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Geographical Clusters of Rape in the United States: 2000-2012

Raid Amin¹, Nicole S. Nabors¹, Arlene M. Nelson¹, Murshid Saqlain¹, and Martin Kulldorff²

¹ Department of Mathematics and Statistics, University of West Florida, Pensacola, FL, USA.

² Division of Pharmacoepidemiology and Phramacoeconomics, Harvard Medical School and Brigham and Women's Hospital, Boston, MA

Abstract

Background—While rape is a very serious crime and public health problem, no spatial mapping has been attempted for rape on the national scale. This paper addresses the three research questions: (1) Are reported rape cases randomly distributed across the USA, after being adjusted for population density and age, or are there geographical clusters of reported rape cases? (2) Are the geographical clusters of reported rapes still present after adjusting for differences in poverty levels? (3) Are there geographical clusters where the proportion of reported rape cases that lead to an arrest is exceptionally low or exceptionally high?

Methods—We studied the geographical variation of reported rape events (2003-2012) and rape arrests (2000-2012) in the 48 contiguous states of the USA. The disease Surveillance software SaTScan™ with its spatial scan statistic is used to evaluate the spatial variation in rapes. The spatial scan statistic has been widely used as a geographical surveillance tool for diseases, and we used it to identify geographical areas with clusters of reported rape and clusters of arrest rates for rape.

Results—The spatial scan statistic was used to identify geographical areas with exceptionally high rates of reported rape. The analyses were adjusted for age, and in secondary analyses, for both age and poverty level. We also identified geographical areas with either a low or a high proportion of reported rapes leading to an arrest.

Conclusions—We have identified geographical areas with exceptionally high (low) rates of reported rape. The geographical problem areas identified are prime candidates for more intensive preventive counseling and criminal prosecution efforts by public health, social service, and law enforcement agencies. Geographical clusters of high rates of reported rape are prime areas in need of expanded implementation of preventive measures, such as changing attitudes in our society toward rape crimes, in addition to having the criminal justice system play an even larger role in preventing rape.

BACKGROUND

Rape is a very serious crime and public health issue. Approximately 1 in 5 women and 1 in 71 men in the US have been raped at some time in their lives according to the National Intimate Partner and Sexual Violence Survey for the year 2010 (Breiding et al. 2014), with

approximately 60% of rape incidences still being left unreported. The FBI's Uniform Crime Reports for 2013 (FBI 2013) defined rape as follows: "Penetration, no matter how slight, of the vagina or anus with any body part or object, or oral penetration by a sex organ of another person, without the consent of the victim." Prior to 2013, the definition of rape was defined as "carnal knowledge of a female forcibly and against her will." The report states that "The revised definition expands rape to include both male and female victims and offenders, and reflects the various forms of sexual penetration understood to be rape, especially non-consenting acts of sodomy, and sexual assaults with objects." Because of the historical data, this study contains data based on the old definition of rape.

There were an estimated 79,770 forcible rapes of females in the US in 2013, which is a decrease of 6.3% from 2012 (FBI 2013). It is also 10.6% less than 2009 and 16.1% less than 2004 estimates (FBI 2013). The forcible rape rate has decreased during the last few decades, dropping from 41.1 out of 100,000 inhabitants in 1993 to 25.2 out of 100,000 in 2013. While rape also occurs against men, only rape of women was considered in this study. Victims do not always report their rape, and not all reported rape crimes result in arrest. The issue of reported rape cases has been addressed by Clay-Warner and Burt (2005), Fisher et al (2003), and by Rennison (2002).

Regarding the geography of rape, and the use of spatial analysis to better understand the geographical extent and the distribution of rape incidences in the USA, Warren et al.(2010) studied crime scene and distance correlates of serial rape, while Kocsis and Irwin (1997) focused on spatial patterns in serial rape, arson, and burglary. Pawson and Banks (1993) studied the geography of rape in New Zealand, concluding that younger women find private spaces less safe than public spaces in this respect. Vetten (1998) investigated the possible effect of urban design upon rape, and she concluded that different urban environmental design can reduce the threat of rape. Carter and Larkin (1993) modeled the spatial activities of sex offenders, concluding that most offenders move out of their home base to carry out their attacks. Thornton and Voigt (2007) studied the possible impact of Hurricane Katrina on the rates of violent crimes and rape in New Orleans. All these important studies are focused on the local geography, such as the spatial pattern of crimes committed by a serial rapist or the geographical distribution of rape within a city. In disease surveillance, it is common to map incidence and mortality rates to detect areas of high risk of cancer, cardiovascular diseases, infectious diseases, or birth defects. This allows public health officials to prioritize the allocation of resources for disease prevention and control. On the national scale, no such spatial mapping has been attempted for rape, even though rape is no less of a serious public health problem. The epidemic of rape is unlikely to be equally distributed geographically. As a surveillance activity, we analyzed the geographical distribution of reported rapes and rape arrests in the contiguous United States. This paper addresses the following research questions:

- Q1. Are reported rape cases randomly distributed across the USA, after being adjusted for population density and age, or are there geographical clusters of reported rape cases?
- Q2. Are the geographical clusters of reported rapes still present after adjusting for differences in poverty levels?

Q3. Are there geographical clusters where the proportion of reported rape cases that lead to an arrest is exceptionally low or exceptionally high?

METHODS

United States Reported Rape and Arrest Data

For each county in the contiguous 48 states, data on the number of reported rape cases and the number of rape arrests were obtained from the Uniform Crime Reporting (UCR) through the Inter-University Consortium for Political and Social Research (ICPSR), University of Michigan. The UCR Program was founded in 1929 by the International Association of Chiefs of Police to meet the need for reliable uniform crime statistics for the nation. In 1930, the FBI was tasked with collecting, publishing, and archiving those statistics. Current published reports from the UCR are available through 2013, but at the time of this study, data were only available through 2012. Only rape against women was considered in this study. For reported rape cases, we obtained data from 2003 to 2012, and for rape arrests, from 2000 to 2012. Since the revised definition of rape did not take effect until 2013 (FBI 2013), the rapes studied in this paper conform to the legacy definition.

Since arrests normally do not occur on the same day as the crime, the arrests during 2000-2012 do not correspond exactly to the reported rape cases during this same period. That is, some arrests in 2003 were for crimes committed in prior years, while perpetrators of rape crimes committed in 2012 would not have been arrested until subsequent years. Furthermore, the UCR program counts one offense for each victim of a rape (FBI 2013). Therefore, in instances of where there is more than one offender per victim, the arrest counts may be higher. The data for 2003-2012 does not allow us to calculate the exact proportion of reported rapes leading to an arrest, but the proportion was estimated by dividing the numbers for the whole 2003-2012. For 1,878 out of 31,090 records (for 2003-2012) that had more arrests than reported rapes, the number of arrests were adjusted and set to be equal to the number of reported rapes. Female population counts for each county were obtained from the United States Census Bureau Data (2012) for 2000-2010, which was derived from the Intercensal files for 2000-2010, while 2011-2012 data is from the Vintage 2013 data set (US Census Bureau 2014). Poverty data was obtained from the United States Census Bureau's Small Area Income and Poverty files for the years 2000-2012 (US Census Bureau 2014).

The Spatial Scan Statistic—To evaluate the geographical variation in rapes, we used the spatial scan statistic, which has been widely used as a geographical surveillance tool for cancer and many other diseases (Kulldorff 2009). This method is able to detect and evaluate the statistical significance of a geographical cluster without pre-specifying the cluster location and size. Furthermore, the spatial scan statistic adjusts for the multiple testing inherent in the hundreds of thousands of potential clusters evaluated.

The purely spatial scan statistic imposes a circular window on the map (Kulldorff 1997). The window is in turn centered on each of several possible grid points positioned throughout the study region. For each grid point, we used the county centroids to ensure that each county is a potential cluster by itself, and the radius of the window was varied continuously in size from zero up to an upper limit corresponding to 5% of the total female population. In this

way, the circular window is flexible both in location and size. In total, the method creates hundreds of thousands of distinct geographical circles with different sets of neighboring counties within them. Each circle is a possible candidate for a cluster.

For the reported rape data, we used the Poisson model, where the number of cases in each county is Poisson distributed. Under the null hypothesis, when there are no clusters, the expected number of cases were calculated based on the female population size, adjusted for age using indirect standardization (or for both age and poverty, in secondary analyses). For the analysis on the proportion of reported rapes leading to an arrest, we used the Bernoulli model, where reported rapes leading to an arrest is represented as a “1” and those that did not lead to an arrest is represented by a “0” (Kulldorff 1995 2005). The freely available SaTScan™ software was used for all the analyses (Kulldorff 2009), and it employs the Gumbel distribution to calculate p-values (Abrams and Kulldorff 2010). We only show gini clusters, and we removed non-gini clusters (larger clusters overlapping smaller ones). Poisson regression is used to remove from all counties any existing differences in their poverty rates. The predicted rape cases (reported and arrests) were then analyzed with SaTScan™ to identify excessive rates after adjusting for both age and poverty.

RESULTS

Geographical Clusters of Reported Rape

The first round of analyses addresses the first two research questions. In Q1, we used the Poisson model for a purely spatial analysis of reported rape rates, adjusted for age. The scan of high rates resulted in 92 statistically significant clusters with p-values <0.05, implying much higher reported rape rates than in the rest of the contiguous USA. There were 102 significant clusters at the 0.05 significance level. See Figure 1 and Table 1 for results. The first column in Tables 1-4, “Location”, gives the name of the largest city that is located inside the cluster. The counties making up the actual cluster are listed in the second column of Tables 1 and 2, while the second column in Tables 3 and 4 contains the number of counties in the actual cluster. For example, Jefferson, TX is given in Table 1 under the column “Location”, while in the second column, it is clarified that the (actual) corresponding cluster is located in Marion County. Of the 92 clusters found, there were four clusters where women had more than a three-fold excess risk of reported rapes compared to the rest of the country; and there were eight clusters where they had more than a two-fold excess risk. The highest rates were found in Marion County in northeastern Texas, with a 19.75 relative risk, followed by Alpine, CA (RR=4.58) and Potter, PA (RR=4.43). All but 12 of the clusters had $p < 0.0001$.

Adjustment for Poverty

Rape is an equally serious crime no matter where and to whom it happens, so from a public health perspective one should not adjust the geographical analyses for potential confounders such as poverty. Preventive measures should be intensified in high risk areas whether those areas are poor or rich. From an epidemiological or sociological research perspective, it is interesting to determine if there are still clusters after adjusting the analysis for other rape risk factors. We repeated the spatial scan statistics adjusting for age and for poverty.

Figure 2 identifies the reported rape rate clusters after adjustment for both age and poverty (in orange). The counties shown in pink are age adjusted reported rape rate clusters that are not associated with poverty rates. The dark red colored counties are included in both the age-adjusted reported rape clusters and the age-poverty adjusted reported rape clusters. Table 2 lists the twenty clusters with the highest Relative Risk after adjusting reported rape rates for age and for poverty. The highest relative risk values were found (again) in Marion, TX with $RR=16.77$, followed by Kenedy, TX ($RR=8.25$), Potter, PA ($RR=4.39$), Minnehaha, NM ($RR=2.75$), and Escambia, FL and Santa Rosa, FL ($RR=2.44$).

It is interesting to note that, while the cluster collection is somewhat different when adjusting for poverty, explaining a few of the original clusters, poverty does not explain away the existence of the geographical variation in reported rape cases. Hence, there are other important local factors that influence the variation in the number of reported rape cases.

Proportion of Reported Rapes Leading to an Arrest

Geographical clusters with a high number of arrests could either be due to many rapes occurring in that area, to a high proportion of rapes leading to an arrest, or to a combination of the two. We have data on both rape arrests and for the corresponding reported rape only for 2003-2012. To specifically evaluate the proportion of rape reports leading to an arrest, we did a separate geographical analysis contrasting the two, using the data for the years 2003-2012. We did such a cluster analysis with the goal to identify clusters with high proportions and clusters with low proportions. Assuming that most arrests are accurate in finding the true perpetrator, the high proportion clusters indicate areas where law enforcement is doing a good job regarding these types of crimes, while additional law enforcement efforts and resources may be needed in the low proportion clusters. Figure 3 identifies in blue the clusters of counties with high rape arrest rates (relative to reported rape cases), while the red clusters represent counties in which the rape arrest rates are low when compared with the corresponding reported rape cases.

Table 3 identifies the Top 10 clusters with high Relative Risk (RR) in counties having high rape arrest rates relative to reported rape rates, while Table 4 identifies the Top 10 clusters with low Relative Risk in counties having low rape arrest rates relative to reported rape rates. There are four counties in NY (NYBronx, NYKings, NYNewYork, NYQueens) forming the cluster with the highest proportion (79.5%), while two counties (DC and Prince George's, MD) form the cluster with the lowest proportion (6.6%) [see Figure 3].

DISCUSSION

In this study, we found several geographical clusters for reported rape and for the proportion of rapes leading to an arrest. Most clusters are located in urban areas, however, some geographical clusters were found in rural areas, but not all urban areas show up in a cluster. There were also a few geographical clusters in rural areas. The clusters are spread across the United States, located in the Midwest, the South and along both coasts.

When interpreting the results, the most important thing is to realize that the clusters can occur for various reasons. For example, clusters of rape reports appear because there are many rapes in an area or because a high proportion of the rapes that do occur are reported to the police. The former is a bad thing while the latter is a good thing. Considering the high relative risks for several of the clusters, we think that it is unlikely that differential reporting can explain more than at most a modest amount of the excess risk. For rape arrests, a cluster may occur either because of the number of rapes or because law enforcement agencies are successful at rape crime solving. It is difficult to determine which results are driven by each of these factors; therefore, we did not conduct such an analysis.

Belknap (1989) and Carter (1991) both state that the proportion of reported rapes are between 10% and 40% , resulting in our reported rape cases being conservative lower bound estimates of the true number of rape cases. Eastal (1992, 1998) states that the criminal justice system can play a major role in preventing rape, and it is recommended that in addition to new legislation, there is a need to change attitudes and behavior of the police and the justice system towards reported rape cases.

To illuminate this issue further, we also did an analysis looking at the proportion of reported rape cases that lead to an arrest. If this proportion is high, it means that the law enforcement agencies are succeeding at investigating and solving the crimes, assuming that they arrest the right persons. The high proportion clusters could theoretically also be due to law enforcement agencies making a large number of erroneous arrests, but we think that is unlikely to explain any of the detected clusters as the relative risks are all quite high.

When adjusting for poverty, we still identify counties with excessive reported rape rates. Hence, geographical variation in poverty cannot explain the majority of the detected clusters. This could be interpreted as empirical evidence that while poverty and rape are associated, there are also other local factors that generate the geographical clusters found. There exists a perception that some demographic variables (such as race and ethnicity, education, and illegal drugs) may be associated and/or confounded with rape rates. On the other hand, Klein and Creech (1982) concluded that there exists a race based bias in assessing pretrial probabilities and perception of evidence. Wyatt (1992) compared differences and similarities in rape cases in African-American and White Caucasian women, suggesting the possibility that different perceptions of the rape incidences may result in the rates of reported rape cases. We decided not to include such factors in this study, but such factors could be investigated by other researchers in future studies on rape rates in the USA. Rape rates have reached epidemic levels among college women, with risky drinking behavior being a significant factor in most cases (Carey 2015). In a recent study, a sexual assault resistance program with strategies to reduce the risk of college women for being sexually assaulted was used to significantly lower the occurrence of rape (Senn et al. 2015).

The CDC has identified changes in the Intimate Partner Violence Surveillance since the original document that was published 18 years ago (Breiding 2015). These changes impact data collection and Intimate Partner Violence (IPV) prevention, which includes rape. For example, the new report discusses stalking and the use of GPS for tracking potential victims of rape, or the use of sexually explicit text messaging (Breiding 2015).

There are a number of limitations to this study. All analyses were adjusted for age of the female population, which is important due to the fact certain age groups of women have a higher incidence of rape. But the frequency of rape may also be related to the age of the male population, but this was not adjusted for, except to the extent that it is correlated with female age. We think that male age is unlikely to explain the detected clusters.

In the analysis that evaluates the proportion of reported rape cases leading to arrests, the two data sets are not perfectly synchronized. Since the ten years are the same for the two data sets, covering 2003 to 2012, the data may include some arrests that occurred in 2003 for a rate reported in 2002, which are not included in the reported rape data set. Likewise, some reported rape cases that occurred in 2012 may have led to an arrest in 2013, with the latter not being included in the data. This is a limitation of this particular analysis, but we were unable to obtain data linking specific reported cases to specific arrests.

Alaska and Hawaii are not part of the contiguous USA, and therefore these two states were not included in this spatial study. In this paper we analyzed female rape victims, ignoring male rape victims. While the latter is a much smaller group, it would have been interesting to include them as well, but we were unable to obtain such data.

Rape is a very serious crime, and a major public health dilemma. The purpose of this paper is to highlight geographical areas where more resources and efforts are needed to better combat this problem. Geographical clusters of high rates of reported rape are prime areas in need of expanded implementation of preventive measures, such as changing attitudes in our society toward rape crimes, in addition to having the criminal justice system playing an even larger role in preventing rape. Geographical clusters with a low proportion of rape cases that lead to arrests are prime areas for additional law enforcement resources that are needed to arrest and convict rapists. While in many states only one type of cluster appears (see Fig. 3), suggesting a possible role of state laws and/or state directed law enforcement activities, we also find side by side small cities (Springfield, IL; and Decatur, IL) in which high arrest rates and low arrest rates are located geographically side by side, which suggests that other factors may play a role in the arrest rate for rape cases. We do not have data on the geographical variation of the availability of support services for rape victims. While such services are important everywhere, it is critical to ensure that there is sufficient capacity of such services in the areas with the highest reported rape rates.

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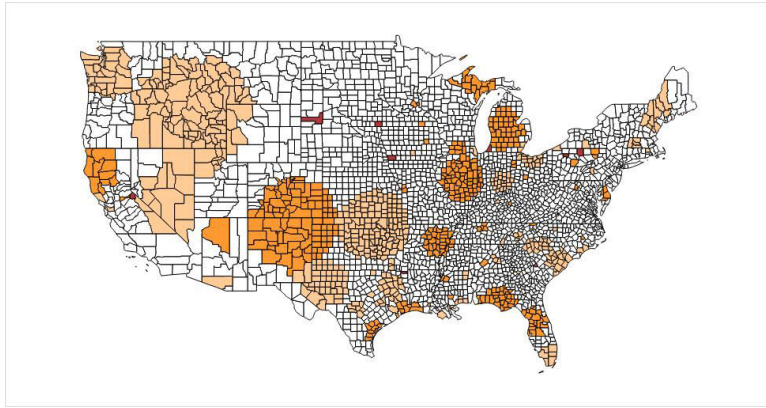


Figure 1.
Cluster Map of the USA for Age Adjusted Reported Rape Rates
■ $RR > 2$ ■ $2 > RR > 1.5$ ■ $RR < 1.5$

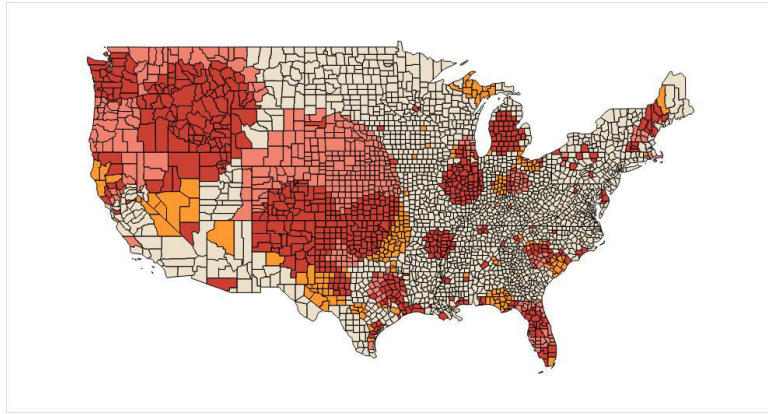


Figure 2.

Statistically significant clusters of reported rape after adjustment for both age and poverty (red and pink). Counties that were part of an age-adjusted cluster, but not an age and poverty adjusted cluster, and are colored orange.

- Included in clusters from both age and age-poverty adjusted analysis
- Only included in clusters from age-adjusted analysis
- Only included in clusters from age-poverty adjusted analysis

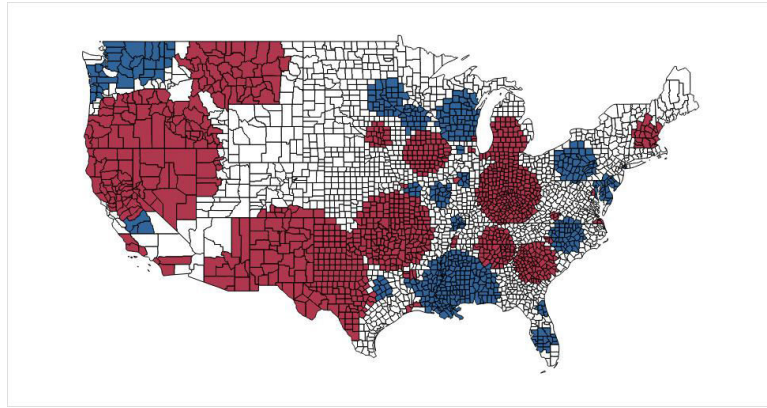


Figure 3. Statistically significant clusters of high (blue) and low (red) proportion of reported rape cases leading to an arrest.

Table 1

Statistically significant cluster of age-adjusted reported rape rates, with a relative risk (RR) greater than or equal to 1.90.

Location	Counties Included	Reported Rapes	Relative Risk	P Value
Jefferson, TX	TXMarion	617	19.75	<0.0001
Markleeville, CA	CAAlpine	15	4.58	0.04
Coudersport, PA	PAPotter	223	4.43	<0.0001
Rapid City, SD	SDPennington	1159	3.99	<0.0001
Council Bluffs, IA	IAPottawattamie	811	2.90	<0.0001
Jenks Township, PA	PAForest	36	2.59	0.01
Sioux Falls, SD	SDDMinnehaha	1250	2.57	<0.0001
Niles, MI	MIBerrien	1079	2.33	<0.0001
Galax, VA	VAGalaxCity	48	2.32	0.006
Augusta, GA	GARichmond	1343	2.17	<0.0001
Petersburg, VA	VAPetersburgCity	205	2.01	<0.0001
Philadelphia, PA	PAPhiladelphia	9538	2.01	<0.0001
Jackson, MS	MSHinds, MSWarren	1904	1.97	<0.0001
Clearfield, PA	PAClearfield	447	1.94	<0.0001
Charlottesville, VA	VACHarlottesvilleCity	277	1.93	<0.0001
Lima, OH	OHAllen, OHPutnam	800	1.92	<0.0001
Central Florida	FLAlachua, FLBradford, FLCitrus, FLDixie, FLGilchrist, FLHernando, FLHillsborough, FLLake, FLLevy, FLMarion, FLOrange, FLPasco, FLPinellas, FLPolk, FLPutnam, FLSumter, FLUnion, FLVolusia	33690	1.92	<0.0001
Columbus, OH	OHFranklin	6803	1.92	<0.0001
Lower Peninsula, MI	43 counties, see Figure 1	26425	1.91	<0.0001
Ironwood, MI	MIGogebic	81	1.90	0.003

Table 2

Statistically significant clusters of reported rate, adjusted for age and poverty, and with a relative risk (RR) greater than or equal to 1.66.

Location	Locations Included	Reported Rapes	Relative Risk	P Value
Jefferson, TX	TXMarion	617	16.77	<0.0001
Sarita, TX	TXKenedy	10	8.25	0.016
Coudersport, PA	PAPotter	223	4.39	<0.0001
Sioux Falls, SD	SDMinnehaha	1250	2.75	<0.0001
Pensacola, FL	FLEscambia, FLSantaRosa	3275	2.44	<0.0001
Ione, CA	CAAmador	177	1.96	<0.0001
Clearfield, PA	PAClearfield	447	1.91	<0.0001
Lower Peninsula, MI	43 counties, see Figure 2	26425	1.90	<0.0001
Myrtle Beach	SCHorry	1441	1.86	<0.0001
Corpus Christi, TX	TXAransas, TXCalhoun, TXGoliad, TXNueces, TXRefugio, TXSanPatricio, TXVictoria	3191	1.79	<0.0001
Petersburg, VA	VAPetersburgCity	205	1.78	<0.0001
Charlottesville, VA	VACHarlottesvilleCity	277	1.74	<0.0001
Central Illinois	68 counties, see Figure 2	18239	1.74	<0.0001
Jackson, MS	MSHinds, MSWarren	1904	1.71	<0.0001
San Angelo and Abilene, TX	TXCoke, TXConcho, TXFisher, TXGlasscock, TXHoward, TXIrion, TXMitchell, TXNolan, TXRunnels, TXScurry, TXSterling, TXTaylor, TXTomGreen	1830	1.69	<0.0001
Winchester, VA	VAFrederick	328	1.69	<0.0001
Philadelphia, PA	PAPhiladelphia	9538	1.69	<0.0001
Central Florida	55 counties, see Figure 2	70453	1.69	<0.0001
Indianapolis, IN	INMarion	4901	1.68	<0.0001
Seneca, SC	SCOconee	357	1.66	<0.0001

Table 3

Statistically significant clusters with a high proportion of arrests for reported rapes.

Location	Counties	Reported	Arrests	% Arrests	RR	P Value
New York, NY	4	11140	8856	79.5	3.03	<0.0001
Jacksonville, FL	6	6343	4313	68.0	2.56	<0.0001
Wisconsin	51	10686	6807	63.7	2.41	<0.0001
Mansfield, LA	5	207	130	62.8	2.34	<0.0001
Waco, TX	11	1926	1169	60.7	2.26	<0.0001
Dixon, IL	2	419	233	55.6	2.07	<0.0001
SE Missouri	10	435	225	51.7	1.93	<0.0001
Southern Minnesota	24	2618	1194	45.6	1.70	<0.0001
Decatur, IL	7	1235	557	45.1	1.68	<0.0001
Central Florida	16	17295	7575	43.8	1.65	<0.0001

Table 4

Statistically significant clusters with a low proportion of arrests for reported rapes.

Location	Counties	Reported	Arrests	% Arrests	RR	P Value
Washington, DC	2	4424	292	6.6	0.24	<0.0001
Liberty, MO	2	985	67	6.8	0.25	<0.0001
Springfield, IL	1	1349	112	8.3	0.31	<0.0001
Sioux City, IA	20	2224	189	8.5	0.32	<0.0001
Austin, TX	3	5319	458	8.6	0.32	<0.0001
Beaumont, TX; Lake Charles, LA	3	2660	282	10.6	0.39	<0.0001
Montana	42	2624	307	11.7	0.43	<0.0001
Shreveport, LA; Marshall, TX	4	2504	318	12.7	0.47	<0.0001
Gary, IN	2	1457	188	12.9	0.48	<0.0001
E Iowa, NW Illinois	69	7977	1045	13.1	0.49	<0.0001

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