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Patterning of Sexual Violence against Women across US Cities and Counties

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Abstract: Sexual violence against women is a global public health concern; yet, determining its patterning is still largely understudied. An excess of males has emerged as a central concern given that men are the primary perpetrators of violent behavior, particularly against women. However, it is increasingly unclear as to whether an excess or, rather, a shortage of men drives purported negative social outcomes. To address these conflicting expectations, we target data from the U.S. Census and the National Incident-Based Reporting System to explore the patterning of sexual violence against women across cities and counties in the United States. Through the use of generalized linear mixed models, we assess the role of adult sex ratio imbalance, along with measures of gender inequality, on sexual violence. Our results indicate mixed support for competing predictions. Violence does not simply increase by way of male surplus or shortage, but instead with increasing skew in the sex ratio. That is, balanced sex ratios exhibit the lowest rates of violence. However, rates of sexual violence against women increase more quickly with increasing male scarcity and are lowest at low levels of male excess (51%). Thus, our findings are particularly challenging to interpret from a 'more males = more violence' framework because violence increases more quickly with female excess and is rarest with a slight male bias in the population. We argue that these results highlight a need to target the specific types of violent behaviors expected to be motivated by partner availability, rather than overly simplistic predictions of male surfeit or deficit leading to an excess of violence.

Keywords: sexual violence; adult sex ratio; mating market; violence against women

1. Introduction

Violence against women is a persistent, cross-cultural feature of societies and has long been recognized as a public health concern (Avakame 1999; Titterington 2006; Amaral and Bhalotra 2017). Current estimates indicate that one in three women experience sexual violence, yet these cases are among the most underreported crimes, suggesting that official statistics are conservative estimates (Smith et al. 2017). Moreover, despite decades of research on violence against women, there is still considerable uncertainty about its patterning (García-Moreno et al. 2013). While there are many moving parts to the study of violence against women, increasingly recognized is the need to focus on the importance of 'place' on behavioral motivations (Schacht et al. 2016).

Variation in place-based patterning can be a result of various drivers of social behavior due to, for example, spatial variation in settlement and migration (Kramer et al. 2017). These factors restructure one key aspect of a population's demographic profile: the adult sex ratio (the proportion of men to women in a population; ASR). Of particular concern is that a numerical surplus of men relative to women will result in increased levels of violence (Amaral and Bhalotra 2017). Indeed, men are much more likely than women to be both the victims and perpetrators of violence across societies (Messner and Sampson 1991; Schacht et al. 2014).

The biological theory of crime suggests that violent behavior is linked to high levels of testosterone, which is a hormone associated with male competition over female mates,

elevated risk-taking, and aggressive behavior (Hudson and Den Boer 2004). Within the animal literature, researchers find that increased levels of testosterone are associated with impulsive and antagonistic behavior among males, specifically related to sexual access to females (Higley et al. 1996; Eberhart et al. 1980). Thus, because human males have higher testosterone levels compared to women, men are expected to be more prone to committing violence, particularly in a mating context. And, specifically, because gender is one of the best individual-level correlates of violence, with men being more likely to be both victims and perpetrators than women (Messner and Sampson 1991), populations with an excess of males, particularly unmarried males, are expected to be more violent (Brooks 2012).

While there is a clear, and seemingly intuitive, anticipation of more criminal and violent outcomes in populations with 'too many men' (Hudson and Den Boer 2002), male-biased populations have been found to be inconsistently associated with elevated levels of violence (reviewed in Schacht et al. 2014; Schacht and Uggla 2022). For example, rates of homicide, sexual assault, and other violent crime have been shown to be both positively and negatively associated with ASR across studies (Obrien 1991; Barber 2000; Edlund et al. 2013; Trent and South 2012; Schacht et al. 2016). Some of this variation is driven by study design (e.g., the use of nation-level data and variable sex ratio measures; see Schacht and Uggla 2022 for discussion); however, given a clear male bias in the production of violent behavior, why is the ASR such an ambiguous predictor?

One interpretation of the mixed state of the literature is that it is inappropriate to think of violence in the aggregate (e.g., more men = more violence) and, instead, it is necessary to reframe our expectations to target the individual behaviors expected to be motivated by ASR imbalance. Specifically, which types of violent behavior are predicted to be responsive to partner availability? One research framework, mating market theory, relates relationship behavior to the availability of opposite sex partners in a society (Becker 1974; Guttentag and Secord 1983). This theory avoids simple numerical, sex-based arguments and instead expects facultative shifts in behavioral strategies in response to partner availability. The number of males and females in a population can be thought of as a mating market, which operates through supply and demand economics. The ASR is key to determining who has dyadic power; that is, which sex can be more demanding in a mating market. For populations in which the ASR is imbalanced, the rarer sex has more bargaining power and can leverage their scarcity to achieve their preferred relationship strategy, while the more common sex must cater to the preferences of the rare sex.

Consequently, it is expected that when women are relatively rare, men will focus their reproductive efforts on long term relationships through attempts to attract and maintain a single partner. In line with these predictions, a growing body of literature finds that, indeed, men are more likely to be married, part of a family, and sexually committed to a single partner in male-biased populations (Angrist 2002; Jones and Ferguson 2006; Schacht and Kramer 2016). However, when women are in excess, male preferences are expected to change in response as they become more likely to forgo a single long-term relationship in order to pursue multiple sexual partners (Schacht and Borgerhoff Mulder 2015). Again, following these predictions, the prevalence of monogamy decreases (Schacht and Kramer 2016), sexual concurrency increases (Adimora et al. 2013), and relationships are less stable (Uggla and Andersson 2018) in female-biased populations. Together, what is clear from this body of work is that, somewhat counterintuitively, a larger proportion of men remain unmarried in female-biased rather than male-biased populations and pursue a short-term mating orientation.

Ultimately, a mating market approach highlights the need to rethink simple 'more males = more violence' arguments, and to instead focus on the specific behaviors affected by supply and demand market dynamics. Moreover, it is clear that concern for elevated rates of violence center not just on 'maleness' per se, but on the demographic conditions that promote growing pools of unmarried (bachelor) males. Accordingly, here, we test predictions developed from a growing body of ASR research using crime and demographic data from the US (details in Methods). We specifically target sexual violence against women

(e.g., rape and sexual assault) and predict that these types of crime and violence will be more common where men are relatively rare, rather than abundant (as conventionally expected).

2. Materials and Methods

2.1. Data

To test these competing research frameworks, two sources of data are used: the National Incident-Based Reporting System (NIBRS; National Archive of Criminal Justice Data 2021) and the American Community Survey (ACS; US Census Bureau 2016). We downloaded the entire 2016 NIBRS extract file via the Inter-Consortium for Political and Social Research, which represents the most recent year of available data, and merged it with the 2016 ACS by matching cities and counties. NIBRS is the leading records management system for crimes reported to law enforcement; for each incident, a variety of data are collected including the specific offense(s) as well as the age and sex of victims and offenders and other incident information (e.g., presence of a weapon). ACS provides demographic data (e.g., age, sex) as well as community-level social disorganization data (e.g., poverty, employment, and education).

Data are aggregated at the city and county level as this is the smallest geographical unit for which NIBRS data are made available. Furthermore, it allows for the ability to assess the effect of the sex ratio across a range of important social contexts. Cities and counties with a total population size less than 1500 people were eliminated from the study. This decision is based on the understanding that rare events in small populations can be disproportionately over or underrepresented in the rates of cross-sectional data. In addition, the ASR ranges were truncated from 0.4 to 0.6, meaning that the sex ratios range from 40% male to 60% male. This range was used to appropriately bookend the typical standard distribution of sexes in a population, and accounts for 98% of the sample. Furthermore, 26 of the cities or counties had discrepancies in the total population size due to the use of multiple U.S Census datasets with different reporting systems. In order to identify cities and counties with a large discrepancy, the differing total populations were divided by each other. Any city or county that had comparison ratio discrepancies smaller than 0.5 or larger than 1.5 were eliminated from the study due to the inconsistency in population size. The final dataset included 3165 cities and counties from all 36 states that participate in NIBRS.

2.2. Dependent Variable

The analysis uses a single outcome measure: the rate of male-on-female forcible sex offenses per 100,000. This composite variable includes the following four offenses in NIBRS: rape, sodomy, sexual assault with an object, and forcible fondling (but excludes the two non-forcible sex offenses, statutory rape and incest).

2.3. Independent Variables

Age, sex ratio, measurements of gender inequality, and location were the main predictors used to account for community variation. The measurement used for the adult sex ratio is defined as the proportion of adult males in a population compared to the total adult population. Two adult age groups were considered for each of the predictors based on the available data. The first age group of the sex ratio includes men and women 15 to 44 years old. This age group was selected to target the individuals most actively involved in the mating pool in each city or county. The second age group extends the range to 64.

We also include three measures of gender inequality, which all have been well-established as predictors of violence against women, as control variables. These are female rates of education, employment, and poverty. Education was based on the attainment of at least an associate degree or higher. This measurement is defined as the proportion of women who obtained at least one degree compared to the number of adult females in a population. Employment was measured similarly: the proportion of women employed in a population compared to the adult female population. Finally, poverty is measured as the proportion of women whose income is below the poverty line compared to the adult female

population. To account for the overrepresentation of Southern agencies in NIBRS, as well as the southern culture of violence theory which argues that crime rates are higher in the south (Lee et al. 2007), a dummy variable is included (1 = Southern agency; 0 = non-Southern agency). The population of each city and county is also accounted for in the regression models as an offset.

2.4. Analytic Strategy

Due to the clustered nature of the data (i.e., cities and counties within states), independence cannot be assumed due to the potential for biased standard errors (Snijders and Bosker 2012). To account for this, we apply a multilevel modeling approach to appropriately estimate our models. To formally assess clustering in the dataset, we calculate the intraclass correlation coefficient (ICC). For both models, the ICC exceeds 0.30, which is substantial, as values above 0.10 indicate multilevel modeling is necessary (Snijders and Bosker 2012). Moreover, because we find the distribution of the dependent variable to be highly skewed, OLS regression is not appropriate. While the favored alternative is usually Poisson regression, because of overdispersion, which occurs when the variance exceeds the mean, applying this method could result in biased standard errors and erroneous tests of significance. Accordingly, given the characteristics of our dataset, this necessitates the use of negative binomial models (Long 1997). This was confirmed through a likelihood test that indicated that the negative binomial model improves goodness of fit (Osgood 2000). As such, multilevel negative binomial models were estimated using the log of the population as the offset, which accounts for the population at risk (Long 1997; Osgood 2000). Data preparation was performed in R 4.1.1 (R Core Team 2020); the packages "lme4" 1.1.27 (Bates et al. 2015) and "ggeffects" 1.1.1 (Lüdecke 2018) were used for statistical modeling.

3. Results

Our analysis began with descriptive statistics of the independent and dependent variables, an examination of bivariate relationships, and then multivariate modeling. Because the multivariate models were identical in terms of significance and direction for all of the independent variables for both age groups, only the results for the ages 15–44 are presented. Overall, the mean incident rate for male-on-female sex offenses was 70.44 (SD = 66.45). On average, communities had slightly more men than women (52%), slightly less than half of the women were employed (48%), the majority of women had obtained at least an associate degree (54%), and only 7% of women aged 15–44 were living under the poverty line. Slightly more than one third (37%) of sexual assaults occurred in the South (Table 1).

Table 1. Descriptive statistics (*n* = 3165).

	Mean	SD	Minimum	Maximum
Sex Offense Rate	70.44	66.45	0.00	758.00
Adult Sex Ratio	0.52	0.03	0.40	0.60
Education	0.54	0.06	0.00	0.89
Employment	0.48	0.05	0.25	0.70
Poverty	0.07	0.04	0.00	0.36
South	0.37	0.48	-	-

After examining the bivariate relationship between the adult sex ratio and forcible sex offenses, there was evidence of a quadratic relationship. When including the squared term, we observed a significant relationship and an increased goodness of fit of the model to the data (i.e., lower AIC). These results indicate that as sex ratio skew increases, sex offenses do as well (Figure 1). However, rates of offending were higher when there were fewer men in the population. For example, a municipality that is 45% male is predicted to have an offense rate of 95.57 per 100,000, whereas one that is 55% male is predicted to have a rate of 73.95. Furthermore, locations that were 51% male had the lowest predicted sex offense rate, 63.68 per 100,000. This curvilinear relationship was absent for the other

independent variables. Additionally, while there was a statistically significant positive relationship between both the poverty and employment variables and the outcome variable, this relationship was negative for degree rate.
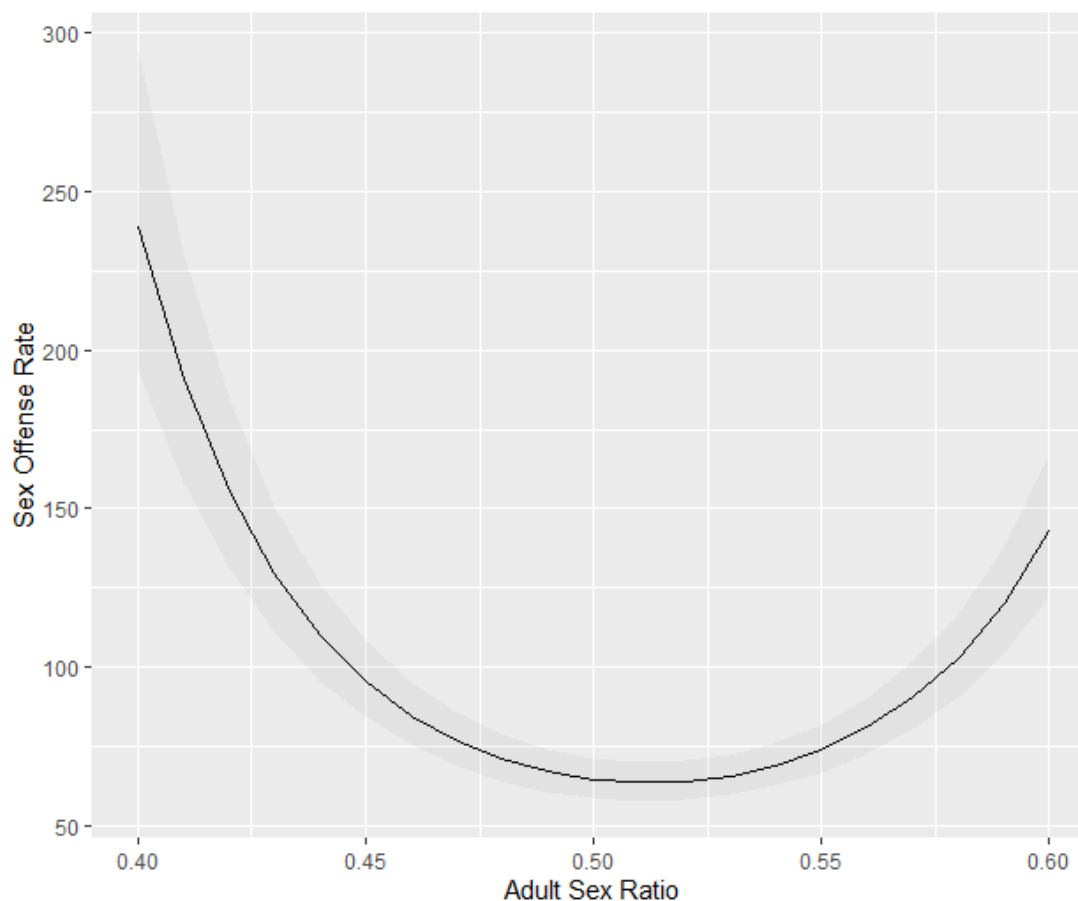

Figure 1. Predicted sex offense rate based on the adult sex ratio (with 95% Confidence Interval).

Table 2 depicts the negative binomial regression coefficients and includes the quadratic term when modeling the sex offense rate for the age group 15 to 44. An ANOVA test confirmed including the quadratic term improved the fit of the model, $X^2(1) = 261.27$, $p < 0.001$. In the full model, all of the independent variables were statistically significant. When controlling for the other independent variables, the curvilinear relationship between the adult sex ratio and the penetrative sex offense rate remains, confirming that sexual violence is occurring at higher rates when the ratio is imbalanced, regardless of the direction (though it is much higher when there are fewer men in the population). The poverty rate was positively associated with higher rates, indicating that a greater proportion of women living under the poverty line is associated with an increase in sexual violence against women. Education rate is negatively associated with the outcome, suggesting that an increase in women who obtain a degree is indicative of a decrease in sexual violence against women. Finally, employment rate was found to be positively associated with sexual violence against women and was statistically significant in the full model. The location of the sexual assault was unrelated to the sex offense rate.

Table 2. Multilevel negative binomial regression model predicting the sex offense rate.

	b	**SE**	**z**	*P*
Intercept	89.05	1.472	51.69	<0.001
Adult Sex Ratio	−368.00	6.37	−57.74	<0.001
Adult Sex Ratio^2	360.73	6.18	58.35	<0.001
Education	−1.52	0.31	−4.99	<0.001
Employment	1.50	0.48	3.14	0.002
Poverty	2.12	0.69	3.07	0.002
South	−0.33	0.20	−1.60	0.110
Log likelihood		−18,543.3		
AIC		37,104.6		
MSE		0.51		
Intraclass Correlation		0.36		

Note. *n* = 3165; *N* = 36. AIC = Akaike Information Criterion. MSE = Mean Standard Error.

Furthermore, to test the robustness of the results, the dependent variable was limited to three offenses (rape, sodomy, sexual assault with an object) to match the definition used by the FBI in the Uniform Crime Report, dropping forcible fondling (Federal Bureau of Investigation 2021). Evidence of a curvilinear was also present and multivariate results were identical in terms of significance and direction for the independent variables for both age groups, though the beta coefficients differed slightly.

4. Discussion

A male-biased sex ratio at birth is a characteristic feature of humans (James 1987); however, sex ratios regularly become increasingly skewed in adulthood (in either direction) due to a variety of demographic factors, including male-biased mortality and sex-biased economic migration (Das Gupta et al. 2009; Kramer et al. 2017). Because sex is one of the best individual-level correlates of violence (Messner and Sampson 1991), much of the focus of academic work has centered on concerns over male excess (e.g., Hudson and Den Boer 2002, 2004). Specifically, the bachelor male threat is central to this alarm where, with increasing partner rarity, unmarried males are argued to face elevated levels of competition to secure a mate, leading to more violent interactions between men and women.

Alternatively, however, researchers employing a mating market approach to violence point to growing evidence in the opposite direction (Schacht et al. 2016). What is increasingly well-documented is that men are more likely to be partnered in male-biased populations, where relationship partners are rare (Schacht and Kramer 2016; Uggla and Andersson 2018). Instead, the pool of unmarried males increases with partner excess at female-biased sex ratios. That is, men's mating psychology appears responsive to partner availability and oriented towards short-term mating preferences where potential partners are available (as they are in female-biased sex ratios).

Accordingly, here, we seek to adjudicate between these competing predictions: are sexual offenses against women more common with a male surfeit or deficit? Put simply, as a result of our analyses, we find support for both research frameworks. That is, sexual offense rates against women increase with both male surplus and shortage. However, equivalent amounts of male excess and shortage across populations do not result in equivalent associations with violence. Specifically, rates of offending were actually higher when there were fewer men in the population. For example, a locality that has a 10% excess of males is predicted to have a sexual violence rate of 74 per 100,000, yet when there is a 10% deficit of men, the rate increases to nearly 100 per 100,000. Moreover, the lowest predicted sex offense rate is where populations have a slightly male-biased ASR (51%). Thus, while our results provide mixed support for both frameworks, our findings are particularly challenging to interpret from a 'more males = more violence' framework—violence increases more quickly with female excess and is lowest with a slight male bias in the population.

A key take home from our results is that violence against women should not simply be expected to be triggered by either a male or female bias in the ASR, but instead by sex ratio skew generally. In populations with closely balanced sex ratios, no one sex has greater bargaining (dyadic) power in the mating market. Future work could usefully compare the types of violence against women expected to be more common where men hold relatively stronger or weaker dyadic power. For example, in female-biased populations, men are relatively rarer and appear to leverage this rarity in pursuit of multiple, uncommitted sexual relationships. This mating effort intensive strategy may result in higher levels of violence against women by way of sexual violence committed by a stranger (e.g., rape and sexual assault).

Conversely, where women are rare and hold dyadic power, men are more likely to be partnered and engage in long-term committed relationships. Here, men may be more likely to employ violence to maintain a relationship. This pattern of behavior has been well-documented in the animal literature, where the defense and control of a partner through male mate guarding can result in males directing violence at females (Byrne et al. 1987). Thus, intimate partner violence may be more common where women are rare because of mate guarding behaviors by their partners. Preliminary evidence suggests that both domestic abuse and female homicide victimization by a partner are higher at male-biased sex ratios (D'Alessio and Stolzenberg 2010; Titterington 2006). Because male aggression likely manifests itself in different ways across sex ratios, disaggregating measures of violence (intimate partner violence from sexual assault for example) could lead to a clearer and more productive understanding of the patterning of violence against women (Schacht et al. 2014).

Results from the current study indicate that violence against women increases when the ASR is imbalanced and provides mixed support for evaluated theoretical frameworks (although violence rates are higher where men are rarer, challenging straightforward 'more men = more violence' expectations). These results were robust even when accounting for differing definitions of sexual violence (i.e., the inclusion of forcible fondling), different populations at risk (i.e., 15–44 and 15–64), measures of gender inequality, and a wide range of social contexts across more than 3000 cities and counties in the United States. Our findings here contribute to more nuanced understandings of the causes of male perpetrated sexual violence against women and highlight the need for future researchers to more clearly target specific *types* of male perpetrated violence in response to ASR skew.

Limitations

Participation in NIBRS is voluntary and not all agencies submit data to the FBI. Approximately one third of agencies report (from across 36 states) and smaller agencies and departments in the southern US are overrepresented and larger cities are unrepresented (Roberts 2009). However, we do control for the overrepresentation of Southern agencies, which had no relationship with the sexual assault rate, and account for the population of cities and counties in the regression models. Research conducted comparing NIBRS to the UCR, the latter of which is nationally representative, has found that despite the incomplete coverage of NIBRS crime data, it is comparable to the UCR regarding representativeness for violent crime, particularly sexual assault (Addington 2008; McCormack et al. 2017; Strom and Smith 2017).

Furthermore, NIBRS only includes reported and founded incidents. However, sexual assault is the least reported of the violent index crimes and it is estimated approximately one in five are reported to law enforcement in the United States (Hart and Rennison 2003; Tjaden and Thoennes 2006). Moreover, the characteristics of a law enforcement agency can impact reporting as well; departments with a larger proportion of female officers are associated with an increase in reporting (Meier and Nicholson-Crotty 2006; Walfield 2016). Finally, we caution against drawing causal claims given that we use one year of cross-sectional data from the US Census Bureau (2016) and because this technique limits potential generalizability across other societies and time periods. Future research should

consider evaluating international data, such as the European Sourcebook of Crime and Criminal Justice Statistics (Aebi et al. 2021) and Canada's Incident-Based Survey (UCR2), to further examine these findings.

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