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The relationship between violence in Northern Mexico and potentially avoidable hospitalizations in the USA–Mexico border region

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ABSTRACT

Background Substantial proportions of US residents in the USA–Mexico border region cross into Mexico for health care; increases in violence in northern Mexico may have affected this access. We quantified associations between violence in Mexico and decreases in access to care for border county residents. We also examined associations between border county residence and access.

Methods We used hospital inpatient data for Arizona, California and Texas (2005–10) to estimate associations between homicide rates and the probability of hospitalization for ambulatory care sensitive (ACS) conditions. Hospitalizations for ACS conditions were compared with homicide rates in Mexican municipalities matched by patient residence.

Results A 1 SD increase in the homicide rate of the nearest Mexican municipality was associated with a 2.2 percentage point increase in the probability of being hospitalized for an ACS condition for border county patients. Residence in a border county was associated with a 1.3 percentage point decrease in the probability of being hospitalized for an ACS condition.

Conclusions Increased homicide rates in Mexico were associated with increased hospitalizations for ACS conditions in the USA, although residence in a border county was associated with decreased probability of being hospitalized for an ACS condition. Expanding access in the border region may mitigate these effects by providing alternative sources of care.

Keywords ambulatory care sensitive condition, healthcare access, USA–Mexico border region, violence

Introduction

Hospitalizations for ambulatory care sensitive (ACS) conditions, those for which appropriate outpatient care can prevent hospitalization or for which early interventions can reduce complications, are a costly issue for the US healthcare system.[1] Regional rates of ACS admissions are indicators of primary care access, with more ACS admissions indicating lower access. ACS hospitalization rates are associated with socioeconomic status, insurance, race, outpatient care access and primary care supply.[2–6]

The population in the USA–Mexico border region—US counties within 100 km of the border—has risk factors known to increase ACS hospitalizations including high rates of uninsurance, poverty and chronic disease.[7–9] A significant proportion of legal US residents in the border region cross into Mexico for health care and pharmaceuticals,[10–14] with over a third of residents crossing into Mexico in the previous year for either a doctor's visit (37%) or medication purchases

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(43%) as of 2008.[14] Individuals do not generally seek care in Mexico for inpatient or emergency conditions.[14]

Sharp increases in violence in northern Mexico starting in 2006 may have affected patterns of cross-border care. Medical tourism in Tijuana was reduced by an estimated 50%,[15] with 30–50% of private clinics and pharmacies in Juarez and Tijuana closed as of 2010.[15,16] Previous research found that increased homicide rates were negatively associated with legal border crossing from Mexico into the USA, but found no association between homicide rates and self-reported access for residents of border counties or changes in the composition of emergency department (ED) encounters.[17,18] However, markers of reduced access measured using administrative utilization data and well-established access indicators such as ACS admissions may be more sensitive than self-reported data and more reliable than changes in ED encounter ratios.

We used data on inpatient hospitalizations from three border states to measure the association between homicide rates in the nearest Mexican municipality and the likelihood of hospitalization for an ACS condition. We hypothesized that higher homicide rates in the nearest Mexican municipality would be associated with an increased likelihood of a hospitalization being for an ACS rather than a marker condition in border counties. Marker conditions are non-discretionary admissions with clear diagnostic criteria, for which the timely provision of outpatient care has little impact on medical necessity of hospitalization (e.g. appendicitis or hip fracture).[3] Since marker admissions should not be affected by variables related to healthcare access such as physician supply,[3,6] they provide a control group for hospitalizations with ACS conditions. The incidence and treatment location of marker conditions were not expected to be influenced by violence in Mexico. Additionally, we hypothesized that after controlling for patient socioeconomic and demographic characteristics and county physician supply, hospitalizations from border counties would have a lower likelihood of being for an ACS condition given the supply of care available in Mexico not accounted for by the model.

Methods

We used a hospitalization-level difference-in-difference approach to examine associations among homicide rates, border region residence, and admissions for ACS and marker conditions. We compared differences between ACS and marker conditions, and differences between high violence and low violence areas. We measured violence with a continuous measure, with differences across time and place.

Data and analytic sample construction

Hospital discharge records from Arizona, California and Texas were used to identify hospitalizations for patients aged 18–64 between 1 January 2005 and 31 December 2010 with at least one ACS or marker condition. The sample was limited to non-elderly adults as they were more likely to seek care in Mexico and have a defined set of ACS and marker conditions. Data from California and Arizona hospitals contained hospitalizations from all acute-care, short-term hospitals.[19,20] Texas data contained hospitalizations from acute-care, short-term hospitals subject to reporting requirements.[21] Hospitalization data contain limited patient information (e.g. age, gender, zip code) as well as diagnosis and procedure codes from the hospital stay.

We included hospitalizations identified as being for ACS conditions by the Prevention Quality Indicators Module of the QI SAS® software, Version 4.4:[22] diabetes short- and long-term complications, chronic obstructive pulmonary disease or asthma, hypertension, heart failure, dehydration, bacterial pneumonia, urinary tract infection, angina, uncontrolled diabetes and lower extremity amputation for patients with diabetes. Hospitalizations identified as marker conditions were for appendicitis with appendectomy, acute myocardial infarction, intestinal obstruction and hip/femur fracture.[23]

Hospitalizations were excluded if they were a transfer from another hospital or patient residence was not in the same state as the hospital. This criterion excluded 6.7% of hospitalizations with marker or ACS conditions. Hospitalizations were excluded if age, gender, primary payer, primary diagnosis code, hospitalization quarter, length of stay or patient residence were missing; this criterion excluded 17.6% of hospitalizations with marker or ACS conditions (0.5% in Arizona, 26.7% in California, 9.3% in Texas). Most missing demographic information was due to censoring by data providers to prevent identification of patients. In Texas, we excluded patients residing in a county with a non-reporting hospital; this criterion excluded a small subset (0.76%) of the sample with marker or ACS conditions.

Outcomes and covariates

The outcome variable was a hospitalization-level binary variable indicating that the admission was an ACS (1) or a marker condition (0). We estimated associations with lagged homicide rates in the Mexican municipality adjacent to the border crossing nearest the patient's residence, as this location represents the place an individual would be most likely to seek care in Mexico if he so chose. Mexican municipalities were matched to patient residence using Google Maps driving distances[24] based on five-digit patient zip code. Homicide rates were calculated monthly using the number of homicides from the Mexican National Institute of Statistics and Geography and matched to admission month.[25] For the denominator of homicide rates, 2005 and 2010 population estimates were used, with population between census years estimated using linear interpolation. Socioeconomic status used the 2008 zip code-level income quartile calculated using median household income for the four states in the USA–Mexico border region (CA, NM, AZ, TX)[26] and county-level unemployment rates.[27] Regional characteristics included annual county-level physician to population ratios[28] and an indicator of whether the county of patient residence was in an urban area.[29]

Statistical methods

We adapted the empirical technique developed by Basu *et al.* (2002)[6] using a model at the hospitalization unit of analysis. This approach uses marker conditions as a base case for comparison of ACS hospitalizations. We used this technique as the border region was growing rapidly in population,[9] and thus, there may be differential measurement error in population estimates between border and non-border counties. Furthermore, using this technique minimized impacts of missing data due to missing demographic information and non-reporting hospitals.

The empirical model was specified as follows using a logit model:

$$\begin{aligned}\Pr(\text{ACSadmission}_{\text{hast}} = 1|X_{\text{acst}}) &= \frac{\exp\{X\beta\}}{1+\exp\{X\beta\}} \text{with } X\beta \\ &= \beta_0 + \beta_1 H_{\text{as,lag}(t)} \\ &\quad + \beta_2 \text{Border}_{\text{as}} \\ &\quad + \beta_3 (H_{\text{as,lag}(t)} * \text{Border}_{\text{as}}) \\ &\quad + \beta_4 X_{\text{hast}} + \beta_5 Z_{\text{ast}} + \mu_{\text{s}} \\ &\quad + m_t + y_t \qquad (1)\end{aligned}$$

where h indexed the hospitalization, a the zip code area, s the state and t the time period (admission month). The outcome variable, *ACSadmission*, was a binary indicator of ACS condition (1) versus marker condition (0); H was a set 6 of 3 months of lagged homicide rates in the nearest Mexican municipality (i.e. $t-1$, $t-2$ and $t-3$); *Border* was a binary variable of border county; X was a set of individual characteristics including age, sex and insurance status; Z was a set of regional characteristics including county physician supply, zip code income quartile, county unemployment rates and county urban status; μ_s represents state fixed effects to control for time-invariant state characteristics; m represents admission-month fixed effects to control for seasonality; and y represents year fixed effects to control for secular trends. In California, only admission quarter was available, so we randomly assigned each hospitalization to a month within a quarter. Robust standard errors were used.

The estimated effect of interest was, for patients residing in border counties, the change in the relative predicted probability (which we will refer to as 'probability') of a hospitalization being for an ACS rather than a marker condition associated with a one-unit increase in the homicide rates for the 3 months prior. Bias-corrected confidence intervals were calculated for the combined effect using bootstrapping with 1000 replicates.[30] Additionally, we calculated the average marginal effect for patient residence in a border county and used the delta method to calculate standard errors.[31]

Data set construction and ACS/marker identification were conducted using SAS 9.2 (SAS Institute, Cary, NC, USA); regression analyses used Stata 12.1 (StataCorp, College Station, TX, USA). An alpha level of 0.05 was considered statistically significant. The University of North Carolina Institutional Review Board and the Texas Department of State Health Services Institutional Review Board approved this study.

Subgroup analyses

We did subgroup analyses to determine whether certain subgroups thought likely a priori to be more likely to seek care in Mexico were differentially affected by increased homicides, specifically the uninsured and underinsured (i.e. hospitalizations with the primary payer of self-pay, charity care, no charge or Medicaid)[32,33] and persons residing in zip codes in the lowest income quartile.

Sensitivity analyses

We also conducted sensitivity analyses. Individuals may take time to update their knowledge of and preferences for the risk of seeking care in Mexico. Thus, it is not immediately obvious that homicide rate would have the most effect on patient behavior. We estimate the sensitivity of the primary results using a specification with the 1-month lagged homicide rate.

As more patient demographic data (e.g. sex, age, admission month) were missing in California, we conducted a sensitivity analysis restricted to Texas and Arizona including age in 5-year categories. Information on patient race was available, but these data are often inconsistent with patient reports of race/ethnicity.[34] We conducted a sensitivity analysis including a categorical indicator of patient race.

Results

Analytic sample

The final analytic sample included 1 873 407 hospitalizations containing an ACS or marker condition (Fig. 1). Approximately 10% of total hospitalizations for those aged 18–64 were for ACS or marker conditions. Seventy-eight percent of these were for ACS conditions. Patient residence matched to 24 unique Mexican municipalities corresponding to the crossings along the USA–Mexico border.

Twenty percent of hospitalizations were for patients residing in a border county (Table 1). Compared with hospitalizations in non-border counties, hospitalizations in border counties were less likely to be for ACS than marker conditions. Forty-nine percent of hospitalizations in border counties were in Arizona. Hospitalizations for patients in border counties were more likely to be covered by Medicaid and had shorter length of stay. Hospitalizations were more likely to be for male, younger (18–39 years) and Hispanic patients in border counties than non-border counties. Hospitalizations in border counties were more likely to have patient residence in areas with higher unemployment rates and lower income quartiles. Physician supply was lower for hospitalizations in border counties.

Analysis

Results for the estimation of Equation (1) (Table 2) showed a significant positive association between homicide rates and the probability of being hospitalized for an ACS versus marker condition in border counties. A 1-unit increase (1 homicide per 100 000 population) in the homicide rate persistent over the 3 months prior was associated with a 0.36 percentage point increase in the probability of being hospitalized for an ACS condition versus marker for patients in border counties. In non-border counties, there was no association between

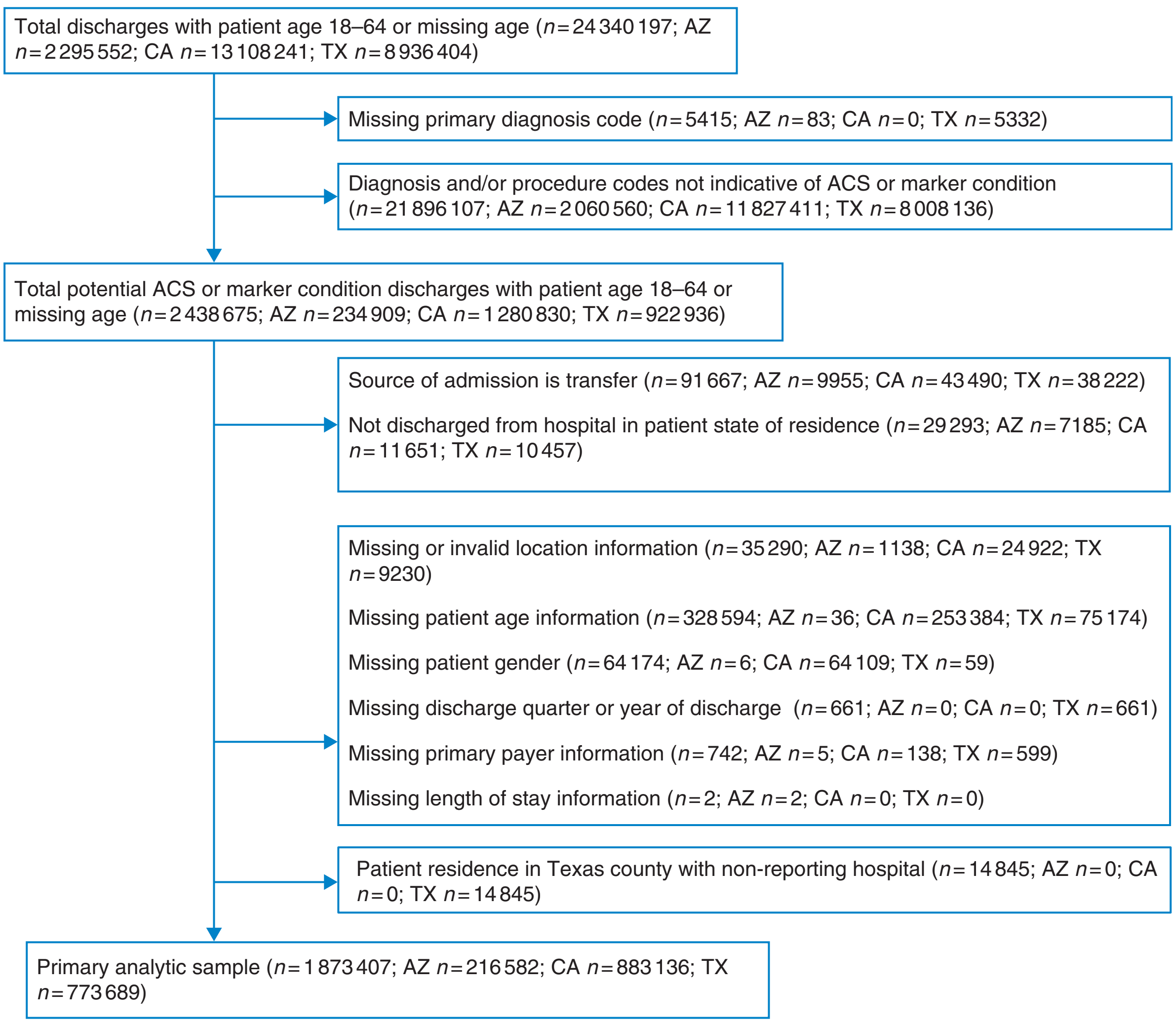

Fig. 1 Construction of analytic sample.

Table 1 Summary statistics for analytic sample

	Patient residence in border county			
	Overall (N = 1 873 407)	*Non-border (N = 1 489 611)*	*Border (N = 383 796)*	
	Mean (standard deviation) or %			P-value
ACS Condition (1) versus Marker (0)	78.0	78.3	76.9	<0.001***
Homicide rate per 100 000 population in matched municipality	3.1 (6.5)	2.6 (5.6)	5.1 (9.1)	<0.001***
Patient state of residence				<0.001***
AZ	11.6	1.8	49.4	
CA	47.1	51.2	31.5	
TX	41.3	47.0	19.0	
Primary payer				<0.001***
Medicare	19.3	19.5	18.4	
Medicaid	23.2	21.8	28.6	
Private insurance	36.5	36.6	36.3	
Self-pay/uninsured	11.0	11.7	8.6	
No charge	5.4	5.9	3.5	
Other	2.6	2.5	3.2	
Government	1.9	2.0	1.5	
Patient gender				<0.001***
Male	46.4	46.2	47.4	
Female	53.6	53.8	52.6	
Age category				<0.001***
18–39 years	24.6	23.9	27.3	
40–64 years	75.4	76.1	72.7	
Patient race/ethnicity				<0.001***
White	48.3	48.0	49.3	
Black	14.8	16.9	6.7	
Hispanic	19.3	16.4	30.6	
Asian/Pacific Islander	2.2	2.4	1.4	
Native American	0.7	0.5	1.7	
Other or missing	14.6	15.7	10.3	
Length of stay (days)	4.4 (5.3)	4.4 (5.4)	4.3 (4.9)	<0.001***
County unemployment rate	7.1 (3.3)	7.0 (3.1)	7.3 (3.8)	<0.001***
Income quartile of patient residence (5-digit zip)				<0.001***
0–24th percentile (<$48 850)	28.5	27.2	33.7	
25th–49th percentile ($48 850–$63 953)	27.2	27.7	25.2	
50th–74th percentile ($63 954–$88 000)	26.1	25.6	28.0	
75th–100th percentile ($88 001 and greater)	18.2	19.5	13.0	
Patient residence in urban county	92.8	92.1	95.6	<0.001***
County MDs per 1000 population	2.3 (1.0)	2.4 (1.1)	1.9 (0.8)	<0.001***
Driving distance (km) to nearest border crossing	430.6 (263.7)	506.3 (238.9)	136.9 (96.9)	<0.001***
Any ACS condition hospitalization	78.0	78.3	76.9	<0.001***
Acute ACS condition hospitalization	27.8	27.5	28.9	<0.001***
Dehydration	6.5	6.3	7.2	<0.001***
Bacterial pneumonia	13.0	13.1	12.8	<0.001***
Urinary tract infection	8.3	8.1	9.0	<0.001***
Chronic ACS condition hospitalization	50.2	50.8	48.0	<0.001***
Diabetes short-term complication	6.2	6.2	6.3	0.004**

Continued

Table 1 Continued

	Patient residence in border county			
	Overall (N = 1 873 407)	*Non-border (N = 1 489 611)*	*Border (N = 383 796)*	
	Mean (standard deviation) or %			P-value
Diabetes long-term complication	9.8	9.6	10.6	<0.001***
COPD or asthma in older adults	12.4	12.7	11.1	<0.001***
Hypertension	3.5	3.5	3.4	0.06
Congestive heart failure	12.4	12.9	10.5	<0.001***
Angina	1.9	2.0	1.7	<0.001***
Uncontrolled diabetes	1.4	1.4	1.6	<0.001***
Asthma in younger adults	2.1	2.1	2.3	<0.001***
Lower extremity amputation in diabetic	1.2	1.2	1.1	<0.001***
Any marker condition	22	21.7	23.1	<0.001***
Appendicitis with appendectomy	11	10.8	12.0	<0.001***
Acute myocardial infarction	2.8	2.8	2.9	<0.001***
Intestinal obstruction	6.8	6.8	6.7	0.17
Hip fracture	1.4	1.4	1.5	<0.001***

P-values by *t*-test for continuous variables and χ^2 test for binary/categorical variables.
$^{**}P < 0.01$.
$^{***}P < 0.001$.

homicide rates and the probability of being hospitalized for an ACS versus marker condition.

Patient residence in a border county was associated with a 1.3 percentage point decrease in the probability of being hospitalized for ACS versus marker controlling for covariates included in the model. Patients residing in higher income zip codes were less likely to be hospitalized for an ACS condition, as were men, those with private insurance, those living in a urban area and younger patients. Higher physician supply in the county of patient residence was associated with a lower likelihood of being admitted for an ACS condition.

Subgroup analyses

For the uninsured and underinsured, the effects of homicide rates were similar in direction and significance but of larger magnitude than those in the full sample (Table 3A). For hospitalizations where the primary payer was self-pay, charity care, no charge or Medicaid, a significant positive association existed between homicide rates and the probability of being hospitalized for an ACS versus marker condition in border counties. In border counties, a 1-unit increase (1 homicide per 100 000 population) in the homicide rate persistent over the 3 months prior was associated with a 0.47 percentage point increase in the probability of being hospitalized for an ACS condition versus marker. Patient residence in a border county was, on average, associated with a 1.7 percentage point decrease in the probability of being hospitalized for ACS versus marker controlling for covariates included in the model.

For patients residing in zip codes in the lowest income quartile, the association between homicide rates and the probability of being hospitalized for an ACS condition in border counties was smaller in magnitude and not significant at the 5% level (Table 3B). For this population, patient residence in a border county was, on average, associated with a 2.2 percentage point decrease in the probability of being hospitalized for ACS versus marker condition controlling for covariates included in the model.

Sensitivity analyses

We examined a 1-month lagged homicide rate in place of the set of lagged rates used in the primary analyses (Supplementary data, Table S1, Panel A). For the main analytic sample, the results were qualitatively similar. When the sample was limited to hospitalizations in Texas and Arizona,

Table 2 Regression estimation results

		95% confidence interval[a]	
A. Marginal effects and change in predicted probabilities			
Marginal effect of patient residence in border county	−0.0131[b]	[−0.0140, −0.0112]	
Combined change in relative predicted probabilities based on lagged homicide rates in border county	1.00362[b]	[1.0022, 1.0050]	
Combined change in relative predicted probabilities based on lagged homicide rates in non-border county	1.00061	[0.9996, 1.0017]	
B. Full regression results for primary sample			
Variable[c]	Odds ratio	Robust standard error	P-value
Patient residence in border county	0.9134[b]	0.0060	<0.001
1-month lag of homicide rate	1.0005	0.0004	0.26
1-month lag of homicide rate border county	1.0009	0.0007	0.17
2-month lag of homicide rate	1.0003	0.0005	0.56
2-month lag of homicide rate border county	1.0002	0.0007	0.84
3-month lag of homicide rate	0.9998	0.0005	0.73
3-month lag of homicide rate border county	1.0019[b]	0.0007	0.01
Age category (18−39 years)	0.4808[b]	0.0019	<0.001
State			
Arizona	1.0037	0.0080	0.65
Texas	1.2187[b]	0.0061	<0.001
Unemployment rate	0.9942[b]	0.0010	<0.001
Income quartile (reference group = first—lowest quartile [<$48 850])			
2nd [$48 850−$63 953]	0.9148[b]	0.0049	<0.001
3rd [$63 954−$88 000]	0.7831[b]	0.0042	<0.001
4th—highest quartile [$88 001 and greater]	0.5885[b]	0.0034	<0.001
Patient residence in urban area	0.9745[b]	0.0082	0.002
Physician supply (physicians per 1000 population)	0.9643[b]	0.0020	<0.001
Male	0.7670[b]	0.0028	<0.001
Primary payer (reference group = private insurance)			
Medicare	2.9591[b]	0.0177	<0.001
Medicaid	2.8101[b]	0.0150	<0.001
Self-pay/uninsured	1.5884[b]	0.0096	<0.001
No charge	1.7373[b]	0.0146	<0.001
Other	1.3526[b]	0.0151	<0.001
Government	1.2378[b]	0.0156	<0.001
Number of observations	1 873 407		
Psuedo R^2	0.071		

[a]Confidence interval for marginal effect of patient residence in border county was calculated using the delta method. Confidence intervals for combined changes in relative predicted probabilities based on lagged homicide rates are calculated using bias-corrected bootstrapping methods with 1000 replicates.
[b]Indicates significance at a 95% confidence level.
[c]Controls for month and year of admission were also included. Omitted categories were Patient residence—California, 18−39 years, Lowest income quartile, and Primary payer—private insurance. Robust standard errors were used.

results were similar in magnitude and direction to the primary analysis (Supplementary data, Table S1, Panel B).

Finally, we controlled for race in addition to the other covariates in the model. The association between homicides and probability of ACS hospitalization was similar to the primary analysis (Supplementary data, Table S1, Panel C), with a significant positive association between homicide rates and the probability of being admitted for an ACS versus marker

Table 3 Subgroup analyses

		95% confidence interval[a]
A. Uninsured and underinsured subgroup ($N = 741\,680$)		
Marginal effect of patient residence in border county	−0.01753[b]	[−0.0202, −0.01482]
Combined change in relative predicted probabilities based on lagged homicide rates in border county	1.00476[b]	[1.0024, 1.0072]
Combined change in relative predicted probabilities based on lagged homicide rates in non-border county	0.99936	[0.9978, 1.0010]
B. Lowest income quartile subgroup ($N = 534\,123$)		
Marginal effect of patient residence in border county	−0.0220[b]	[−0.0251, −0.0189]
Combined change in relative predicted probabilities based on lagged homicide rates in border county	1.0022	[0.9996, 1.0045]
Combined change in relative predicted probabilities based on lagged homicide rates in non-border county	0.9975	[0.9941, 1.0013]

[a]Confidence interval for marginal effect of patient residence in border county is calculated using the delta method. Confidence intervals for combined change in relative predicted probabilities based on lagged homicide rates are calculated using bias-corrected bootstrapping methods with 1000 replicates.
[b]Indicates significance at a 95% confidence level.

condition. After controlling for race, patient residence in a border county was not significantly associated with the probability of being admitted for an ACS versus marker condition.

Discussion

Main findings of this study

We used a common measure of access to outpatient care with an innovative method using patient-level hospital hospitalization data to examine the impact of homicides in northern Mexico on access to care in US border counties over the period of 2005–10. Using data on hospitalizations in California, Arizona and Texas, we found a positive relationship between homicide rates in the nearest Mexican municipality and the probability of being hospitalized for an ACS versus marker condition for patients residing in border counties.

We also found that individuals in border counties had reduced probabilities of being hospitalized for an ACS versus marker condition, indicating a higher level of access for these individuals than indicated by the model that controls for US physician supply. This finding is likely due to the fact that they had increased access to physicians in Mexico not included in the model.

What is known about this topic

Reducing hospitalizations for ACS conditions is an important policy priority to lower healthcare costs.[35] Thus, recognizing and ameliorating barriers to accessing outpatient care is important, particularly when such access may be compromised by events external to the US healthcare system such as violence in Mexico.

Using health care in Mexico is a common alternative to the US healthcare system for residents of the border region.[14] Access to care in Mexico may have been jeopardized by violence in Mexico, although previous research found that any reductions in access measured based on self-reported access and ED encounter types are small and not statistically significant. Options for improving access to care in the USA–Mexico border region may be more complicated than in other regions[12] due to the availability of formal care in Mexico and informal care options, options that are not present in other regions.[17,18]

What this study adds

These results suggest two relationships: (i) access to ambulatory care in Mexico may be reduced due to the violence in northern Mexico, with measurable changes in hospitalizations for ACS conditions and (ii) access to ambulatory care in Mexico may contribute to lower than expected rates of ACS conditions in US hospitals.

Violence in northern Mexico was associated with increased hospitalizations for ACS conditions in the USA. An increase of 1 SD (6.1 homicides per 100 000 population) was associated with a 2.2 percentage point increase in the probability of being hospitalized for an ACS versus marker condition. The size of this effect was similar to the change in patient access resulting from a safety net hospital closure near the patient in California during the 1990–2000 period.[36] The association between homicide rates and the probability of being admitted for an ACS versus marker condition was stronger for the uninsured and underinsured. Associations with homicide rates were not statistically significant for those residing in low-income zip codes, which may be due to measurement error in income at the individual level (i.e. we were not able to identify the income of an individual patient). The results in border counties persisted when changing the specification of the homicide rate measure and when controlling for more precise age categories and patient race.

Despite the frequent use of care in Mexico by US border residents, previous research has not quantified effects of this access on health care in the USA. Patient residence in a border county was associated with a reduced probability of being hospitalized in the USA for an ACS versus marker condition. This relationship persisted after controlling for local economic conditions, patient age, insurance status and physician supply, and the effect was stronger for uninsured and underinsured individuals as well as residents of low-income US counties. This finding suggests that while border counties are underserved[8] and affected by reduced access to ambulatory care in Mexico in some regions due to violence, border county residents have lower ACS admissions than non-border residents. Efforts in border regions to improve access through provisions such as free care by public health departments in border regions to immigrant communities may also be having a measurable positive impact on access for these populations. Cross-border care available in Mexico likely contributes to this improved access, despite changes due to the violence in northern Mexico. To our knowledge, this study is the first to quantify the size of this access benefit in terms of reduced hospitalizations, an effect that is small but significant in both statistical and practical sense. The fact that access to care in Mexico has measurable effects on hospitalizations in the USA suggests that policy responses may be appropriate to incorporate this access and improve care coordination between USA and Mexican providers.

Limitations

Our analysis had several limitations. First, we were not able to fully control for healthcare access. We included controls for physician supply, but physician supply is not a direct proxy for access to care for individuals.[37] Second, if there were compensatory responses (e.g. increased free care from public health clinics) to reduced access due to violence in the border region, results will underestimate effects of changes in access to care in Mexico. Additional changes in outpatient access during this period include the expansion of retail clinics[38] and reduction in the prices of generic prescriptions in the USA (e.g. $4 prescriptions).[39,40] Third, we had limited patient demographic data and significant missing age and gender data in California; we conducted sensitivity analyses to test whether this missing data was driving the results and found that this did not affect the primary results. We did not test sensitivity for the 13.5% of potential ACS/marker hospitalizations with missing age, as we could not definitively classify these.

Conclusion

In total, an increase in hospitalizations for ACS conditions in border counties was associated with increased homicide rates. We were able to quantify the association between residence in a border county and reduced hospitalizations for ACS conditions in the USA. Increased hospitalizations for ACS conditions may indicate reduced access to ambulatory care in Mexico associated with homicides, crucial for a population with high poverty and uninsurance rates that relies heavily on this care.[14] Mitigating reductions in access due to violence in Mexico is a crucial step for policymakers and health professionals in the border region as the violence continues to be widespread.[41] Future research should examine options to improve access to care in the USA, as well as to improve access and coordination of care between USA and Mexican providers for those residing in border counties.

Supplementary data

Supplementary data are available at the *Journal of Public Health* online.

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