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Social and Economic Determinants

Association between Native American-owned casinos and the prevalence of large-for-gestational-age births

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Abstract

Background: A small number of studies have used a natural experiment approach to examine the health impacts of increased economic resources stemming from Native American-owned casinos. We build on this work by examining whether casinos are associated with obesity-related health *in utero*.

Methods: We examined whether casino openings or expansion (as proxy for increased economic resources) are associated with a decreased likelihood of infants being born large-for-gestational-age (LGA), an important risk factor for childhood overweight/obesity. We used repeated cross-sectional data from California birth records (1987-2011) to assess the prevalence of LGA births among Native Americans ($n = 21\,011$). Using zip code fixed-effect regression models, we compared how prevalence of LGA births changed in association with casino openings or expansions, while controlling for secular trends through the inclusion of a comparison group of Native American newborns in zip codes that were eligible to open or expand casinos, but did not do so. In sensitivity analyses, we evaluated whether there was any change in small-for-gestational-age births (SGA).

Results: Average prevalence of LGA births over the period was 11%. Every one slot machine per capita increase was associated with a 0.13 percentage point decrease (95% confidence interval: −0.25, −0.01) in the prevalence of LGA births but was not associated with SGA prevalence.

Conclusions: Casino expansion in California is associated with a lower prevalence of LGA births. Interpreted in combination with previous work showing that California casino expansions were associated with a lower body mass index (BMI) among schoolchildren, these results suggest that casinos are associated with improvement in a surrogate marker of excess adiposity. Further studies are needed to elucidate the mechanisms by which casinos might be associated with obesity-related health outcomes among Native Americans.

Key words: Native Americans, casinos, large-for-gestational-age, child overweight/obesity

Key Messages

- Building on previous studies that have modelled Native American-owned casinos as a proxy for increased economic resources, we explore whether casinos are associated with a decreased likelihood of infants being born large-for-gestational-age (LGA), an important risk factor for childhood overweight/obesity.
- Opening or expanding a casino, measured through gains in slots per capita, was associated with a 0.13 percentage point decrease in the prevalence of LGA births.
- An increase of five slots per capita, the approximate mean change in slots per capita in this sample, would be associated with a decrease of two-thirds of a percentage point in the prevalence of LGA births.
- Results suggest that casinos may be associated with improved obesity-related health among Native American newborns.

Introduction

Native Americans, as compared with White Americans, are disproportionately burdened by chronic health conditions including obesity and diabetes.[1–4] These health inequities emerge early in life and track through the life course.[5,6] High rates of poverty and high levels of community deprivation[7–9] in Native American communities are hypothesized to partially drive these health inequities. However, in 1988, the US federal government legalized Native American-owned casinos to alleviate poverty among Native Americans. The subsequent introduction of casinos has improved economic fortunes for some Native American tribes[6,10] and offers an opportunity to test whether increased economic resources (at either the individual or the community level, stemming from casinos) are associated with improved obesity-related health outcomes.

Several studies have used a natural experiment approach to examine the health impacts of increased economic resources stemming from Native American-owned casinos. Specifically related to obesity, using nationwide data from Native American adults, Wolfe and colleagues found that increased income from a casino was associated with a decrease in the prevalence of obesity—finding a 1.6% decrease in obesity prevalence for every \$1000 in casino-associated income increase.[6] Within 100 tribes in California, Jones-Smith and colleagues found that opening or expanding a casino was associated with a decreased risk for childhood overweight/obesity.[11] Conversely, using data from the Eastern Band of Cherokee Indians in North Carolina, Akee and colleagues report that receiving per capita payments from a casino was associated with increased obesity among adolescents from families who were poorest at baseline.[12]

We build on this work by examining whether Native American-owned casinos in California are associated with obesity-related health *in utero*. Specifically, we examine whether opening or expansion of a casino (as a proxy for increased economic resources) is associated with decreased likelihood of being born large-for-gestational-age (LGA), which is associated with increased risk for obesity in childhood and later in life.[13–15] LGA births are also inversely associated with socioeconomic status, and Native Americans have the highest prevalence of LGA babies among race/ethnic groups in the USA.[16,17]

We have previously shown that opening or expanding a casino improved average per capita income and poverty rates for Native Americans living on tribal lands in California, above and beyond secular trends seen among tribes that did not open or expand a casino.[11] We hypothesize that opening or expanding a casino may be associated with risk for LGA births through increasing individual or family income, which may decrease the barriers around healthful eating and activity,[18,19] or through the provision of enhanced community services, particularly health insurance or health clinics, which may result in improved prenatal care and monitoring of gestational weight gain (GWG).[20]

Methods

Study population

Data come from birth records maintained by the state of California from 1987 to 2011. Native American casinos were legalized in 1988, so the beginning of our observation period precedes the opening of most casinos in the state (several casinos existed with tenuous legal status before 1988). Since casinos in California can only be built on tribal lands, we limited the sample to singleton newborns of Native American women or men who lived within zip codes that also contained Native American tribal land (n = 29 668 births). Race was self-reported on the birth certificate. From 2000 onward, women could report up to three races; for these years we included newborns from mothers or fathers who answered 'American Indian' to any of the race options. We excluded observations from zip codes where there were zero Native Americans living on tribal lands yet there was a casino, and observations from zip codes with extremely high values on our exposure variable (> 41 slots per capita, which was the 95th percentile of the distribution) to prevent highly atypical values from influencing our primary results. These extreme values mostly occur in places where a casino opened but there were less than 20 Native Americans living on tribal lands in the area, resulting in an extremely large value for our casino exposure variable (described below).

Dependent variables

Our primary outcome of interest was term LGA births, defined as weight for gestational age greater than the 90th percentile compared with sex-and-gestational-age-specific reference values. We limited our primary analyses to term births since reference charts based on neonatal measurements (such as the Oken charts) may provide a biased estimate of expected size among preterm births.[21]

In sensitivity analyses, we examined several other dependent variables. First we investigated the association between opening or expanding a casino and small-for-gestational-age (SGA) births, defined as birthweight less than the 10th percentile compared with sex-and-gestational-age-specific reference values.[22] We used the INTERGROWTH-21st reference charts (which are considered prescriptive growth charts[23]) as an alternative standard to define LGA births. We also examined being very-large-for-gestational-age (>97th percentile) and high birthweight (> 4000 g) as the dependent variables, in addition to investigating the probability of preterm birth (gestational age <37 weeks). Beginning in 2007, the California birth records included information about self-reported maternal pre-pregnancy height and weight and measured delivery weight, which allowed for the calculation of pre-pregnancy body mass index (BMI) and GWG. Therefore, in additional sensitivity analyses we explored whether casinos were associated with maternal pre-pregnancy BMI or excessive GWG, which are risk factors for LGA. These sensitivity analyses were limited to women included in the primary analysis who also had non-missing information on these additional outcomes (n = 5434 for BMI; n = 5509 for excessive GWG). Pre-pregnancy BMI (kg/m^2) was based on self-reported pre-pregnancy weight and height. Excessive GWG was calculated by subtracting pre-pregnancy weight from delivery weight and classifying weight gained based on the 2009 Institute of Medicine (IOM) guidelines (excessive GWG: underweight pre-pregnancy and gained > 18 kg; normal weight and gained >15.9 kg; overweight and gained > 11.4 kg; or, obese and gained more than 9 kg).[24]

Independent variable

Opening or expansion of a Native American-owned casino served as a proxy for increased economic resources in a community.[11] We created a variable to account for our hypothesis that the amount of economic resources in Native American communities would increase with the size of the casino and decrease with the size of tribal membership. 'Slots per capita' (a continuous variable) was defined as the total number of casino slot machines in a zip code divided by the total number of Native Americans living on tribal lands in that zip code (using the average population between 1990 and 2010 from the US Census so that the denominator does not change). Slot machines are a commonly used metric of casino size and are used to determine how much money each tribe pays back to the state in California.[25] Slots per capita is time-varying, changing values in the year(s) in which a tribe opens or expands a casino. Similarly to previous nationwide studies, information about the presence of casinos and number of slot machines was gathered from a variety of sources (Supplementary material, available as Supplementary data at *IJE* online). We use the value of slots per capita from the year preceding each newborn's birth (i.e. the 1-year lagged value), since we would expect any impact, from exposure to increased slots per capita, on birthweight to occur during or before pregnancy.

Covariates

Time-invariant potential confounders hypothesized to influence both the independent variable (opening or expanding a casino) and each outcome of interest, such as baseline community-level urbanicity and poverty, are controlled for by using zip code fixed-effects regression models (described below). We include dummy variables for each calendar year that control for the decrease in LGA over time, even in areas that did not expand casinos. Thus, we are estimating the effect of casino expansions over and above any general decline (i.e. secular trends) in LGA births among Native Americans in this sample. The opening of a casino could influence the composition of women that are having babies; therefore, we controlled for a set of maternal and child demographic and health characteristics in all models: maternal age (10-< 20, 20-< 30, 30-< 40, ≥ 40), child sex, parity (number of births, including current birth) (1, 2-5, 5-10, > 10) and gestational age in days (continuous). Smoking during pregnancy (yes/no) and maternal education (< high school, high school degree, some college,

college graduate and above) were missing for a number of years (1987-91, 1995-96 and 2006), so we include them in a sensitivity analysis.

Statistical analysis

We used zip code fixed-effects linear probability regression models with cluster-robust standard errors to test whether opening or expanding a casino (as indicated by a change in slots per capita) was associated with the probability of LGA births. Linear probability models (i.e. ordinary least squares with dichotomous outcomes) are a recommended alternative to logistic models when outcomes are common, as well as when risk differences rather than ratios are the desired measure of effect.[26] The coefficients from these models are probabilities and were multiplied by 100 so that they can be interpreted as the percentage point (pp) change. These models overcome many barriers to causal inference with inclusion of: (i) the fixed-effect for zip code, which controls for all observed and unobserved time-constant community characteristics (e.g. poverty, urbanicity) and allows us to compare each zip code with itself over time; and (ii) indicator variables for each calendar year (centred at the baseline year) to account for time trends that would have reasonably been expected had the treatment group not opened or expanded a casino.

Sensitivity analyses

We ran sensitivity analyses to assess the robustness of our results. For our primary models, we tested whether our results would have been substantively changed if we had: (i) used the 2-year lagged value for slots per capita; (ii) modelled very-large-for-gestational-age (> 97th percentile); (iii) modelled high birthweight; (iv) used an alternative population reference (INTERGROWTH-21st[23]) for defining LGA births; (v) excluded children to Native American fathers only; (vi) excluded women who smoked during pregnancy; (vii) included preterm births; and (viii) included smoking during pregnancy and maternal education as covariates. Additionally, we modelled pre-pregnancy BMI and excessive GWG as dependent variables as they are established risk factors for LGA births. We also examined the association for opening versus expanding a casino by creating a variable that captured the initial slots per capita increase associated with opening, and a second variable that captured the additional slots per capita increases associated with expanding. We also examined how robust the results were to a different choice of cut-points for defining extremely large values of slots per capita. In order to assess spillover effects, we tested whether there was any relationship between slots per capita and LGA births among non-Native Americans, expecting that any relationship would be of smaller magnitude or null. Since we limited our primary analysis to term babies, we additionally tested whether slots per capita was associated with the probability of a preterm birth. Finally, we tested whether slots per capita was associated with SGA births. Analyses of these de-identified data were determined exempt from review by the Johns Hopkins Internal Review Board.

Results

The primary analyses used an analytical sample of n = 21 011 births after excluding: observations with missing gestational age (n = 2521) or preterm births (n = 2937); observations with missing values on covariates (birthweight, n = 2, maternal age, n = 5 or number of previous children, n = 73); observations from zip codes where there were zero Native Americans living on tribal lands yet there was a casino (n = 508); observations from zip codes with extremely high values on our exposure variable (> 41 slots per capita, n = 2558); and observations from zip code years with transient spikes in the number of Native Americans (n = 53). Of the 21 011 births to Native Americans, 5924 had both a mother and father who identified Native American, 8219 had only a mother who identified as Native American, and 6868 had only a father who identified as Native American. For our sensitivity analyses, these exclusions resulted in an analytical sample of 5434 for pre-pregnancy BMI and 5509 for excessive GWG. For our sensitivity analysis that included births to non-Native Americans [including all race/ethnicity groups except those identifying as Native American (i.e. White, Black, Asian, Asian Indian, Pacific Islander and two or more races); Hispanic origin was asked separately and both Hispanic and non-Hispanics of each of the above races as applicable are included in the analysis], the same exclusion criteria resulted in an analytical sample of 313 392 births.

There were 124 zip codes that encompassed a tribal land and had at least one Native American birth. Of these zip codes, during our observation period, 47 never had a casino, 11 had pre-existing casinos that expanded, 65 opened a new casino and 1 had a pre-existing casino that did not expand. The overall mean [standard deviation (SD)] and median [interquartile range (IQR)] levels of 1-year lagged slots per capita in 1987 were 0.2 (1.1) and 0 (0, 0). This increased to a mean (SD) of 5.7 (6.9) and median (IQR) 4.5 (0.2, 7.7) by 2011. The overall mean prevalence of LGA births over the period was 11%. The overall mean prevalence of SGA births over the period of observation was 9.0%. Self-reported mean (SD) maternal pre-

Table 1. Key sample characteristics, 1987-2011

	Overall[a]	New casino	Pre-existing, expanding casino	Never casino
Zip codes (*n*)	124	65	11	47
Newborns (*n*)	21011	13878	2694	4438
Slot machines per capita,[b] mean (SD)	2.8 (4.7)	3.3 (5.3)	5.1 (3.5)	0.0 (0.0)
1-year lagged slot machines per capita[b] in 1987, mean (SD)	0.2 (1.1)	0.0 (0.0)	3.0 (2.5)	0.0 (0.0)
Slot machines per capita[b] in 2011, mean (SD)	5.7 (6.9)	7.3 (7.5)	6.5 (4.2)	0.0 (0.0)
Overall mean prevalence of LGA births among Native Americans (1987-2011),[c,d] *n* (%)	2403 (11%)	1635 (12%)	340 (13%)	428 (10%)
Prevalence of LGA among Native American newborns[d] in 1987, *n* (%)	77 (13%)	52 (13%)	8 (17%)	17 (13%)
Prevalence of LGA among Native American newborns[d] in 2011, *n* (%)	125 (10%)	78 (10%)	19 (10%)	28 (11%)
Overall mean BMI among Native American mothers[d,e] (2007-11), mean (SD)	28.3 (7.1)	28.2 (7.1)	28.6 (7.2)	28.3 (7.1)
Overall mean prevalence of excessive GWG among Native American mothers[d,f] (2007-11), *n* (%)	3505 (56%)	1984 (58%)	461 (52%)	625 (59%)
Overall mean prevalence of SGA births among Native Americans[d,g] (1987-2011), *n* (%)	1885 (9.0%)	1203 (8.7%)	253 (9.4%)	429 (9.7%)
Prevalence of SGA births among Native Americans[d] in 1987, *n* (%)	49 (8.4%)	35 (8.7%)	4 (8.3%)	10 (7.5%)
Prevalence of SGA births among Native Americans[d] in 2011, *n* (%)	109 (8.9%)	63 (8.0%)	22 (11%)	23 (9.6%)
Maternal age (years)	25 (6)	25 (6)	25 (6)	25 (6)
Maternal smoking during pregnancy, *n* (%)	1983 (11%)	1335 (12%)	140 (6%)	508 (14%)
Maternal education, *n* (%)				
< High school	4730 (28%)	3018 (27%)	701 (30%)	1010 (29%)
High school complete	7523 (44%)	4941 (44%)	1016 (44%)	1566 (44%)
Some college	3764 (22%)	2477 (22%)	489 (21%)	798 (23%)
College degree and higher	960 (6%)	681 (6%)	119 (5%)	160 (5%)
Parity (including current birth), mean (SD)	2.4 (1.5)	2.3 (1.5)	2.4 (1.5)	2.4 (1.5)

[a]There is one zip code that had a casino that was pre-existing and did not expand. Only one birth to a Native American occurred in this zip code during the observation period. This birth is included in the models, but key characteristics for pre-existing, non-expanding casinos are not provided since only one birth occurred in that category.

[b]Slots per capita refers to the total number of casino slot machines in a zip code divided by the total number of American Indians living on tribal lands in that zip code, using the average population between 1990 and 2010 from the U.S. Census so that the denominator does not change. The distribution of slots per capita was right-skewed; median (IRQ) values were as follows. Slots per capita across all years: overall, 0.58 (0, 4.5); new, 1.4 (0, 4.5); pre-existing, expanding, 4.7 (3.0, 4.8); never, 0 (0,0). Slots per capita in 1987: overall ($n = 581$), 0 (0, 0); new ($n = 401$), 0 (0, 0); pre-existing, expanding ($n = 48$), 3.0 (1.1, 3.0); never ($n = 132$), 0 (0,0). Slots per capita in 2011: overall ($n = 1220$), 4.5 (0.0, 5.9); new ($n = 781$), 4.7 (2.0, 9.8); pre-existing, expanding ($n = 190$), 4.8 (4.5, 4.8); never ($n = 249$), 0 (0,0).

[c]LGA births are defined as > 90th percentile compared with the Oken sex-and-gestational-age-specific reference population values.[22]

[d]Race was self-reported on the birth certificate. For years allowing multiple race identifications (2000-11), we included newborns from women or men who answered American Indian to any of the race options.

[e]Maternal pre-pregnancy BMI was based on self-reported pre-pregnancy weight and height and calculated as weight (kg)/height (m^2). Sample size for 2007 and 2011 BMI are as follows. 2007: overall, 996; new, 646; pre-existing, expanding, 151; never, 199. 2011: overall, 1140; new, 730; pre-existing, expanding, 186; never, 224.

[f]Gains were classified as excessive if a woman: was underweight (BMI $< 18.5\,kg/m^2$) and gained more than 18 kg; was normal weight (BMI ≥ 18.5 and $< 25\,kg/m^2$) and gained more than 15.9 kg; was overweight (BMI ≥ 25 and $< 30\,kg/m^2$) and gained more than 11.4 kg; or was obese (BMI $\geq 30\,kg/m^2$) and gained more than 9 kg.

[g]SGA births are defined as < 10th percentile compared with the Oken sex-and-gestational-age-specific reference population values.[22]

pregnancy BMI was 28.3 (SD: 7.1) and prevalence of excessive GWG was 56% (Table 1).

Gains in slots per capita (through opening or expanding a casino) were associated with a decrease in the prevalence of LGA births[($\beta = -0.13$ pp; 95% confidence interval (CI): -0.25, -0.01] (Table 2). An increase of five slots per capita [the approximate mean change in slots per capita in this sample (Table 1)] would be associated with a decrease of two-thirds of a percentage point in the prevalence of LGA births.

Table 2. Zip code fixed-effects linear probability regression estimates for the relationship between casino slot machines per capita and large-for-gestational-age births among Native Americans, 1987-2011 (N=124 zipcodes; n=21011 births)[a,b,c,d]

	β (95% confidence interval)
Casino slots per capita	−0.13 (−0.25, −0.01)*

[a]The coefficient is estimated using a zip code fixed-effects linear probability regression model for large-for-gestational-age births (LGA). The model includes an indicator variable for each year (centred at the baseline year) to account for secular trends and controls for maternal age, child sex, gestational age in days and parity. Results were multiplied by 100 so that the coefficient presented is interpreted as the percentage point change expected. Robust clustered (at the zip code level) standard errors were used.

[b]Slots per capita refers to the total number of casino slot machines in a zip code divided by the total number of Native Americans living on tribal lands in that zip code, using the average population between 1990 and 2010 from the US Census so that the denominator does not change.

[c]Race was self-reported on the birth certificate. For years allowing multiple race identifications (2000-11), we included newborns from women or men who answered American Indian to any of the race options.

[d]LGA births are defined as > 90th percentile compared with the Oken sex-and-gestational-age-specific reference population values.[22]

*$P < 0.05$.

Sensitivity analyses (Table 3) suggested that results were similar in direction and significance when: (i) using a 2-year lag for slots per capita; (ii) very LGA or high birthweight was instead used as the outcome; (iii) controlling for smoking and maternal education; (iv) excluding women who smoked during pregnancy; and (v) excluding children of Native American fathers only. Results were of similar magnitude, when including infants born preterm. Results were of larger magnitude when we used the INTERGROWTH-21st reference charts to define LGA births. Results were of smaller magnitude for the initial opening of a casino compared with the coefficient for expanding a casino; however, the coefficients for both opening and expanding were negative. Results were robust to a range of lower cut-off points, but less robust to higher cut-off points for very high slots per capita. There was no association between slots per capita and LGA births among non-Native Americans (β = −0.01; 95% CI: −0.07, 0.05), nor was there an association between slots per capita and the probability that a birth was preterm (β = −0.01; 95% CI: −0.16, 0.15). Slots per capita was also not associated with either maternal pre-pregnancy BMI (β = −0.02; 95% CI: −0.14, 0.09), prevalence of excessive GWG (β = -0.03; 95% CI: −1.24, 1.19) or SGA births (β = 0.09; 95% CI: -0.04, 0.21).

Discussion

This study capitalizes on pre-existing vital records and the legalization of Native American gaming in California, to investigate the relationship between the opening or expansion of a casino (as a proxy for increased economic resources) and obesity-related health outcomes at birth among Native Americans. We found that opening or expanding a casino was associated with a decreased prevalence LGA births among Native Americans. Our design compares communities with themselves over time, thereby controlling for time-constant community-level differences that may result in different probabilities of opening a casino, such as proximity to an urban centre, baseline community level socioeconomic indicators, or tribe size. In addition, we control for time trends in LGA births.

Our finding that opening or expanding a casino was associated with decreased prevalence of LGA births among Native American newborns is consistent with previous findings in California. Jones-Smith *et al*. found that opening or expanding a casino was associated with decreased prevalence of childhood overweight/obesity among Native American adolescents living nearby.[11] These results are also consistent with a nationwide study that found that, among Native American adults, living in a county with a casino was associated with a decrease in the probability of obesity and diabetes.[6] Other research, reporting opposite effects, suggests that results may vary by context: a study in North Carolina found an increase in obesity among the young adults who were poorest at baseline and no association among those who were less poor at baseline.[12]

Although Native American-owned casinos have previously been associated with improved obesity-related health among Native American adolescents and adults in some settings, to our knowledge, no studies have examined the impact of casinos on LGA births nor have others examined the impact of other positive economic shocks on LGA births.

Nationwide and in the state of California specifically, economic indicators, such as per capita income and percentage of the population living in poverty, have improved for Native Americans in association with casino openings and/or expansions.[6,10,11,27] Many tribes distribute a portion of the profits from casinos directly to their enrolled members. Other mechanisms by which casinos may impact the resources of Native Americans living nearby is through providing the means for investment in community resources, such as improved housing, health clinics, recreation centres, parks and playgrounds and sometimes improved access to healthy foods.[28] We speculated that these resources could affect health behaviours, including potentially increased prenatal care and monitoring, during the gestational period. We also speculated that perhaps adult women may be able to afford healthier food and prevent weight gain before pregnancy, thus entering pregnancy at a lower BMI, which is associated with lower

Table 3. Sensitivity analyses for zip code fixed-effects regression estimates for the relationship between casino slot machines per capita and childhood large-for-gestational-age (LGA) births among Native American newborns, 1987-2011[a,b]

	Zip codes N	Observations n	Slots per capita[b] β (95% CI)	P-value
Final model	124	21011	−0.13 (−0.25, −0.01)	0.04
2-year lag[c]	124	21011	−0.14 (−0.26, −0.02)	0.02
Controlling for smoking and education[d]	123	15786	−0.25 (−0.39, −0.11)	< 0.01
Very LGA birth (> 97th percentile)[e]	124	21011	−0.08 (−0.15, −0.02)	0.01
High birthweight (> 4000 g)	124	21011	−0.13 (−0.24, −0.02)	0.02
LGA birth by INTERGROWTH-21st standards[f]	124	22033	−0.24 (−0.33, −0.09)	< 0.01
Excluding AIAN fathers	123	14143	−0.18 (−0.33, −0.03)	0.02
Excluding smokers	123	15431	−0.20 (−0.34, −0.06)	0.01
Including preterm births[g]	124	23503	−0.10 (−0.21, 0.01)	0.09
Modelling opening slots separately from expanding slots[h]				
Only first casino opening	124	21011	−0.05 (−0.14, 0.05)	0.32
Expansion	124	21011	−0.27 (−0.46, −0.09)	< 0.01
Non-Native American newborns[i]	127	313392	−0.01 (−0.07, 0.05)	0.80
Varying cut-off for very high slots per capita[j]				
Slots < 18	118	19144	−0.26 (−0.46, −0.05)	0.01
Slots < 20	119	19269	−0.24 (−0.44, −0.03)	0.03
Slots < 24	123	20846	−0.20 (−0.32, −0.08)	< 0.01
Slots < 60	128	21905	−0.04 (−0.12, 0.05)	0.41
Slots < 70	132	22348	0.01 (−0.07, 0.10)	0.77
Slots < 100	133	25223	0.01 (−0.05, 0.07)	0.79
Probability of preterm birth[k]	124	23505	−0.01 (−0.16, 0.15)	0.93
Pre-pregnancy BMI[m]	114	5434	−0.02 (−0.14, 0.09)	0.68
Excessive GWG[n]	114	5509	−0.03 (−1.24, 1.19)	0.97
Probability of SGA birth	124	21011	0.09 (−0. 04, 0.21)	0.18

AIAN, American Indian/Alaska Native.

[a]Coefficients estimated using zip code fixed-effects linear probability regression models which include an indicator variable for each year (centred at the baseline year) to account for secular trends. All models include maternal age, parity, child sex and gestational age in days. Results from linear probability models were multiplied by 100 so that the coefficients presented are interpreted as the percentage point change expected. Robust clustered (at the zip code level) standard errors were used in all models.

[b]Slots per capita refers to the total number of casino slot machines in a zip code divided by the total number of Native Americans living on tribal lands in that zip code.

[c]In this model, the main exposure of interest is the 2-year lagged value of slots per capita (rather than the 1-year lagged value).

[d]Information on smoking during pregnancy and maternal education was missing for a number of years (1987-91, 1995-96 and 2006), resulting in a smaller sample.

[e]Very-LGA births are defined as > 97th percentile compared with the Oken sex-and-gestational-age-specific reference population values,[22] and is the dependent variable in this models.

[f]INTERGROWTH-21st standards[23] are used to define LGA births as the dependent variable.

[g]Model includes observations with gestational age > 22 weeks completed.

[h]Models the slots per capita gained with casino opening and expanding as two separate variables included in the same model.

[i]Model includes same specifications as 'final model', but includes all races except Native Americans.

[j]Final model uses the 95th percentile of slots per capita (41 slots per capita) to define a cut-off of extremely high slots per capita. These models vary that cut-off point, including observations below each cut-off point. Extremely high slots per capita levels tend to occur in zip codes where there is a casino, but very few Native Americans living on tribal lands.

[k]The outcome in this model is preterm birth (< 37 weeks completed) as a function of slots per capita and controlling for year, maternal age, parity and child sex. Since we limit our primary analyses to term births, we tested whether slots per capita was related to probability of term birth.

[l]SGA births are defined as < 10th percentile compared with the Oken sex-and-gestational-age-specific reference values.[22]

[m]The model of pre-pregnancy BMI additionally included smoking before pregnancy and maternal education. Maternal pre-pregnancy BMI was based on self-reported pre-pregnancy weight and height.

[n]Gains were classified as excessive according to 2009 IOM guidelines if a woman: was underweight (BMI < 18.5 kg/m^2) and gained more than 18 kg; was normal weight (BMI ≥ 18.5 and < 25 kg/m^2) and gained more than 15.9 kg; was overweight (BMI ≥ 25 and < 30 kg/m^2) and gained more than 11.4 kg; or was obese (BMI ≥ 30 kg/m^2) and gained more than 9 kg.

GWG[29] and lower risk of giving birth to a large newborn.[30] However, during the short period of time for which we observed maternal pre-pregnancy BMI, our sensitivity analyses indicated that neither pre-pregnancy BMI nor prevalence of excessive GWG decreased in places that opened or expanded a casino. The confidence intervals are wide and basically centred around zero. It is possible that if we had information on these outcomes for a longer period, we might have seen different results. Additionally, sensitivity analyses suggested that an increase in slots per capita was not associated with SGA, suggesting no additional risk for SGA in concert with the decrease in LGA, but also that weight status at the lower end of the spectrum had not improved in the same way as weight status at the upper end of the spectrum improved in association with this exposure.

Limitations of this study should be noted. First, we do not have individual-level income data, detailed information about community resources or repeated birth records from the same individual, which could allow us to more directly assess whether those individuals who receive more economic resources after casinos open are the same individuals as those who also experience a decrease in the probability of LGA births. Instead, we rely on proximity to a casino as a proxy for our exposure. However, we have previously shown that for Native Americans living on these tribal lands in California, tribes that opened or expanded a casino experienced an increase in per capita income and a decrease in poverty, thus providing evidence that average incomes did increase in association with casino openings and expansions during this time.[11]

Second, although we control for community-level measured and unmeasured time-invariant confounding, these models do not control for potential unmeasured time-varying confounding. We are additionally limited in our ability to trace the mechanisms by which opening or expansion of casinos may result in a decreased prevalence of LGA babies. Our measures of maternal pre-pregnancy BMI and GWG were self-reported and were only collected from 2007 onward. By using cluster-robust standard errors at the zip code level, our models account for the potential correlation in outcomes among multiple children from the same woman if she remains in the same zip code.[31–33] However, there remains the possibility that women may move from one zip code to another and have births in multiple different zip codes. Our standard errors clustered at the zip code level would not account for the potential for correlated outcomes of the same individual living in different zip codes for multiple different births, putting our inferences potentially at risk for type 1 error, as with most such studies using vital statistics data over time, but we expect the impact of this to be relatively small.[32] Finally, our results may not be generalizable to other states.

Conclusions

We build on previous studies that have modelled Native American-owned casinos as a proxy for increased economic resources, in order to identify obesity-related health impacts of increases in these resources. Opening or expanding a casino was associated with decreased prevalence of LGA births. Further studies are needed to elucidate the potential mechanisms by which casinos might be associated with obesity-related health outcomes among Native Americans.

Supplementary Data

Supplementary data are available at *IJE* online.

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