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The mixed effects of migration: Community-level migration and birthweight in Mexico

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ABSTRACT

Research on the relationship between migration and infant health in Mexico finds that migration has mixed impacts on the risk of low birthweight (LBW). Whereas the departure and absence of household and community members are harmful, remittances are beneficial. We extend this work by considering a different measure of infant health in addition to LBW: macrosomia (i.e., heavy birthweight), which is associated with infant, child, and maternal morbidities but has a different social risk profile from LBW. We link the 2008 and 2009 Mexican birth certificates with community data from the 2000 Mexican census to analyze the association between various dimensions of community-level migration (i.e., rates of out-migration, receipt of remittances, and return migration) and the risk of LBW and macrosomia. We examine this association using two sets of models which differ in the extent to which they account for endogeneity. We find that the health impacts of migration differ depending not only on the dimension of migration, but also on the measure of health, and that they are robust to potential sources of endogeneity. Whereas community remittances and return migration are associated with lower risk of LBW, they are associated with increased risk of macrosomia. By contrast, out-migration is associated with increased risk of LBW and lower risk of macrosomia. Our analysis of endogeneity suggests that bias resulting from unmeasured differences between communities with different levels of migration may result in an underestimate of the impacts of community migration on birthweight.

1. Introduction

Approximately 7% of infants in Mexico are born into households split by migration (Sunil et al., 2012). Research shows that this split-household migration has mixed consequences for the health of mothers and infants in sending communities, reflecting the complex ways that migration impacts those left behind (Frank and Hummer, 2002). Infants born into migrant-sending households are vulnerable to the adverse health consequences of emotional hardship resulting from the migration of family members, but they benefit from improved material wellbeing due to migrant remittances. Research also shows that the "mixed" effects of migration on infant health may extend beyond migrant households to non-migrant households, which contribute a larger number of births in Mexico (Kanaiaupuni and Donato, 1999). That the migration of unrelated community members has an impact on the health of infants born in sending communities reveals the far-reaching and important transnational linkages formed through migration.

Research on infant health in Mexican migrant-sending communities has focused on two key measures of infant health: low birthweight (LBW) and infant mortality. LBW, defined as births under 2500 g, is a risk factor for various child morbidities as well as for infant mortality, especially among those with very low birthweight (Paneth, 1995). LBW and infant mortality have similar social risk profiles, with increased risk for socioeconomically disadvantaged mothers. Thus, it is not surprising that LBW and infant mortality are related in similar ways to migration (Hildebrandt and McKenzie, 2005).

A different and less studied indicator of infant health is macrosomia, or birthweights greater than 4000 g. Like LBW, macrosomia is a risk factor for child morbidities and infant mortality, especially among severely macrosomic infants (Zhang et al., 2008). But macrosomia's social risk profile is unique, with increased risk for socioeconomically advantaged women (Frank et al., 2000). Thus, it is possible that macrosomia has a different relationship with migration than does LBW, which, if true, would suggest that

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the relationships between migration and infant health are mixed not only along different dimensions of migration, but also along different dimensions of health.

Recent research on the relationship between migration and overweight in sending communities suggests that this may indeed be the case. This research shows that household and community migration are associated with increased risk of child and adult overweight in Mexico, arguably because remittances—both monetary and social—result in less healthy diets and lower levels of physical activity (Creighton et al., 2011; Riosmena et al., 2013). Maternal weight prior to pregnancy and maternal weight gain during pregnancy raise infant birthweight (Siega-Riz et al., 2009). If migration raises the weight of adults in sending communities, it may thereby also raise the weights of infants both above the threshold for LBW and above the threshold for macrosomia, which would mean that migration has mixed impacts on the health of infants, decreasing risk for some but raising it for others. Heavy birthweight infants are at risk of heavy weight throughout life (Oken and Gillman, 2003). By raising the risk of macrosomia, migration may contribute to the obesity epidemic in Mexico by placing infants at risk of overweight at the very beginning of their lives.

In this paper, we simultaneously examine the impacts of several dimensions of community migration on LBW and macrosomia. We link newly available natality files from the 2008 and 2009 Mexican vital statistics, which provide a complete census of all registered, live births in Mexico in those years, with data on community characteristics, including three measures of the different dimensions of migration within a community: the rate of community out-migration measures departures and absences, the rate of community receipt of remittances measures the potential for improvements in material conditions, and the rate of community return migration captures the influence of ideas and practices that are transmitted by migrants from the destination to the sending country (i.e., "social remittances"). By focusing on the community level, our analysis will capture mechanisms occurring in both migrant and non-migrant households in migrant-sending communities, as compared to households in non-migrant sending communities.

We also address a different explanation for the association between migration and infant health in sending communities: migrant-sending communities may differ from non-migrant sending communities in ways that produce both high levels of migration and unique health profiles. Most existing studies address this possibility by controlling for a limited set of potential confounders. We follow a strategy used by Hildebrandt and McKenzie (2005) and use historic state migration rates to instrument for community receipt of remittances to determine whether our results are robust after we account for unmeasured differences across communities with varying levels of migration.

2. Background

2.1. Infant health at both ends of the birthweight distribution

LBW and macrosomia represent opposite ends of the birthweight spectrum: births less than 2500 g and births greater 4000 g, respectively. In Mexico, LBW occurs more than twice as often as macrosomia (8.4 vs. 3.0% of all births) (INEGI, 2012).

LBW is the more serious of the two outcomes, with LBW being a key risk factor for infant mortality as well as for infant and child morbidities (Paneth, 1995). Macrosomia is associated primarily with an increased risk of birth-related injuries to the infant and mother, including shoulder dystocia, asphyxia, postpartum hemorrhage, and severe perineal lacerations, which are for the most part short-term morbidities that can be addressed with prompt medical attention (Oral et al., 2001; Stotland et al., 2004). However, macrosomic infants are at increased risk of diabetes and overweight in childhood, associations that are independent of gestational diabetes (Jolly et al., 2003; Ornoy, 2011; Schaefer-Graf et al., 2005; Sparano et al., 2013). Extremely macrosomic infants (>5000 g) are at increased risk of subsequent mortality (Zhang et al., 2008).

The number of studies on LBW far exceeds that on macrosomia. The few existing studies of the demographic and social correlates of macrosomia suggest a very different risk profile for macrosomia than for LBW (Frank et al., 2000; Jolly et al., 2003; Stotland et al., 2004). This literature is based on analysis of U.S. populations, so it is an open question how relevant the results are to Mexico. In the U.S., adequate prenatal care, education, marriage, and white race are all associated with lower risk of LBW but higher risk of macrosomia. Why macrosomia occurs at higher rates among the socioeconomically advantaged is not clear, as the observed associations occur among full-term pregnancies and are net of health and health behaviors.

Mother's health and health behaviors also have contrasting associations with LBW and macrosomia, but these differences reflect the unique etiologies of LBW and macrosomia. Stress reduces birthweight and increases the risk of LBW (Wadwha et al., 1993). Underweight mothers and inadequate pregnancy weight gain are risk factors for LBW (Chomitz et al., 1995). By contrast, overweight mothers, excessive pregnancy weight gain, and gestational diabetes are independent risk factors for macrosomia (Jolly et al., 2003). While gestational diabetes is a strong risk factor for macrosomia, only 5% of births between 4000 and 4999 g, and 11.5% of births greater than 5000 g, are to mothers with gestational diabetes (Zhang et al., 2008). The incidence of gestational diabetes in Mexico is not definitively known, as diagnostic criteria and frequency of screening vary, but a recent report by the Ministry of Health shows estimates ranging between 3 and 20% of births, with 4 out of 6 studies reporting rates below 7% of pregnant women (Calderón Cisneros et al., 2009). Smoking during pregnancy slows intrauterine growth, and, as such, it increases the risk of LBW and decreases the risk of macrosomia (Wilcox, 1993).

2.2. Mechanisms linking migration to infant health

Prior work identifies three mechanisms linking migration and infant health. These mechanisms are (1) stress, (2) improvements in material conditions, and (3) changes in dietary norms and habits. While these mechanisms have been primarily identified at the household level, we draw out their relevance to the community level. Because we do not have information about migration at the household level, our estimates of the impact of community-level migration on birthweight captures both household and community-level impacts. Thus, mechanisms operating at both conceptual levels are relevant for interpreting our results.

2.2.1. Stress

A growing body of work shows that migration-induced separation between family members has adverse effects on the psychological wellbeing of those who remain behind (Wilkerson et al., 2009). Migration deprives family members of the instrumental and social support of key family members (Kanaiaupuni, 2000). Children left behind feel abandoned by their parents and experience feelings of being unloved, rage, and worry as a result (Dreby, 2010). The geographic distance and length of separation creates social distance and undermines marital unions between migrants and their family members (Frank and Wildsmith, 2005). These consequences arguably account for why migration-induced absence raises the risk of LBW and mortality among infants born in migrant-sending households (Frank, 2005).

Studies have also found deleterious consequences of out-migration at the community level, net of household migration. Kanaiaupuni and Donato (1999) found that a high degree of out-migration from a community is associated with increased odds of infant mortality. Out-migration is disruptive not only of household lives but also of community life, as it removes the instrumental and social support that migrants provide to their communities.

Taken together, these findings suggest that the risk of LBW will be higher in communities with higher rates of out-migration. However, given the negative association between maternal stress and weight gain during pregnancy, we expect rates of macrosomia to be lower in communities with higher rates of out-migration.

2.2.2. Monetary remittances

The World Bank estimates that international migrants remitted more than $21 billion to Mexico in 2009 (World Bank, 2013). Each remittance dollar increased Mexico's GNP by between $2 and $3 through consumption of goods produced in the domestic market (Adelman and Taylor, 1990). Migrant hometown associations in the U.S., migrant communities, and government remittance matching programs in Mexico have used monetary remittances to finance community development projects (Smith, 2005).

Given that *migradollars* increase consumption and are often invested in community infrastructure, it is not surprising that receipt of remittances in households and communities is associated with lower risk of LBW, as found in two studies on Mexico. The odds of LBW were nearly 50% lower in households receiving remittances (Frank and Hummer, 2002). Infants born in communities receiving more than $10,000 annually in remittances also had lower odds of infant mortality (Kanaiaupuni and Donato, 1999).

Taken together, these finding suggest that infants born in communities with larger proportion of households receiving remittances will have lower risk of LBW. However, we expect community remittances to raise the risk of macrosomia if they are used towards increased caloric consumption, as has been suggested in work on adult overweight (Riosmena et al., 2013).

2.2.3. Social remittances

Migrants also transmit social remittances to their communities of origin. Social remittances are the ideas, practices, and identities that emerge through migration, which can include health behaviors (Levitt, 1998). Research on migration and overweight in Mexican migrant-sending communities has argued that social (and monetary) remittances from migrants have ushered along the nutrition transition in Mexico (Creighton et al., 2011; Riosmena et al., 2013). The nutrition transition refers to the shift from locally sourced foods high in fiber and protein to foods sourced from national and international food chains and high in fats and sugars, with increasing rates of overweight as a result. Research shows that Mexican immigrants gain weight with time spent in the U.S., suggesting that practices and ideas related to weight change through exposure to the U.S. food culture and landscape (Antecol and Bedard, 2006; Van Hook et al., 2012). The transmission of these practices and ideas back to Mexico may be one way that migration leads to increased rates of overweight among children and adults in sending communities (Riosmena et al., 2013).

Drawing from prior empirical research, we expect that social remittances will be associated with lower risk of LBW but higher risk of macrosomia as a result of increased caloric consumption and weight gain.

2.2.4. Endogeneity problems

An assumption in the literature on the health consequences of migration is that migration is exogenous, i.e., the association between migration and health among those left behind is causal. However, it is possible that the association reflects unmeasured differences between communities with varying levels of migration, differences that influence both migration and health. For example, migration results from changes associated with economic development, including market transitions, demographic growth, and urbanization. The macro phenomena accompanying economic development also affect population health. If economic development shapes both community-level migration and health outcomes, then the association between community-level migration and health may be spurious. Failure to fully control for these differences will yield biased estimates of the association between community-level migration and birth outcomes.

Hildebrandt and McKenzie (2005) made efforts to eliminate these potential biases in their examination of the impact of household migration on LBW and infant mortality in Mexico. Their results reveal that failure to account for these potential biases understates the overall positive effect of household migration on infant health because migrant households are negatively selected—that is, they possess characteristics unrelated to migration that are associated with worse infant health compared to non-migrant households (Hildebrandt and McKenzie, 2005: 259). It is equally possible that failure to account for unmeasured differences across communities with varying levels of migration may bias our understanding of the association between community-level migration and risk of LBW and macrosomia. Natural disasters, economic crises, or crime may simultaneously increase community-level migration but undermine infant health, or, conversely, highly developed communities may have low rates of migration but very good infant health. In either case, the impact of migration would be underestimated. We apply Hildebrandt and McKenzie's approach to our analysis of community-level migration and birthweight. We show that state historic migration rates are a strong instrument for contemporary community migration and draw from their work to demonstrate instrument validity. We turn now to the data and methods of our analysis.

3. Data and methods

3.1. Data

To investigate the impact of community-level migration on birth outcomes, we linked data from the 2008 and 2009 natality files from Mexican vital statistics to municipality-level measures of migration constructed using data from the 2000 Mexican Census data and published by the Mexican National Population Council (CONAPO).

The 2008 and 2009 natality files come from Mexican vital statistics, which are collected by the Mexican Ministry of Health, and provide a census of all registered, live births occurring in Mexico in those years. The Mexican Ministry of Health instituted a new vital registration system in 2007, which made registration of births free and compulsory in order to achieve universal registration of births (Secretaría de Salud, 2007). A recent evaluation of the new system was reported in a paper by Buekens et al. (2013), who compared estimates of LBW in the vital statistics data to other data sources. They found that the new registration system provided estimates very similar to those using hospital data but slightly lower than those using survey data from the early 2000s. A more recent estimate of the rate of LBW in Mexico, from the 2012 National Survey of Health and Nutrition, was 8.4% (de Castro et al., 2012), which is very similar to the rate found in the vital statistics data when multiparous births are included (8.3%).

For the first time, this new system required that birth certificates include birthweight. Recorded close to the time of birth with the participation of parents and/or birth attendants, birthweight recorded on birth certificates is considered highly reliable (e.g. Buescher et al., 1993). The birth certificates also included information about basic socio-demographic characteristics, health care, and geographic identifiers for mother's municipality of residence. Just over four million births were reported on Mexican birth certificates in 2008 and 2009.

Birth certificates do not report household-level migration, but they do include indicators of the municipality of birth. We use these indicators to link births to data at the municipal level, captured in the Mexican Census. In 2000, there were 2443 municipalities in Mexico; in 2009, there were 2456 owing to the creation of 13 new municipalities between 2000 and 2009. 8740 births (less than 1% of the total) occurred in these new municipalities. We link these births to their 2000 municipal codes, i.e. to the municipalities from which the new municipalities split. Because we lack household-level migration in our data, our estimates of community-level impacts of migration capture mechanisms occurring at both the household and the community levels, and cannot be thought of as unique community-level effects. Rather, they are likely overestimates of community-level impacts, capturing both aggregated migrant-household effects and net community impacts across all households.

We restricted our analysis to singleton births and those with complete information on all covariates, which leaves 3.6 million births for our analysis. 4711 births out of out of 1,978,380 were missing birthweight in 2008 and 3879 out of 2,058,707 births were missing birthweight in 2009, representing fewer than 1% of births in each year.

3.2. Dependent variable

Birthweight is a categorical variable distinguishing among infants born with LBW (i.e., <2500 g or <5.5 pounds), normal birthweight (between 2500 g and 4000 g), and heavy birthweight, or macrosomia (4000+ grams or 8.8+ pounds). We also estimated models that define macrosomia as birthweights above 4500 g, as both cutoffs have been used in the literature (Zhang et al., 2008). These two sets of analyses yield virtually the same results. In our analysis of endogeneity, we use birthweight in grams.

3.3. Independent variables

Our analyses include three measures of community-level migration. **Community out-migration** captures the proportion of households in a municipality with at least one household member who migrated to the U.S. between 1995 and 2000. **Community receipt of remittances** captures the proportion of households in the municipality receiving remittances from the U.S. **Community return migration** captures the proportion of households with at least one member who was in the U.S. in 1995 but returned to Mexico by 2000. For comparability, we standardized all measures of migration so that the coefficients represent the effects of one standard deviation change in community-level migration.

Ideally, we would have measures of community migration in the year immediately preceding the births, but national data on migration appropriate for the estimation of municipal characteristics is only available in the decennial census, i.e., in 2000 or 2010. Of the two time points, we opted for the community-level migration information from 2000 in order to ensure appropriate temporal ordering of the independent and dependent variables. We estimated the same models using migration measured in data from the 2010 census, as well as using community migration interpolated for 2008 and 2009 (under the assumption of linear change over time), and the results were consistent with those presented below.

3.4. Control variables

We control for the following maternal characteristics: age at birth in years and age squared; marital status (married by church, by civil union, never married, or previously married); parity of birth (first, second, third, or fourth-and-higher); and education (primary schooling or less, some or completed middle school, some or completed high school, and or some post-secondary schooling). Our models also control for mother's health insurance coverage (social security for the private sector, social security for federal employees, public health insurance, and no insurance) and timing of prenatal care (no prenatal care vs. prenatal care begun during the first, second, or third trimester of pregnancy).

Finally, we control for two municipal characteristics. Level of marginality is measured with Mexico's Population Council's index of marginality, which is approximately normally distributed, with higher values indicating higher marginality, or lower development. Municipalities may contain both rural and urban populations, which are defined in Mexico based on a lower level of aggregation, the locality. Thus, our measure of rurality is the percent of the municipal population living in localities of 2500 people or less.

3.5. Analytical strategy

Our analysis is comprised of two parts. We begin with a series of multinomial logistic regression models predicting the competing odds of giving birth to an infant with LBW or macrosomia versus normal weight. Standard errors are adjusted for clustering within municipalities. An alternative approach is to use multi-level models, which allow for random effects at the municipal level. Random effects multinomial logistic regression models are computationally prohibitive due to large size of our data files. We assessed the robustness of our results by comparing them to hierarchical multinomial logistic regressions estimated in HLM software and to random effects multinomial logistic regression models using the GLLAMM command in STATA, both using a 1% random sample of our data. Both analyses yielded very similar results to those presented below.

In the second part, we adapt the strategy used by Hildebrandt and McKenzie (2005) to build a stronger case of causality for the impact of community-level migration on birth outcomes. Specifically, we use historic rates of state-level migration (i.e., counts of the state of migrant origin among Mexican migrants admitted to the U.S. through border entry points in April 1924, adjusted by the state population in 1921) as an instrumental variable for two-stage least squares (2SLS) regressions predicting birthweight in grams. In the first stage of this model, the percentage of households in a municipality who receive monetary remittances is regressed on historic migration rates and all control variables. In the second stage, birthweight in grams is regressed on the fitted values of the percentage of households in a municipality who receive monetary remittances from the first stage regression and other covariates. We do not instrument for all three measures of community-level migration because of multicollinearity. We analyze remittances instead of out-migration because the effect of out-migration changes depending on whether the model controls for the other measures of migration (as shown below). The results are similar in models with out-migration and return migration as the endogenous variable, and with LBW or macrosomia as the dependent variable.

Historic state migration rates are a very strong instrument for contemporary community migration; the F statistic for the coefficient on the instrument in the first-stage regression was 58.5, well above the standard cutoff for a strong instrument (Stock et al., 2002) and larger than the F-statistics reported by Hildebrandt and McKenzie (2005), suggesting that the instrument they used for household migration is appropriate for an analysis of community migration.

The logic of using state historic migration rates as an instrument for contemporary community migration rates rests on the history of Mexico–U.S. migration (Hildebrandt and McKenzie, 2005). Historic migration rates reflect the unique historical processes generating migration out of Mexico in the early 20th century, including the development of the railroad, the recruitment efforts of agricultural contractors, and local responses to the Mexican Revolution. These rates are associated with contemporary migration rates through the social inertia built into migration flows. Because the original historical processes generating geographic continuities in migration were idiosyncratic, they are arguably unassociated with unmeasured community characteristics that may impact both migration and infant health outcomes, an important assumption in the use of instrumental variables. Hildebrandt and McKenzie (2005) conducted several tests of plausible violations to this assumption, giving us reasonable confidence in the validity of the instrument. Specifically, they demonstrated that state historic migration rates are uncorrelated with state historic health conditions and uncorrelated with three of four measures of contemporary health infrastructure. Because it is plausible that state historic migration rates are related to state socioeconomic development, we control for community-level development (i.e., marginality) in our models.

4. Results

4.1. Descriptive results

Table 1 presents means and percent distributions for all variables included in our analysis. Among our population of live, singleton births in Mexico in 2008 and 2009, 7.4% were LBW and about half as many, 3.5% were macrosomic. In the average municipality, 6.3% of households had at least one household member who was a U.S. migrant and 6.5% of households received monetary remittances from the U.S. Far fewer households had a household member who was a return migrant: 1.2%.

4.2. Multinomial logistic regressions

Table 2 presents results of multinomial logistic regression models predicting the competing risk of LBW and macrosomia relative to normal birthweight. Models 1 to 3 show the unadjusted associations between each measure of community-level migration and birthweight. The unadjusted associations reveal a consistent, negative association between each measure of community-level migration and LBW and a consistent, positive association between each measure of community-level migration and macrosomia.

Model 4 adds all three measures of community-level migration into the same model. Although the three measures of community-level migration are correlated, each measure has an independent association with birthweight. Net of other dimensions of migration, the coefficient for community out-migration and birthweight changes signs: now out-migration is associated with increased risk of LBW and decreased risk of macrosomia. The coefficient changes sign because on its own community out-migration captures the consequences of absences, remittances, and return, and the effects of remittances and return outweigh those of absences. Net of remittances and return, out-migration captures the unique impacts of absences. Conversely, the signs for the other dimensions of migration remain the same.

The association between each measure of community migration and LBW takes the opposite sign from the association between the same measure and macrosomia, meaning that processes that increase the risk of LBW decrease the risk of macrosomia and vice versa. Another way of interpreting this finding is by considering the associations of community migration with birthweight in grams. In OLS models (not shown), we find that out-migration is associated

Table 1
Descriptive characteristics of births, mothers, and communities.

Birth outcomes	
Birthweight (mean)	3157.2
Birthweight categories (%)	
Low birthweight	7.4
Normal weight	89.2
Macrosomia	3.5
Mothers' characteristics	
Age (mean)	25.8
Parity (%)	
1st	36.5
2nd	28.7
3rd	19.0
4th+	15.8
Marital status (%)	
Married	50.3
Civil union	39.3
Unmarried	10.5
Education (%)	
Primary or less	27.1
Secondary	37.6
Post-secondary	35.3
Insurance (%)	
IMSS	27.0
ISSTE	3.6
Seguro popular	29.8
Other	2.5
None	37.2
Prenatal care	
First trimester	71.8
Second trimester	20.4
Third trimester	4.5
None	3.2
Sample	3,675,489
Community characteristics	
Out-migration (mean)	6.3
Remittances (mean)	6.5
Return migration (mean)	1.2
Marginality index (mean)	−1.1
Percent rural (mean)	23.7
Sample	2443

Table 2
Relative risk ratios from multinomial logistic regressions of LBW and macrosomia on community-level migration.

	Models 1–3				Model 4			
	LBW		Macrosomia		LBW		Macrosomia	
	exp (B)	B/se	exp (B)	B/se	exp (B)	B/se	exp (B)	B/se
Remittances	0.94***	−7.25	1.08***	5.67	0.91***	−5.19	1.21***	5.52
Out-migration	0.96***	−4.76	1.01	0.81	1.07***	4.94	0.76***	−7.78
Return migration	0.94***	−6.79	1.12***	5.69	0.96*	−2.51	1.15**	3.41

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
Note: Models 1–3 in the first column of results show unadjusted coefficients from bivariate regression models with each regressor introduced independently; Model 4 in the second column of results shows adjusted coefficients from a regression with all three regressors included.

with an average reduction in birthweight, whereas remittances and return migration are associated with an average increase in birthweight. Because the combined positive impacts of remittances and return are greater than the negative impact of out-migration, on balance community migration raises mean birthweight. Migration impacts birthweight across the distribution, not just at particular thresholds, and this matters for rates of both LBW and macrosomia. We also estimated quantile regressions of birthweight on community migration as a test that the effects of community migration are similar across the birthweight distribution (results not shown). We examined two sets of quantiles, the first disaggregated the birth weight distribution into quartiles and the second into deciles. Across all points of the birth weight distribution, the effects of community migration are in the same direction, suggesting that migration indeed shifts the entire birthweight distribution.

Next, we assessed whether the associations between community-level migration and LBW and macrosomia persist net of maternal characteristics, community conditions, and mother's health care. Table 3 presents the results. The relative risk ratios for the three measures of community migration hardly change across models, suggesting that differences across communities in marginality and rurality, and across mothers in socio-demographic characteristics and health care, do not account for the relationship between community-level migration and LBW or macrosomia. Our results show that the risk of LBW is considerably higher among mothers who did not receive any prenatal care and lacked health insurance. In contrast, the risk of macrosomia is considerably higher among mothers who have some form of health insurance coverage, consistent with research in the U.S.

Table 4
Coefficients from OLS and two-stage least squares regressions of birthweight in grams.

	OLS		2SLS	
	B	B/se	B	B/se
Community characteristics				
Remittances	13.2***	5.85	133.9***	5.02
Marginality	−24.9***	−3.59	38.6**	3.08
Percent rural	0.9***	4.53	−2.1**	−3.19
Mothers' characteristics				
Age	19.5***	38.24	20.2***	32.88
Age squared	−0.3***	−35.03	−0.3***	−31.36
Parity (ref = one)				
Two	41.0***	26.91	44.5***	22.72
Three	52.4***	23.28	55.3***	19.56
Four+	73.3***	24.67	72.3***	20.73
Education (ref = primary)				
Secondary	10.0***	5.53	17.4***	7.05
Preparatory	9.6**	3.35	25.5***	6.81
College	−8.4*	−2	9.6	1.94
Marital status (ref = married)				
Civil union	−11.5***	−4.25	18.7*	2.53
Never married	−26.3***	−10.18	−4.9	−0.91
Divorced/widowed	−18.1***	−3.5	−12.9*	−2.14
Insurance coverage (ref = none)				
IMSS	42.8***	11.17	51.0***	8.86
ISSSTE	33.8***	6.65	35.5***	6.63
Seguro Popular	42.4***	10.01	15.7*	2.29
Other	40.3*	2.05	70.5**	2.9
Prenatal care (ref = none)				
First	78.1***	15.62	59.8***	7.35
Second	69.1***	14.02	60.4***	9.37
Third	72.9***	16.64	63.8***	10.48
Constant	2681.7***	204.37	2686.5***	151.39

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 3
Relative risk ratios from multinomial logistic regressions of LBW and macrosomia on community-level migration and community and mothers' characteristics.

	Model 5				Model 6			
	LBW		Macrosomia		LBW		Macrosomia	
	exp (B)	B/se	exp (B)	B/se	exp (B)	B/se	exp (B)	B/se
Community characteristics								
Remittances	0.92***	−4.72	1.20***	5.33	0.92***	−4.40	1.19***	5.17
Out-migration	1.11***	7.13	0.74***	−8.98	1.11***	7.22	0.75***	−9.17
Return migration	0.94***	−3.36	1.15**	3.29	0.94**	−3.08	1.14**	3.22
Marginality	0.99	−0.66	0.84***	−4.62	0.98	−1.17	0.86***	−4.26
Percent rural	1.00***	−4.16	1.01***	5.17	1.00***	−3.71	1.01***	5.04
Mothers' characteristics								
Age	0.93***	−30.15	1.13***	25.86	0.93***	−28.87	1.13***	25.39
Age squared	1.00***	34.29	1.00***	−19.19	1.00***	33.31	1.00***	−18.71
Parity (ref = one)								
Two	0.86***	−20.96	1.23***	21.61	0.86***	−21.72	1.23***	21.54
Three	0.86***	−17.00	1.31***	18.89	0.85***	−17.93	1.31***	19.03
Four+	0.88***	−11.49	1.52***	25.28	0.87***	−12.86	1.53***	25.85
Education (ref = primary)								
Secondary	0.96***	−6.18	1.05***	4.03	0.97***	−4.03	1.03***	2.96
Preparatory	0.94***	−6.67	1.02	0.88	0.96***	−4.68	0.99	−0.51
College	0.94***	−5.68	0.85***	−6.19	0.95***	−4.28	0.83***	−7.36
Marital status (ref = married)								
Civil union	1.09***	11.18	0.96**	−2.91	1.08***	9.43	0.99	−0.72
Never married	1.20***	19.15	0.95**	−3.28	1.17***	16.45	0.98	−1.24
Divorced/widowed	1.12***	3.77	0.93	−1.58	1.11**	3.29	0.94	−1.26
Insurance coverage (ref = none)								
IMSS					0.96***	−3.00	1.30***	11.62
ISSSTE					0.98	−1.20	1.29***	8.61
Seguro Popular					0.93***	−5.39	1.28***	10.45
Other					0.92	−1.70	1.25*	2.53
Prenatal care (ref = none)								
First					0.63***	−27.25	1.04	1.49
Second					0.64***	−27.31	1.00	0.03
Third					0.62***	−26.63	0.97	−1.33
Constant	0.23***	−33.28	0.00***	−67.57	0.35***	−22.80	0.00***	−67.58

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

4.3. Two-stage least squares regressions

Table 4 presents results from an ordinary least square (OLS) regression model and a two-stage least squares regression using historic state-level migration rates as an instrument for community remittances and predicting birthweight in grams. The results are consistent with those in Tables 2 and 3: community remittances raise mean birthweight. In the OLS regression, one standard deviation increase in the percent of households in a community receiving remittances is associated with a 13.2 g increase in mean birthweight. On the right, the results of the two-stage least squares regression show a larger effect. In this model, each standard deviation increase in the percent of households in a community receiving remittances increases mean birthweight by 133.9 g. The difference in these estimates means that bias due to unmeasured differences between communities results in an underestimate of the overall positive association between community remittances receipt and birthweight: unmeasured factors affecting community migration and birthweight are those that increase migration and decrease birthweight among those left behind, or vice versa.

5. Discussion

A growing body of research shows that migration has important effects on the health of people left behind in sending communities, even the newest members of these communities. Research focusing on infant health in Mexico has demonstrated that migration at both the household and community levels matters, but how migration matters depends on the dimension of migration studied. Specifically, this research finds that whereas remittances are beneficial for infant health, the absence of household and community members is harmful for infant health (Frank, 2005; Hamilton et al., 2009; Kanaiaupuni and Donato, 1999). This conclusion is based on studies focused on two highly related indicators of infant health—LBW and infant mortality. Given the severity of both outcomes, this focus is warranted, but in this paper we argue that it misses important complexity in the relationship between migration and infant health. When broadening the measurement of infant health to include macrosomia, or heavy birthweight, it is apparent that the relationship between migration and infant health is mixed not only along dimensions of migration, but also along dimensions of infant health.

Indeed, our analysis shows that three measures of community migration—the rate of out-migration, the rate of remittance receipt, and the rate of return migration—matter for infant health in complex ways. Remittances and return migration are associated with lower risk of LBW but higher risk of macrosomia, whereas out-migration (net of remittances and return) is associated with increased risk of LBW but lower risk of macrosomia. These opposite associations with LBW and macrosomia reflect a consistent impact of each dimension of migration across the birthweight distribution, including across the thresholds defining LBW and macrosomia at opposite ends. That is, decreased risk in LBW and increased risk in macrosomia associated with remittances and return migration result from an average increase in birthweight across all points of the birthweight distribution, whereas the increased risk in LBW and decreased risk in macrosomia associated with out-migration result from an average decrease in birthweight across all points in the birthweight distribution. On balance, these offsetting impacts of different dimensions of migration produce a net increase in mean birthweight; that is, return and remittances have a stronger combined influence than out-migration. In other words, the cumulative effect of community migration is to increase birthweight, lowering the risk of LBW, but raising the risk of macrosomia, among infants born in Mexican migrant-sending communities.

Given that LBW and macrosomia are both risk factors for infant and child health problems, including infant mortality (especially for very low and very heavy birthweight infants), and that macrosomia has health implications for mothers as well, it is crucial that studies consider the impact of migration across the entire birthweight distribution. This is especially important in the context of Mexico's obesity epidemic, where migration is emerging as an important vector of change, as ideas and practices related to diet, activity levels, and body size are transmitted between sending and destination communities. Indeed, studies show that immigrants and their children are particularly vulnerable to U.S. norms related to diet and activity (Van Hook et al., 2012), and that children and adults in migrant-sending communities in Mexico are heavier than their counterparts in non-migrant sending communities (Creighton et al., 2011; Riosmena et al., 2013). Our study shows that these impacts extend to the newest members of Mexico's population, placing infants at risk of overweight at the very beginning of their lives.

Our results are robust to a reasonable test for endogeneity. That is, in an analysis instrumenting for community-level migration with historic state migration rates, we still find a positive impact of remittances on birthweight. The results of this analysis suggest that the relationship between migration (measured by receipt of remittances) and health is under-estimated in regressions that do not account for endogeneity, meaning that unmeasured characteristics of communities are those that on average raise migration and reduce birthweight, or vice versa. For example, natural disasters, crime, and economic crises may increase migration and decrease birthweight. Conversely, improving economic conditions may decrease migration and increase birthweight. Said differently, migrant-sending communities are negatively selected on birthweight, or would have lower mean birthweight than non-migrant communities in the absence of migration. Hildebrandt and McKenzie (2005) found a similar result in their analysis of household-level migration. The positive health selection of individual Mexican migrants is thought to explain the relatively low rates of LBW and infant mortality among Mexican immigrants in the United States (Palloni and Morenoff, 2001). These results suggest that, for this to be true, Mexican immigrants are not representative of either the households or communities from which they originate, at least in terms of maternal and infant health, as measured by birthweight.

Although past work has addressed several concerns with the approach we use for addressing endogeneity, we nevertheless urge caution in interpreting our results in a truly causal framework. Future work on these questions should continue to search for better ways of identifying the exogenous and unique impacts of migration on health, as well as investigating and bringing to light the multiple mechanisms through which migration in fact affects the health of non-migrants.

With that in mind, several plausible mechanisms connect community migration to infant health. Because our analysis does not separately test for household-level impacts, these mechanisms are located at both the household and community levels. Through both consumption and investment, monetary remittances improve material conditions in migrant-sending households and communities, reducing the risk of LBW. That monetary remittances increase the risk of macrosomia could be due to increased consumption of high-glucose foods, or it could reflect a more general impact of improved socioeconomic status, as macrosomia is more prevalent among the socioeconomically advantaged.

The departure and absence of migrants deprives households and communities of the social supports of key members, which causes stress and worry, undermines marriages, and starves community life. Thus, net of remittances and returns, out-migration is associated with increased risk of LBW, arguably due to the impact of maternal stress on inter-uterine growth. Stress may also explain why out-migration is associated with lower risk of macrosomia: if stress slows fetal growth, it may reduce birthweight among infants at risk of macrosomia as well.

Identifying a negative effect of out-migration requires controls for remittances and return migration. Because communities with high rates of out-migration also have high rates of remittance receipt and return migration, absent controls for these other dimensions of migration, rates of out-migration will on average produce the balance of the offsetting effects. This could explain why some studies have reported null effects of community migration on health using the rate of out-migration or a general migration index (e.g. Hamilton et al., 2009; Riosmena et al., 2013). On the other hand, studies have suggested that the impact of community out-migration may shift directions once migration becomes institutionalized, or normative, in a sending community (Kanaiaupuni and Donato, 1999). The null effects reported in other studies may capture heterogeneity in the impacts of community out-migration across communities with differing histories of migration; the net negative impact uncovered in our study may reflect the dominating influence of less institutionalized migration flows. It is also possible that return migration and remittances capture variation in institutionalization: places with more remittances and more return migration may have more institutionalized migration flows. The degree to which our results reflect a process unfolding over time is impossible to empirically assess given that historical, community-level measures of different dimensions of migration do not exist.

We argue that return migration captures a third mechanism proposed in the literature—social remittances, or the ideas and practices that migrants transmit from destination to origin (Levitt, 1998). Community return migration is associated with lower rates of LBW but higher rates of macrosomia, possibly because of ideas and practices related to the nutrition transition, as has been argued in studies of overweight in sending communities (Riosmena et al., 2013). However, we acknowledge that this measure may simply capture the opposite effect of out-migration, that is, the return of household and community members, and the possibly stress-reducing impact of their return and presence.

To properly identify the mechanisms linking community migration to infant health, measures of proximate determinants are necessary. Future work can tease out these alternatives by incorporating measures of consumption, diet, and stress, as well as better measures of access to and use of health care. Indeed, one limitation of vital statistics data is the sparse set of socioeconomic characteristics included on birth certificates. However, existing studies using survey data with rich measures of household expenditures and behaviors have been unable to explain the association between migration and health (e.g. Creighton et al., 2011). This may be because migration involves complex social and cultural change that is difficult to measure.

An important limitation of this study is that we do not have controls for household migration status in vital statistics data. Without these controls, we are unable to differentiate between mechanisms operating at the household level and those at the community level—community level associations could simply reflect an average household impact. However, studies with both measures find that community migration networks persist net of household migration (Creighton et al., 2011; Hamilton et al., 2009; Kanaiaupuni and Donato, 1999), and other studies have used a similar approach (Riosmena et al., 2013). Rather, our results should be interpreted as reflecting mechanisms that occur at both the household and community levels, and thus they likely represent an overestimate of pure community-level effects (i.e. net of household effects).

Despite these limitations, this study broadens the examination of the health consequences of migration to include macrosomia, with the conclusion that migration not only has mixed impacts on infant health depending on the dimension of migration, but also depending on how health is measured. This means that it is difficult to make concise summary statements about the impact of migration on the health and wellbeing of those left behind. Rather, as with many aspects of migration, its impacts on health are multiple and diverging, reflecting the complexity of the contexts inhabited by migrants, their families, and their communities.

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