

# The Use of Spatial Statistics to Control Human and Sex Trafficking

Jose Javier Lopez and Sherrisse Truesdale-Moore

**Abstract**—Sex trafficking is an issue that has received considerable attention during the past fifteen years. An understanding of this crime’s geographic distribution provides social services agencies a better idea of which areas are more vulnerable to the problem due to the presence of facilitators and enablers of this exploitative practice. In order to develop a thorough understanding of this crime’s geographic patterns, social scientists need basic knowledge of spatial statistics. This type of statistical analysis is a product of the quantitative revolutions of the 1950s and 1960s. With the advent of user-friendly information systems technologies, numerous government agencies and non-governmental social services groups have initiated the inclusion of this area of knowledge in their fight against human trafficking. This paper provides examples of the use of spatial statistics as an analytical and crime-solving resource for the detection of sex trafficking activities in some areas of the United States. Particular attention is given to the role geographic information systems (GIS) and crime reports play in the development of inferential spatial statistical analyses. The case studies of sex trafficking in the American states of Virginia and Minnesota are included in this article.

**Index Terms**—Geographic information systems, sex trafficking, spatial statistics.

## I. INTRODUCTION

Sex trafficking is an issue that has received considerable attention during the past fifteen years, and this type of exploitative activity is affected by the prevailing social norms and customs of a place and its relative location [1]. For example, a study of sexually-oriented massage parlors in Southern California by Chin, Kim, Takahashi, and Wiebe found that “neighborhood characteristics significantly explain variations in clusters” [2]. As Mletzko, Summers and Arnio [3] posited, a considerable number of sex and human trafficking events are located in space, and the social geography of places can assist or obstruct this type of illegal activity. Since place and space and the attributes of them, in many ways, reveal sex and human trafficking’s dynamics, spatial statistics and Geographic Information Systems (GIS) can assist sociologist, criminologists, social workers, and psychologists in their quest of finding solutions to this problem. Blazek, Esson and Smith [4] provide a description of human trafficking that stresses the “inherently spatial”

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nature of an abusive activity that includes “cross-cutting processes of exploitation within and across local, regional, national, and international borders.”

Moore [5] encourages educators to work with their students in the development of research questions pertinent to human trafficking that can be answered by using GIS technologies since these spatial analysis-related technologies “can map the spatial distribution of trafficking activity.” An understanding of the geographic distribution of this criminal practice provides social services agencies ideas to better comprehend which areas have the potential to become more vulnerable to the problem due to the presence of facilitators and enablers of this exploitative practice. Sex trafficking, a form of human trafficking, has been analyzed using GIS technology and spatial statistics. According to Voloshin, Derevitskiy, Mukhina and Karbovskii [6], “spatial analysis of data on commercial sex service venues can provide a basis for the detection of clusters of establishments that are potentially involved into human trafficking and forced labor.” In addition, the information obtained with the help of GIS technologies helps governments to prevent the occurrence of human trafficking and the solicitation of sex services [1], [6].

One of the advantages of GIS technologies is they permit the identification and understanding of the distributions of trafficking routes, migration flows, places with large slave populations, and “produce maps, graphs, charts, and textual data describing and analyzing human trafficking” [5]. However, the understanding of sex trafficking requires more than a visual inspection of simple thematic maps showing the locations affected by this form of human trafficking. For example, in the case of sex trafficking, advanced spatial statistics and analyses are necessary for the development of better-informed strategies for the allocation of “resources aimed at securing sexual workers and preventing dangerous behaviors among both providers of escort services and their clients” [6]. Cole and Sprang [7] note that sex trafficking of minors has occurred across diverse areas of a predominantly rural state regardless the degree of proximity to metropolitan regions. Even though a geographic analysis assisted by spatial statistics of sex trafficking and the sexual exploitation of minors itself cannot reflect the real extent of human trafficking, the identification of the geographic distributions of these crimes can give researchers “an idea of which regions have the potential of becoming vulnerable to the presence of facilitators and enablers of this cruel practice” [8].

## II. LITERATURE ON HUMAN AND SEX TRAFFICKING

Human trafficking is defined as the recruitment,

transportation, transfer, harboring, or illegally receiving through means of force, abduction, fraud, or coercion for the purpose forced labor (involuntary servitude, peonage, debt bondage, or slavery) or sexual exploitation [9], [10]. Governments around the world have made significant efforts in combating human trafficking. Over 170 countries have commitments to eradicating human trafficking. Some of these states have been very proactive in finding effective responses to prosecute those responsible for human trafficking, protect the victims, and prevent the occurrence of this crime. Nevertheless, combating human trafficking and assisting the victims of this illegal trade are tasks that encounter difficulties because “victims, especially ones transported across international borders, are often terrified of violence, face language and cultural barriers, and experience poverty and family dysfunction” [5]. In addition, new communication technologies have helped enablers and facilitators of this form of exploitation avoid detection from government institutions that are trying to combat the problem. For example, in the case of sex trafficking “given the advantages Internet offers, people involved into commercial sex work in different roles have seemingly minimized their physical visibility in the eyes of law enforcement and public health officials and acquired new techniques of “recruiting” and addressing potential clients with new services more efficiently” [6]. Also, Moore points out “the Internet allows for anonymity, and payments can be made by wire transfers that are difficult to trace” [5].

### III. U.S. LEGISLATION ON HUMAN TRAFFICKING

Supported by the 13th Amendment to the Constitution, which bars slavery and involuntary servitude, the United States, in particular, makes significant strides through key legislation which include: The Trafficking Victims Protection Act of 2000 that equipped the government with new tools and resources to establish an intensified comprehensive and coordinated campaign to eradicate human trafficking [11]. This campaign is recognized by the three P’s: protection for victims, prosecution of perpetrators, and prevention [12]. In order to protect minors, this American act considers every form of trafficking a criminal act if recruitment involved individuals “under age 18 irrespective of whether coercion or deception are involved” [13]. The Trafficking Victims Protection Reauthorization Act of 2003 [14] refined the federal criminal provisions against trafficking to include the Racketeer Influenced and Corrupt Organization Act and civil remedies for victims who file lawsuits against their traffickers in the federal court [15]. The Trafficking Victims Protection Reauthorization Act of 2005 [16] provides extraterritorial jurisdiction over trafficking offenses committed overseas by persons employed by or accompanying the federal government, and grants are provided to state and local agencies combating human trafficking.

The William Wilberforce Trafficking Victims Protection Reauthorization Act of 2008 [17] shows new measures to prevent and deter human trafficking, and means to hold perpetrators accountable, including: creating new crimes that impose serious penalties; prosecution of sex traffickers using force, fraud, or coercion; eliminating the requirement that a

defendant knew a sex trafficking victim was a minor; expanding the crime of forced labor definition to include abuse or threatening abuse of legal process; impose criminal liability who knowingly with intent to defraud or recruit; increase the penalty for conspiring to commit trafficking-related crimes; and penalizing those who knowingly benefit financially from trafficking-related crimes.

The Trafficking Victims Protection Reauthorization Act of 2013 [18] focuses on the elimination of human trafficking from the supply chain of goods. This means that government efforts seek to ensure that citizens do not use items, products, or materials produced or extracted with the use of labor of trafficked victims. The Justice for Victims of Trafficking Act of 2015 [19] provides additional tools for eliminating human trafficking by adding the terms “patronizes” and “solicits” to facilitate prosecutions of customers of sex trafficking victims. In addition, advertisement is a mode of commission and there is no need to prove whether a person knew defendant was a minor if the defendant had a reasonable opportunity to observe the victim.

### IV. CHARACTERISTICS OF HUMAN TRAFFICKING

A recent report by the United Nations [20] indicates that human trafficking was at a 13-year record high, but it is unclear whether this is a result of government efforts in strengthening the capacity to investigate these matters or whether various methodological research approaches have contributed to the visibility of these issues. Tracking these incidents have improved in many parts of the world, which is due to international efforts in developing standards in data collection [20].

Around the world women, men, girls, and boys are targets for human trafficking, but women and girls remain the primary target all around the world. There are some regional differences that are explained based on the illustrated in Table 1. For example, in North America, South America, and some parts of Europe, including Western, Southern, Central, and South Eastern Europe, women are the primary targets for human trafficking. In Central America and the Caribbean, only girls were reported as a primary target. In Eastern Europe, Central Asia, Middle East, East Africa, and Southern Africa, both women and men are targeted for human trafficking. When considering who is trafficked in North Africa and South Asia, the data indicates that women, men, girls, and boys are targeted. In East Asia and the Pacific, women and girls are targeted, while only children (girls and boys) are typically targeted in West Africa. Based on the review of the data, women and girls are the main target for human trafficking around the world [20].

The National Human Trafficking Hotline [21] maintains aggregated information based on leads from phone calls, emails, and online tips, which is used to combat human trafficking. Since 2007, approximately 195,215 leads were reported that resulted in 45,308 cases. In 2018, out of the 5,147 calls, sex trafficking was approximately 72 percent ( $n = 3,718$ ) of all the cases [21]. Like most regions of the world, females have the highest percent of victimization [22].

TABLE I: REGION AND PERSONS TRAFFICKED AROUND THE WORLD

Region	Persons Trafficked
North America	Women
Western & Southern Europe	Women
Eastern Europe & Central Asia	Women and Men
Central America & Caribbean	Girls
North Africa	Women, Men, Girls, and Boys
Middle East	Women and Men
West Africa	Girls and Boys
East Africa	Women and Men
South Asia	Women, Men, Girls, and Boys
East Asia	Women and Girls
South America	Women
Southern Africa	Women and Men

(U.N. News, 2019) <https://news.un.org/en/story/2019/01/1031552>.

## V. VENUES SUPPORTING HUMAN TRAFFICKING

Human trafficking is a \$32 billion dollars global industry and forty percent of women in the United States were recruited by organized businesses [23]. Close attention is made towards particular businesses that support human trafficking because research has shown a correlation between certain types of commercial business and human trafficking. Escort/Delivery services were the most reported business exposing human trafficking [22], [23]. Chin, Kim, Takahashi, and Wiebe [2] observe that some sexually oriented businesses tend to operate in very specific neighborhoods due to limited police presence. Residence-based human trafficking was the second highest, particularly if the residence is a rental unit. The argument is that rental units represent transiency and a lack of community cohesion, which means perpetrators are capable of engaging in human trafficking more anonymously [22], [24]. Other locations include hotel/motels, bars, strip clubs, domestic work, and transportation [23]. Mletzko, Summers, and Arnio [3] bivariate analyses of spatial patterns of urban sex trafficking show the number of sex trafficking offenses is negatively associated with the distance to the interstate highway and positively associated with the number of motels. Increasingly, human trafficking starts with an advertisement that is viewed by someone attempting to secure a transaction [23].

## VI. SPATIAL STATISTICS AND CRIME ANALYSIS

In order to develop a thorough understanding of this crime's geographic patterns, social scientists and governments' analysts need a basic knowledge of spatial statistics. This type of statistical analyses is a product of the quantitative revolutions of the 1950s and 1960s. With the advent of user-friendly information systems technologies,

numerous government agencies and non-governmental social services groups have initiated the incorporation of this area of knowledge in their fight against human trafficking. The use of spatial statistics by criminal justice practitioners is part of an approach and methodology known as the geography of crime, and Georges defines it as "the study of the spatial manifestation of criminal acts" [25]. The social, economic, and cultural attributes of places and spaces affected by human trafficking can be complex, and according to Blazek, Esson, and Smith [4], "space is made through the practices that have already taken place and it will be modified by those that are only due to materialize." Some of these practices can be officially documented as socio-economic variables and data recorded by government agencies. Scientists involved in the use spatial statistics to better understand criminal activity oftentimes use geographic information science software that helps them process geographically related data that has been "stored as information in virtual layers (one layer for each variable) to be displayed on the computer in the form of a multilayer, virtual map" [26].

Our essay presents examples of the use of spatial statistics as an analytical and crime-solving resource for the detection of sex trafficking in some regions of the United States. Particular attention is given to the role geographic information systems (GIS), and judicial branch and police records play in the development of inferential spatial statistical analyses. The case studies of sex trafficking in the American states of Minnesota and Virginia are included in our discussion.

## VII. THE MINNESOTA CASE

One of the most popular inferential spatial statistics used by social scientists interested in examining the distribution of crimes is the nearest neighbor index. This index is commonly used in crime mapping to compare the clustering of the spatial distributions of different criminal acts, or to contrasts distributions of the same offense at different time periods [27]. We have been researching the geography of sex trafficking and sexual exploitation of children in Minnesota for some time, and dot maps indicating the absolute location of communities affected by human trafficking-related offenses have been produced. These dot maps permit us to conduct a point pattern analysis using the nearest neighbor approach for determining the spatial arrangement of the human trafficking-related cases.

In order to conduct this analysis, we have considered the distance existing between an affected community and its nearest neighboring affected community. We repeat this measuring step for the other communities that reported court cases dealing with sex trafficking and sexual exploitation of children, and these distances to each Nearest Neighbor (NND) are measured from the map. From the set of nearest neighbor distances, the average nearest neighbor distance is determined and we compare this average value for the observed pattern to the expected average produced from a certain distinct point distribution that hypothetically indicates a random spatial pattern, which is the average nearest neighbor distance in a random pattern [28]. These average values allow us to calculate the nearest neighbor statistic, denoted as letter R, which is defined as the ratio between the

observed and expected average nearest neighbor distances [29]. The value of R can vary between 0 and 2.15, with values close to zero indicating a clustered pattern and values close to 2.15 indicating a dispersed pattern [30]. With the assistance of this spatial statistic we can determine if some forms of human trafficking reveal patterns that are more clustered than random for any of the time periods selected for comparison.

Our nearest neighbor analysis for Minnesota reveals that the greatest clustering for any of the offenses potentially related to human trafficking is for cases that involve solicitation, inducement and promotion of prostitution. The typical individual who participates in this trade is usually a contact-driven offender and for that reason, is realistic to find in the maps various clusters of places that have transient populations, transportation hubs and corridors, and a considerable number of tourists visiting the region [8]. In line with this observation, Mletzko, Summers, and Arnio [3] multivariate regression analysis of urban sex trafficking reveals that distance to the interstate highway, number of cheaper hotels/motels, number of sexually oriented businesses, and level of concentrated disadvantage are significant predictors of this form of human trafficking.

#### VIII. THE VIRGINIA CASE

Another spatial statistic that is useful to analyze the geographic distribution of sex trafficking is the Moran I statistic. This technique has been used by Chin, Kim, Takahashi, and Wiebe [2] to examine the spatial distribution of indoor sex work in Los Angeles and Orange Counties in California, and it evaluates whether the crime pattern expressed is clustered, dispersed, or random. The rationale for this statistic is to evaluate whether the pattern expressed for each year is clustered, dispersed, or random, and is essentially a spatial autocorrelation statistic. Generally, units of analysis that exhibit positive spatial autocorrelation are termed clustered, and a Moran I spatial autocorrelation statistic value ranges from  $-1.0$  to  $+1.0$ , where positive results indicate spatial autocorrelation of a clustering nature exists [26], [27]. Due to the spatial nature of crime data used by Mletzko, Summers, and Arnio [3] in their study of urban sex trafficking, they checked for the presence of spatial autocorrelation using the Moran I coefficient and they found statistically significant clustering of census block groups with high frequency of sex trafficking offenses.

To determine if there are clusters of counties and independent cities with high prostitution arrest rates in the state of Virginia, we employed the Moran I statistic [31]. In addition, z-score values are produced by this type of spatial statistic to help analysts determine whether they can reject the possibility the distribution of counties and independent cities with high sex trafficking-related arrests rates is random. If the z-score is statistically significant and indicates a non-random distribution, it would have a value greater than 1.645 and a p-value smaller than 0.05. We examined prostitution arrests in Virginia during 2002-2013 period and found that during the years 2011, 2012, and 2013 spatial distributions were similar, with Moran's I ratios indicating patterns with statistical significance. In essence, the last three years we examined produced clustered patterns. For this period, there is a less than five percent likelihood these

clustered patterns could be the result of random chance. The Moran I coefficients for these years reflect how neighboring counties and independent cities with relatively high prostitution arrests rates are "spatially-associated" with each other. On the other hand, the first nine years exhibit patterns that do not appear to be significantly different than random. Essentially there is no spatial autocorrelation at all for this earlier time period. The Moran I coefficients for years 2011, 2012, and 2013 indicate that clusters of counties and independent cities with the highest prostitution arrest rates are those that:

- are closer to large military installations and tourism development.
- are linked to important transportation corridors.
- are not far from areas where important crime-fighting efforts, like the anti-prostitution initiatives implemented in Maryland and Washington D.C., have displaced the events.

These results concur with research connecting sexually oriented businesses with areas with high percent of male employment and the hospitality industry [2].

#### IX. CONCLUSION

Our two investigations involving the use of spatial statistics to examine sex trafficking helped us to explore patterns and answer questions regarding this form of human trafficking. In some geographic regions, the distributions of sex trafficking activities are rapidly changing; therefore, in order to understand the problem, social scientists and government agencies should consider the use of the quantitative analytical methods described above since they are very effective explaining spatial patterns. Some of the newest GIS software has been designed to include spatial statistics like the nearest neighbor index and spatial autocorrelation coefficients, and more criminologists are becoming well-versed in these techniques to deal with the ever growing demands of their work. In addition to a basic understanding of spatial statistics, collaboration between agencies with their responses to sex trafficking activity is necessary to remove institutional barriers that have compromised effective intervention to victims [7].

The importance of understanding better informed strategies for the allocation of resources and investigations of human and sex trafficking based on the use of spatial statistics cannot be overemphasized. The international community is dealing with a serious problem that requires sophisticated analytical methods. As noted earlier, over 170 countries have committed to eradicating human trafficking, and the United States particularly has given significant attention to laws, investigations, and prosecutions that assist in combating this problem. Based on reports by the United Nation, women and girls are unquestionably the primary victims of human trafficking, but researchers must go beyond pinpointing characteristics; they must understand geographic patterns of human trafficking. During the past forty years, spatial statistics have become one of the most popular inferential statistical tools used to examine the geographic patterns of crime, and can be used very effectively to assist with the investigation of human trafficking.

### CONFLICT OF INTEREST

The authors declare no conflict of interest.

### AUTHOR CONTRIBUTIONS

Jose Javier Lopez analyzed the quantitative and spatial data; Sherrise Truesdale-Moore conducted research pertinent to U.S. legislation on human trafficking and the characteristics of sex trafficking; all authors had approved the final version.

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