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Environmental Justice Dimensions of Oil and Gas Flaring in South Texas: Disproportionate Exposure among Hispanic communities

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Abstract

Unconventional extraction techniques including hydraulic fracturing or "fracking" have led to a boom in oil and gas production the Eagle Ford shale play, Texas, one of the most productive regions in the United States. Nearly 400,000 people live within 5 km of an unconventional oil or gas well in this largely rural area. Flaring is associated primarily with unconventional oil wells and is an increasingly common practice in the Eagle Ford to dispose of excess gas through combustion. Flares can operate continuously for months and release hazardous air pollutants such as particulate matter and volatile organic compounds in addition to causing light and noise pollution and noxious odors. We estimated ethnic disparities in exposure to flaring using satellite observations from the Visible Infrared Imaging Spectroradiometer between March 2012-December 2016. Census blocks with majority Hispanic (>60%) populations were exposed to twice as many nightly flare events within 5 km as those with <20% Hispanics. We found that Hispanics were exposed to more flares despite being less likely than non-Hispanic White residents to live near unconventional oil and gas wells. Our findings suggest Hispanics are disproportionately exposed to flares in the Eagle Ford Shale, a pattern known as environmental injustice, which could contribute to disparities in air pollution and other nuisance exposures.

INTRODUCTION

Unconventional extraction technologies, a drive for energy independence, and an ever-growing demand for fossil fuels has led to a surge in domestic oil production in the United States (U.S.) over the past decade and a corresponding rapid proliferation of unconventional oil and natural gas (UOG) extraction activity.[1, 2,3] Since 2010, oil production has nearly doubled while natural gas production rose 50%, reversing a longstanding decline in production nationally.[4] This has been made possible, in part, by advancements in high

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volume hydraulic fracturing techniques ("fracking") that involve the injection of fluids, sands, and chemical additives into wells to reduce friction, decrease drill time, or stimulate production.[5,6,7] Compared with conventional techniques, unconventional oil extraction typically requires a higher well density and more sustained drilling activities.[8] As of 2014, there were over 800,000 onshore oil and gas wells in the continental U.S., and the industry is estimated to continue to grow by tens of thousands of wells per year.[9,10, 11] Approximately 17.6 million people live near (<1.6 km) an active oil or gas extraction site, the majority of whom are living in rural communities in the continental U.S.[9] UOG extraction has been linked to worsened air pollution,[11–15] contaminated ground and surface water,[16, 17] increased noise,[18, 19] more traffic,[20] and disruptions to the local social fabric.[21, 22]

One consequence of the rapid expansion of unconventional petroleum extraction is flaring, the practice of combusting excess natural gas to the open atmosphere, which is common in places with insufficient infrastructure for the capture and utilization of natural gas.[23] Flaring is a means of disposal of unwanted flammable gases during extraction, and refers specifically to the intentional, controlled combustion of gases during the exploration, production and processing of natural gas, liquids and/or oil. In recent years, the U.S. has boasted the highest number of flares of any country globally, flaring an estimated 14.1 billion m^3 of natural gas in 2018.[23,24] This is nearly a 50% increase from the prior year, with no indications of a decline.[25] Air quality monitoring studies indicate that incomplete combustion during flaring—which typically lasts for multiple days or weeks[26]—releases a variety of volatile organic compounds and polycyclic aromatic hydrocarbons along with carbon monoxide, nitrous oxides, sulfur dioxide, heavy metals, and black carbon.[27–30] Many of these compounds are known to be either toxic, carcinogenic, or associated with reproductive harm.[12, 13, 31] Studies of exposure and health impacts of flaring have been limited. Since flaring is a waste disposal process, there is a lack of systematic reporting requirements of the locations and volumes of flares.

The Eagle Ford shale in South Texas is one of the most active and productive drilling sites in the U.S., ranking highest in the country for the volume of oil produced and fourth highest for gas production as of 2013.[32] This region sits atop "tight oil plays," which refers to a low-permeability continuous shale that requires hydraulic fracturing with large water volumes to extract oil.[33] This shale play extends across dozens of predominantly rural counties in southern and central Texas and is roughly 50 miles wide and 400 miles long (Figure 1). UOG extraction began in the Eagle Ford in 2008 and has increased at an unprecedented rate. Roughly 1.3 million barrels of oil and 5000 million cubic feet of gas are extracted daily in 2014 from this region – approximately a tenfold increase since 2010.[34] In the Eagle Ford shale play, nearly 44,000 nightly flares accounting for ~4.5 billion cubic meters of flared gas have occurred between March 2012 and December 2016, however the density and frequency of flaring varies greatly across the shale play.[23]

Much of the region is home to low income families and approximately 40% of residents identify as Hispanic (Figure 2), raising environmental justice concerns about the potential health impacts of the Eagle Ford oil and gas boom,[35,36] which have yet to be considered. We aimed to assess racial and ethnic disparities in exposure to flaring within this region.

METHODS

Oil and gas related data

The study area is comprised of the 27 counties defined as part of the Eagle Ford Shale formation by the Texas Railroad Commission (TRRC). Information and location of all oil and gas wells were extracted from DrillingInfo, an oil and gas permit, completion, and production mapping database.[37] We extracted well-specific information including the American Petroleum Institute (API) identification number, well production type (oil or gas), drill type (horizontal, vertical, or directional), well status (active, inactive, abandoned), plug date (date production permanently ends), and well geolocation (latitude, longitude). Using monthly well production data of oil and/or gas from DrillingInfo, our analysis included all permitted unconventional (e.g., horizontal or directional) well locations in the Eagle Ford Shale that were actively producing anytime between March 2012 through December 2016.

Flaring data

Flaring is not systematically reported.[23] Therefore, flares were identified using the Visible Infrared Imaging Radiometer Suite (VIIRS) onboard the Suomi National Polar Partnership satellite (SNPP), a multi-spectral instrument with bands for day and night observation that launched in October 2011 and began providing data in March 2012. The VIIRS Nightfire (VNF) algorithm, developed by the National Oceanic and Atmospheric Administration (NOAA) Earth Observation Group, uses the near-infrared and shortwave infrared bands to detect locations of sub-pixel (<750 m) combustion sources. The Nightfire product provides information on source temperature, area, and radiant heat. The VNF data have been used to improve global estimates of flared gas volume[24] and to detect industrial heat sources.[38] Among VNF-detected hotspots, UOG-related flaring events were distinguished from biomass burnings by their high temperature (> 1600K).[39] Our team recently developed a sophisticated spatiotemporal modeling approach to identify nightly gas flare events in the Eagle Ford shale of south Texas.[23] Using this approach we identified the locations of persistent nightly gas flares, the primary exposure metric for subsequent analyses.

Population characteristics

Our primary analyses examined the presence of nightly gas flares to Hispanic populations, as an individual's vulnerability to the presence of polluting facilities nearby is modified by the race and ethnicity of other people in their community.[40] Based on data from the 2010 U.S. Census we defined the following racial/ethnic categories: non-Hispanic White (non-Hispanics who identified as White and no other race), Hispanic of any race, non-Hispanic Black and all other races. People of Color were defined as all people not categorized as non-Hispanic White. We used the census block, the smallest geographic unit for which demographic administrative data are available, as the spatial level of analysis and extracted race/ethnicity-specific population counts from tables and associated shapefiles obtained from the National Historical Geographic Information System (NHGIS).[41]

Since flaring practices are uncommon and often restricted in urban areas, we excluded census blocks located within municipal boundaries of cities with a 2010 population greater than 75,000 (resulting in the exclusion of census blocks inside of the Cities of Laredo, College Station and Bryan, TX). The final study area consisted of 63,479 census blocks, 39% of which (24,961) had a population of one or more persons. Populated blocks contained between 1 and 3097 people (median: 12, total: 668,854) and covered an average of 1.80 square kilometers (median: 0.64 km^2, range: 2.51×10^{-4} to 414 km^2). We further calculated the population density of each census block, defined as the number of people per square kilometer. Population density is a measure of rurality, which is strongly associated with land value and the availability of land for oil and gas drilling. Due to its non-normality, population density was log-transformed and centered around its median for analytical purposes.

During the study period, we calculated a flare metric for each census block by summing both (1) the number of nightly flare events within the block and (2) the number of nightly flare events within a 5-km radius of the block centroid (Supplemental Figure S1). Metric (2) is referred to as "flares within 5 km" in the rest of the text. We chose to use 5-km circular buffers around all census block centroids to help standardize flare exposure as the blocks vary greatly in size and shape. In addition, high-population census blocks tended be smaller and had few or no flare events strictly within the block itself, yet there could still be nearby flaring events. There were 219 (0.9%) blocks where the block itself extends beyond the 5-km buffer. We also conducted a sensitivity analysis using 3-km and 10-km radius buffers. An analogous metric for UOG well locations was calculated in a similar manner.

Statistical Analysis

A population weighted negative binomial regression model was used to quantify the relationship between the racial/ethnic makeup of census blocks and the presence of one or more nightly flares within 5 km of each census block during the study period. Our main analysis focused on the proportion of Hispanic residents given that roughly 90% of residents identified as Hispanic or non-Hispanic White; a secondary analysis looked at the proportion of People of Color. We categorized the proportion of Hispanic residents residing in each census block using 20% increments and calculated the incidence rate ratio (IRR). We also included the cubic natural log of population density; the polynomial term maximized model fit, as is consistent with previous research.[40]

Additionally, to address the spatial nature of our data, we used generalized additive models (GAMs)[42] to fit 2-dimensional thin plate splines smoothers on the coordinates (longitude and latitude) of the block centroids. GAMs allow for flexible non-parametric representations of covariates and have been used in similar contexts to address spatial confounding in block-level areal data where other spatial covariates such as population density do not fully capture spatial autocorrelation in the outcome.[43] Akaike information criterion (AIC) and Pearson goodness-of-fit were used to compare models (Supplemental Table S1). Zero-inflated Poisson and zero-inflated negative binomial models were also considered, but the models were unstable and failed to converge. A parallel analysis was conducted for active UOG extraction wells. Statistical analyses were conducted in R version 3.5.3 using the mgcv package for GAM modeling. Spatial processing was done in Postgres 10.5 with the PostGIS extension as well as in R using the sf package.

RESULTS

Forty percent of the approximately 669,000 people living in the Eagle Ford Shale counties (after excluding the 3 urban cities) identified as Hispanic, while 49% identified as non-Hispanic White. The remaining 11% identified as African-American, Native American, or Asian/Pacific Islander. We identified 23,808 active unconventional extraction wells in the study region of which the 15,340 oil wells produced 1.73 billion barrels of oil (BBL) during the study period while the 8,468 gas wells produced 1.2 billion barrels of oil equivalent (BOE) (Figure 3). Nearly 402,286 people (60% of the population in the 27 counties) lived in a census block within 5 km of an active UOG well (Table 1 and Supplemental Table S2). For the study area, the mean number of nearby wells per census block was 17.8, with a range from 1 to 291.

Between March 2012 through December 2016, there were 46,233 nightly flare events identified in the region with the most flaring occurring in 2014 (Figure 3). Flares were observed in 26 of 27 counties in the study area, with an overall regional median of 9,668 flares per year (range 5,223 to 12,373). Five of the 27 counties (La Salle, McMullen, Karnes, Dimmit, DeWitt) accounted for 80% of the flaring activity. Over 160,000 people lived near (<5 km) at least one flare during this study period, that is, and almost one out of four people in the study area (Table 1 and Supplemental Table S3). The median number of nightly flares per census block during the study period is 28, with a range from 1 to 1,777. Hispanics were exposed to a mean of 30.5 flares during the study period compared to 25.1 for non-Hispanic whites.

The amount of flaring varied with the ethnic composition of the census blocks (Figure 4). For example, Figure 4 shows that among blocks with no flaring, roughly 20% of the population lived in a block with over 80% Hispanic makeup; whereas among blocks with over 500 flares, more than 50% of the population lived in a predominantly Hispanic block. Unadjusted models showed that on average, blocks with more than 80% Hispanics were exposed to twice as many flares within 5 km as blocks with <20% Hispanics (IRR: 2.11 95% CI: 2.05, 2.18). This relationship was amplified when adjusted for rurality (Figure 5), increasing the ratio to 2.60 (95% CI: 2.51, 2.69) comparing the most Hispanic to the least Hispanic blocks. Accounting for spatial autocorrelation in the GAM attenuated the Hispanic effect estimates, but it remained that the highest quintile of Hispanic blocks exposed had the largest statistically significant effect estimate (IRR: 1.86, 95% CI 1.80, 1.93). The non-parametric spatial trend estimate was statistically significant in all GAMs suggesting residual spatial confounding in the baseline and rurality-adjusted models.

The pattern among exposures to predominantly Hispanic neighborhoods was not evident with respect to proximity to UOG wells (Figure 6). Majority Hispanic blocks were located near slightly fewer UOG wells compared with blocks <20% Hispanic residents (Supplemental Table S5), a result that was consistent across unadjusted and adjusted model forms. For example, the base IRR for the >80% Hispanic quintile was 0.83 (95% CI: 0.82–0.84) and 0.94 (95% CI: 0.92–0.95) after adjusting for rurality, suggesting that Hispanic residents were less likely than non-Hispanics whites to live near unconventional extraction wells. The GAM models showed a large reduction in the effect estimates indicating a significant spatial trend in locations of UOG wells. We further explored associations between ethnicity and proximity only to unconventional oil wells (Supplement Figure S2) and found inconsistent results where higher risks of exposure among the most Hispanic blocks (>80%) were observed in the rurality-adjusted model (IRR: 1.1;, 95% CI: 1.12,1.17) but not in the unadjusted (IRR: 0.86; 95% CI: 0.84, 0.88) or GAM (IRR: 0.80; 95% CI:0.79, 0.81) models. This finding suggests it is not greater proximity to oil wells alone that explains the greater exposure to flaring among blocks with higher proportions of Hispanics.

Sensitivity Analysis

The pattern of ethnic disparities held with changes in the distances defining the exposure metric (Table 2 and Supplemental Table S6). Using 3-km buffers, we observed a similar pattern of increasing exposure to flares as the proportion of Hispanics increased. In fact, the effect estimates were more pronounced when we restricted the proximity measure. Compared with the quintile of lowest proportion Hispanic population, we saw that the exposure was 3.2 times as high (95% CI: 3.14, 3.42) for blocks of 80% or more Hispanic residents when adjusting for population density and 2.1 times as high (95% CI: 2.00, 2.21) when addressing spatial autocorrelation. By contrast, the disparities in exposures to flares by ethnicity was attenuated when the radius was increased to 10 km. Nonetheless, the principal findings were robust to the exposure distance metric, as the blocks with the highest burden are majority Hispanic.

Additionally, we classified census blocks by the proportion people of color. Similar to the findings with respect to Hispanic residents, we observed more flaring near blocks with >60% People of Color (Supplemental Figure S3, Supplemental Table S7). Across all models the blocks with the highest proportion people of color are the most burdened.

IMPLICATIONS FOR RESEARCH & POLICY

Rural America is frequently the site of concentrated poverty, a dumping grounds for locally unwanted land uses that is nevertheless understudied in terms of environmental health and justice issues.[44] The upstream phase of oil and natural gas development – which occurs primarily in rural areas – is an emerging area of environmental justice scholarship.[36] Oil and gas drilling has historically consisted of small-scale, widely dispersed operations. New extractive technologies allow more flexibility in well pad siting decisions and, by making previously inaccessible shale formations accessible, resulted in a boom in well construction that has brought oil and gas development activities in closer proximity to where people live.[45] Evidence to date about economic and racial disparities with respect to the location of drill sites have been mixed.[46–49] We observed that communities with the highest proportions of Hispanic residents were less likely to live near (<5 km) active unconventional oil and gas wells than communities with the lowest proportions of Hispanic residents in the Eagle Ford Shale play, but we did not observe a step-wise trend between the ethnic makeup of communities and the presence of oil and gas wells. Similarly, studies in the Marcellus shale region (Pennsylvania, West Virginia and Ohio) found that UOG wells were not disproportionately located near low-income or people of color, although unlike our study area, these regions are predominantly composed of non-Hispanic white residents.[46,49] This pattern may reflect the predominance of non-Hispanic white ownership of rural land across the United States, as an estimated 90% of recent UOG development has occurred on private lands.[36]

In contrast, prior research has found that waste disposal wells associated with oil and gas development disproportionately concentrate in areas of poverty or communities of color in South Texas and Ohio.[35, 50] This is consistent with and established body of literature demonstrating that waste facilities are disproportionately sited near communities of color and low-income communities across the United States.[35,51,52] We add to the evidence of environmental injustice with respect to UOG waste disposal by considering flaring and demonstrate that the disposal of unwanted outputs from UOG development in the Eagle Ford shale is not only occurring in physical waste disposal sites, but via these highly visible combustion events.[53] We found evidence of inequities in exposure to flaring activity in the Eagle Ford Shale Play, where the environmental burdens of waste disposal via gas flaring is disproportionately borne by Hispanic residents. We observed a similar pattern when examining proximity to flaring on the basis of a census block's proportion of Hispanic and non-Hispanic People of Color (grouped together). Our findings with respect to wells suggest that the disproportionate use of flaring to dispose of unwanted gases in more Hispanic communities across the Eagle Ford shale is not merely an artifact of living near more UOG wells. To our knowledge, this is the first study to evaluate the environmental justice dimensions of gas flaring

A strength of our analysis is that it leverages satellite data, which are more objective than administrative records, to identify flare events in the region. However, the satellite is only able to detect flare activity at night, and may undercount total flares by missing waste gas that is inconsistently flared, very small or flared only during the day.[54] We could not measure individual exposures to flares or assess the specific reason for any individual flaring event. The particular rationale for any single flare event may be particular to well conditions, feasibility of transporting natural gas to market or using it on site for power generation, existing infrastructure, or safety concerns. Our analysis is limited to available census data from 2010 and cannot capture population changes during the study period. We use the smallest available geographic unit – census blocks – but in some cases the blocks can be large and the exact location of residents within the block is not known.

Another strength of our analysis was the use of GAM models to control for spatial autocorrelation. While the spatial GAMs attenuated the Hispanic and race effect estimates compared to the baseline and rural-adjusted negative binomial models, the non-parametric spatial terms were statistically significant. The importance of the spatial term indicates that there was residual spatial autocorrelation when only race and rurality were included in the model, and without addressing it effect estimates of interest could be biased and have underestimated standard errors.[55] Other studies of socioeconomic disparities have used GAM models to address spatial autocorrelation in areal data at the census block or tract level, and found that GAM models sufficiently dealt with spatial correlation.[56, 57] Alternatives to GAM models for addressing spatial autocorrelation in census-based areal data are Simultaneous Autoregressive Regression or Conditional Autoregressive Model (SAR and CAR, respectively)[58] where the spatial autocorrelation is accounted for in the variance/covariance matrix of the model. There are however significant computational challenges to autoregressive models particularly with small scale census-block level data as the Eagle Ford study area included 24,961 census blocks. Parallelization is not possible for autoregressive models due to the nature of the adjacency matrix computation required in both SAR and CAR approaches. A Bayesian CAR model was used to examine the association of socioeconomic predictors of proximity to wastewater from hydraulic fracturing in Ohio.[50] Their study area included approximately 9,205 block groups, which is a sample size more tractable than ours. While autoregressive type models are more common for areal data, studies involving small census-level spatial areal data have found that comparatively GAM and autoregressive models both address spatial correlation adequately.[43]

Our results with respect to the disparities in flares may be driven by difference in political marginalization between Hispanic and non-Hispanic white communities in the region. Marginalized communities are often targeted for the citing of locally unwanted land uses because of the perceived lack of political power and limited resources to challenge industrial practices.[59, 60] These communities often receive less government oversight, which may increase the local levels of pollution, ultimately exacerbating health disparities.[61] While the development of UOG extraction is a recent phenomenon, communities in Texas have experienced upstream petroleum extraction for over a century. Historically, public concerns regarding flaring activities led to strict state regulation of flaring that resulted in substantial reductions.[62, 63] Research suggests that these mandated "no-flare" orders drastically reduced flare activity during the production of oil and gas until adequate infrastructure to prevent wasteful flaring was developed.[64] However, as unconventional extraction technologies grew, state regulations were relaxed to permit flaring as a routine waste disposal practice and decreased the administrative burden to obtain permission for routine flaring of limited amounts of waste gas.[62] As a result of this deregulation, flaring is now used more frequently in UOG extraction compared to current or historical conventional extraction.[65, 66] Regulations, existing technologies and investment in infrastructure can reduce flare events and emission associated with flaring.[62,65, 66]

Our study holds implications for other oil and gas producing regions. Flaring has dramatically increased over the past 5 year across the U.S., spiking by some 50 percent in 2018 from the previous year, the largest absolute gains compared to any other country.[25] This increase is largely due to ongoing flaring practices in Texas (Permian Basin) and North Dakota (Bakken Shale), where much of the US unconventional oil production occurs, but is largely underregulated and rarely monitored by regulatory agencies.[62, 67, 68] These regions are also home to large Hispanic and Native American populations.

Low income communities near flaring not only face additional burdens due to potential toxic releases, but often do not have the social or financial resources to mitigate their exposures.[69, 70] Air quality monitoring studies indicate that incomplete combustion during flaring—which typically lasts for multiple days or years[26]—releases a variety of air toxics, including those associated with carcinogenicity or reproductive harm.[12, 13, 27–31] Local short-term field sampling campaigns further suggest substantial increases in local concentrations of non-methane hydrocarbons, NO_x, and ozone due to gas flares.[28, 29] These hazards may be amplified by other negative socioeconomic and health factors, including higher rates of chronic diseases, lack of access to healthy foods, substandard housing, and stress from racism, poverty, unemployment, and crime.[71,72,73,74,75] While research is needed to understand health consequences for residents and workers due to flaring, the regulation and reduction of flare events in the Eagle Ford shale would likely result in improved local air quality and improve efficiency of well operations.[62,65, 66] The reliance on flaring as a waste disposal method in the Eagle Ford and other oil shale plays across the US has the potential to exacerbate existing environmental health disparities.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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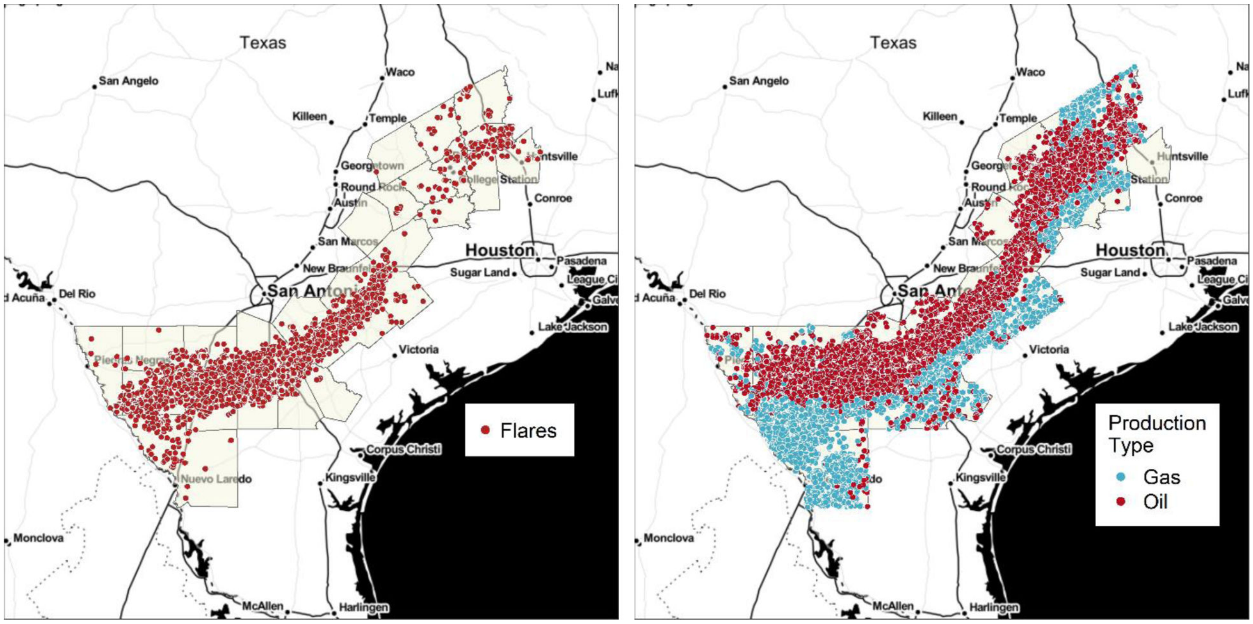

(a) **(b)**

Figure 1.

A map of the study region with (a) the locations of flares and (b) unconventional oil and gas wells in the Eagle Ford shale play.

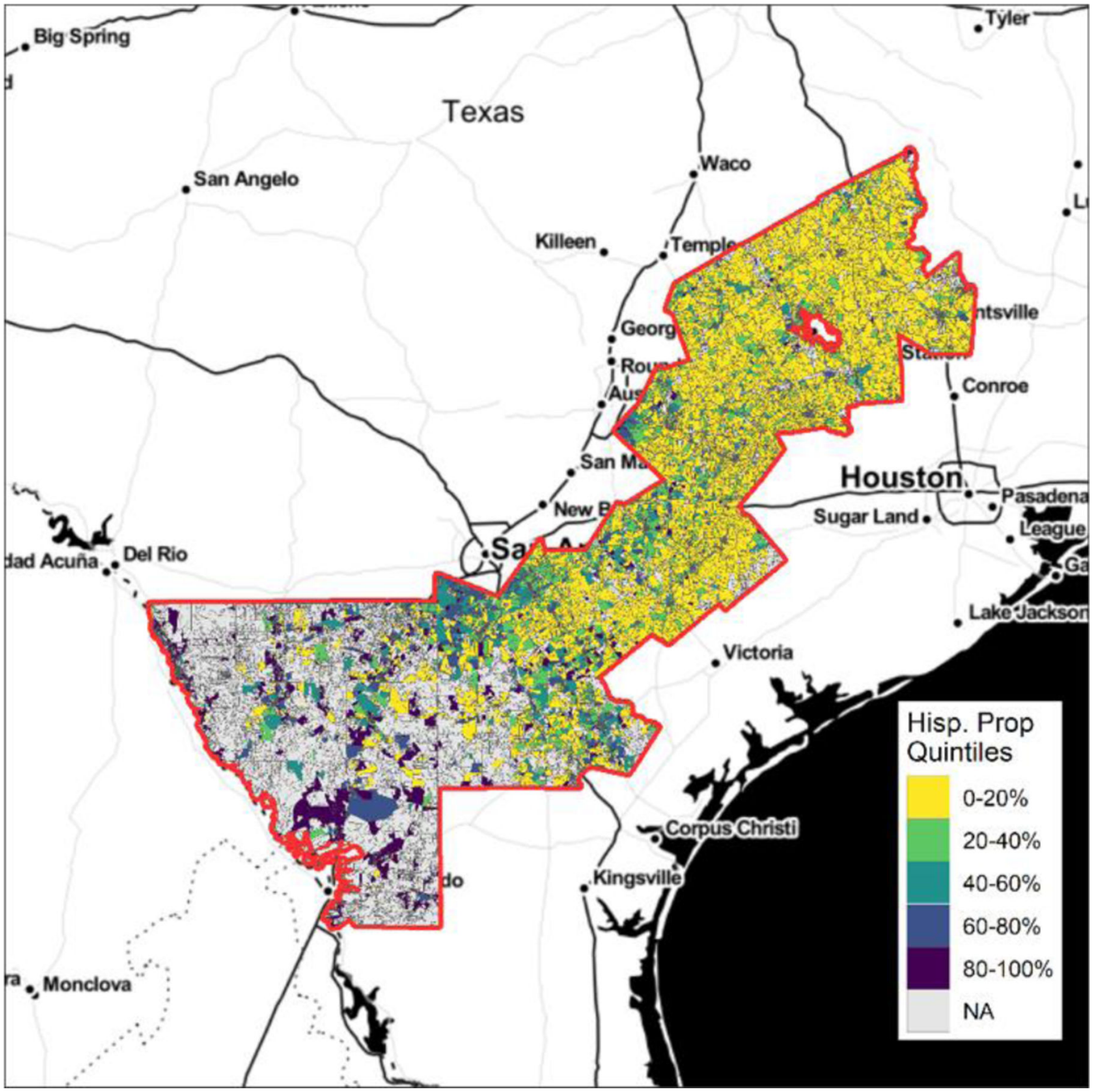

Figure 2.

A map of census blocks in the study area by proportion of Hispanic population. The red outlines the study area (including the 3 cities excluded from the analysis). Gray census blocks (NA) are unpopulated and are not included in the analyses.

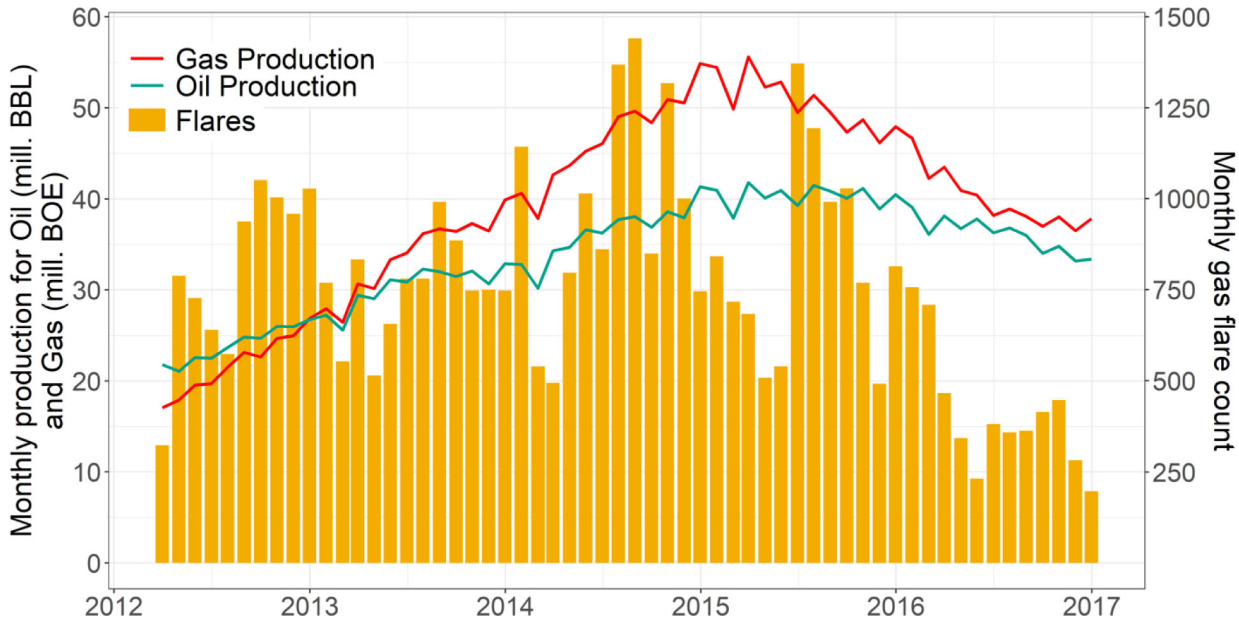

Figure 3.

Oil and gas production (lines) and monthly flare counts (bars) for the Eagle Ford shale play region from 2012–2016. Values represent total reported oil (green, in million barrels, mill. BBL) and gas (red, in million barrels of oil equivalent, mill. BOE) production, respectively, for each month during the study period. Flare counts (yellow) are the sum of nightly VIIRS-detected gas flare events for each month.

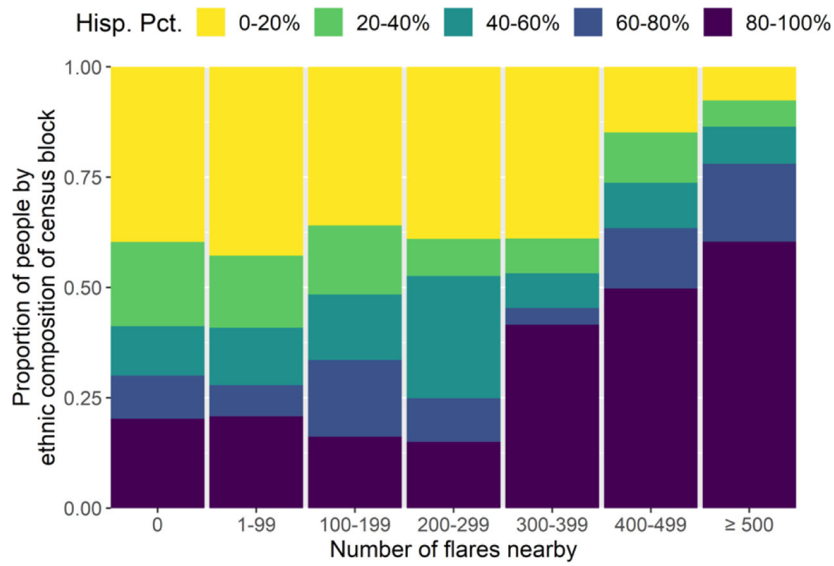

Figure 4.

The relationship between the percent of Hispanics in a census block and the numbers of flares occurring within 5km of the centroid of the census block during the study period (March 2012 – December 2016).

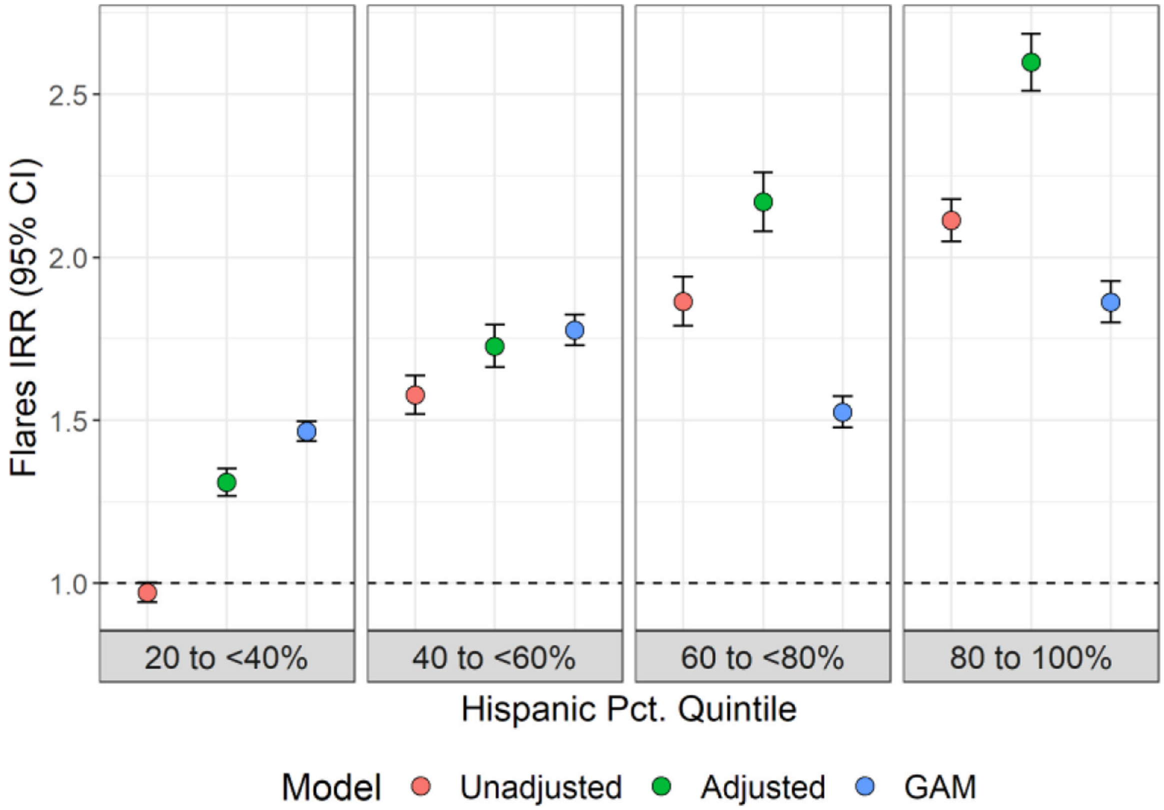

Figure 5.
Incidence Rate Ratios (IRRs) comparing the number of flares within 5 km of census blocks with more than 20% Hispanic residents compared to those <20% Hispanic, unadjusted, adjusted for rurality and accounting for rurality and spatial autocorrelation (GAM) in the Eagle Ford shale play, Texas, 2012–2016.

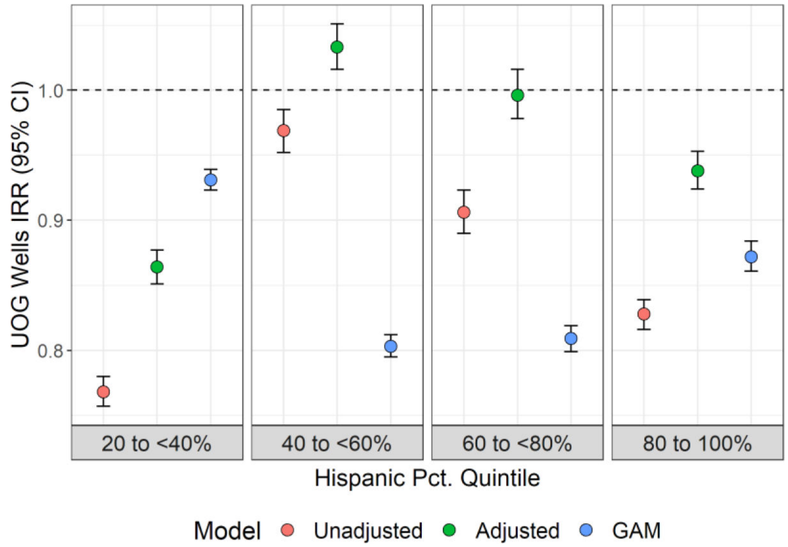

Figure 6.

Incidence Rate Ratios (IRRs) comparing the number of active unconventional oil and gas (UOG) wells within 5 km with census blocks with more than 20% Hispanic residents compared to those <20% Hispanic, unadjusted, adjusted for rurality and accounting for rurality and spatial autocorrelation (GAM) in the Eagle Ford shale play, Texas, 2012–2016.

Table 1.

Ethnic composition of TX census blocks in the study area with the mean number of flares or active oil and gas extraction wells within 5 kilometers (based on census blocks) between 2012–2016.

		Unconventional Oil & Gas Wells within 5km			Flares within 5km		
Hispanic Percent	**Population**	**Population**	**Percent of Population**	**Mean # of Wells**	**Population**	**Percent of Population**	**Mean # of nightly flare events**
0 – 20%	266988	175989	65.9	25.4	65438	24.5	72.6
20 – 40%	122214	68017	55.7	23.7	25378	20.8	74.2
40 – 60%	78279	47201	60.3	26	21266	27.2	105.0
60 – 80%	62887	38482	61.2	24.5	13331	21.2	114.0
80 – 100%	138486	72597	52.4	27.3	35719	25.8	117.0
Total	*668854*	*398712*	*59.6*	*25.5*	*161132*	*24.1*	*89.1*

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Table 2.

Incident Rate Ratios of flare exposure in Eagle Ford blocks by Hispanic Quintiles in unadjusted, population density-adjusted, and full models.

Buffer Size	Proportion Hispanic	Unadjusted	Pop. density-adjusted	GAM
		IRR (95% CI)	IRR (95% CI)	IRR (95% CI)
3KM				
	0 to <20	1	1	1
	20 to <40	0.99 (0.95, 1.03)	1.35 (1.29, 1.40)	1.65 (1.61, 1.70)
	40 to <60	1.30 (1.24, 1.36)	1.56 (1.49, 1.64)	1.24 (1.19, 1.29)
	60 to <80	1.60 (1.52, 1.69)	2.22 (2.10, 2.33)	1.40 (1.34, 1.47)
	80 to 100	2.16 (2.08, 2.25)	3.28 (3.14, 3.42)	2.10 (2.00, 2.21)
10KM				
	0 to <20	1	1	1
	20 to <40	1.10 (1.08, 1.12)	1.16 (1.14, 1.19)	1.22 (1.21, 1.23)
	40 to <60	1.83 (1.79, 1.88)	1.99 (1.94, 2.03)	1.19 (1.18, 1.21)
	60 to <80	2.13 (2.08, 2.18)	2.34 (2.28, 2.40)	1.36 (1.34, 1.38)
	80 to 100	2.43 (2.39, 2.48)	2.66 (2.61, 2.71)	1.38 (1.36, 1.40)