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Review article

Shale gas development and crime: A review of the literature

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ABSTRACT

This systematic review summarizes the relationship between shale gas development and crime. A comprehensive search uncovered 25 shale–crime quantitative studies published between 2005 and 2019. These outputs suggest the study of shale gas development and crime is multidisciplinary, increasing rapidly and mainly carried out in the United States. When considered in aggregate these studies provide clear evidence that shale gas development is likely to increase crime. A majority of studies find that shale gas development increases total crime, violent crime, property crime, social disorganization crimes and violence against women. We conclude by suggesting that these findings should be considered by policymakers and planners when determining whether and how shale development should be allowed.

1. Introduction

A growing number of literature reviews have examined the social consequences of shale gas development. In particular, existing reviews describe how shale gas development has affected property values, tourism revenue, traffic accidents, community attachment and government services (Buse et al., 2019; Jacquet, 2014; Krupnick and Gordon, 2015; Sovacool, 2014; Stedman et al., 2012; Theodori 2018; Thomas et al., 2017). Few literature reviews have, however, considered the potential impact of shale gas on crime. As James and Smith (A. 2017:26) suggest, "systematic studies documenting the relationship between resource sector(s) and criminal activity are [needed but] surprisingly scant" (see also Bartik et al., 2019). One advantage of a systematic approach is that it has considerable utility when it brings an established methodology to bear on a relatively neglected topic (Welsh and Farrington, 2005).

We suggest that a systematic review of the shale gas-crime literature is important for two reasons. First, when it comes to energy development it is important to establish if shale gas is likely to increase, decrease or have no impact on community crime rates. If the weight of the evidence suggests that crime will increase because of shale gas development, then policymakers and planners should require mitigation plans by industry. However, if shale gas development is associated with a decrease in crime it might be viewed as desirable, and therefore encouraged. Second, it is important for academics to take stock of the quickly accumulating research on shale gas development and crime. A review of the literature may prove to be a useful tool for guiding future theoretical perspectives and research design.

The current study contributes to the existing literature by summarizing the state of knowledge about the hypothesized relationship between shale gas development and crime. This is accomplished through a systematic review 25 quantitative studies that examine the shale gas-crime correlation at the local or regional level. To our knowledge the present investigation represents the only systematic review, and one of only two literature reviews, of shale gas development and crime to date (Ruddell, 2017; Chapter 3).

The remainder of this review is organized into four sections. The first section explores the common theoretical grounding used by the researchers carrying out the studies of shale gas development and crime. That section suggests that the concept of boomtowns is ubiquitous and often used to contextualize four major theoretical explanations in the literature: (1) social disorganization; (2) masculinity; (3) the Dutch disease and (4) the natural resource curse. The second section describes the study methodology, including the inclusion criteria used to identify the 25 studies selected for study. The third section briefly describes the shale-crime outputs and summarizes the correlations between shale gas and five different configurations of crime (total crime, violent crime, property crime, social disorganization related crimes and violence against women). In the final section we draw some conclusions about the measurement of key variables in shale-crime outputs and explore the policy implications of the research findings as well as provide recommendations for future research.

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2. Theoretical context

We begin our analysis by describing the theoretical perspectives employed by researchers who produced the 25 outputs selected for the systematic review (see 'Methods' for a detailed description of the output selection criteria). In nearly all shale -crime outputs, rapid social change and 'boomtowns' are mentioned. The concept of boomtowns crosses academic disciplines and is used by scholars in economics, sociology, agriculture, criminology, criminal justice and public policy. Historically, boomtowns are a label for communities undergoing rapid development as a result of hunting and mining (Ruddell, 2017). In total, 64% ($N = 16$ of 25) of the outputs in this investigation referenced boomtowns to justify testing the correlation between shale gas development and crime (i.e., Berger and Beckmann, 2010; Gourley and Madonia, 2017; Haggerty et al., 2014; A. James and Smith, 2017; Jones, 2016; Komarek, 2018, Lim, 2018; Luthra et al., 2007; C. O'Connor, 2017; Poirrier, 2016; Price et al., 2014, Putz et al., 2011; Raimi, 2012; Rhubart and Brasier, 2019; Ruddell et al. 2014; Stretesky et al., 2018).

Boomtowns are not consistently conceptualized or operationalized in the shale– crime literature. In the $N = 16$ studies that mention boomtowns, scholars focus on the pace and/or the level of resource extraction as the main independent variable. For instance, some studies focus on the volume of extracted shale gas as a measure of boomtowns while other studies focus on the number of 'fracking' or shale gas wells. In the past scholars maintain that boomtowns are characterized by population increases (England and Albrecht, 1984). Today, several studies consider population change as a mediating factor between shale gas development and crime. A few scholars such as Ruddell (2017) argue that boomtowns are complex and characterized by four different components: (1) rapid population growth (2) out-migration of long-term residents (3) an increase in short-term housing and (4) a disproportionate percentage of young men. Few shale–crime studies have operationalized boomtowns using all four indicators proposed by Ruddell..

When it comes to shale gas and crime, the 25 outputs selected for our review rely on four theoretical frameworks. These frameworks predict that shale gas development will increase crime and therefore do not compete theoretically. That is, hypotheses about direction of the relationship between shale gas and crime are similar. The most common theoretical perspective suggests that boomtowns indirectly cause crime by increasing community social disorganization. The origins of social disorganization theory can be found in the work of Shaw and McKay (1942) who studied juvenile delinquency in Chicago in the middle of the 20th century. They suggest that crime rates are a function of cultural transmission of delinquent values that guide norms about behavior within communities. Thus, crime rates are a function of the social characteristics of place. Freudenberg (1986) adopted this approach to study juvenile delinquency that resulted from oil and gas development. Freudenberg proposed that oil and gas development led to a reduction in density acquaintanceships, meaning that fewer residents in communities characterized by rapid increases in oil and gas development know each other. This reduction in density acquaintanceships changed the values in communities that Freudenberg studied and made them more crime prone. That is, fewer people recognize each other and know people's routines and can therefore engage in behaviours that guard against crimes against people and property. As a result, community norms that regulated behavior changed, making communities more susceptible to crime.

Sixty percent ($N = 15$ of 25) outputs selected for study in this analysis rely, at least partly, on social disorganization as a theoretical framework to hypothesize that shale gas development increases crime (i.e., Berger and Beckmann, 2010; Deller and Schreiber, 2012; Gourley and Madonia, 2017; Haggerty et al., 2014; A. James and Smith, 2017; Jones, 2016; Lim, 2018; Luthra et al., 2007; C. O'Connor, 2017; Poirrier, 2016; Putz et al., 2011; Raimi, 2012; Rhubart and Brasier, 2019; Ruddell et al., 2014; Stretesky et al., 2018). While most of these outputs focus on serious crimes such as murder, rape, assault, robbery, burglary, larceny and motor vehicle theft, the notion of social disorder type violations such as drunk driving, drunkenness, drug abuse, illegal gambling, liquor law violations, disorderly conduct and vagrancy were also mentioned (i.e., Andrews and Deza, 2016; Beleche and Cintina, 2018; Jacquet, 2015; Jones, 2016; Komarek, 2018; Raimi, 2012; Rhubart and Brasier, 2019; Ruddell et al., 2014). Findings regarding alcohol related crimes are not surprising given that recent research on shale gas booms is associated with an increase in heavy and binge drinking behaviors (Mayer and Hazboun, 2019).

The concept of masculinity is also used by some shale gas researchers because it extends the idea of social disorganization to violence against women and sexual assault. Masculine values like dominance, risk-taking and aggression give way to norms such as fighting, bullying and sexual aggression toward women (Messerschmidt, 1993). This situation is particularly relevant to shale gas workers who are mostly young males who, because of these masculine values, are more likely to be involved in crime (Ruddell, 2017; Ruddell et al., 2014). Carrington et al. (2011:39) is known for advancing the notion of masculinity in the resource extraction literature and points out that the 'rapid masculinization of the local population may be particularly problematic in resource extraction communities.' Carrington's ideas are similar to the notion of 'toxic masculinity' developed by Kupers (2005, p.717) to explain prison culture, but could easily be extended to the harmful culture in shale gas communities where 'extreme competition and greed [and a] a readiness to resort to violence" is normalised. Thus, it is easy to see how young men employed in extractive industries could reshape areas by emphasizing the wrong types of masculine values. As Carrington et al. (2011) suggests, young males employed in extraction may commute to work or live in work camps, hotels or short-term accommodation near extraction sites and are often isolated from their families and friends who may attenuate their toxic masculine tendencies and reduce crime. Thus, masculine-associated behaviors such as drinking, fighting and sexual assaults become well established within shale gas communities (Carrington et al., 2010). Given these observations concerning masculinity it should not be surprising that 24% ($N = 6$ of 25) of all shale outputs suggest that masculinity emerges in a community where shale gas development is occurring because there is an influx of young men into the community who engage in violence against women (i.e., Jayasundara et al., 2016; A. James and Smith, 2017; Jones, 2016; Komarek, 2018; C. O'Connor, 2017; Ruddell et al., 2014).

Other studies selected for systematic analysis hypothesize that shale gas development will lead to increases in crime because of the natural resource curse and/or the Dutch disease. In particular, 20% ($N = 5$ of 25) outputs reference the 'Dutch disease' and 20% ($N = 5$ of 20) reference the 'natural resource curse' (i.e., Bartik et al., 2019; Deller and Schreiber, 2012; Feyrer et al., 2017; Gourley and Madonia, 2017; Haggerty et al., 2014; A. James and Smith, 2017; Jones, 2016; Komarek, 2018; Street, 2018; Stretesky et al., 2018). The Dutch disease is a theoretical concept that emerged in the 1970s to explain economic downturns that arise from the rapid development of different types of natural resources (Corden and Neary, 1982). Corden (1984) notes that new extraction development can weaken manufacturing and agriculture industries and produce economically depressed communities as a result (Corden, 1984; Corden and Neary, 1982). The harm to communities occurs because extraction related development can increase labor costs in the region that then increases in the price of products in other local industries, which weakens industry as a whole because it is less competitive in the global marketplace. Thus, communities may suffer over time from an over-reliance on shale gas because other industries are pushed out of business. Importantly, when global oil and gas prices drop the impacts are felt in those local economies that derive most of their income from shale gas (Corden, 1984).

When the Dutch disease is generalized over the long-term, these competitive disadvantages to agriculture and manufacturing lead to a 'resource curse' because overall economic growth (typically measured as Gross Domestic Product [GDP]) in a community declines (Ross, 2003; Sachs and Warner, 2001). When it comes to crime, studies have suggested that economic downturns and reductions in GDP are associated with increases in crime rates through a variety of mechanisms, including absolute poverty, inequality and unemployment (Andresen, 2015; Bourguignon, 1999). Both the Dutch disease and natural resource curse literature point out that a weakening of formal institutions of social control such as the police that help maintain the social order often occurs because extractive companies do not pay sufficient taxes or re-invest their financial gains back into the local communities. Thus, local services such as police and courts could suffer from a dwindling local tax base at the very same time there is increasing pressure to undertake more enforcement. Studies of shale gas development suggests that a swelling of the population in rural areas stretches the capacity of local social services, especially, the police (Archbold et al., 2014; Ruddell, 2017). As a result, social services are cut when resources are most needed to prevent and control crime (Ross, 2003; Sachs and Warner, 2001). Such a condition therefore leads to increasing crime.

3. Methods

A systematic literature review is employed to synthesize existing quantitative evidence on the relationship between shale gas development and crime. Systematic reviews are popular in the social sciences and are useful for providing an overview of the existing state of knowledge for quantitative research (Butler et al., 2019; Petticrew and Roberts, 2008). This current study targets those quantitative outputs that assess the association between shale gas development and crime to determine if shale gas development increases crime rates. The remainder of this section outlines the inclusion and search strategies for shale–crime outputs.

3.1. Inclusion criteria

As noted, the focus of this research is on the quantitative relationship between shale gas development and crime. We therefore include outputs that (1) look at shale gas as an independent variable and crime as a dependent variable and (2) use cross sectional, time series or panel data to generate coefficients that summarize the correlation between shale gas and crime at the local or regional level. We focus on outputs published since 2005 as that date marks the beginning of the expansion in global shale gas production (Soeder and Borglum, 2019). We identified $N = 25$ outputs that meet this criterion in the literature. The search strategy and filter process to obtain these 25 outputs is described below and the screening/coding instrument is included in Appendix A.

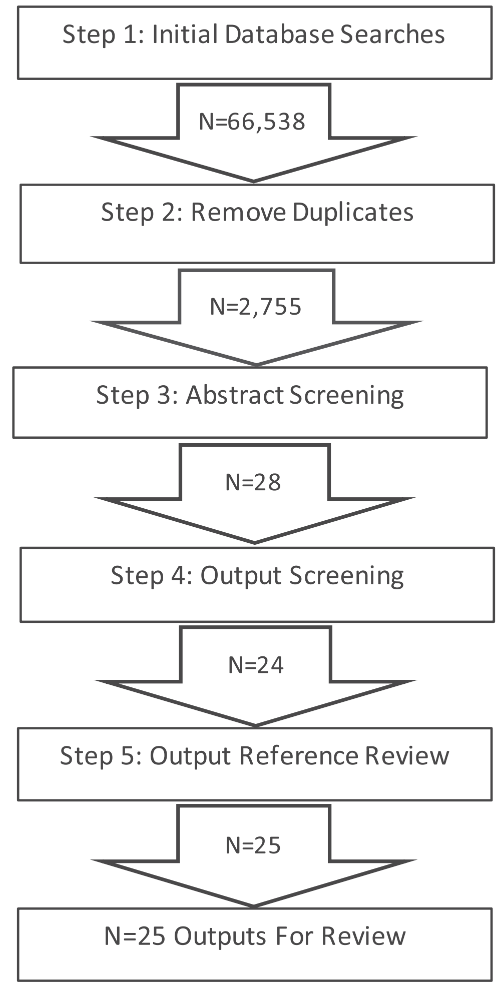

Fig. 1. Steps in the Output Selection Process.

3.2. Search strategy and filter process

We employ five steps to identify the outputs in this study. These steps are summarized in Fig. 1. In step 1, one researcher undertook a key word search using the 'anywhere in the article' function in *Google Scholar,* the 'topic' function in *Web of Science* and the 'title, abstract and keyword' function in *Scopus*. The Boolean operator "and" was used to narrow search results to statistical investigations of the shale gas-crime relationship. To caste as wide a net as possible we include all combinations of three sets of search terms. First set of search terms included (1) 'shale' (2) 'hydraulic fracturing' (3) 'fracking' and (4) 'gas'. The second set of search terms included (1) 'crime', (2) 'violence', (3) 'homicide', (4) murder (5) 'rape', (6) 'assault', (7) 'burglary', (8) 'larceny', (9) 'robbery', and (10) 'delinquency'. The third set of search terms included (1) 'statistics or statistical', (2) 'variable or variables', (3) 'method or methods' and (4) 'results.' One word from each set of search terms was selected for each search until all combinations were searched. Thus, for example, the first search returned 1840 outputs in *Google Scholar* using the search 'shale' and 'crime' and 'statistics'. Together, all searches returned $N = 66{,}538$ outputs published between 2005 and 2019. These results were saved. Next, in step 2, duplicate outputs (same author name(s), publication date and title) were removed from the list, leaving the researchers with 2,755 unique outputs.

In step 3, one researcher reviewed each of the $N = 2{,}755$ abstracts (or executive summaries) to determine if two inclusion criteria were met. That is, did the output (1) examine shale gas as an independent variable and crime as a dependent variable and (2) provide summaries of coefficients examining the correlation between shale gas and crime. This screening resulted in $N = 28$ outputs. In step 4, two researchers read through each output identified in step 3 to determine whether it continued to meet the search criteria. This resulted in four ($N = 4$) outputs being removed from the analysis (i.e., Bartik et al., 2016; Frantál, and Novakova, 2014; Leslie, 2017; Seydlitz et al., 1999), leaving a total of $N = 24$ remaining outputs. Two ($N = 2$) of these outputs were removed because they examined coal or coal power plants, one ($N = 1$) was a duplicate of output with a different publication date and one ($N = 1$) had an incorrectly listed date.

Once the researchers agreed that the $N = 24$ outputs met the inclusion criteria one researcher scanned the references in each selected output's reference list to determine if any additional outputs might have been missed in the database searchers (step 5). Those efforts turned up one ($N = 1$) additional output (i.e., Feyrer et al., 2017), bringing the total number of outputs to $N = 25$. These $N = 25$ outputs were then coded by two researchers. The two researchers then compared and discussed their codes to ensure reliability. Given the relatively simple nature of the data collected there were no major coding discrepancies.

3.3. Coding crime, shale gas and correlations

In order to make meaningful comparisons between shale gas development and crime, we coded the most frequent categories of crimes that appeared in the outputs selected for study. The three most frequently measured categories of crime were 'total crime,' 'violent crime' and 'property crime.' Crimes in these categories were typically measured using the official crime data such as the US Federal Bureau Investigation's Uniform Crime Reports (https://www.fbi.gov/services/cjis/ucr). In the case of total crime this generally represented crimes such as 'murder', 'robbery', 'rape', 'aggravated assault', 'larceny-theft', 'burglary', 'motor vehicle theft' and 'arson.' Violent crime was generally composed of 'murder', 'rape', 'robbery' and 'aggravated assault' while property crime was generally composed of 'larceny-theft', 'burglary', 'motor vehicle theft' and 'arson'. We also created two categories of crime labelled crimes of social disorganization and violence against women. Social disorganization crimes include broad classifications of 'drug offenses', 'driving under the influence of alcohol or drugs', 'disorderly conduct', 'simple assault', and 'drunkenness'. Many of these crimes come from the FBI's Part II index crimes and local law enforcement agencies. Finally, for the category of violence against women we focus on crimes typically carried out by men against women such as 'rape' (when measured alone), 'domestic violence', 'dating violence', 'stalking', 'sex offenses' and 'sex assaults.' While most studies obtained rape through the FBI, other crime estimates were usually obtained through local police and court records and data.

To code shale gas development, we largely focused on two categories to ensure that all studies that evaluated shale gas and crime were included in this review but could still be distinguished from one another for analytical purposes. First, we focused on those studies that included shale gas together with other forms of gas and oil. This mixed measure of shale gas development was found in those studies that examined shale gas theoretically, but used variables such as 'employment in the gas industry' or 'average income generated from oil and gas' or 'number of barrels of oil and gas produced' indicators of shale gas. In short, when it was not clear that shale gas was separated from other forms of oil and gas development, we coded it as 'shale and other oil and gas.' Second, we categorized studies as shale gas only studies when they examined only shale gas development. These studies examined variables like 'number of hydraulic fractured wells' or 'shale gas production.'

Unfortunately, there is considerable heterogeneity in the way crime and shale gas were operationalized. This diversity makes it difficult to draw upon the studies to estimate average effect sizes. As a result, we provide only a brief summary of effect sizes at the conclusion of the analyses and instead summarize the associations between all categories of crime and all categories of shale gas according to a few basic descriptions of those correlations found in each output. For each category of crime and shale gas we establish whether the output reports evidence of a positive and statistically significant association; a negative and statistically significant association; no association; or, mixed evidence. The mixed evidence category includes studies that reported both positive and significant findings alongside findings of no association. There were no studies that reported negative and significant findings that fell into the mixed category. We now turn to the results of that analysis. Statistical significance levels are judged at $p < 0.05$.

4. Results

We begin our analysis with some basic descriptive statistics of the shale gas-crime outputs selected for study. Fig. 2 demonstrates the temporal variation in shale gas-crime outputs. That figure shows the growing academic interest in the relationship between shale gas development and crime rates. Fig. 2 shows a clear upward trend in the number of published shale gas–crime outputs between 2005 and 2019. The first output included in this investigation was published in 2007 (i.e., Luthra et al., 2007). In contrast, six outputs ($N = 6$) examining the statistical correlation between shale gas development and crime were published in 2018. This trend correlates with the rise in shale gas production starting in the mid-2000s, mainly driven by the studies in the United States.

Next, we turn to some basic descriptive characteristics of outputs in Table 1. First, Table 1 demonstrates the spatial variation in shale gas–crime setting, by country. As Table 1 demonstrates, 95% ($N = 24$ of 25) of the outputs included in this analysis study the association between shale gas development and crime in the United States. It is striking that there is only one quantitative output that examines shale gas development and crime outside of the US (i.e., Stretesky et al., 2018). This spatial clustering of studies is likely to represent the fact that most global production of shale gas (and hence its development) is occurring within the US. A more in-depth analysis (not shown) reveals that most of the US outputs examine rural counties over shale plays such as the Bakken or Marcellus (i.e., A. James and Smith, 2017; Jones, 2016; Kowalski and Zajac, 2012; Lim, 2018; C. O'Connor, 2017; Rhubart and Brasier, 2019; Ruddell et al., 2014; Street, 2018). Only one output examined the shale–crime relationship across the entire US (e.g.,

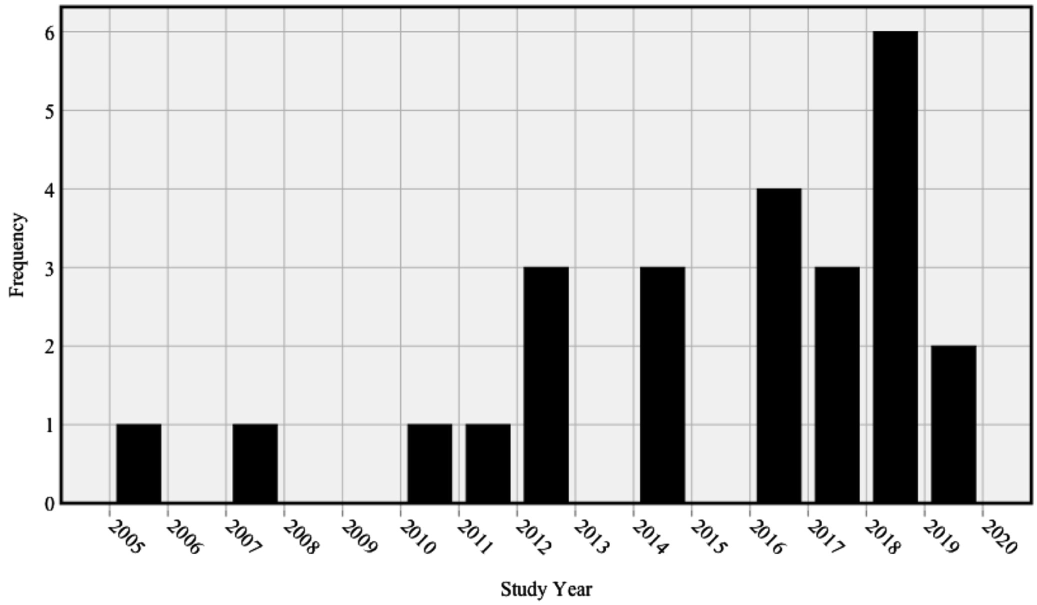

Fig. 2. Shale Gas – Crime Outputs by Year, 2005 – 2019 (N = 25).

Bartik et al., 2019).

Table 1 also suggests that 52% (N = 13 of 25) of all outputs appear in peer-reviewed journals, indicating that the methodologies employed to achieve the results were scrutinized by peer reviewers. Other shale-crime outputs take the form of dissertations and thesis projects (N = 3), technical reports (N = 5) and unpublished papers (N = 4). Table 1 also shows that N = 14 outputs rely on pooled time series datasets that are analyzed using fixed and/or random effects regression (Clark and Linzer, 2015). As a result, the most common unit of analysis is expressed in unit-time such as 'county – years' (N = 12 of 25), 'county – months' (N = 1 of 25), 'local authority – years' (N = 1 of 25), 'parish – years' (N = 1 of 25) and 'household – years' (N = 1 of 25). Only 28 percent (n = 7 of 25) of the outputs rely on a cross sectional analysis of shale gas and crime and one (N = 1) output focuses on time series data at one location. Not shown in Table 1 is the observation that higher quality research designs based on pooled or panel data recommended by scholars like Ruddell (2017) appear to be increasing over time. Indeed, 91% (N = 10 of 11) of the outputs published since 2017 rely on statistical analysis that simultaneously compare multiple units over time.

The variety of independent variables used to capture oil and gas development are also displayed in Table 1. As previously noted, when coding studies we discovered that some outputs analyze all forms of oil and gas development, including shale gas, in one independent variable. These studies either claimed to primarily study shale gas development or situated the research question in shale gas. Stretesky et al. (2018), for instance, did not differentiate shale gas development (there was only one non-commercial site located in the UK during the period of study) from other conventional forms of oil and gas development. Studies that included shale development together with other natural gas (and sometimes oil) accounted for 52% (N = 13 of 25) of the outputs analyzed. In addition, we discovered that the way that conventional and/or unconventional oil and gas development are operationalized in the 25 outputs varies considerably. That is, independent variables were operationalized using the number or density of shale gas wells (N = 8 of 25), the amount of shale gas produced (N = 16 of 25) or employment in the shale gas industry (N = 1 of 25). When production was examined and linked to resource booms or boomtowns, various cut-offs were used in these outputs which reduced the consistency of comparisons between studies.

Table 1 also confirms that the dependent variable (crime) in the selected outputs is often operationalized using official crime statistics. For instance, 32% (N = 8 of 25) outputs examined the variation in all US 'index' crimes by combining serious crime together (i.e., 'homicide', 'aggravated assault', 'robbery', 'rape', 'larceny theft', 'burglary' and 'auto theft' [and sometimes arson]). Table 1 also shows that 64% (N = 16 of 25) of all outputs test violent crime and 60% (N = 15 of 25) test property crime. Finally, 24% (N = 6 of 25) examine disorder offenses like 'drunk driving', 'fighting' and 'calls for service', while 40% (N = 7 out of 25) outputs examine 'domestic violence', 'rape', 'sexual assault' and other crimes where women are disproportionately victims. Many outputs (N = 18 of 25) included control variables that hold constant other factors that may influence the relationship between shale gas and crime. The most common control variables were 'population', 'sex', 'income', 'employment in industry' and 'age'. Other less common control variables included, 'race', 'ethnicity', 'weather conditions', 'political party', 'level of police presence', 'percent divorced', 'unemployment', 'income inequality', 'average levels of education', and 'population change'. Finally, Table 1 shows that 72% (N = 18 of 25) of all outputs employed a control group (units that did not have any wells or production).

The 25 outputs examined in this analysis are associated with several different academic disciplines. Table 2 displays the first author's academic department for each of the 25 outputs. The most common department is 'economics' (N = 9 of 25) followed by 'sociology' (N = 5 of 25) and 'criminology' and 'criminal justice' (N = 3 of 25). This finding

Table 1
Output Characteristics (*N* = 25).

Characteristic		*f*	Percentage %
Country			
	United States	24	96
	United Kingdom	1	4
Type of Analysis			
	Panel / Pooled	14	56
	Cross Sectional	7	28
	Time Series	3	12
	Cross Sectional & Pre-Post	1	4
Unit of Analysis			
	County	4	16
	County-Month	1	4
	County-Year	12	48
	Household-Year	1	4
	Local Authority-Year	1	4
	Parish-Year	1	4
	Shale Region	1	4
	Year	4	16
Publication Type			
	Peer Reviewed Article	13	52
	Dissertation/Thesis	3	12
	Report or Technical Paper	5	20
	Unpublished Paper	4	16
Resource			
	Oil & Gas (Conventional & Shale)	13	52
	Shale Only	12	48
*Independent Variable**			
	Oil/Gas Employment	1	4
	Production (Level/Presence/ Value)	16	64
	Wells (Number/Density)	8	32
Dependent Variable(s)			
	Total Crime	8	32
	Violent Crime	16	64
	Property Crime	15	60
	Disorder Offenses**	6	24
	Violence Against Women***	10	40
Decade Data Represent (More than one possible)	1970–1979	1	4
	1980–1989	3	12
	1990–1999	8	24
	2000–2009	24	96
	2010–2018	19	76
Control Variables			
	Yes	17	68
	No	8	32
Control Groups			
	Yes	18	72
	No	7	28
Study 'N'	Mean = 4593; Min. = 5; Max. = 31,169		

* Represents broad classifications (e.g., 'average income from production', 'counties in oil producing region', 'barrels of oil', 'household in fracking county', 'oil producing county', 'value of reserves', 'well density', 'number of wells').

** Represents broad classifications (e.g., 'rape', 'domestic abuse', 'dating violence', 'stalking', 'sexual assault.').

*** Represents broad classifications (e.g., 'drug offenses', 'disorderly conduct', 'simple assault', 'drunkenness').

Table 2
Academic Discipline of Corresponding Author.

Discipline	*f*	Percentage%
Agriculture	1	4
Criminal Justice	1	4
Criminology	2	8
Earth Sciences	1	4
Economics	9	36
Environmental Management	1	4
Government – Food & Drug Administration	1	4
Public Policy	1	4
Social Sciences	1	4
Sociology	5	20
Sociology Anthropology	1	4
Wildlife Conservation	1	4

N = 25.

Table 3
Summary of Association Direction (Statistical Significance) for Shale Gas (Independent Variable) and Crime (Dependent Variable) Outputs.

	All Outputs (N = 25)			
	+ ($p<0.05$)	– ($p<0.05$)	Not Sig.	Mixed
Dependent Variable				
Total Crime (N = 8)	50.0%	12.5%	37.5%	0.0%
Violent Crime (N = 17)	52.9%	0.0%	5.8%	41.2%
Property Crime (N = 15)	46.7%	0.0%	26.7%	33.3%
Social Disorganization Crimes (N = 6)	66.7%	0.0%	33.3%	0.0%
Violence Against Women (N = 10)	70.0%	0.0%	10.0%	20.0%
	Mixed Shale/Oil/Gas Outputs (N = 13)			
	+ ($p<0.05$)	– ($p<0.05$)	Not Sig.	Mixed
Dependent Variable				
Total Crime (N = 4)	75.0%	0.0%	25.0%	0.0%
Violent Crime (N = 9)	55.6%	0.0%	0.0%	44.4%
Property Crime (N = 7)	42.9%	0.0%	28.6%	28.6%
Social Disorganization Crime (N = 4)	75.0%	0.0%	25.0%	0.0%
Violence Against Women (N = 7)	71.4%	0.0%	14.3%	14.3%
	Shale Only Outputs (N = 12)			
	+ ($p<0.05$)	– ($p<0.05$)	Not Sig.	Mixed
Dependent Variable				
Total Crime (N = 4)	25.0%	25.0%	50.0%	0.0%
Violent Crime (N = 8)	50.0%	0.0%	12.5%	37.5%
Property Crime (N = 8)	50.0%	0.0%	25.0%	25.0%
Social Disorganization Crime (N = 2)	50.0%	0.0%	50.0%	0.0%
Violence Against Women (N = 3)	66.7%	0.0%	0.0%	33.3%

+ = Shale gas development increases crime at $p<0.05$.
\- = Shale gas development decreases crime at $p<0.05$.
Not Sig. = Shae gas is not related to crime.
Mixed = Shale gas development increases or is not related to crime.

is interesting because the study of crime and crime rates is typically attributed to the discipline of criminology and criminal justice. Nevertheless, natural resource related crime appears to be of interest to multiple disciplines (Lynch and Stretesky, 2016).

Finally, Table 3 presents a summary of the shale-gas crime relationship for the 25 quantitative outputs included in this study. That table displays three sets of associations between shale gas and all measures of crime (total crime, violent crime, property crime, social disorganization crime and violence against women). First, Table 3 summarizes the association between all indicators of shale gas and all indicators of crime for all the outputs ("All Outputs" [*N* = 25]). Second, the Table 3 summarizes the associations for those outputs that do not differentiate between shale gas and other types of oil and gas ("Mixed Outputs" [*N* = 13]). Third, Table 3 summarizes the association for those outputs that focus on shale gas only ('Shale Only Outputs' [*N* = 12]). The results in Table 3 also summarize relationships between shale gas and crime in four ways: '+ ($p<0.05$)' represents that the relationship between shale gas and crime category is positive and statistically significant (at α = 0.05) suggesting that as shale gas development increases so does the crime rate; '– ($p<0.05$)' denotes that the relationship between shale gas is negative and statistically significant; 'Not Sig.' indicates that the relationship between shale gas and crime does not exist; and 'Mixed' means that the relationship sometime exists (and is + [$p<0.05$]) sometimes and does not exist (and is Not Sig.). There were no relationships in the mixed category that were identified as negative and statistically significant.

As Table 3 indicates, $N = 8$ (of 25) outputs test the relationship between all the shale gas indicators and total crime. Of these eight outputs, 50% ($N = 4$ of 8) suggest that as shale gas development increases, so does the crime rate (denoted by the '+ [$p<0.05$]'). One output ($N = 1$) reports a negative relationship between shale gas development and total crime rate (denoted by a '– [$p<0.05$]') and three ($N = 3$) outputs suggest that there is no statistically significant relationship between shale gas and crime ('Not Sig.'). No studies suggest there is mixed evidence for the relationship between shale gas development and crime.

Violent crime is one of the most studied categories of crimes in studies of the shale-crime relationship. A total of $N = 17$ studies look at this type of crime. Overall 52.9% ($N = 9$ of 17) of the studies in this crime category report there is a statistically significant relationship between shale gas development and violent crime rates. Only $N = 1$ (of 17) studiy finds no relationship and the remainder of the studies suggest that the relationship between shale gas development and crime is mixed (41.2% or $N = 7$ of 17). None of the 17 studies suggest that there is a negative relationship between shale gas development and violent crime. We find similar outcomes for the property crime. That is, 46.7% ($N = 7$ of 15) of the outputs reported that shale gas development leads to an increase in crime rates; 33.3% ($N = 5$ of 15) suggest the results are mixed; 26.7% ($N = 3$ of 15) suggest that there is no relationship between shale gas development and crime; and no studies find a negative relationship between shale gas development and crime. In the case of social disorganization crimes and violence against women we again find a similar pattern of relationships. That is, for the $N = 6$ studies that examine social disorganization crimes, we find that outputs suggested that shale gas development leads to increases disorganization crimes in 66.7% ($N = 4$ of 6) of that outputs while only $N = 2$ (of 6) studies suggest that there is no relationship between shale gas development and social disorder. For the $N = 7$ studies that test the association between shale gas development and crime against women we find that 71.4% ($N = 5$ of 7) demonstrate a positive relationship; 14.3% ($N = 1$ of 7) suggest mixed results (sometimes positive association and sometimes no relationship) and 14.3% ($N = 1$ of 7) suggest there is no relationship.

When we break down the findings for crime for the different categories of shale gas the findings remain largely the same. In particular, for the $N = 13$ studies that lump shale gas and other types of oil and gas production together we see that for each category of crime the modal relationship for the studies is '+ ($p<0.05$)' (e.g. 75% for total crime; 55.6% violent crime; 42.9 percent for property crime; 75% for social disorganization crimes and 71.4% for violence against women). Moreover, none of the studies find a negative and statistically significant relationship between shale gas development and any measure of crime. The same pattern of findings is true for those studies that only study shale gas and do not lump shale gas in with other forms of oil and gas. That is, the modal category is for violent crime, property crime, social disorganization crimes and violence against women is a positive and statistically significant. Only in the case of total crime in the shale only outputs ($N = 4$) is the modal category not positive and statistically significant. In that case, $N = 2$ (of 4) of the studies suggest there is no relationship between shale gas development and crime while one study suggests there is a positive relationship and one study suggests there is a negative relationship.

Taken together, the findings in Table 3 are clear. For those studies that test the relationship between shale gas and crime the most likely outcome for any type of crime and any measure of shale gas development (except for Shale Only - Total Crime outputs) is positive and statistically significant. In all cases the least likely outcome is that the association is negative and statistically significant. As a result, the way that the shale gas is operationalized does not appear to impact to any great extent the pattern of results in Table 3.

As previously noted, the current studies are diverse and it is nearly impossible to estimate average effect sizes, thus limiting the extent to which data can be combined. However, we present some basic comparisons of effect size where possible. Those studies that look at pre- and post- increases in shale gas production estimates that shale gas development leads to an increase in total crime on the order of 28% to 46% where it occurs. For those outputs that examine violent crime rates, shale gas development is likely to increase crime between 17.7% and 50.0%. In the case of crimes relating to social disorganization the increases range from 19% to 46%. Finally, for property crimes the range is between 10% and 11% across the pre- and shale gas periods. When wells are considered instead of volume of production (or areas of exposure) we find similar impacts. For instance, each additional well is associated with a 1.2% to 1.5% increase in violent crime and a 0.4 to 0.9% increase in property crime. Other comparisons of the consistency in coefficients is not yet possible.

5. Discussion and conclusion

The current study describes the state of knowledge surrounding the potential relationship between shale gas development and crime, including the potential for shale gas development to increase, decrease or have no effect on crime. To do this we located and summarized findings from 25 quantitative outputs published between 2005 and 2019. We find that these studies are US-based. In the US hydraulic fracturing has become popular and advances in drilling technology have made it possible and profitable to develop shale deposits that were previously inaccessible (Gandossi, 2013). As a result, US shale gas development has dramatically increased (US Energy Information Administration, 2015). This increase in development has led to a proliferation of studies that examine the impact of shale gas development on crime. Theoretically, these emerging studies focus on boomtowns as an explanation for the potential correlation between shale gas and crime. Perspectives such as social disorganization, masculinity, the Dutch disease and the natural resource curse have all been employed to explain why shale gas development may increase crime. It is interesting to note that few of the outputs examined in this review seriously question the underlying assumptions in these theoretical perspectives and whether they can be applied to shale gas. Whether these perspectives can be easily generalized among industries has been questioned by some extractive industry scholars (e.g., Rolston, 2013; Mayer, 2017; Mayer and Hazboun, 2019). For instance, Rolston (2013) suggests that the boomtown-crime literature has exaggerated the impact of social disorganization on crime. That is, while social disorganization may lead to an increase in some types of crime, important characteristics that enhance communities are often neglected in the literature. Rolston suggests the overemphasis on social disorganization may result in bias findings. Thus, future researchers should consider whether and how different theoretical perspectives should be applied to shale gas development and crime rates.

We discover that there is considerable consistency among the shale gas development - crime outputs we reviewed. The modal category that summarizes the relationship between shale gas and crime is “positive and statistically significant” for all types of crimes no matter how shale gas exposure is operationalized. There is only one exception to this finding and that is for the those studies that examine the association between shale gas only and total crime. Thus, that the weight of the evidence from 25 empirical studies indicate that it is likely that shale gas development leads to an increase in crime, no matter what type of crime. With respect to the positive findings, the categories of crime with the highest level of agreement among the empirical studies are for social disorganization crimes (66.7% are positive and significant) and violence against women (70% are positive and significant). This finding for social disorganization confirms what researchers studying oil and gas extraction anticipate. That is, ‘if investigators find a clear and consistent boom-crime relationship it is likely that it will be established [for] simple assaults, driving while intoxicated, disorderly conduct, and drug possession’ (Ruddell et al., 2014:16). We also see this pattern in the studies that we review. In addition, we suggest that the findings for violence against women should also be considered convincing. That is, existing studies suggest that shale gas development is likely to lead to an increase in crimes of violence against women.

Importantly, while most studies suggest that shale gas development will increase crime, only one study suggests that shale gas development will decrease crime (see Street, 2018, p.12 who concludes that there is ‘an initial drop of 0.44 percentage points in overall crime by residents in fracking counties relative to residents in non-fracking counties.’) Thus, this review can state with relative certainty that any suggestion that shale gas development will decrease community crime rates is suspect. The importance of this finding should not be diminished. That is, companies and industry often promote the economic prosperity and security that comes along with shale gas production. However, when it comes to total crime, violent crime, property crime, social disorganization and violence against women, the combined and existing evidence suggests that local levels of security are not likely improved. Thus, what might be good for national security may have adverse consequences for local communities such that the burdens of energy development are not shared equally across a nation. When it comes to the strength of the association between shale gas development and crime the literature is less definitive since existing outputs employ too diverse a set of variables and methodological designs. However, we see a pattern in the coefficients that suggests that the effect of shale gas development may be stronger for violent crime than property crime. These findings also seem to be consistent with a focus on violence in the economic theories such as those that look at the Dutch disease and the natural resource curse (Bannon and Collier, 2003).

Future research should consider the impact of efforts to ‘rapidly accelerate the development of unconventional gas resources worldwide’ on crime (Dong et al., 2012:222). Aloulou and Zaretskaya (2016) point out that since 2010 Canada, China and Argentina produce significant amounts of commercial shale gas and the industry is rapidly emerging in Mexico and Algeria. And, by 2040 shale gas is projected make up 30% of worldwide natural gas production (Aloulou and Zaretskaya, 2016:par 1). Given this expansion it seems that social scientists are well-placed to continue to study the shale gas – crime correlation across the globe in various comparative settings. We suggest that it is important for this research to move beyond the US context to examine communities in other nations. In particular, as O'Connor's (C. 2017:488) suggests, ‘different [areas] might experience increases and decreases in crime and disorder differently…[*and*]…depends on a combination of complex factors including resources, size, history, culture, work camp locations, worker migration, and previous experiences with booms and busts.’

As additional research is carried out in different settings, we also suggest that researchers consider how they operationalize variables such as shale gas and crime. First, the way shale gas is operationalized may impact results. Future studies should make it clear what type of development is being studied and separate out quantitative findings for different types of extraction development when possible. While findings in our study do not seem to suggest that there are major differences between categories of oil and gas when separated out, it is hard to know because many outputs mix up different types of oil and gas extraction—and therefore types of development. We suggest such an approach of separating out different types of development would not cost much in terms of data collection and may prove useful in making future comparisons. Second, we propose that development might also be measured using volume and number of wells. No studies that we located combined these indicators in a measure of well intensity. Measuring shale gas development in two different ways (with various cut-offs employed) is possible and could allow for easier comparisons in future reviews. In short, the operationalization of shale gas development is important. We are not the first researchers to make this point (e.g., see Ruddell, 2017).

Third, with respect to crime we suggest that researchers also break down crime by categories so that studies include an overall measure as well as a measure of violent and property crime instead of choosing to examine only one category of crime. Again, such a decision would increase the utility of shale gas–crime studies as it allows for additional comparisons that can build evidence in this area of research more quickly.

In terms of policy, governments and planners should ask how industry can ensure that they minimize risks associated with any likely increases in crime. These shale gas-crime considerations should be in addition to environmental impacts. In particular, industry should be required to submit specific plans to tackle changes in the local culture that might give way to crime, disorder and violence against women during the permitting process. Our review suggests crime is a legitimate concerns that should be addressed when any oil and gas permitting decisions for are made. Thus, communities should have a right to ask for crime mitigation plans and that resources be directed toward crime prevention efforts.

In the end, while there are a large and growing number of studies examine the local impact of shale gas development on crime, there are relatively few reviews that summarize those studies. This situation is not unusual and, as we suggest through our review, there is utility in bringing a systematic methodology to bear on a relatively neglected area of study. To our knowledge the present investigation represents one of the few studies to undertake such a review and we hope that it encourages future reviews and research on all forms of extraction related development on crime.

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Appendix A

CODING SHEET

Two Screening Questions

Q1. Shale Development is independent variable and any measure of crime is dependent variable.

Yes No

Q2. Analyses generates coefficients that summarise the correlation between shale gas and crime.

Yes No

Coder / Output

Q3. Coder: ______________________________

Q4. Study Number: ______________________________

Q5. Output Citation:

Author / Output Information

Q6. Study Location (Country) ______________________________

Q7. Timeframe Data Represent ______________________________

Q8. Publication Type (Peer / Dissertation / Thesis / Technical): ______________________________

Q9. Academic Department (or PhD non-academic) First Author ______________________________

Variables / Unit of Analysis / Sample Size / Statistical Method

Q10. Independent Variable Resource: _______Shale Gas Only _______Shale Gas & Other Oil and Gas

Q11. Independent Units _____Wells (Density or Number) _____Production (Level or Area) ____Other (List)

Q12. Dependent (Crime) Variable (List All)

a

b

c

d

e

Add______________________________

Q13. Control Variable Used? Yes No

Q14. Control Cases Used? Yes No

Q14. Unit of Analysis (List) ______________________________

Q16. Sample Size (Range): ______________________________

Q17. Type of Analysis (list) Panel/Cross/Time/Mix ______________________________

Relationship Between Variables (Q18)

a.List ______	+, Sig	-, Sig	No Sig	Mix (-)	Mix (+)	Best M. Coef. =
b.List ______	+, Sig	-, Sig	No Sig	Mix (-)	Mix (+)	Best M. Coef. =
c.List______	+, Sig	-, Sig	No Sig	Mix (-)	Mix (+)	Best M. Coef. =
d.List______	+, Sig	-, Sig	No Sig	Mix (-)	Mix (+)	Best M. Coef. =
e.List______	+, Sig	-, Sig	No Sig	Mix (-)	Mix (+)	Best M. Coef. =
Add						

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