)					
<20	5 261	13.34	18.80	13.06	75.53**
20–34	27 500	69.71	69.33	69.73	
>34	6 688	16.95	11.86	17.21	
Maternal education (years)					
None	10 782	27.33	5.07	4.26	19.01**
1–5	23 941	60.69	56.36	60.90	
≥6	4 726	11.98	13.78	11.89	
Married					
Yes	22 575	57.23	49.90	57.42	11.09**
No	16 874	42.77	50.10	42.58	
Locality size					
<100 000	24 326	61.66	76.76	60.91	38.31**
≥100 000	15 123	38.34	23.24	39.09	
Infrastructure					
Poor	10 240	25.96	25.80	25.97	0.120
Not poor	29 209	74.04	74.20	74.03	
Health coverage					
Yes	20 675	52.41	39.64	53.05	79.18**
No	18 774	47.59	60.36	46.95	
Income					
1st quartile	3 035	22.79	27.08	22.59	7.78***
2nd quartile	3 417	25.66	26.74	25.61	
3rd quartile	3 375	25.34	22.92	25.46	
4th quartile	3 490	26.21	23.26	26.35	
Health problems during pregnancy					
Yes	16 958	42.99	56.68	57.03	30.25
No	22 491	57.01	43.32	42.97	
Mother's residence					
Border	8 188	20.76	11.65	21.21	329.20**
Capital	2 418	6.13	2.99	6.29	
Center	10 016	25.39	33.71	24.98	
Historic	10 081	25.55	34.46	25.11	
Southeastern	6 626	16.8	8.76	17.20	
Prenatal care					
Yes	38 433	97.42	97.92	97.40	7.26**
No	1 016	2.58	2.08	2.60	
Parity					
First birth	9 374	23.76	25.48	23.68	9.97**
Low parity	18 892	47.89	45.94	47.99	
High parity	10 686	27.09	27.99	27.04	
Pre-term					
Yes	5 045	12.79	11.91	12.83	4.13*
No	34 404	87.21	88.09	87.17	
Total N of infants	39 449	37 577	1872		

* $P < 0.05$; ** $P < 0.001$; *** $P < 0.10$. Migrant households were defined as households with at least one migrant to the USA prior to 2001.

and were generally low parity. The findings suggest that majority of the non-migrant households had health coverage that supports earlier arguments that health expenditures may be viewed an impetus for migration. As regards maternal education, around 4% of the mothers did not report any level of formal education, and two-thirds of the mothers in the sample completed less than 6 years of schooling. Additionally, approximately 25% of the sample was estimated to have poor infrastructure conditions in their dwelling unit.

Interesting differences in infant–maternal health and maternal characteristics are found when comparing migrant and non-migrant households (columns 2 and 3, Table 1). First, infants in migrant households have lower percentages of LBW (5.6%) compared with infants in non-migrant households (6.3%). The same pattern holds for premature births in migrant households compared with non-migrant households. Mothers in migrant households have a slightly higher percentage of prenatal care use compared with mothers in non-migrant households. The chi-squared value indicates statistically significant association between these two variables. The distributions of other variables in the analysis are as expected based on the migration experience of the household, indicating that mothers in migrant households tend to be younger with lower incomes, living in rural areas compared with mothers of non-migrant households. There are no significant associations between migration status of the household and the variables such as poor infrastructure, health problems during pregnancy and parity. Furthermore, a significant association is found between migration status of the household and mother's residence in Mexico.

Table 2 shows the odds ratios of LBW with several covariates using multivariate logistic regression.

Model I shows the bivariate relationship between the outcome of interest, LBW and the variable measuring migration experience of the household. Model II provides estimates of socio-economic status, place of residence and housing infrastructure. Model III controls for mother's age, prenatal care and maternal health-related problems during pregnancy. In order to identify the regional differences in infant birth outcomes, model IV adds dummy variables for the region

in which the infant was born. The odds ratio of LBW for infants born in migrant households is significantly lower compared with infants born in non-migrant households. Migrant households show approximately 20% lower odds of having LBW children (see model I). The significant effect was not changed through the different inclusion of covariates, suggesting a robust association between migration and LBW. As expected, the size of locality is associated with birth outcomes. The results show that non-metropolitan areas have 18% higher odds of children having LBW compared with metropolitan areas. Although the odds ratio for mothers with no formal education resulted in higher rates of LBW compared with mothers with 1–5 years of education, there was no statistical significance in this variable. The findings also suggest that adjusting for the mother's socio-economic characteristics, households in the second quartile of total income are associated with 25% higher odds of LBW compared with those in the highest quartile of the income distribution (see model II). Poor infrastructure in the dwelling unit is also associated with higher odds of LBW, while mothers' health coverage during pregnancy lowers the odds of having children with LBW by approximately 12%. After adjusting for the mother's characteristics, women reporting health problems during pregnancy have significantly higher odds of LBW compared with those with no health problems (see models III and IV). Marital status further seems to affect the odds of LBW, as married mothers exhibit 12% lower odds than single mothers. Not having prenatal care was only significant in the full model (model IV), and it is associated with 45% higher odds of LBW. Contrary to our expectations, mothers less than 20 years of age have lower odds of LBW compared with the reference group (mothers aged 20–34 years). Moreover, first-born infants have higher odds of LBW than low-parity infants, whereas high parity showed no statistical significance. Regional differences on the odds of LBW can be examined in model IV. Two regions demonstrated significant values: the Border and Center regions. Infants born in the Border region exhibit approximately 15% lower odds of LBW compared with those born in the Capital, while there are 36% higher odds of LBW for infants born in the Center region compared with the Capital region. Premature births exhibit sixfold higher odds of

Table 2. Odds of low birthweight with migration status of the household

	Model I	Model II	Model III	Model IV
Migration status (non-migrant households)				
Migrant	0.79* (0.1058)	0.74** (0.0994)	0.75** (0.1010)	0.72** (0.0966)
Locality size ($\geq 100\ 000$)				
<100 000		1.22*** (0.0799)	1.23*** (0.0815)	1.18** (0.0778)
Maternal education (1–5 years)				
No education		1.03 (0.1286)	1.03 (0.1371)	1.02 (0.1377)
≥ 6		0.93 (0.0913)	0.99 (0.0918)	0.99 (0.0903)
Income (4th quartile)				
1st quartile		1.11 (0.1130)	1.15 (0.1176)	1.17 (0.1196)
2nd quartile		1.25** (0.1251)	1.25** (0.1262)	1.26** (0.1267)
3rd quartile		0.89 (0.0953)	0.87 (0.0946)	0.86 (0.0934)
Infrastructure (not poor)				
Poor		1.24*** (0.0829)	1.26*** (0.0847)	1.26*** (0.0845)
Health coverage (No)				
Yes		0.86** (0.0498)	0.86** (0.0499)	0.88** (0.0515)
Age of the mother (20–34 years)				
<20			0.60*** (0.0680)	0.59*** (0.0675)
>34			0.91 (0.0732)	0.91 (0.0733)
Married (No)				
Yes			0.88** (0.0536)	0.87** (0.0533)
Health problems during pregnancy (no)				
Yes			2.15*** (0.1340)	2.15*** (0.1341)
Prenatal care (Yes)				
No			1.43* (0.2754)	1.45* (0.2802)
Parity (low parity)				
First birth			1.16** (0.0846)	1.16** (0.0849)
High parity			1.14 (0.0783)	1.13 (0.0779)
Mother's residence (Capital)				
Border				0.85* (0.0815)
Historic				1.19 (0.1148)
Center				1.36*** (0.1231)
Southeastern				1.02 (0.0954)
Pre-term (No)				
Yes	6.52*** (0.3770)	6.78*** (0.3935)	5.35*** (0.3265)	5.32*** (0.3247)

Standard errors are reported in parentheses. * $P < 0.10$; ** $P < 0.05$; *** $P < 0.001$.

LBW compared with full-term births (model I), and once the model includes the rest of the covariates, premature births have approximately five times higher odds of LBW (model IV).

These findings seem to support the initial hypothesis that the odds of the incidence of LBW will be lower for infants born in households engaged in international migration compared with household with no migration experience; also in addition, the positive effect of migrant households on birth outcomes remains robust after including a separate set of different explanatory variables. In the next step of the analysis, we examined the pathways through which migration on birth outcomes is related to remittances received by households or whether there is evidence for other potential mechanisms.

Table 3 shows the odds ratios of LBW using different operationalizations of the migration variable. In the first case, it was possible to differentiate those migrant households that were the recipients of remittances from those migrant households reporting not being receivers. A sample design for households was specified when running all the regression models. Specifically, Table 3 shows the odds ratios classifying migrant households being both receivers of remittances and non-receivers of remittances.

It was expected that migrant households with remittances would exhibit a statistically significant lower odds of LBW births compared with migrant non-remittance households. However, it was found that migrant households that do not receive remittances have 29% lower odds of having LBW births (model IV). Conversely, no significance in lowering the odds ratio was found for migrant household with remittances. The rest of the covariates exhibited the same pattern as discussed in Table 2. We also ran another set of logistic regression analyses with an interaction variable between household income and migration status and found no significant interaction effect (analysis not shown).

Discussion

The main purpose of this paper was to provide new evidence on the effects of international migration on the risk associated with LBW in Mexico. The general

notion is that Mexican households tend to benefit from migration to the USA. The pathways through which migration affects Mexican households were primarily categorized into three factors – economic, non-economic and selection (Frank 2005). The economic factors include the financial remittances received from the USA. It was assumed that remittances received will be used towards providing better education and medical care and other basic needs within the household. The non-economic pathway through which migration positively affects health outcomes is that of social remittances that are defined as ‘the ideas, behaviours, identities, and social capital that flow from receiving to sending country communities’ (Levitt 1998, p. 927). Here, it is assumed that migrants who return to their communities not only bring remittances but carry with them the values, norms and practices they were exposed to in the USA. The diffusion of these new practices, particularly dealing with healthcare practices, leads to better health outcomes at the individual and community levels (Kanaiaupuni & Donato 1999). The third pathway through which migration affects health outcomes is the selection of study participants. It is possible that the selection of study participants disproportionately favours healthy individuals, which would bias the results upward (Palloni & Arias 2004; Frank 2005).

While the present study results are consistent with previous studies, some additional inferences can be drawn. First, although the migrant households in Mexico seem to have lower odds of LBW children, the mechanisms through which migration affects birth outcomes is far from clear. Similar to a previous study by Frank & Hummer (2002), we also differentiated the migrant household variable by receipt of remittances from abroad. It was found that migrant households without remittances were likely to have lower odds of LBWs compared with migrant households with remittances. In analyzing the channels through which migration affects birth outcomes, the findings provide no compelling evidence for remittances as the mechanism associated with lowering the odds of LBW. This is also reflected in the household income variable. That is, infants born in the third income quartile showed a decline in LBW but with no statistical

Table 3. Odds of low birth weight with migration status and remittances

	Model I	Model II	Model III	Model IV
Migration status (non-migrant households)				
Migrant HH with remittances	0.86 (0.4216)	0.76 (0.3749)	0.82 (0.3992)	0.78 (0.3809)
Migrant HH with no remittances	0.79* (0.1089)	0.74* (0.1028)	0.75* (0.1040)	0.72* (0.0996)
Locality size ($\geq 100\ 000$)				
<100 000		1.22** (0.0798)	1.24** (0.0815)	1.18* (0.0778)
Maternal education (1–5 years)				
No education		1.03 (0.1286)	0.99 (0.1371)	1.02 (0.1377)
≥ 6		0.92 (0.0913)	1.03 (0.0918)	0.99 (0.0903)
Income (4th quartile)				
1st quartile		1.11 (0.1133)	1.15 (0.1178)	1.16 (0.1198)
2nd quartile		1.25* (0.1252)	1.25* (0.1263)	1.26* (0.1268)
3rd quartile		0.89 (0.0954)	0.87 (0.0946)	0.86 (0.0934)
Infrastructure (not poor)				
Poor		1.24** (0.0829)	1.26** (0.0847)	1.26** (0.0845)
Health coverage (no)				
Yes		0.86* (0.0498)	0.86* (0.0499)	0.88* (0.0515)
Age of the mother (20–34 years)				
<20			0.60** (0.0683)	0.59** (0.0676)
>34			0.91 (0.0732)	0.91 (0.0733)
Married (no)				
Yes			0.88* (0.0536)	0.87* (0.0533)
Health problems during pregnancy (no)				
Yes			2.15** (0.1340)	2.16** (0.1341)
Prenatal care (yes)				
No			1.43*** (0.2754)	1.45*** (0.2802)
Parity (low parity)				
First birth			1.16* (0.0846)	1.16* (0.0849)
High parity			1.14 (0.0783)	1.13 (0.0779)
Mother's residence (Capital)				
Border				0.85 (0.0815)
Historic				1.19 (0.1148)
Center				1.36** (0.1231)
Southeastern				1.02 (0.0954)
Pre-term (no)				
Yes	6.52** (0.3770)	6.78** (0.3935)	5.35** (0.3265)	5.32** (0.3247)

Standard errors are reported in parentheses. * $P < 0.05$; ** $P < 0.001$; *** $P < 0.10$.

significance. The infants born in the second income quartile only showed significant higher odds of LBW.

We provide two explanations for this. First, although ENADID 2006 has included several questions to elucidate income, errors associated with reporting income remain a significant problem. We found a significant discrepancy between percentage of migrant households and households receiving remittances. That is, in the present data, although about 6% of the households reported households with migrants, less than 1% of the households reported receiving remittances, or *migradollars*, from abroad. These percentages were approximately 7% and 2%, respectively, in ENADID 1997. It is possible that either a large percentage of the households are not reporting the receipt of remittance from abroad, or only a small percentage of the households in fact receive remittances from the USA. If the latter is true, it leads to the second explanation of social remittances. The strong and robust association between migrant households and LBW may provide new insights about the possibility that households may be benefitting from international migration indirectly. One may argue that if the majority of the households were not receiving financial remittances while the percentage of migrant households increased overall, one may see the influence of social remittances affecting LBW in Mexico. Hildebrandt & McKenzie (2005) posit the idea that households may gain some type of health knowledge from the migration experience to the USA. This in turn may generate spillovers that can be transmitted from one migrant family to another, and eventually, this process may also benefit non-migrant households. This and many other studies have shown that migrants may learn basic health knowledge such as nutrition, diet, exercise, fewer number of children, etc. while living abroad and then pass this information to their family members (Coale & Watkins, 1986; Massey & Parrado 1994; Kanaiaupuni & Donato 1999; Menjivar, 2002; Frank 2005). The basic assumption here is that the diffusion of these innovative healthcare practices will slowly become the norm of the communities; this would have a significant impact on health outcomes. Although the results presented here do not provide any conclusive evidence to

support the significance of social remittances, it was clear that migrant households with no remittances have lower odds of having LBW infants compared with migrant households with remittances. In-depth analysis directed specifically at the effects of economic and social remittances on infant health is limited with this and other existing data sources. For example, available data sources on migration and health are limited in capturing in-depth information on different sub-populations within Mexico, such as non-migrants in Mexico, internal Mexican migrants and characteristics of migrant households and communities (Frank & Hummer 2002). Another factor to be taken in to account, as mentioned previously, is underreporting of income information collected in the survey. While the ENADID 2006 survey has significantly improved from the previous survey (ENADID 1997) by adding additional questions to accurately measure household income and the sources of household income to control measurement error, the accuracy of reported household income is still questionable.

Despite the limitations of the data, the present study has provided some evidence on the mechanisms through which international migration affects LBW in Mexico. Future studies must include changes at the macro-level because migration from Mexico to the USA is not a recent phenomenon. The migration phenomenon has been institutionalized in many communities within Mexico, and changes attributed to this may be reflected at the macro-level. Additionally, one may not only be interested in testing whether this health knowledge is associated with lower risk of LBW or infant mortality, but may also consider a more extended set of maternal health variables. These research questions are left for further research.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

References

- Amuedo-Dorantes C., Sainz T. & Pozo S. (2006) *Remittances and Healthcare Expenditure Patterns of Populations in Origin Communities: Evidence from Mexico*. Inter-American Development Bank, Working Papers Series 2006.
- Amuedo-Dorantes C. & Pozo S. (2006) Remittances as insurance: evidence from Mexican immigrants. *Journal of Population Economics* **19**, 227–254.
- Barker D. (1994) Outcome of birthweight. *Hormone Research* **42**, 223–230.
- Behrman J. & Deolalikar A. (1989) Wages and labor supply in rural India: the role of health nutrition and seasonability. In *Causes and Implication of Seasonal Variability in Household Food Security* (ed. D. Sahn) pp. 107–118. The John Hopkins University Press: Baltimore.
- Behrman J. & Rosenzweig M. (2004) Returns to birthweight. *The Review of Economic Studies* **86**, 568–601.
- Bird S., Chandra A., Bennett T. & Harvey M. (2000) Beyond marital status: relationship type and duration and the risk of low birth weight. *Family Planning Studies* **32**, 281–287.
- Bobadilla J. & Langer A. (1990) La mortalidad infantil en Mexico: un fenomeno en transicion. *Revista Mexicana de Sociologia* **52**, 111–131.
- Canas J., Coronado R. & Gilmer R. (2006) *U.S., Mexico Deepen Economic Ties*. Federal Reserve Bank of Dallas. Southwest Economy, January/February: 11–14.
- Chevalier A. & O'Sullivan V. (2007) *Mother's education and birth weight*. UCD Geary Institute Discussion Paper Series: UCD Dublin.
- Coal A. & Watkins S. (1986) The decline of fertility in Europe. pp. 31–181. Princeton University Press: NJ.
- CONAPO (2002) *Consejo Nacional de Poblacion*. Series sobre Migracion: Poblacion residente en Estados Unidos. Available at: http://www.conapo.gob.mx/index.php?option=com_content&view=article&id=323&Itemid=251
- Durand J., Kandel W. & Parrado E. (1996a) International migration and development in Mexican communities. *Demography* **33**, 249–264.
- Durand J., Massey D. & Zenteno R. (2001) Mexican immigration to the United States: continuities and change. *Latin American Research Review* **36**, 107–127.
- Durand J., Parrado E. & Massey D. (1996b) Migradollars and development: a reconsideration of the Mexican case. *International Migration Review* **30**, 423–444.
- Escobar-Latapi A. (2008) *Mexican Policy and Mexico-U.S. Migration*. The Center for Comparative Immigration Studies. University of California, San Diego. Working Paper 167 (May).
- Frank R. (2005) International migration and infant health in Mexico. *Journal of Immigrant Health* **7**, 11–22.
- Frank R. & Hummer R. (2002) The other side of the paradox: the risk of low birth weight among infants of migrants and non-migrants households within Mexico. *International Migration Review* **36**, 746–765.
- Hamilton E., Villarreal A. & Hummer B. (2008) Mother's, household, and community U.S. migration experience and infant mortality in rural and urban Mexico. *Population Research and Policy Review* **28**, 123–142.
- Hildebrandt N. (2005) *Beyond Remittances: The Effects of Migration on Mexican Households in International Migration, Remittances and the Brain*. Edited by Maurice Shiff and Caglar Ozden. Palgrave MacMillan.
- Hildebrandt N. & McKenzie D. (2005) The effects of migration on child health in Mexico. *ECONOMIA* **6**, 257–289.
- Hill K. & Wong R. (2005) Mexico–US migration: views from both sides of the border. *Population and Development Review* **31**, 1–18.
- Hillemeier M., Weisman C., Chase G. & Dyer A. (2007) Individual and community predictors of preterm birth and low birthweight along the rural continuum in Central Pennsylvania. *The Journal of Rural Health* **23**, 42–48.
- Hosain M., Chatterjee N., Begum A. & Saha C. (2005) Factors associated with low birthweight in rural Bangladesh. *Journal of Tropical Pediatrics* **52**, 87–91.
- IMF (2006) *Mexico: Selected Issues*. International Monetary Fund Country Report; No. 06/351.
- INEGI (2000) *Censo General de Poblacion y Vivienda 2000*. Instituto Nacional de Estadística Geografía e Informática. Available at: <http://www.inegi.org.mx/inegi/default.aspx>.
- Kanaiaupuni S. & Donato K. (1999) Migradollars and mortality: the effects of migration on infant survival in Mexico. *Demography* **36**, 339–353.
- Khader Y. & Ta'ani Q. (2005) Periodontal diseases and the risk of preterm birth and low birth weight: a meta-analysis. *Journal of Periodontology* **76**, 161–165.
- Kleinman J. & Kessel S. (1987) Racial differences in low birth weight. *New England Journal of Medicine* **317**, 749–753.
- Levitt P. (1998) Social remittances: migration-driven local-level forms of cultural diffusion. *International Migration Review* **32**, 926–948.

- Massey D. & Parrado E. (1994) Migradollars: the remittances and savings of Mexican migrants to the USA. *Population Research and Policy Review* **13**, 3–30.
- Massey D. & Parrado E. (1997) International Migration and Business Formation in Mexico. *Social Science Quarterly* **79**, 1–20.
- Menjívar C. (2002) The ties that heal: Guatemalan immigrant women's network and medical treatment. *International Migration Review* **36**, 437–466.
- Newland K. & Patrick E. (2004) *Beyond Remittances: The Role of Diaspora in Poverty Reduction in their Countries of Origin. A Scoping Study by the Migration Policy Institute for the Department of International Development*. Migration Policy Institute.
- Palloni A. & Arias E. (2004) Paradox lost: explaining the hispanic adult mortality advantage. *Demography* **41**, 385–415.
- Rothman K., Greenland S. & Lash T. (2008) *Modern Epidemiology*. 3rd edn, Lippincott Williams & Wilkins: PA.
- Sussman B., Steinmetz S. & Peterson G. (1999) *Handbook of Marriage and Family*. Springer, Plenum press: NY.
- Unger K. (2005) *Regional Economic Development and Mexican Out-Migration*. National Bureau of Economic Research. Working Paper 11432.
- Vandenbosche R. & Kirchner J. (1998) Intrauterine growth retardation. *American Family Physician* **58**, 1384–1390.
- Varloove-Vanhorick S., Verwey R., Brand R., Gravenhorst J., Keirse M. & Ruys J. (1986) Neonatal mortality rates in relation to gestational age and birthweight: results of a National Survey of Preterm and Very-Low Birthweight in the Netherlands. *Lancet* **1**, 55–57.
- Wilcox A. (2001) On the importance and the unimportance of birth weight. *International Journal of Epidemiology* **30**, 1233–1241.