Original Investigation

# Association Between Casino Opening or Expansion and Risk of Childhood Overweight and Obesity

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**IMPORTANCE** Economic resources have been inversely associated with risk of childhood overweight/obesity. Few studies have evaluated whether this association is a direct effect of economic resources or is attributable to unmeasured confounding or reverse causation. American Indian–owned casinos have resulted in increased economic resources for some tribes and provide an opportunity to test whether these resources are associated with overweight/obesity.

**OBJECTIVE** To assess whether openings or expansions of American Indian–owned casinos were associated with childhood overweight/obesity risk.

**DESIGN, SETTING, AND PARTICIPANTS** We used repeated cross-sectional anthropometric measurements from fitness testing of American Indian children (aged 7-18 years) from 117 school districts that encompassed tribal lands in California between 2001 and 2012. Children in school districts encompassing American Indian tribal lands that either gained or expanded a casino were compared with children in districts with tribal lands that did not gain or expand a casino.

**MAIN OUTCOMES AND MEASURES** Per capita annual income, median annual household income, percentage of population in poverty, total population, child overweight/obesity (body mass index [BMI] ≥85th age- and sex-specific percentile) and BMI *z* score.

**RESULTS** Of the 117 school districts, 57 gained or expanded a casino, 24 had a preexisting casino but did not expand, and 36 never had a casino. The mean slots per capita was 7 (SD, 12) and the median was 3 (interquartile range [IQR], 0.3-8). Among districts where a casino opened or expanded, the mean change in slots per capita was 13 (SD, 19) and the median was 3 (IQR, 1-11). Forty-eight percent of the anthropometric measurements were classified as overweight/obese (11 048/22 863). Every casino slot machine per capita gained was associated with an increase in per capita annual income (β = $541; 95% CI, $245-$836) and a decrease in percentage in poverty (β = −0.6%; 95% CI, −1.1% to −0.20%) among American Indians living on tribal lands. Among American Indian children, every slot machine per capita gained was associated with a decreased probability of overweight/obesity by 0.19 percentage points (95% CI, −0.26 to −0.11 percentage points) and a decrease in BMI *z* score (β = −0.003; 95% CI, −0.005 to −0.0002).

**CONCLUSIONS AND RELEVANCE** In this study, opening or expanding a casino was associated with increased economic resources and decreased risk of childhood overweight/obesity. Given the limitations of an ecological study, further research is needed to better understand the mechanisms behind this association.

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Obesity is a threat to human health[1] and disproportionately affects children with low economic resources at the family[2] and community[3] levels. However, it is difficult to randomly assign economic resources to determine a causal effect.[4,5] Some studies, though less methodologically rigorous, have capitalized on economic shocks experienced by individuals or groups to evaluate this relationship. A small number of these studies have used American Indian–owned casinos.[6-10] Casinos were legalized on tribal lands with the explicit intention of fostering tribal economic development and self-sufficiency; profits must be reinvested in the tribal welfare or community or donated to charitable organizations.[11] Casinos have been associated with increases in per capita income and employment and decreases in working poor.[8]

Five studies have examined health outcomes as a function of casinos; 3 derive from a longitudinal study involving 1 large tribe. However, these studies yielded mixed results, indicating improvements in psychiatric illnesses,[9] an increase in accidental deaths among adults,[10] and an increase in obesity among low-income young adults.[7] Two other studies used nationwide data and found that casinos were related to a decrease in total mortality,[8] diabetes, hypertension, and obesity among American Indian adults.[6]

We evaluated the relationships among casino exposure, economic resources, and childhood overweight/obesity among children from approximately 100 tribal lands. We compared the same communities longitudinally and included comparison communities, thus controlling for time-invariant measured and unmeasured factors in the community that could produce spurious relationships.

Although increases in income may result in weight gain for populations with insufficient food,[12] we hypothesized that casinos could alter individual, family, or community resources, reducing barriers to healthful eating and physical activity and decreasing the risk of overweight/obesity. These resources could include increased income, either via employment or per capita payments, and health-promoting community resources, such as housing, recreation and community centers, and health clinics.

## Methods

### Study Population

California public school students are required to participate in physical fitness testing, including measured height and weight, in fifth, seventh, and ninth grade. This study used the deidentified physical fitness testing results that have been maintained by the California Department of Education since 2001. Aggregate data are available on the California Department of Education's website.[13] Our primary sample consisted of American Indian/Alaska Native (henceforth, American Indian) children who attended public schools in California and completed physical fitness testing between 2001 and 2012. Race information came from school enrollment forms, completed by parents, and provided the option to choose only 1 race/ethnicity. According to the Johns Hopkins Bloomberg School of Public Health institutional review board, the project did not meet the criteria for "human subjects research" because it included only secondary data analysis of deidentified data and therefore did not require review. The requirements for informed consent do not apply to projects that are not governed by the human subjects research regulations.

In California, casinos can be built only on American Indian tribal lands, so we limited the sample to American Indian children attending school districts that encompassed tribal lands. We excluded observations with missing or implausible information on our dependent variable (body mass index [BMI]/overweight/obesity) or covariates (age and sex). We also excluded those with extreme values on our independent variable, casino exposure, to prevent highly atypical observations from influencing the primary results, and school district years with a transient spike in the number of American Indian children, to protect against reflecting a change in population composition.

### Dependent Variables

#### Economic and Demographic Outcomes

Although our main dependent variable of interest was childhood overweight/obesity, we first assessed the extent to which opening or expanding a casino was associated with increased economic resources among American Indians living on the affiliated tribal lands. Dependent variables in these analyses were inflation-adjusted per capita income, median household income, percentage of the population living in poverty, percentage employed, and total population size among American Indians living on tribal lands from the 1990 and 2000 long form US Census and 2006-2010 American Community Survey (which replaced the Census long form after Census 2000), with the exception of median household income, which was not available for 1990.

#### Health Outcomes

The main dependent variables were (1) overweight or obesity, defined as BMI (weight in kilograms divided by height in meters squared) in the 85th percentile or higher of the age- and sex-specific Centers for Disease Control and Prevention/National Center for Health Statistics 2000 growth charts[14] (henceforth, overweight/obesity) and (2) continuous BMI $z$ score. We examined overweight/obesity since this is a recognized threshold for greater risk of overweight/obesity in adulthood[15] and associated morbidities.[16]

### Key Independent Variable

We used proximity to American Indian–owned casinos to indicate a likely exposure to increased economic resources.[6,8] Trends among children in school districts encompassing American Indian tribal lands that opened a new casino or expanded an existing casino were compared with those in districts with tribal lands without a new casino or with a preexisting casino that did not undergo expansion. 2010 US Census geography files[17] provided school district and tribal land boundaries.

We further characterized casino exposure to account for the size of the casino and the approximate size of the tribal population because we expected that economic benefits would increase with larger casino size and smaller tribe size. Size of the casino was approximated by the number of slot machines, which is used to determine how much money each tribe pays to the state in California.[18] The size of the affiliated tribal population was approximated by the number of people who live on the tribal land and identify as single-race American Indian by the Census (including both adults and children), using the average of 2000 and 2010 population values. Within each school district, we divided the total number of slots by the total single-race American Indian population for each tribal land in the district to create a casino exposure variable (slots per capita). Slots per capita could equal zero if the district did not contain a casino and could vary over time for each school district depending on casino opening/expansion dates. Information about the presence of casinos, tribal ownership, opening date, expansion dates, and number of slot machines was obtained from a variety of sources, including the California State-Tribe gaming compacts, the Internet, and archived newspaper articles (eAppendix in the Supplement).[8]

## Statistical Analysis

### Economic and Demographic Outcomes

We first evaluated the extent to which casinos were associated with increased economic resources among American Indian tribal land residents. We used regression-based difference-in-difference models[19] to compare communities with themselves over time and tested the extent to which opening/expanding a casino (as indicated by increasing slots per capita on tribal lands) was associated with changes in 4 indicators of family/individual economic resources: average per capita income, median household income, percentage of the population living in poverty, and percentage of the population employed.

We also assessed whether population composition change was a likely explanation for any result, using the same models to compare the difference in the change in population size for tribal lands in association with increasing slots per capita.

### Health Outcomes

Regression-based difference-in-difference models estimated the association of gaining or expanding a casino with childhood overweight/obesity (as indicated by increasing slots per capita) and BMI $z$ score.[19,20] Models compared the change in overweight/obesity and BMI $z$ score in association with increased slots per capita before and after casino openings/expansions in districts that opened/expanded a casino with districts that did not open/expand a casino. By comparing each district with itself over time, these models controlled for all baseline (time-invariant) characteristics (observed and unobserved) that may differ between districts that opened/expanded a casino and districts that did not. Including the group that did not open/expand a casino controlled for the change in weight outcomes that would be expected over time had the casinos not opened/expanded.

We used district fixed-effects regression models, with linear models for BMI $z$ score and linear probability models for overweight/obesity. Linear probability models were used for dichotomous outcomes because we were interested in absolute (rather than relative) effect measure estimates; these models estimate the probability of overweight/obesity, and coefficients are interpreted as risk differences.[21] Robust standard errors accounted for heteroskedasticity and potentially correlated outcomes among students in the same school district and among repeated measures over time for the same students.[22]

All models included indicator variables for each district (accounting for baseline differences by district), indicator variables for each year (representing the secular trend in BMI $z$ score/overweight/obesity among American Indian children in districts that do not open/expand casinos), a linear time trend (year, centered at year 2000 and specified as an ordered categorical variable taking the values 1-12), and a district×time trend interaction (allowing the time trend in BMI $z$ score/overweight/obesity to vary by district). Child age and sex were included as covariates.

We assessed whether modeling casino exposure (slots per capita) as a continuous variable was reasonable, and we tested whether the casino overweight/obesity association varied by child sex or time since casino opening.

## Sensitivity Analyses

In robustness checks, we tested whether results would substantively change if we had (1) used the interpolated value for American Indian population on each tribal land instead of the average of 2000 and 2010 Census numbers; (2) used a different cut point for exclusion of extreme slots per capita values; (3) modeled obesity (BMI ≥95th percentile) instead of overweight/obesity as the outcome; (4) included indicator variables for each cohort; (5) examined new and expanded casinos separately; (6) removed places that had a preexisting casino that did not expand; (7) limited the sample to district-years with overlapping values of baseline economic indicators; or (8) used multiple imputation to impute missing overweight/obesity and BMI $z$ score data.

We also used sensitivity analyses to evaluate the likelihood of alternative explanations for our findings. It was conceivable that any association attributed to casinos was actually due to an unaccounted factor that covaried with casino ownership, varied over time, and influenced BMI. One potential factor was the economic recession[23] that started in 2008, if it affected casino-owning and non–casino-owning populations differently. To evaluate this possibility, we reran our models with only pre-2008 data.

Between 2008 and 2012, student identification codes allowed us to track the same students over time. On this subsample, we ran within-student fixed-effects regression, which compared each student with themselves over time to assess how BMI $z$ score and overweight/obesity changed as casino exposure changed.

We assessed spillover effects from casino openings/expansions. Because the profits from casinos are mandated to be reinvested in the welfare of the tribe, we expected that any associations found would be largest among American Indian populations. At the same time, it is possible that increased economic resources from casino openings/expansions might be experienced by the non-American Indian population (ie, through employment, charitable giving, or community resources available to the wider community). To partially test this, we performed the same analyses with the same exclusion criteria among white children in school districts with tribal lands and hypothesized that any associations seen would be of smaller magnitude.

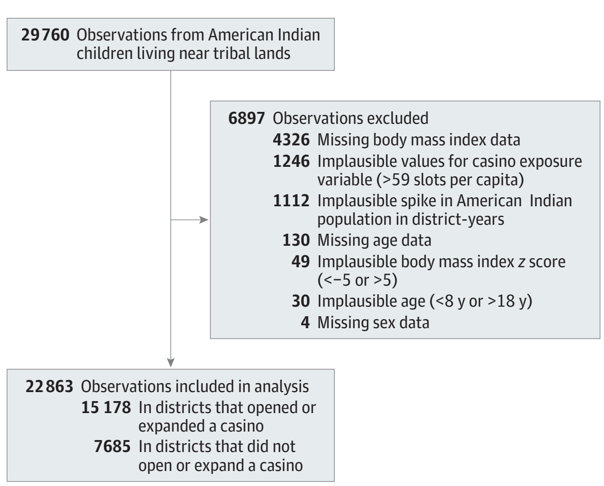
All analyses were performed using Stata version 12.1 (Stata Corp). Statistical tests were 2-sided with $\alpha$=.05.

## Results

Excluding measurements with missing or implausible values (age, n = 130; sex, n = 4; BMI, n = 4326; BMI $z$ score >5 or <−5, n = 49; school district years with transient spikes in number of American Indian children, n = 1112; or districts with extreme values of slots per capita [>59 slots per capita, 95th percentile of values by district], n = 1246), produced a final sample of 22 863 measurements from American Indian children (**Figure**). Using the same exclusion criteria for non-Hispanic white children for the sensitivity analyses resulted in 366 771 measurements after 99 984 observations were excluded because of missing or implausible values. Key sample characteristics are shown in **Table 1**, **Table 2**, and **Table 3**.

Of the 117 districts included, 57 either opened or expanded a casino, 24 had a preexisting casino but did not undergo expansion, and 36 did not have a casino at any time.

Figure. Flow Diagram




There was a median of 12 (interquartile range [IQR], 4-28) American Indian children per district. The mean level of slots per capita for the entire sample was 7 (SD, 12); the median level was 3 (IQR, 0.3-8). Among districts where a casino opened or expanded, the mean change in slots per capita was 13 (SD, 19) and the median was 3 (IQR, 1-11). Forty-eight percent of the observations (n = 11 048) were classified as overweight/obese (Table 2).

### Association of Casinos With Economic Resources

Every 1 slot per capita gained was associated with an increase in average per capita annual income by an estimated \$541 (95% CI, \$245-\$836) and a decrease in the percentage of the population living in poverty by an estimated 0.6% (95% CI, −1.1% to −0.20%), among American Indians, after accounting for the secular trends between 1990 and 2010 (**Table 4**). The median annual household income was higher, but this was not statistically significant (\$741; 95% CI, −\$48 to \$1529; $P$ = .06). There was no significant difference in the percentage of American Indians living on tribal lands who were employed. The population size of American Indians living on tribal lands was not statistically significantly associated with slots per capita (Table 4).

### Association of Casinos With Childhood Overweight/Obesity Risk and BMI *z* Score

Every 1 slot per capita gained was associated with a 0.19-percentage-point decrease in the percentage of overweight/obesity (95% CI, −0.26 to −0.11 percentage points) (**Table 5**). Every 1 slot per capita increase was associated with a decrease in BMI $z$ score of 0.003 (95% CI, −0.005 to −0.0002).

Results for overweight/obesity were robust to (1) an interpolated population value for American Indians living on each tribal land; (2) a large range of cut points for excluding extremely high values of slots per capita; (3) controlling for cohort effects; (4) investigating new and expanded casinos separately; (5) excluding preexisting casinos that did not expand; (6) limiting the sample to district-years with overlapping values of baseline economic indicators; and (7) using multiple imputation for outcome values (eTable 1 in the Supplement). When limited to pre-2008 data, the point estimate was similar ($\beta$ = −0.17 percentage points); however, the sample size was significantly reduced (n = 12 637 measurements) with a $P$=.09. When we modeled obesity alone, the direction of the association was the same, but it was no longer statistically significant ($\beta$ = −0.007; 95% CI, −0.08 to 0.06) (eTable 1 in the Supplement). Results for BMI $z$ score were similar, with the exception

Table 1. Key School District Sample Characteristics, 2001-2012

| Characteristics | No. of Districts | No. of Students | Median No. per District per Year (IQR) [Range] |
|---|---|---|---|
| School districts containing ≥1 American Indian tribal land | 117 | 22 863 | 12 (4-28) [1-167] |
| School districts that received a new casino | 19 | 2238 | 7 (3-13) [1-89] |
| School districts that experienced a casino expansion | 38 | 12 940 | 25 (9-46) [1-146] |
| School districts that had a casino but did not expand the size of the casino | 24 | 4815 | 15 (6-25) [1-167] |
| School districts that never had a casino | 36 | 2870 | 6 (2-13) [1-63] |

Table 2. Key Student Sample Characteristics, 2001-2012

| Characteristics (n = 22 863 Observations) | Mean (SD)[a] | Median (Interquartile Range) |
|---|---|---|
| Slot machines per capita[b] | 7 (12) | 3 (0.3-8) |
| Slot machines per capita in 2001 | 4 (6) | |
| Slot machines per capita in 2012 | 8 (13) | |
| Change in slot machines for those who gained or expanded a casino | 13 (19) | 3 (1-11) |
| Prevalence of overweight/obesity among American Indian school children, No. (%)[c,d] | 11 048 (48) | |
| Prevalence of overweight/obesity among American Indian school children in 2001, No./total (%) | 650/1484 (44) | |
| Prevalence of overweight/obesity among American Indian school children in 2012, No./total (%) | 980/1961 (50) | |
| Body mass index *z* score[e] among American Indian school children[d] | 0.92 (1.07) | 0.98 (0.2-1.8) |
| Age, y[d] | 13 (1.7) | |
| Male, No. (%)[d] | 11 413 (50) | |

[a] Data are expressed as mean (SD) unless otherwise indicated.

[b] Slot machines per capita were calculated for each school district in every year and represent the number of slot machines per single-race American Indian living on tribal lands within the school district; places with zero slot machines are included in the estimate.

[c] Overweight/obesity was defined as ≥85th percentile for age- and sex-specific body mass index based on the 2000 Centers for Disease Control and Prevention/National Center for Health Statistics (CDC) growth charts.

[d] Based on 22 863 observations between years 2001 and 2012.

[e] Body mass index *z* score was based on the age- and sex-specific 2000 CDC growth charts.

Table 3. Key Tribal Land Sample Characteristics, 2001-2012

| Characteristics[a] | Mean (SD) | Median (Interquartile Range) |
|---|---|---|
| Per capita annual income, US$ | 16 719 (21 200) | 11 414 (7988-17 219) |
| Annual household income, US$ | 41 138 (36 221) | 30 881 (21 269-47 719) |
| Percentage of population living in poverty | 42 (31) | |
| Percentage of population employed | 80 (22) | |
| Population size per tribal land | 163 (294) | 70 (19-172) |

[a] Tribal land characteristics were derived from 1990, 2000, and 2010 US Census and American Community Survey aggregate summary files for people who live on the tribal land and report their ethnicity as single-race American Indian. Median household income for single-race American Indian/Alaska Native populations was not reported in the 1990 US Census. Income was deflated to 2010 values.

that when expanded casinos were modeled alone, the result was no longer statistically significant (eTable 2 in the Supplement).

Using the subsample of children whose observations could be tracked between 2008 and 2012 produced results that were similar in direction but not statistically significant for BMI *z* score (β = −0.012; 95% CI, −0.025 to 0.001; *P* = .07). The results for overweight/obesity changed directions and were not statistically significant (overweight/obesity β = 0.14 percentage points; 95% CI, −0.52 to 0.79; *P* = .69). The fact that the direction of the estimate changed could potentially be concerning; however, the *P* value was very large (*P* = .69), and the confidence interval was wide and did include the point estimate for overweight/obesity from the primary models (−0.19 percentage points) (eTable 3 in the Supplement).

We found no evidence for spillover effects among white children (eTable 4 in the Supplement).

## Discussion

We found that opening or expansion of casinos was associated with increased economic resources and decreased risk of overweight/obesity among American Indian children. We compared communities with themselves before and after the opening or expansion of a casino, controlling for observed and unobserved confounders that do not change over time and establishing temporality. We additionally included a comparison group of similar communities that did not open or expand a casino to isolate the association of casinos and overweight/obesity beyond the time trends expected had these communities not opened or expanded a casino.

We found that increasing "dose" of casino was associated with lower risk of overweight/obesity among American Indian children, with every 1 slot per capita gained associated with a 0.19-percentage-point reduction in overweight/obesity risk. To put this in the context of the typical level of change in slots per capita, we calculated the expected reduction in overweight/obesity at the median (3) and mean (13) levels of change in slots per capita. At the median and mean levels, respectively, this would equate to a 0.57- and a 2.47-percentage-point reduction, or roughly a 1.2% and 5.1% decrease for the mean prevalence of 48% overweight/obese in our population. Consistent with our findings, Wolfe et al[6] found that increased income from casinos was associated with a 2% to 4% reduction in risk for obesity among adults. Contrarily, among one large tribe, Akee et al[7] found that increased income from casino per capita payments was associated with increased obesity risk among young adults from the poorest households at baseline. To compare the size of our associations with the literature on community-based overweight/obesity reduction, we note that the multilevel Shape Up Somerville community intervention was associated with a 3- to 4-percentage-point reduction in overweight/obesity after 2 years.[24] Pathways, a school-based nutrition and physical activity intervention among American Indian schoolchildren, found no significant effect on adiposity.[25]

We found that casinos were associated with an increase in 2 family/individual economic resource indicators: mean per capita income and percentage of population living in poverty. That the population in poverty was lower after casino opening/expansion suggests that the gains observed in mean per capita income are not limited to changes in only the upper end of the income distribution. Employment did not increase, but

Table 4. Tribal Land Fixed-Effects Linear Regression for the Relationship Among Casino Slot Machines per Capita, Economic Indicators, and Population Size Among American Indian Populations Living on Tribal Lands[a]

| | Per Capita Annual Income, β (95% CI), US$ | *P* Value | Median Annual Household Income, β (95% CI), US$ | *P* Value | Percentage of Population in Poverty, β (95% CI) | *P* Value | Percentage of Population Aged >16 y Employed, β (95% CI) | *P* Value | Population Size, β (95% CI) | *P* Value |
|---|---|---|---|---|---|---|---|---|---|---|
| Per slot machine per capita on tribal land | 541 (245-836) | <.001 | 741 (−48 to 1529) | .07 | −0.6 (−1.1 to −0.20) | <.001 | −0.03 (−0.45 to 0.39) | .89 | −0.06 (−0.20 to 0.08) | .42 |
| 1990 | Reference | | | | Reference | | Reference | | Reference | |
| 2000 | 5756 (1418-10 093) | .01 | Reference | | −31 (−39 to −23) | .001 | 3 (−3 to 10) | .35 | 20 (2 to 39) | .03 |
| 2010 | 7973 (3087-12 859) | .002 | 7970 (−2669 to 18 610) | .01 | −31 (−40 to −23) | <.001 | 9 (2 to 16) | .02 | 47 (28 to 66) | <.001 |
| Constant | 10 288 (7117-13 459) | <.001 | 33 649 (26 667 to 40 631) | <.001 | 66 (61 to 72) | <.001 | 76 (71 to 81) | <.001 | 141 (128 to 154) | <.001 |
| No. of observations | 243 | | 164 | | 248 | | 234 | | 291 | |
| No. of tribal lands | 94 | | 92 | | 95 | | 92 | | 99 | |

[a] Slot machines per capita were approximated by the number of slot machines per American Indian for each tribal land, using an average of the 2000 and 2010 US Census values. The total number of slots was time-varying, depending on casino opening dates and expansion dates. Average per capita annual income, percentage in poverty, and percentage employed for each tribal land were from 1990, 2000, and 2010 US Census and American Community Survey summary for people who live on the tribal land and report their ethnicity as single-race American Indian. Median household income for single-race American Indian/Alaska Native populations was not reported in the 1990 US Census. Income was deflated to 2010 values.

Table 5. District Fixed-Effects Regression Estimates for the Relationship Between Casino Slot Machines per Capita and Body Mass Index *z* Score and Childhood Overweight/Obesity Among American Indian Children, 2001-2012 (N = 117 Districts and 22 863 Observations)[a]

| | β (95% CI) |
|---|---|
| Body mass index z score[b] | |
| Change per increase of 1 slot per capita | −0.003 (−0.005 to −0.0002)[d] |
| Age, y | −0.025 (−0.038 to −0.011)[d] |
| Male | 0.010 (−0.022 to 0.043) |
| Overweight/obesity, %[c] | |
| Absolute change in % overweight or obese per increase of 1 slot per capita | −0.19 (−0.26 to −0.11)[d] |
| Age, y | −1.5 (−2.0 to −0.98)[d] |
| Male | 0.91 (−0.78 to −2.6) |

[a] The statistical models for body mass index *z* score are district fixed-effects linear regression models; the statistical models for overweight/obesity are district fixed-effects linear probability models. In addition to including district fixed effects (ie, an indicator variable for each district), all models also include indicator variables for each year, an ordered categorical variable for year to provide a linear time trend, and interactions terms between district indicator variables and the linear time trend to allow the trend in BMI *z* score/obesity to vary by district (coefficients are not shown). All models used robust standard errors that also correct for correlated outcomes within individuals and school districts. Casino slot machines per capita were calculated for each school district in every year and represent the number of slot machines per single-race American Indian living on tribal lands within the school district. This number could change over time for each school district, depending on casino opening and expansion dates.

[b] Body mass index *z* scores were age- and sex-specific using the 2000 Centers for Disease Control and Prevention/National Center for Health Statistics (CDC) growth charts.

[c] Overweight/obesity was defined as a having a body mass index *z* score ≥85th percentile of the age- and sex-specific 2000 CDC growth charts.

[d] $P<.05$.

we would expect that this association might be less pronounced than income associations because a casino may offer better-paying jobs to people who are already employed, or, for enrolled tribal members, income may have increased as a result of per capita payments from the casino rather than from employment.

Our estimates are consistent with previous reports suggesting that in California, between 1990 and 2000, American Indians living on reservations with a casino experienced a $3179 greater mean increase in per capita income compared with American Indians on reservations without a casino.[26] Nationwide studies have also found casinos to result in significant improvements in income and employment.[6,8] Our income variable was from the US Census and the American Community Survey, and it is unclear how income deriving from casino per capita payments would be reflected in this measure. In addition to increasing incomes, many tribes have used casino profits to improve community infrastructure. The association we found between casinos and childhood overweight/obesity may be working through pathways of both increased family/individual and community economic resources (or their downstream effects). However, we can offer only empirical support for the role of increased family/individual resources.

One alternative explanation is that our results reflect a change in the population affiliated with casino-owning tribes rather than a true casino effect. This could occur if the casino influenced American Indians to move onto tribal lands with casinos and if this population is systematically different from the existing population in ways that relate to children's BMI. However, we found no evidence of a disproportionate change in population. Evans and Kim[27] report similar results using nationwide data. Additionally, using the subpopulation for which we can estimate the within-individual change over time, we found that higher casino exposure was associated with decreasing BMI *z* score, indicating a within-individual change.

A second alternative explanation is that the association we attribute to casinos is actually due to an unaccounted factor that covaries with casino ownership, varies over time, and influences BMI. One such factor could be the economic recession,[23] if it affected casino-owing and non-casino-owning populations differently. However, our results using only pre-2008 data were substantively unchanged, indicating that the recession is not likely to be driving our results. Another potentially relevant secular change was the introduction of mandatory school wellness policies in 2006. The strength and comprehensiveness of these policies has been found to vary[28]; however, we have no reason to believe these would be implemented differently according to the casino status of districts.

There are several limitations. Body mass index is not a direct measure of adiposity; however, it is highly correlated with direct measures of adiposity and used as a standard to assess overweight/obesity.[29] This is an ecological study, we used a community-level exposure, we do not have individual-level economic resources in association with casinos or tribal affiliation data for children, and we cannot distinguish whether the relationships we found are due to community- or individual-level resources. The ability to track the same student over time was possible only beginning in 2008. We relied on school enrollment forms to identify American Indian children, which allowed parents to choose only 1 race/ethnicity. American Indian children of 2 or more race/ethnicities could have been missed. We relied on school district geographies for the classification of American Indian children as exposed or unexposed to a casino. Similar exposure classification has been used previously.[6,8] This could result in exposure misclassification; however, this misclassification is likely nondifferential with respect to child body weight. Many American Indians do not live near tribal lands and we excluded this population from our sample. However, this exclusion allowed us to focus on the most comparable comparison group (those living near tribal lands without a casino). This may limit the generalizability to American Indians living near tribal lands. Our conclusion should not be generalized to tribes with more than 80% poverty because we did not observe a tribe with this level of poverty. Similarly, we did not observe a tribe with a median income of more than $100 000.

Although testing officials were trained in basic techniques for measuring anthropometrics[30] and these data have previously been used in published research,[31] the anthropometrics were not collected for research purposes, and roughly 15% of the observations were missing BMI data. Importantly, missing BMI was unrelated to slots per capita; however, it was related to other covariates in our model. The probability of missing BMI data decreased over time (likely a result of districts adjusting to the fitness testing requirements), and some districts had higher probability of missing BMI than others (eTable 5 in the Supplement). Although this pattern of missing values reveals some potential issues with uniform enforcement of mandatory fitness testing, missing in relation to these factors would not bias our results since these were covariates included in the models. Also, there is not an established database for the information about casino characteristics. We assembled these data, and similar strategies have been used in previous studies[6]; however, we recognize that there could be some nondifferential error. Both of these limitations are tradeoffs in the use of designs that capitalize on substantial "shocks" to populations outside of the investigators' control, which can begin to answer difficult questions about relationships that are impractical, infeasible, or unethical to study with randomized trials.

## Conclusions

Opening or expanding a casino was associated with increased economic resources and decreased risk of childhood overweight/obesity. Given the limitations of an ecological study, further research is needed to better understand the mechanisms underlying this association.

### ARTICLE INFORMATION

**Author Contributions:** Dr Jones-Smith had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
*Study concept and design*: Jones-Smith, Dow.
*Acquisition, analysis, and interpretation of data:* All authors.
*Drafting of the manuscript:* Jones-Smith.
*Critical revision of the manuscript for important intellectual content:* All authors.
*Statistical analysis:* All authors.
*Obtained funding:* Jones-Smith.
*Study supervision:* Dow.

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