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Epidemiological Paradox or Immigrant Vulnerability? Obesity Among Young Children of Immigrants

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Abstract According to the "immigrant epidemiological paradox," immigrants and their children enjoy health advantages over their U.S.-born peers—advantages that diminish with greater acculturation. We investigated child obesity as a potentially significant deviation from this paradox for second-generation immigrant children. We evaluated two alternate measures of mother's acculturation: age at arrival in the United States and English language proficiency. To obtain sufficient numbers of second-generation immigrant children, we pooled samples across two related, nationally representative surveys. Each included measured (not parent-reported) height and weight of kindergartners. We also estimated models that alternately included and excluded mother's pre-pregnancy weight status as a predictor. Our findings are opposite to those predicted by the immigrant epidemiological paradox: children of U.S.-born mothers were less likely to be obese than otherwise similar children of foreign-born mothers; and the children of the least-acculturated immigrant mothers, as measured by low English language proficiency, were the most likely to be obese. Foreign-born mothers had lower (healthier) pre-pregnancy weight than U.S.-born mothers, and this was protective against their second-generation children's obesity. This protection, however, was not sufficiently strong to outweigh factors associated or correlated with the mothers' linguistic isolation and marginal status as immigrants.

Keywords Child obesity · Acculturation · Hispanic

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Introduction

The demographic importance of second-generation immigrant children—that is, children born in the United States to foreign-born parents—has grown sharply and will continue to grow in decades ahead (Passel 2011). Already, one in four U.S. children now have at least one foreign-born parent, with 84 % of these children (and 94 % of those aged less than 6) born in the United States. Although some researchers have expressed optimistic views on the prospects of this "new" second generation (Farley and Alba 2002; Kao and Tienda 1995; Perlmann and Waldinger 1997), several indicators point to major vulnerabilities. These include high levels of both poverty (Borjas 2011) and unauthorized immigrant status among parents (Passel 2011), the latter resulting in reduced access to family welfare benefits (Fix and Zimmerman 2001), health care (Acevedo-Garcia and Stone 2008), and the formal economy (Massey and Gelatt 2010). These adverse developmental contexts may underlie the more pessimistic findings in recent studies examining second-generation children's cognitive development and educational outcomes (Glick et al. 2009; Magnuson et al. 2006; Mistry et al. 2008).

One of the reasons for optimism about the prospects of the immigrant second generation has been their good health, beginning at birth, relative to children of U.S.-born parents in spite of their frequently poorer socioeconomic conditions. In one of the stronger statements of this "epidemiological paradox" as it applies to immigrant Hispanic children in the United States, Flores and Brotanek (2005:296) summarized: "Research documents that less acculturation in Latino children and their parents is associated with lower infant and post-neonatal mortality, decreased low birth weight rates, better immunization coverage, a healthier diet, possibly a lower prevalence of asthma and allergies, less sexual activity in adolescents, fewer suicide attempts, and decreased use of tobacco, alcohol, and drugs." The strong corollary in this message, moreover, is that the "protection" afforded by their immigrant status dissipates as they assimilate to the more harmful lifestyle practices of the U.S.-born population (Lara et al. 2005; Rumbaut 1997). Perreira and Ornelas (2011) reviewed studies of childhood health conditions by immigrant generation status and concluded that childhood obesity prevalence followed the same pattern of increase across the first, second, and third-plus generations as did asthma and behavioral problems, including substance use, depression, and suicide.

The term "epidemiological paradox" was, to our knowledge, first coined by Karno and Edgerton (1969:233), who used it to describe the very low rates of mental illness services use by Mexican-origin adults in California despite ". . . life conditions of poverty [and] problems of acculturation [that] pose special threats to mental health." Teller and Clyburn (1974) subsequently identified a low rate of infant mortality among Mexican-origin children born in south Texas and associated it with the high proportion of immigrants in the Hispanic population. In addition, Williams et al. (1986) found low incidence of low birth weight (LBW) children among Mexican-born women in California. Guendelman et al. (1990), using the national Hispanic Health and Nutritional Examination Survey (HHANES), confirmed the immigrant association with LBW, finding that the risk of LBW among children born to Mexican-origin mothers was 60 % higher when the mother was U.S.-born than when she was Mexican-born. Superior birth outcomes were also observed in Asian and black immigrant groups (Singh and Yu 1996; Weeks and Rumbaut 1991; Yu 1982). The case for an "immigrant epidemiological paradox" became increasingly strong for birth outcomes, and for second-generation children's health outcomes more generally (Mendoza 2009; National Research Council 1999).

Nevertheless, there are reasons to be skeptical about the applicability of the immigrant epidemiological paradox to child obesity. A recent study of more than 60,000 children from a nationally representative sample of U.S. children—the 2007 National Survey of Children's Health (NSCH) (Hamilton et al. 2011a)—found that consistent with the immigrant epidemiological paradox, prevalence of allergies, asthma, developmental problems, and learning disabilities all increased across generations of the four major U.S. racial/ethnic groups, and that these results remained after adjusting for demographic, social, environmental, health access, and parental health variables. Child obesity, however, did not fit this pattern. Instead, Hamilton et al. (2011a) found inconsistent patterns of cross-generational differences in obesity prevalence across the four major racial/ethnic groups. Fuentes-Afflick (2006) had previously raised alarm about a child obesity exception to the "Latino epidemiological paradox" in an editorial comment on a study examining a survey sample of urban births (the Fragile Families and Child Wellbeing Study (FFCWS)), in which a high prevalence of obesity among Hispanic children was found already by age 3 (Whitaker and Ozul 2006). In part, this alarm may be attributed to confounding an "immigrant epidemiological paradox" with a "Hispanic epidemiological paradox," as it was first identified by Markides and Coreil (1986). Nevertheless, using these same FFCWS data, Hamilton et al. (2011b) found an elevated risk of obesity at age 3 for Mexican-origin children born to Mexican-born mothers as well as to children born to U.S.-born mothers, whereas Padilla et al. (2009) had found an elevated risk of experiencing any of a set of possible chronic conditions only when the Mexican-origin child had a U.S.-born mother.

In our upcoming review of the empirical literature on childhood obesity by the child's immigrant generation and by measures of immigrant parents' acculturation—which we limit largely to analyses of nationally representative surveys—we identify three major empirical issues that have hampered the search for a definitive answer. First, parental reports of their children's height and weight may be unreliable, and both the 2003 and 2007 waves of the NSCH rely exclusively on parental reports. Second, large total sample sizes of children, such as those found in the NSCH, are needed to identify differences by nativity and parental acculturation, but surveys with measured height and weight often have smaller sample sizes. Third, whereas maternal weight status has been found to be the single strongest predictor of whether the child is obese in studies that have been able to include it among their predictor variables (Hamilton et al. 2011b; Li et al. 2011; Salsberry and Reagan 2005; Weden et al. 2012; Whitaker 2004), this variable is not available in the larger nationally representative data sources that have been used to study the immigrant epidemiological paradox. None among the NSCH, the National Longitudinal Study of Adolescent Health (Add Health), and the Early Childhood Longitudinal Study, Kindergarten Cohort (ECLS-K) includes the height and weight variables needed to calculate maternal body mass index (BMI). Omitted variable bias is then likely in models that exclude maternal weight status among the regressor variables. Moreover, because the prevalence of overweight and obesity is lower among foreign-born than U.S.-born adults (Akresh 2008; Bates et al. 2008), studies that omit maternal weight status are unable to examine the role of this potentially important protective factor for second-generation children.

We evaluate the immigrant epidemiological paradox specifically with respect to obesity prevalence at kindergarten age. Examining obesity prevalence at this young age allows us to revisit the question posed by Fuentes-Afflick (2006) and subsequently by

Hamilton et al. (2011b) of whether the epidemiological paradox of, in particular, healthier-than-expected birth weight among the children of immigrant mothers is already "outgrown" by early childhood. We test not only for differences between children of foreign-born and U.S.-born mothers (that is, differences by maternal nativity) but also for differences by level of acculturation among foreign-born mothers. We use a novel empirical strategy to improve estimation of how obesity at kindergarten age differs by maternal nativity and acculturation. This strategy involves pooling observations from two related nationally representative longitudinal surveys, the Early Childhood Longitudinal Survey, Birth Cohort (ECLS-B), and Kindergarten Cohort (ECLS-K), and using cross-survey multiple imputation to allow estimation of a model that includes predictors from the best specification allowed by either one of the two surveys (Rendall et al. 2013). In particular, the final pooled-survey model that we estimate includes maternal BMI among the regressors, even though only in the ECLS-B were the required height and weight data collected.

Evidence Regarding an Immigrant Epidemiological Paradox for Child Obesity

Research evidence from nationally representative surveys on the associations of parental nativity and acculturation with child obesity is mixed. On balance, however, it points to no immigrant epidemiological paradox extending to second-generation immigrant children, and possibly to the opposite of such a paradox. Earlier studies of obesity in adolescence using the 1995 wave of the Add Health survey support the operation of an immigrant epidemiological paradox for first-generation adolescents only. Gordon-Larsen et al. (2003) found that first-generation Mexicans, Cubans, and island-born Puerto Ricans were "protected" against overweight and obesity by immersion in Spanish-speaking environments and by more traditional diets that include greater proportions of fruits and vegetables. Their study did not distinguish second-generation from third-plus-generation adolescents, but Popkin and Udry (1998) showed that overall prevalence of obesity did not differ between second and third-plus generations for either Hispanic or Asian adolescents, whereas first-generation prevalence of obesity was much lower.

The large total sample sizes of the cross-sectional NSCH of 2003 and 2007 have allowed researchers to conduct multivariate analyses that compare in broad racial/ethnic groups the first, second, and third-plus immigrant generations' obesity prevalence beginning at either age 10 or age 6. Studies have been conducted of children ages 10–17 (Liu et al. (2009) and Singh et al. (2009), using the 2003 NSCH; and Hamilton et al. (2011a), using the 2007 NSCH) and ages 6–11 (Taverno et al. (2010), using the 2003 NSCH for Hispanic children only). Both Singh et al. (2009) and Hamilton et al. (2011a) found that black children were the only racial/ethnic group at ages 10–17 to fit the immigrant paradox pattern of increasing obesity across generations, specifically with much lower obesity prevalence among the second generation than among third-plus generations. No substantial differences were seen in Hispanic obesity rates across the three generations, whereas second-generation Asian children had the lowest obesity prevalence in the 2003 NSCH and the highest prevalence in the 2007 NSCH. The lack of difference between second- and third-plus-generation Hispanic children is consistent with estimates from the FFCWS for 3-year-old Mexican-origin children born in large U.S. cities (Padilla et al. 2009).

Taverno et al. (2010) analyzed Hispanic children at ages 6–11, classifying children both by immigrant generation and by whether they lived in a household in which English was the primary language spoken. They found a substantially higher risk of obesity among second-generation children who lived in a household in which English was not the primary language spoken, and also among first-generation immigrant children. Both these findings are in clear contradiction of the immigrant epidemiological paradox because they imply that children with the least-acculturated parents are at the highest risk of being obese. Serious data limitations in their study, however, caution against acceptance of the findings without further replication. The levels of obesity estimated from Taverno et al.'s sample were implausibly high, at 39.5 % of 6- to 11-year-old Hispanic children, whereas Ogden and colleagues estimated the prevalence of obesity at 22.5 % of Mexican-origin children in 2003–2004 (Ogden et al. 2006) and at 25.1 % of all Hispanic (and 24.7 % of all Mexican) 6- to 11-year-olds in 2007–2008 (Ogden et al. 2010). This overestimation may be partly due to an exceptionally high fraction of missing values on their BMI variable (one-third of all 6- to 11-year-olds in their Hispanic sample; Taverno et al. 2010:146), but it is also likely to be due to errors in parental reporting of height and weight. Parental error in the reporting of their children's heights and weights has been found to be very large for younger children and minority race/ethnicity children (Weden et al. 2013), and to be large particularly among Hispanic children in economically disadvantaged households (Davis and Gergen 1994). The unreliability of parental reporting at younger ages resulted in the nonrelease of 2007 NSCH height and weight data for children under 10 (Blumberg et al. 2012). Liu et al. (2009) also noted the problem of overestimation of younger children's obesity prevalence when using the NSCH's parent-reported height and weight data, leading them to limit their analyses of the NSCH 2003 to children aged 10–17, as did Singh et al. (2009). After controlling for sociodemographic and other health variables, Liu et al. estimated models like those of Taverno et al. in which obesity was additionally specified to be dependent on whether English was the primary language spoken in the household. Unlike Taverno et al., however, they found no significant associations of language with obesity. It is not clear whether the divergent findings are due to true differences between the two age ranges they investigated or to distortions induced by greater parental reporting error of height and weight in Taverno et al.'s younger sample.

The ECLS-K and ECLS-B surveys have a major advantage over the NSCH in allowing for evaluation of the immigrant epidemiological paradox at younger ages from measured height and weight. Studies using these data have provided both evidence opposite to that predicted by the immigrant epidemiological paradox and evidence pointing simply to the lack of any differences that would indicate protective effects of immigrant status against acculturation to obesogenic U.S. lifestyles. In longitudinal analyses of overweight and obesity paths from kindergarten to grade 8 using the ECLS-K, Balistreri and Van Hook (2011) found only one statistically significant difference by the child's immigrant generation and by mother's age at arrival: only second-generation boys whose mother arrived in the United States at age 12 or older differed from third-plus-generation children in their likelihood of having an overweight or obese trajectory. This difference was in the direction of greater overweight and obesity risk for this “least-acculturated” group, contrary to the immigrant epidemiological paradox. Van Hook and Baker’s (2010) findings were mixed, with higher maternal English language proficiency being associated with lower kindergarten percentile BMI (for boys) but with higher percentile BMI growth through grade 8.

Analyzing 4-year-old children in the ECLS-B, Li et al. (2011) found no statistically significant differences in obesity between second-generation and third-plus-generation children, nor between second-generation children whose mothers arrived more versus less than 10 years before the survey, after controlling for sociodemographic variables and the fuller set of perinatal and early childhood variables than collected in the ECLS-K. Noteworthy among these sociodemographic variables was maternal BMI: they found a more than doubling of the odds of the child’s being obese when the mother was in the third tercile of BMI relative to when the mother was in the first tercile. Similarly, using the ECLS-B data, but for non-Hispanic white and black children only, Weden et al. (2012) estimated a quadrupling of the child’s odds of obesity when the mother was obese relative to normal weight status. Hamilton et al. (2011b), analyzing Mexican-origin children at age 9 in the FFCWS, found that having an obese mother quintupled the odds of the child’s being obese relative to having a normal-weight mother.

Methods

We conduct a pooled analysis of kindergartners observed in the ECLS-K and ECLS-B. Both surveys were directed by the National Center for Educational Statistics (NCES) to assess children’s early learning environments, health, and development. The ECLS-K is a school-based sample that followed a nationally representative cohort of children attending kindergarten in the United States in 1998 (U.S. Department of Education 2009b). The baseline kindergarten sample was selected using a three-stage probability sampling design to ensure national and regional geographical representativeness, and oversampled Native Hawaiian/Pacific Islanders and children attending private schools. Sample numbers are rounded to the nearest 10 to comply with NCES requirements. The overall unweighted response rate is 68.8 % for the baseline (kindergarten) wave of 19,070 children (U.S. Department of Education 2009a). The main source of nonresponse was the nonparticipation of 26.3 % of sampled schools, leaving 1,010 schools in the baseline sample. Our analysis is of obesity measured at the spring kindergarten wave. We limit our ECLS-K analytical sample to U.S.-born children whose biological mothers answered the parent survey (91.6 % of the sample) and were present in the spring of grade 1 or later waves when parent’s place of birth was assessed (83.5 % of the kindergarten sample). We exclude children who were born outside the United States (390 cases) both to limit our comparisons to second generation versus third-plus generations and to increase comparability with the ECLS-B, which has only U.S.-born children. An additional 15.1 % of cases are excluded because of missing information on one or more of the other study variables.

The ECLS-B is a nationally representative sample of the cohort of children born in the United States in 2001. Assessments were conducted at 9 months, 2 years, 4 years, and kindergarten. The ECLS-B oversampled LBW, twin, Asian, and Native American children (Snow et al. 2009). Mothers younger than 15 years when they gave birth were excluded in the ECLS-B sample design. Our analyses use the kindergarten wave, when

47 % of the original sample and 61 % of those assessed at the first (9 month) wave remained in the sample. Child height and weight were assessed in the school year the child started kindergarten, either in 2006–2007 or 2007–2008. All ECLS-B counts are rounded to the nearest 50 to comply with NCES requirements. We exclude cases (4.5 % of the total) in which the responding parent was not the biological mother. Additionally, to ensure that ECLS-B and ECLS-K sampled from the same universe of children in kindergarten, we exclude homeschooled children (2.0 %), children who skipped kindergarten and went straight to first grade (0.5 %), and children whose grade was unknown or ungraded (3.2 %). Of the potential 6,300 children who met these criteria, an additional 12.6 % of cases are excluded because of missing information on one or more of the other study variables.

Variables

Our dependent variable is obesity, defined as a BMI at or above the 95th percentile using the U.S. Centers for Disease Control reference population and procedures (Kuczmarski et al. 2002) that account for developmental differences in growth by age and gender. The ECLS-K and ECLS-B used comparable measurement protocols for assessing child height and weight.

Our main explanatory variables of interest are maternal nativity and acculturation. Mothers are defined as foreign-born if they were born outside the United States or in a U.S. territory, including Puerto Rico. The latter are classified with foreign-born mothers because as migrants to the U.S. mainland from territories with distinct linguistic and cultural contexts, they may undergo the same kind of cultural change as do international migrants. Because we include only U.S.-born children in our study, we use the standard terminology of second-generation and third-plus-generation children to distinguish mother's nativity. Maternal acculturation is alternately measured by English language proficiency or by mother's age at arrival in the United States. We focus on mothers and not fathers for both practical and theoretical reasons. Practical reasons include both the greater number of measures for mothers than for fathers. For example, pre-pregnancy BMI and the English language ability in ECLS-K were asked only of the responding parent, more than 90 % of whom were the biological mother. Additionally, father's place of birth and age at arrival was not assessed until even later waves in ECLS-K, for which attrition was even higher. Theoretical reasons include a focus on prenatal and perinatal health outcomes found among immigrant mothers and their children, and that the supervision of children's diet and other activities (Fuller et al. 2010) tends largely to be the responsibility of mothers (Folbre et al. 2005; Sayer 2005).

English language proficiency is assessed only once in both surveys: in the nine-month wave of ECLS-B and in the fall kindergarten wave of ECLS-K. In both surveys, the mother is asked to assess her ability to speak, read, write, and understand English on a four-point scale ranging from "very well" to "not well at all." These questions are administered to mothers who indicated that a non-English language was spoken at home. We code immigrant mothers as "high English proficiency" (HEP) if they answered "very well" on all measures or exclusively spoke English at home (23.2 % in ECLS-K and 18.1 % in ECLS-B), and as having "low English proficiency" (LEP) otherwise. English language use has long been identified as a key indicator of immigrant social integration or isolation (Gordon 1964) and has been previously associated, both positively and negatively, with child health and access to health care (Ayala et al. 2008; Sussner et al. 2009; Taverno et al. 2010; Yin et al. 2009). We follow previous studies (Crosnoe 2006; Han et al. 2012; Landale et al. 2013; Van Hook and Baker 2010) in using the mother's English proficiency in preference to whether English is the primary language spoken in the household (e.g., Liu et al. 2009; Taverno et al. 2010). Thus our "HEP" category applies to children either living in a household in which English is primarily spoken or whose mother has HEP.

We measure mother's age at arrival using Portes and Rumbaut's (2001) distinction between immigrants who arrived in the United States at age 13 or older (the "1.0 generation") and immigrants who arrived prior to age 13 (the "1.5 generation"). We use this measure because socialization in childhood has lifelong consequences for preferences, tastes, and beliefs, and because age at U.S. arrival is frequently used to measure the strength of immigrants' traditional cultural orientation and exposure to U.S. culture. Mother's greater U.S. duration or earlier age at U.S. arrival has been previously associated, either positively or negatively, with child health and access to health care (Balistreri and Van Hook 2011; Leclere et al. 1994; Van Hook and Balistreri 2007). We also tried two expanded categorizations of each acculturation variable, but these did not generally improve model fit over the models estimated with our dichotomous categorizations (see Baker et al. 2012: appendix) and provide less comparability with previous research.

We include control variables for socioeconomic status (SES), child's early life outcomes and conditions, and demographic factors. We assess SES using mother's education, mother's marital status, and household income, all measured in the child's kindergarten year. Household income is a continuous measure in the ECLS-K; it is a categorical measure in the ECLS-B, ranging from 1 = \$5,000 or less to 13 = \$200,001 or more. The NCES used a hot-deck method to impute missing income in both surveys. The ECLS-B categories are recoded to the middle of the range (with the open-ended category coded to \$408,500) to harmonize across the data sets. We adjust these values for inflation using constant 1998 dollars (U.S. Department of Labor 2012) and use the log of this value. We include controls for mother's race/ethnicity (non-Hispanic white, Hispanic, non-Hispanic black, Asian, Native Hawaiian/Pacific Islander, Native American/Native Alaskan, and multiracial). We use these broad groupings partly because of a lack of data on country of origin or finer ethnic classifications for U.S.-born mothers in the ECLS-K. We use the ECLS-B alone to conduct sensitivity analyses with Mexican versus other ethnicity categories among Hispanics; we use the ECLS-K to conduct analyses of acculturation variables with country of origin included for children with foreign-born mothers only (see Baker et al. 2012: appendix). Neither of these analyses produced substantively different conclusions than those from our main analyses' pan-ethnic categories.

We include additional controls for mother's age at birth (measured in years), child's age (in months), child's gender, and number of siblings (mother's report), whether the child was a singleton or twin or multiple birth, and child's birth weight. Birth weight comes from birth certificates in ECLS-B and parental reports in ECLS-K and is categorized as low (less than 2,500g), average (2,500 to 3,999g), and high (4,000g or heavier). Finally, we code mother's pre-pregnancy BMI. In the ECLS-B's nine-month wave, mothers reported their pre-pregnancy weight and their current height. We calculate from these variables the mother's pre-pregnancy BMI as weight (kg) / height (m^2). We use cross-survey multiple imputation to include maternal pre-pregnancy BMI in the ECLS-K data set for the pooled analyses, as described in the upcoming Analyses section. We use pre-pregnancy BMI rather than categorical overweight or obese classifications of maternal weight status in our analyses after finding model fit to be better for BMI.

Analyses

We first compare descriptive statistics on obesity and the predictor variables between second-generation children and third-plus-generation children, and by two maternal acculturation indicators: LEP ("less-acculturated" group) versus HEP; and 1.0 generation ("less-acculturated" group) versus 1.5 generation separately for ECLS-K and ECLS-B. We then estimate logistic regression models to examine the association between child obesity and maternal nativity and acculturation, using children with the less-acculturated immigrant mothers as the reference group. According to the immigrant epidemiological paradox, both the children of more-acculturated mothers and third-plus-generation children are more likely to be obese after controlling for socioeconomic and other relevant variables.

Our main analyses consist of regression models estimated on a sample that pooled children across the two surveys (for supplementary analyses of the ECLS-K and ECLS-B samples separately, see Baker et al. 2012: appendix). The pooled survey methodology used to combine ECLS-K and ECLS-B is adapted from that described in Rendall et al. (2013). We use cross-survey multiple imputation (MI) to impute mother's pre-pregnancy BMI from the ECLS-B to every observation in the ECLS-K. This cross-survey MI method allows our preferred regression specification to be used for the pooled-survey estimation. This model can then be estimated on a sample that is triple the size of the ECLS-B alone, greatly improving our statistical power to detect differences in child obesity by maternal nativity and acculturation. We show in the Results section that estimates of the association of maternal nativity and acculturation with kindergartners' obesity are substantially different after we control for maternal pre-pregnancy BMI. The cross-survey MI method thus overcomes omitted variable bias that would be present if the analyses used only variables observed in the ECLS-K. Because mother's pre-pregnancy BMI is missing for every observation in the ECLS-K, the missing at random (MAR) assumption required for unbiased MI estimation is easily satisfied. The MAR assumption may not hold, however, for nonresponse missingness of other variables in the ECLS-K or ECLS-B; for that reason, we confine our use of MI to the cross-survey imputation of maternal pre-pregnancy BMI and use instead listwise deletion for item nonresponse (Allison 2002).

Because our estimation combines observations from two nationally representative surveys administered eight years apart, we begin by assuming that they sample from a common population (universe) except for a potential difference in the outcome variable (obesity in kindergarten). We test and substantiate the validity of this assumption by conducting diagnostics under a model-fitting framework (see Rendall et al. 2013; Weden et al. 2012). Our finding of model-fit improvement when adding an intercept shift variable for overall child obesity level differences between the surveys, we argue, is not problematic (for further discussion, see Baker et al. 2012: appendix). Crucially, model fit does not improve after we add a full set of covariate interactions with "survey." Estimates are weighted in the analysis model using the ECLS-K and ECLS-B survey weights to account for oversampling and attrition. Following standard multiple-imputation practice as implemented in SAS PROC MI (SAS Institute 2011), we do not use weights in the imputation model. Confidence intervals, standard errors, and significance tests in both the descriptive results and multivariate analyses adjust for clustering. The multivariate analysis results include adjustment also for the additional uncertainty introduced by using multiple imputation (with SAS PROC MIANALYZE).

Results

Descriptive Statistics

Weighted means and percentages are displayed in Table 1 for the ECLS-K and Table 2 for the ECLS-B by mother's nativity and by mother's language proficiency and age at arrival. The separate presentation of these estimates for the two surveys allows for a first opportunity to assess the comparability of the two surveys, and thus their suitability for pooled analysis. Recall that both the ECLS-K and ECLS-B are designed to be nationally representative with respect to the cohorts from which they sample: respectively, children who entered kindergarten in 1998, and children who entered kindergarten in 2006 or 2007. We know from NHANES analyses that the prevalence of child obesity changed relatively little between 1999 and 2007 (Ogden et al. 2010). In this context, we note the substantially higher overall obesity prevalence in the ECLS-B compared with the ECLS-K (17.0 % vs. 11.5 %, $p < .001$). Previous research using the ECLS-B preschool wave (Anderson and Whitaker 2009) found significantly higher levels of obesity compared with similarly aged NHANES children but found comparable differences in obesity by race between the ECLS-B and NHANES. In separate analyses reported elsewhere (Baker et al. 2012: appendix), we found that obesity prevalence was substantially higher in the ECLS-B than in the NHANES. However, the obesity prevalence in the ECLS-K and NHANES were very similar. As we show in our multivariate analyses, obesity in the ECLS-B remains higher after including a range of controls, but does not imply different relationships of the predictor variables to kindergarten obesity.

We also compared the weighted ECLS-K and ECLS-B sample estimates on other predictor variables as shown in Tables 1 and 2. We found that across the measures of nativity and acculturation, ECLS-B mothers were more likely to be Hispanic and less likely to be non-Hispanic white than ECLS-K mothers. Additionally, ECLS-B has a higher prevalence of foreign-born mothers compared with ECLS-K (20.0 % vs. 14.8 %, respectively). These differences are consistent with demographic shifts in the racial/ethnic composition and parental nativity of the U.S. child population that occurred between the two surveys (Ennis et al. 2011; Passel 2011).

Our first substantively important result shown in Tables 1 and 2 is that second-generation children are significantly more likely to be obese than third-plus-generation children in both the ECLS-K (17.2 % vs. 10.5 %) and the ECLS-B (24.2 % vs. 15.1 %). Moreover, we find higher obesity prevalence among children of less-acculturated immigrant mothers for both of our dimensions of acculturation (language proficiency and age at arrival), although differences are statistically significant only for English proficiency. Obesity is more prevalent among children with low-English mothers than among those with high-English mothers (19.9 % vs. 13.0 % in ECLS-K, and 28.2 % vs. 15.4 % in ECLS-B).

Table 1 Weighted percentages and means for study variables from Early Childhood Longitudinal Study, Kindergarten Cohort (ECLS-K) 1998, spring kindergarten wave[a]

	Second Generation						
	Low English Proficiency (LEP)	High English Proficiency (HEP)	Gen. 1.0	Gen. 1.5	Total	Third-Plus Generation	Total
Child Obese (BMI% ≥ 95)	19.9	13.0	17.9	15.5	17.2	10.5	11.5
	$p < .001$		$p = .288$			$p < .001$	
Mother's English Proficiency by Nativity							
LEP second gen.	—	—	74.5	28.0	61.5	—	9.1
HEP second gen.	—	—	25.5	72.0	38.5	—	5.7
Third-plus gen.	—	—	—	—	—	—	85.2
Mother's Generation Status[b]							
Generation 1.0	87.2	47.6	—	—	72.0	—	10.7
Generation 1.5	12.8	52.4	—	—	28.0	—	4.1
Third-plus gen.	—	—	—	—	—	—	85.2
Mother's Race/Ethnicity							
White	6.6	31.5	11.1	29.1	16.2	75.4	66.6
Hispanic	77.4	35.8	65.2	51.7	61.4	7.6	15.5
Black	1.2	13.5	5.5	7.0	5.9	14.1	12.9
Asian	13.4	15.0	16.0	8.9	14.0	0.5	2.5
Native American[c]	—	—	—	—	—	—	1.2
Hawaiian/Pacific Islander	1.2	2.8	1.8	2.1	1.8	0.4	0.6
More than one race[c]	—	—	—	—	—	—	0.6
	$p < .001$		$p < .001$			$p < .001$	
Mother's Education							
Less than 9th grade	30.8	4.7	26.5	5.9	20.8	1.0	3.9
9th–12th grade	16.3	8.1	13.3	12.8	13.1	7.2	8.1
High school diploma/GED	28.0	22.3	24.5	29.1	25.8	31.5	30.6
Some college	14.0	34.8	17.5	33.6	22.0	34.9	33.0
Bachelor's degree	8.2	19.2	12.9	11.1	12.4	17.1	16.4
At least some graduate school	2.7	10.9	5.2	7.5	5.9	8.4	8.0
	$p < .001$		$p < .001$			$p < .001$	
Log Household Income	10.01	10.66	10.17	10.50	10.26	10.66	10.60
	$p < .001$		$p < .001$			$p < .001$	
Mother's Marital Status							
Never married	13.5	9.8	11.7	13.0	12.1	12.8	12.7
Married	78.0	75.4	78.4	73.2	77.0	73.7	74.2
Formerly married	8.5	14.8	9.8	13.8	10.9	13.5	13.1
	$p < .001$		$p = .124$			$p = .049$	
Birth Weight							
Low	4.8	9.0	5.6	8.5	6.4	7.1	7.0

Table 1 (continued)

	Second Generation						
	Low English Proficiency (LEP)	High English Proficiency (HEP)	Gen. 1.0	Gen. 1.5	Total	Third-Plus Generation	Total
Average	83.8	79.9	82.9	80.7	82.3	80.9	81.1
High	11.4	11.1	11.5	10.8	11.3	12.0	11.9
	$p = .009$		$p = .093$			$p = .436$	
Mother's Age at Birth (years)	27.7	29.1	28.6	27.3	28.2	27.7	27.8
	$p < .001$		$p < .001$			$p = .027$	
Singleton	97.9	97.3	97.8	97.4	97.7	97.6	97.6
	$p = .608$		$p = .728$			$p = .886$	
Child's Age (months)	73.6	73.9	73.5	74.2	73.7	74.9	74.7
	$p = .294$		$p = .003$			$p < .001$	
Female	47.6	49.6	48.1	49.3	48.4	48.8	48.8
	$p = .438$		$p = .689$			$p = .789$	
Siblings	1.73	1.48	1.68	1.52	1.64	1.44	1.47
	$p < .001$		$p = .010$			$p < .001$	
Observations[d]	1,220	780	1,460	540	2,000	10,040	12,050

[a] All percentages and means are weighted using ECLS-K and ECLS-B sample weights. Tests of statistical significance are reported for contrasts between HEP foreign-born and LEP foreign-born, generation 1.0 and generation 1.5, and foreign-born and U.S.-born; they adjust for stratification and clustering in the sample designs.

[b] Generation 1.0 is defined as arriving in the United States at age 13 or older; generation 1.5 is defined as arriving in the United States prior to age 13.

[c] Some cells are left intentionally blank to comply with NCES disclosure guidelines.

[d] Observations are rounded to the nearest 50 to comply with NCES disclosure guidelines.

Consistent with other research on immigrants (e.g., Passel 2011), we find that a large percentage of second-generation children have Hispanic mothers, especially among children with LEP mothers. Hispanic is also the dominant racial/ethnic group among children with HEP mothers; however, non-Hispanic white children and Asian children are also numerous. The racial/ethnic distribution is generally similar by mother's age at U.S. arrival. On maternal education and household income, second-generation children, especially those with less-acculturated mothers, were disadvantaged relative to third-plus-generation children. Additionally, children of LEP mothers were more likely to have never-married mothers, and children of HEP mothers were more likely to have formerly married mothers in both surveys. Children's birth weight distributions were consistent with the immigrant epidemiological paradox: second-generation children were less likely to have been LBW than third-plus-generation children, although differences are statistically significant only in the ECLS-B. More strikingly, prevalence of LBW was much lower among children with low-English mothers than among children with high-English mothers in both surveys.

Finally, examining pre-pregnancy weight status (available only in ECLS-B), immigrant mothers' average pre-pregnancy BMI was lower than that of U.S.-born mothers

Table 2 Weighted percentages and means for study variables from Early Childhood Longitudinal Study, Birth Cohort (ECLS-B) 2001, kindergarten waves[a]

	Second Generation						
	Low English Proficiency (LEP)	High English Proficiency (HEP)	Gen 1.0	Gen 1.5	Total	Third-Plus Generation	Total
Child Obese (BMI% ≥95)	28.2	15.4	24.9	21.8	24.2	15.1	17.0
	$p = .004$		$p = .47$			$p < .001$	
Mother's Nativity by English proficiency							
LEP second gen.	—	—	80.8	27.4	68.5	—	13.7
HEP second gen.	—	—	19.2	72.6	31.5	—	6.3
Third-plus gen.	—	—	—	—	—	—	80.0
Mother's Generation Status[b]							
Generation 1.0	90.8	46.9	—	—	77.0	—	15.4
Generation 1.5	9.2	53.1	—	—	23.0	—	4.6
Third-plus gen.	—	—	—	—	—	—	80.0
Mother's Race/Ethnicity							
White	6.4	22.0	10.5	14.1	11.3	69.2	57.6
Hispanic	79.8	42.3	68.5	66.2	68.0	11.2	22.5
Black	3.2	13.4	6.1	7.2	6.4	16.0	14.1
Asian	10.5	21.0	14.4	11.6	13.8	0.5	3.2
Native American[c]	—	—	—	—	—	—	0.7
Hawaiian/Pacific Islander[c]	—	—	—	—	—	—	0.1
More than one race[c]	—	—	—	—	—	—	1.8
	$p < .001$		$p = .28$			$p < .001$	
Mother's Education							
Less than 9th grade	23.4	2.6	19.4	8.2	16.9	0.9	4.1
9th–12th grade	18.0	7.1	14.2	15.8	14.6	8.9	10.0
High school/GED	33.9	19.6	30.7	25.0	29.4	27.1	27.6
Some college	14.7	36.2	16.7	37.5	21.5	33.7	31.3
Bachelor	5.3	19.8	10.4	8.2	9.9	17.8	16.2
At least some graduate school	4.7	14.7	8.6	5.4	7.8	11.5	10.8
	$p < .001$		$p < .001$			$p < .001$	
Log Household Income	10.03	10.75	10.22	10.40	10.26	10.53	10.47
	$p < .001$		$p = .013$			$p < .001$	
Mother's Marital Status							
Never married	21.9	11.9	16.5	26.5	18.8	19.7	19.5
Married	68.7	76.2	72.8	65.1	71.0	68.9	69.3
Formerly married	9.4	11.9	10.7	8.4	10.2	11.4	11.2
	$p = .007$		$p = .096$			$p = .547$	
Birth Weight							
Low	5.5	9.4	6.3	8.2	6.7	7.6	7.4
Average	86.3	85.5	86.5	84.5	86.1	82.4	83.1

Table 2 (continued)

	Second Generation						
	Low English Proficiency (LEP)	High English Proficiency (HEP)	Gen 1.0	Gen 1.5	Total	Third-Plus Generation	Total
High	8.2	5.2	7.2	7.3	7.2	10.0	9.5
	$p = .044$		$p = .606$			$p = .041$	
Mother's Age at Birth (years)	28.0	27.9	28.8	24.9	27.9	27.2	27.4
	$p = .87$		$p < .001$			$p = .023$	
Singleton	98.0	1.0	1.0	1.0	1.0	1.0	96.9
	$p = .849$		$p = .728$			$p = .886$	
Child's Age (months)	67.5	68.0	67.6	67.8	67.6	68.3	68.1
	$p = .268$		$p = .74$			$p = .003$	
Female	47.1	49.4	47.7	48.1	47.8	50.0	49.5
	$p = .61$		$p = .93$			$p = .282$	
Siblings	1.62	1.30	1.55	1.42	1.52	1.49	1.50
	$p < .001$		$p = .115$			$p = .65$	
Mother's Pre-Pregnancy BMI	24.5	24.0	24.1	24.9	24.3	25.1	25.0
	$p = .22$		$p = .14$			$p = .001$	
Observations[d]	850	550	1,100	300	1,400	4,150	5,550

[a] All percentages and means are weighted using ECLS-B sample weights. Tests of statistical significance are reported for contrasts between HEP foreign-born and LEP foreign-born, generation 1.0 and generation 1.5, and foreign-born and U.S.-born; they adjust for stratification and clustering in the sample designs.

[b] Generation 1.0 is defined as arriving in the United States at age 13 or older; generation 1.5 is defined as arriving in the United States prior to age 13.

[c] Some cells are left intentionally blank to comply with NCES disclosure guidelines.

[d] Observations are rounded to the nearest 50 to comply with NCES disclosure guidelines.

(24.3 vs. 25.1, $p < .001$), again indicating a protective effect for second-generation immigrant children's health in the context of known positive intergenerational correlations of weight status (e.g., Martin 2008). In results not shown, we found that 10.5 % of second-generation children's mothers were obese, and 37.0 % were either overweight or obese; whereas the corresponding figures for third-plus-generation children' mothers were 15.9 % and 40.4 %. No statistically significant differences were found in pre-pregnancy BMI between more- and less-acculturated immigrant mothers.

Multivariate Analyses

Results from our pooled logistic regression models predicting kindergarten obesity are presented as odds ratios (OR) in Table 3. Our best-fitting model specification depicted in this table contrasts LEP versus HEP as the acculturation variable. (We discuss alternative acculturation specifications later.) Model 1 includes all predictor variables except mother's pre-pregnancy BMI. Model 2 includes pre-pregnancy BMI. The comparison of these models allows us to examine how controlling for this variable,

Table 3 Logistic regression models predicting obesity (BMI% ≥ 95) among kindergarteners using data from the Early Childhood Longitudinal Study, 1998 Kindergarten Cohort (ECLS-K) and 2001 Birth Cohort (ECLS-B) by Hispanic ethnicity: Odds ratios (OR) and 95 % confidence intervals (CI)

	Hispanic				Non-Hispanic[a]				All Children			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Mother's English Proficiency by Nativity												
(LEP second generation)												
HEP second generation	0.65	(0.43, 0.99)	0.62	(0.41, 0.94)	0.95	(0.61, 1.47)	0.86	(0.55, 1.35)	0.75	(0.56, 1.01)	0.71	(0.53, 0.95)
Third-plus generation	0.71	(0.53, 0.96)	0.61	(0.45, 0.83)	0.83	(0.53, 1.31)	0.70	(0.44, 1.12)	0.72	(0.58, 0.90)	0.62	(0.50, 0.78)
Mother's Race/Ethnicity (white)												
Hispanic	—	— —	—	— —	—	— —	—	— —	1.55	(1.28, 1.87)	1.39	(1.14, 1.70)
Black	—	— —	—	— —	1.44	(1.18, 1.76)	1.26	(1.03, 1.53)	1.40	(1.15, 1.69)	1.22	(1.00, 1.49)
Asian	—	— —	—	— —	0.99	(0.67, 1.46)	1.06	(0.72, 1.57)	0.94	(0.69, 1.27)	1.02	(0.75, 1.38)
Native American	—	— —	—	— —	1.44	(1.04, 2.00)	1.32	(0.95, 1.84)	1.41	(1.02, 1.95)	1.31	(0.94, 1.82)
Hawaiian/Pacific Islander	—	— —	—	— —	1.40	(0.85, 2.30)	1.30	(0.76, 2.20)	1.38	(0.86, 2.24)	1.24	(0.74, 2.06)
More than one race	—	— —	—	— —	1.59	(0.89, 2.83)	1.47	(0.81, 2.64)	1.56	(0.88, 2.79)	1.45	(0.80, 2.63)
Mother's Education (less than 9th grade)												
9th–12th grade	0.77	(0.49, 1.21)	0.73	(0.46, 1.15)	0.79	(0.41, 1.53)	0.79	(0.41, 1.53)	0.73	(0.52, 1.03)	0.73	(0.51, 1.03)
High school/GED	0.65	(0.45, 0.94)	0.67	(0.46, 0.97)	0.72	(0.38, 1.37)	0.71	(0.37, 1.35)	0.66	(0.49, 0.89)	0.66	(0.49, 0.90)
Some college	0.65	(0.42, 1.01)	0.66	(0.42, 1.03)	0.71	(0.38, 1.36)	0.68	(0.36, 1.30)	0.66	(0.49, 0.90)	0.64	(0.47, 0.88)
Bachelor's	0.59	(0.31, 1.10)	0.63	(0.32, 1.23)	0.46	(0.24, 0.89)	0.48	(0.25, 0.93)	0.43	(0.31, 0.61)	0.46	(0.32, 0.66)
Some grad. school	0.38	(0.16, 0.91)	0.45	(0.19, 1.07)	0.48	(0.24, 0.96)	0.52	(0.25, 1.05)	0.43	(0.29, 0.65)	0.48	(0.31, 0.72)
Log Household Income	0.95	(0.82, 1.09)	0.97	(0.84, 1.12)	0.89	(0.82, 0.97)	0.92	(0.84, 1.00)	0.91	(0.84, 0.97)	0.94	(0.87, 1.01)

Table 3 (continued)

	Hispanic				Non-Hispanic[a]				All Children			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Mother's Marital Status (never married)												
Married	0.73	(0.52, 1.03)	0.72	(0.51, 1.02)	0.94	(0.74, 1.19)	0.91	(0.72, 1.16)	0.84	(0.69, 1.03)	0.82	(0.67, 1.01)
Formerly married	0.98	(0.64, 1.48)	0.98	(0.64, 1.49)	0.92	(0.70, 1.21)	0.92	(0.70, 1.21)	0.91	(0.73, 1.14)	0.91	(0.73, 1.13)
Birth Weight (average)												
Low	0.63	(0.38, 1.02)	0.64	(0.38, 1.05)	0.66	(0.52, 0.83)	0.66	(0.52, 0.83)	0.65	(0.53, 0.80)	0.66	(0.53, 0.81)
High	2.64	(1.85, 3.76)	2.42	(1.68, 3.48)	1.84	(1.50, 2.26)	1.55	(1.25, 1.93)	2.01	(1.68, 2.40)	1.74	(1.44, 2.10)
Mother's Age at Birth	1.02	(1.00, 1.04)	1.01	(0.99, 1.03)	1.01	(1.00, 1.03)	1.00	(0.99, 1.02)	1.02	(1.01, 1.03)	1.01	(1.00, 1.02)
Singleton	1.07	(0.58, 1.98)	1.13	(0.58, 2.19)	1.10	(0.78, 1.55)	1.20	(0.85, 1.71)	1.09	(0.81, 1.48)	1.19	(0.87, 1.63)
Child Is Female	0.77	(0.61, 0.98)	0.78	(0.61, 1.00)	1.05	(0.91, 1.20)	1.02	(0.89, 1.17)	0.96	(0.86, 1.08)	0.95	(0.85, 1.07)
Child's Age	0.98	(0.95, 1.00)	0.97	(0.94, 1.00)	1.01	(0.99, 1.02)	1.01	(0.99, 1.02)	1.00	(0.98, 1.01)	1.00	(0.98, 1.01)
Number of Siblings	0.86	(0.75, 0.98)	0.84	(0.74, 0.97)	0.78	(0.73, 0.83)	0.76	(0.72, 0.82)	0.80	(0.76, 0.85)	0.79	(0.74, 0.84)
Maternal Pre-Pregnancy BMI[b]	—	— —	1.07	(1.04, 1.09)	—	— —	1.07	(1.06, 1.09)	—	— —	1.07	(1.06, 1.09)
Survey Sample Control ECLS-B (vs. ECLS-K)	1.61	(1.21, 2.14)	1.61	(1.21, 2.15)	1.47	(1.24, 1.76)	1.45	(1.21, 1.73)	1.51	(1.30, 1.75)	1.49	(1.28, 1.73)
Observations[c]	3,100				14,500				17,600			

Notes: All regressions are weighted using ECLS-K and ECLS-B normalized sample weights; confidence interval estimates adjust for stratification and clustering in the sample designs. Those 95% confidence intervals that do not span 1.00 imply that the odds ratio is statistically significantly different from 1 at $p < .05$.

[a] Includes white, black, Asian, Native American, Hawaiian/Pacific Islander, and multiracial who indicated that they were not Hispanic.

[b] Mother's pre-pregnancy BMI is calculated from reported height and weight for the ECLS-B sample and is imputed for the ECLS-K sample.

[c] All observations are rounded to comply with NCES disclosure guidelines.

which we expect to be a protective factor for second-generation children, influences our estimates of the impact of maternal nativity and acculturation on early childhood obesity. Model estimates are presented separately for Hispanics, non-Hispanics, and for all children.

For our reference group, we always use the "least-acculturated" category. If the immigrant epidemiological paradox holds, obesity should be greater for both third-plus-generation children and more-acculturated second-generation children. Our results show instead either the opposite direction of association or no statistically significant association. When maternal BMI is not controlled for (Model 1), compared with second-generation children with low-English-proficient mothers, third-plus-generation children have lower odds of being obese both for Hispanic children (OR: 0.71, 95% confidence interval (CI): 0.53, 0.96) and for all children (OR: 0.72, CI: 0.58, 0.90). Second-generation children with HEP mothers also have lower odds of obesity in kindergarten than do second-generation children with LEP mothers, although this is statistically significantly only for the Hispanic group (OR: 0.65, CI: 0.43, 0.99 for Hispanics; OR: 0.75, CI: 0.56, 1.01 for all children). The odds of obesity were statistically indistinguishable between second-generation children with HEP mothers and third-plus-generation children (results not shown). Therefore, only for second-generation children with less-acculturated mothers do we find a statistically significant difference in obesity from third-plus-generation children. Crucially, this difference is opposite to the direction predicted by the immigrant epidemiological paradox.

Model 2 includes maternal pre-pregnancy BMI. Maternal pre-pregnancy BMI is strongly positively associated with obesity. For Hispanic, non-Hispanic, and all children, a one-unit increase in maternal pre-pregnancy BMI is associated with a 7 % increase in the odds of child obesity (all children OR: 1.07, CI: 1.06, 1.09). Consistent with a protective effect of second-generation children's mothers' lower BMI, on average, we find that the adverse child obesity contrast between second-generation children with low-English-proficient mothers and third-plus-generation children increases in magnitude after we control for pre-pregnancy BMI. Among all children, the odds of obesity become 38 % lower for third-plus-generation children than for children of LEP mothers second-generation children (OR: 0.62, CI: 0.50, 0.78), whereas they were 28 % lower in Model 1. Lower maternal BMI may be especially protective for less-acculturated second-generation children: in the all-children estimates for Model 2, the contrast between second-generation children of LEP and HEP mothers becomes statistically significant after we control for maternal pre-pregnancy BMI in Model 2 (OR: 0.71, CI: 0.53, 0.95), whereas only for Hispanic children is there a statistically significant adverse association of early childhood BMI with being less acculturated in Model 1. We find a similar direction of change in the ORs for both the Hispanic and non-Hispanic samples in Model 1, although differences are significant only for the Hispanic sample. Overall, then, we find that less-acculturated second-generation children are afforded protection from lower exposure to high maternal pre-pregnancy BMI, but that this is not sufficient to counter the major obesity disadvantages of second-generation children relative to third-plus-generation children.

The relationships of the control variables other than maternal BMI to child obesity are similar between the Hispanic and non-Hispanic samples, and as such, our discussion of these variables focuses on the all-children models. Examining the ORs for the socioeconomic variables in Model 2, we see results consistent with other research on early-childhood obesity (Classen and Hokayem 2005; Shrewsbury and Wardle 2008; Weden et al. 2012). Children with Hispanic mothers have the highest odds of obesity relative to the children of non-Hispanic white mothers (OR: 1.39, CI: 1.14, 1.70), followed by children with black mothers (OR: 1.22, CI: 1.00, 1.49). Mother's education has a strong inverse relationship to child obesity. Compared with the reference category of less than grade 9, the odds of the child's obesity decrease from 0.66 (CI: 0.49, 0.89) for children of mothers with a high school diploma to 0.48 (CI: 0.31, 0.72) for children of mothers with a college degree. Both child's birth weight and mother's age at birth are strong predictors of obesity in kindergarten, consistent with previous studies (Classen and Hokayem 2005; Salsberry and Reagan 2005; Weden et al. 2012). LBW children have lower odds (OR: 0.66, CI: 0.53, 0.81) and high birth weight children have higher odds of obesity (OR: 1.74, CI: 1.44, 2.10). A one-year increase in mother's age at birth is associated with a 1 % increase in the odds of child obesity (OR: 1.01, CI: 1.00, 1.02). Further, each additional sibling is associated with a 21 % reduction in the odds of child obesity (OR: 0.79, CI: 0.74, 0.84).

Next, we compare the preceding results for our preferred maternal nativity and acculturation variable (English language proficiency) with those from two alternate specifications of acculturation (see Table 4). Again, we present results separately for Hispanics, non-Hispanics, and all children; and again, Model 1 includes all controls except maternal pre-pregnancy BMI, and Model 2 adds maternal pre-pregnancy BMI. The first two rows of Table 4 present the same ORs as shown earlier in Table 3, in which English language proficiency is the acculturation variable.

In the third and fourth rows, maternal acculturation is specified instead by age at U.S. arrival, with those arriving age 13 or older (the 1.0 generation) as the less-acculturated reference category and those arriving age 13 or younger (the 1.5 generation) as the more-acculturated group. We find that contrasts between less-acculturated second-generation children and either more-acculturated second-generation children or third-plus-generation children are weaker than when English language proficiency is used as the measure of acculturation. For example, in Model 2, the odds of obesity for all third-plus-generation children are 34 % lower than for all second-generation children with 1.0-generation mothers (OR: 0.66, CI: 0.52, 0.82), whereas they were 38 % lower than for all second-generation children with low-English mothers. Moreover, without controlling for maternal pre-pregnancy BMI (Model 1), none of the contrasts between third-plus-generation children and children of 1.0-generation mothers are statistically significant. No statistically significant differences between the children of 1.0- and 1.5-generation mothers are seen in any of the combinations of models and samples. These results together suggest that mother's earlier age at arrival in the United States is a weaker indicator of acculturation as it affects children's (reduced) risk of early obesity than is mother's greater English language proficiency. Additional evidence for this was found in the worse model fit when using age at arrival compared with English language proficiency as our measure of acculturation (see Baker et al. 2012: appendix table A2). We therefore conclude that English proficiency better captures the consequences of maternal acculturation for children's obesity than maternal age at arrival in the United States. Again, these relationships are stronger after controls for mother's pre-pregnancy BMI are included in the model. Thus, second-generation children do have more favorable maternal health characteristics in the form of maternal pre-pregnancy BMI; however, this initial endowment again is insufficient

Table 4 Alternative maternal nativity and acculturation specifications for logistic regression models predicting obesity (BMI% ≥ 95) among kindergarteners using data from the Early Childhood Longitudinal Study, 1998 Kindergarten Cohort (ECLS-K) and 2001 Birth Cohort (ECLS-B): Odds ratios (OR) and 95 % confidence intervals (CI)[a]

	Hispanic				Non-Hispanic				All Children			
	Model 1		Model 2[b]		Model 1		Model 2[b]		Model 1		Model 2[b]	
	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Mother's English Proficiency by Nativity												
(LEP second generation)												
HEP second generation	0.65	(0.43, 0.99)	0.62	(0.41, 0.94)	0.95	(0.61, 1.47)	0.86	(0.55, 1.35)	0.75	(0.56, 1.01)	0.71	(0.53, 0.95)
Third-plus generation	0.71	(0.53, 0.96)	0.61	(0.45, 0.83)	0.83	(0.53, 1.31)	0.70	(0.44, 1.12)	0.72	(0.58, 0.90)	0.62	(0.50, 0.78)
Mother's Generation[c] (generation 1.0)												
Generation 1.5 Third-plus generation	0.99	(0.69, 1.43)	0.90	(0.62, 1.29)	1.00	(0.60, 1.68)	0.91	(0.54, 1.52)	0.97	(0.72, 1.32)	0.87	(0.64, 1.17)
	0.80	(0.58, 1.09)	0.67	(0.48, 0.92)	0.86	(0.58, 1.28)	0.74	(0.50, 1.11)	0.81	(0.64, 1.01)	0.66	(0.52, 0.82)
Mother's Nativity (immigrant)												
Native-born	0.80	(0.60, 1.05)	0.69	(0.52, 0.92)	0.86	(0.62, 1.20)	0.77	(0.55, 1.07)	0.81	(0.69, 0.96)	0.68	(0.56, 0.83)
Observations[d]	3,100				14,500				17,600			

Notes: Analyses are weighted using normalized sample weights; confidence interval estimates adjust for stratification and clustering in the sample designs. Those 95% confidence intervals that do not span 1.00 imply that the odds ratio is statistically significantly different from 1 at $p < .05$.

[a] All models control for race/ethnicity, mother's education, log of household income, mother's marital status, mother's age at birth, child's age, gender, birth weight, number of siblings, and singleton status.

[b] Model 2 adds mother's pre-pregnancy BMI, which is calculated from reported height and weight for ECLS-B and is imputed for ECLS-K.

[c] Generation 1.0 is defined as arriving in the United States at age 13 or older; generation 1.5 is defined as arriving in the United States prior to age 13.

[d] All observations are rounded to comply with NCES disclosure guidelines.

to protect them from developing higher obesity than third-plus-generation children by kindergarten age.

In a second alternative specification shown in Table 4, we include nativity but no acculturation variables (no English proficiency or age at U.S. arrival). Compared with all second-generation children, all third-plus-generation children had 19 % lower odds of being obese (OR: 0.81, CI: 0.69, 0.96). After controlling for the protective role of maternal pre-pregnancy BMI (Model 2), however, third-plus-generation children had 32 % lower odds of being obese (OR: 0.68, CI: 0.56, 0.83). Controlling for maternal pre-pregnancy BMI additionally brought the magnitude of third-plus-generation versus second-generation contrast for Hispanic children above the threshold of statistical significance (OR: 0.69, CI: 0.52, 0.92), although still not quite past the threshold for the contrast between non-Hispanic third-plus-generation children and second-generation children (OR: 0.77, CI: 0.55, 1.07).

Discussion

In the present study, we evaluated whether the immigrant epidemiological paradox extended from healthy birth weight outcomes to healthy early childhood weight statuses as well. We used data from two nationally representative longitudinal surveys that have measured (not parent-reported) child weight and height at kindergarten ages and that assess mother's country of birth, age at arrival in the United States, and level of English proficiency. We used an innovative pooled cross-survey multiple imputation method to overcome the limitations in single-survey analyses of small sample sizes of children of immigrants while including in our models the key predictor variable of maternal BMI that was observed in only one of the two surveys. We were thus able to demonstrate persuasively that the immigrant epidemiological paradox does not extend to early childhood and that, furthermore, there is an immigrant vulnerability to child obesity that is over and above that generated by their economic disadvantages. We found that despite second-generation immigrant children's initial endowment of good health, both from their lower prevalence of LBW and from the lower BMI of their mothers, by kindergarten age they were already about two-thirds more likely to be obese than were children born to U.S.-born mothers (third-plus-generation children). Among second-generation children whose mothers had LEP, their prevalence of obesity in kindergarten was already almost double that of third-plus-generation children. In our multivariate analyses, in which we multiply-imputed maternal pre-pregnancy BMI from the ECLS-B to the ECLS-K, we found that foreign-born mothers' lower BMI and lower prevalence of obesity protected their children from what would otherwise have been even greater obesity prevalence. After we controlled for maternal pre-pregnancy BMI in addition to socioeconomic variables and birth weight, third-plus-generation children had odds of being obese in kindergarten that were one-third lower than second-generation children; controlling only for socioeconomic variables, third-plus-generation children were one-fifth less likely to be obese in kindergarten than were second-generation children. This demonstrated importance of the role of maternal pre-pregnancy BMI is unsurprising: this factor has previously been found to be the single most powerful predictor of a child's risk of obesity (Li et al. 2007; Oken and Gillman 2003; Reilly et al. 2005; Salsberry and Reagan 2005; Weden et al. 2012; Whitaker

2004), and foreign-born women's prevalence of obesity has previously been found to be lower than that of U.S.-born women (Akresh 2008; Bates et al. 2008).

A further implication of the immigrant epidemiological paradox is that being less acculturated to the unhealthy lifestyles of the United States is protective of the health of immigrants and their children (Mendoza 2009). We found that instead, U.S.-born children with less-acculturated foreign-born mothers—in particular, mothers with LEP—are at the greatest risk of obesity. Indeed, after controlling for their socioeconomic characteristics and birth circumstances (including their mother's pre-pregnancy weight), we found that the greater obesity risk of this group almost completely explains the overall greater obesity risk of second-generation children. Second-generation children whose mothers had HEP had odds of being obese in kindergarten that were 29 % lower than second-generation children whose mothers had LEP, whereas third-plus-generation children' odds of being obese in kindergarten were 38 % lower than second-generation children whose mothers had LEP. Age at mother's arrival in the United States, on the other hand, did not prove to be a significant predictor of children's obesity risk. The greater strength of English proficiency than of age at arrival as an acculturation indicator is consistent with the former being considered to be a direct measure of acculturation, whereas the latter is considered to be a proxy only (Lopez-Class et al. 2011). The literature has suggested at least three possible reasons for low maternal English proficiency having a disadventageous effect on children in the case of early childhood obesity. First, it may prevent immigrant mothers from receiving beneficial messages concerning child obesity from health practitioners and other sources (Guendelman et al. 2010; Rosas et al. 2010). Second, increasing acculturation increases their propensity to identify child obesity as a health problem (Baker and Altman 2014; Guendelman et al. 2010). Third, these mothers may experience greater difficulties sheltering their children from unhealthy aspects of mainstream culture as their children develop independence—a phenomenon that Portes and Rumbaut (2001) described as "dissonant acculturation."

The present study is not the first to question the applicability of the immigrant epidemiological paradox to childhood obesity. Using FFCWS data representing the population of children born in large U.S. cities, Padilla et al. (2009) and Hamilton et al. (2011b) found that the paradox of low rates of LBW and low infant mortality for Hispanic children had already "worn off" by age 5, while Jackson et al. (2012) found a similar lack of a paradox between children of foreign-born versus U.S.-born mothers more generally across racial/ethnic groups for the FFCWS children at age 9. Using 2003 NSCH data on children ages 6–11, Taverno et al. (2010) reached conclusions similar to ours about the especially high obesity risks of children from families with lower English proficiency and usage. The FFCWS data, however, are not nationally representative, and the NSCH data on young children have serious obesity measurement problems that stem especially from their reliance on parental reporting of their children's heights and weight. Previous studies using either the ECLS-B (Li et al. 2011) or the ECLS-K (Balistreri and Van Hook 2011; Van Hook and Baker 2010) have yielded few statistically significant results between second-generation children and third-plus-generation children. We found that our pooled-survey approach was crucial both for overcoming statistical power issues present in estimates with either one of the two surveys and for overcoming omitted variable bias, including in the pooled analyses a crucial predictor—maternal BMI—that was not collected in the ECLS-K. Both the high-quality data we used and the statistical methods we used to combine them were therefore important in producing a more definitive answer than has previously been available in response to the question of whether there is a childhood-obesity exception to the immigrant epidemiological paradox.

Although Hispanic children constitute a large fraction of second-generation immigrant children, our results offer evidence in support of a more general rejection of the immigrant epidemiological paradox with respect to protection against child obesity. In results presented elsewhere (Baker et al. 2012: appendix), model fit did not improve when we estimated models that further disaggregated by race/ethnicity. Moreover, in our main results presented here (see Tables 3 and 4), the point estimates for maternal nativity and acculturation coefficients are of the same sign and similar magnitudes between the Hispanic and non-Hispanic samples, even while only for the Hispanic (and all race/ethnicity) sample did those coefficients attain statistical significance. Nevertheless, more detailed analyses with sufficient sample sizes for other immigrant groups would ideally be conducted to provide stronger evidence on this.

Our findings have worrisome implications for minority ethnic disadvantage in the United States as the country enters a period of rapid growth of its second-generation immigrant population (Passel 2011). Poor child health—and more specifically, obesity—has been linked to lower academic achievement (Crosnoe 2006), lower rates of college attendance (Crosnoe 2007; Glass et al. 2010), disadvantages in the job market (Finkelstein et al. 2005; Pagan and Davila 1997), and social stigma (Carr and Friedman 2005). Obesity may be an especially important barrier for the successful adaptation and integration of the new second generation. Failure to address nativity and acculturation differences in the development of obesity beginning in early childhood may therefore not only widen health disparities in the future, but also economic and social inequalities in the American population.

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