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Using GIS to Analyze Twenty-Two Years of Homicides from 1990 to 2012 in the State of Minnesota

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Abstract: *Crime against all classes of individuals is a serious social problem. In the United States, the percentage of total hate crimes committed against victims increased to 18.8 percent in 2009, the highest percentage in ten years. According to the Federal Bureau of Investigation, some men and women have frequently been the second most common victim of hate crime over the past decade. The purpose of this research was to provide an overview of statistical and spatial analyses of twenty-two years of homicides from 1990 to 2012 in the state of Minnesota. According to the research, approximately 90.4 percent of homicides happened between 1990 and 2001 and 9.6 percent happened between the years 2001 and 2012. The most important goal was to compare patterns of homicides through five key elements (ID of victims (groups), Race of victims, Sex of victims, Weapon used, and Cause of Death) within a geographic information system (GIS). The records of homicides in the state of Minnesota demonstrated how geographic analysis conducted within a GIS can assist in the investigation of homicide and how GIS can provide useful tools and techniques to visualize and analyze spatial data.*

Keywords: *Homicide, Crime, GIS, Existing Data Base, Density Analysis*.

Introduction

The success and development of the modern movements, which began around 1960, has not been without substantial resistance by the dominant culture in the form of violence (Drake, 2004). Homicide is causing the death of another without any excuse, reason, or explanation. The killing of one human being by another is a tragedy regardless of the status of the victim (Drake). Adding to this tragedy is social disorganization – common in many minority communities – that prevents an adequate community response in the aftermath of such death (Drake). The purpose of sex-related homicide research in general is to examine factors that have significantly increased the rate of homicide, and to detect which phase of homicide case supervision and investigation result in the best outcomes for the community and society overall (Schlesinger, 2004).

Research Topic

With technology of GIS and state records of homicide, how can statistical methods are used to enhance spatial data analysis and provide users with a set of comprehensive and valid analytical tools? This question guided research to also consider the elements of crime and how important they are to use in GIS analysis as well as examining statistics integrated with GIS to provide a better understanding of total crime.

Background

Massive amounts of resources are dedicated to the problem of reducing homicide; however, these resources are not proactive enough to reduce the rising homicide rates in the United States. Details about

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each homicide incident reported are entered into homicide databases controlled by government and law enforcement agencies. These databases contain rich data about all crime related activities, including the location, time, and descriptions of the perpetrators and victims of the crime. Esri's GIS software includes the Geostatistical Analyst extension to ArcGIS, which assists in studying spatially-referenced data. According to Drake (2004), the National Coalition of Antiviolence Programs (NCAVP) acts as the unifying voice of antiviolence programs across the United States, in part by assessing and reporting on the occurrence of homicides. This organization has the goal of supporting the development of new anti-violence organizations and programs to help communities. There are records maintained to differentiate the number of homicides; consequently, this allows researchers to trace homicides and determine possible patterns. It is necessary to remember homicide crime data varies according to its source, including how the data was collected, under what standard, and how well the persons closest to the homicide investigation reported any specific incident, based on skill, involvement, and level of training (Drake, 2004).

Methods

Existing Database

The Database is a place where organizations such as the Center for Homicide Research (CHR), Bureau of Criminal Apprehension (BCA), FBI, and Bureau of Justice Assistance (BJA) store and retrieve data. The ID of victims, victim sex, victim race, the weapon, and cause of death are the essential information included. The Database provides a collection of data related to the sexual orientation and gender of individual victims to provide datasets necessary to researchers, students, advisers, attorneys, and whoever interested in scientific-based information about victims. This database provided a location to store homicide records and data for this research. Data presented in this work were generated through information provided in this database. Also, this database encourages the collection of sexual orientation data and the analysis of data sources that have already been collected. It is imperative to understand databases such as the Database help researchers to discover more cases that are not reported to police or other governmental agencies. Lastly, when all data is gathered and becomes available from different sources, researchers have a better understanding of what investigations are possible.

Data Collection Procedure

Typically, each homicide record has a crime type and data associated with it, including the county in which the crime occurred. The ID of the homicide is an essential part of this analysis. Depending on the type of homicide, data availability varies. Race, sex, weapon, and cause of death are types of data which impact the research. For analyzing data, it is better to consider the number of homicides per county relative to population. According to Milovanovic (2006), researchers working with geographic data need at least one of the following:

1. A way to validly present a map of state data. Displaying raw counts or rates can be misleading pictures of the geographical distribution of homicide or crime.
2. Statistical methods for combining data at different resolutions.

Data used for this study were collections of crime reports gathered from different agencies such as counties, cities, CHR, BCA, FBI, and BJA. Microsoft Access and Excel were used for collecting homicide data from agencies and entering new information based on news, articles, police reports, and the Internet. For the final analysis, all data were formatted for use by statistical tools and geocoding. Google Earth and Esri's ArcMap geocoding services were used to locate address of incidents. Point features were created from addresses of victims: either where the murder occurred or the victim's physical address. Geocoded points were converted to a shapefile. Other shapefiles, such as rivers, roads, railroads, and Minnesota counties, were downloaded from the U.S. Census Bureau website for reference. Statistical Package for the Social Science (SPSS) was used for statistical exploration helping to understand high and low crime rates.

Examination of Collected Data

Based on research conducted, findings show there were 580 homicide cases within the state of Minnesota from 1990 to 2012. These 580 cases were gathered from state agencies, police reports, counties, cities, states, CHR, FBI, and BJA.

An overview of homicide locations showed where homicide was most concentrated within the state of Minnesota (Figure 1). Homicides were mainly concentrated in Hennepin, Ramsey, Anoka, and Wright counties. This increased density extended to other areas within the state where population is high, such as Olmsted and St. Louis counties.

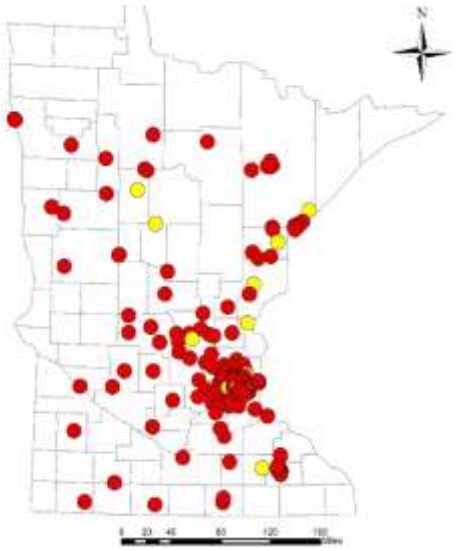

Figure (1): Overall homicide locations within the state of Minnesota

A kernel density function was performed on homicide locations to illustrate high and low rates of homicide within the state (Figure 2). Figure 2 suggests counties with higher population densities have higher numbers of homicides.

Approximately 90.4 percent of homicides happened between 1990 and 2001 and 9.6 percent happened between the years 2001 and 2012 (Table 1).

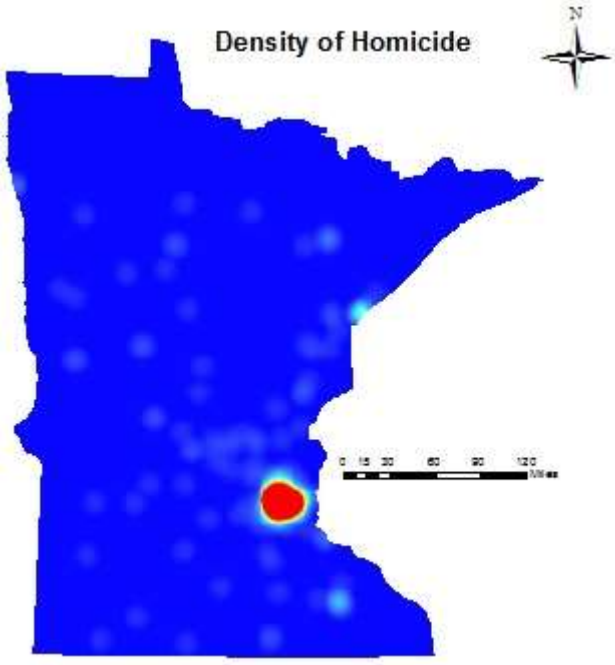

Figure (2): Homicide density analysis for groups within the state of Minnesota. Red areas indicate greater densities

Table (1): Total homicides by time period

Years	Total Number of Cases	Percentage Result
1990 - 2001	554	90.4
2001 - 2012	28	9.6
Total	580	100.0

Analysis

The goal was to compare patterns of homicides through five key elements ID, race, sex, weapon, and cause of death using GIS.

Spatial Analysis

In this study, five key elements of analysis (ID, race, sex, weapon, and cause of death) were geocoded based on the victim's address. Variables were also compared statistically and spatially based on each element separately.

Region of Homicides Analysis

Slightly more than three-quarters (75.7%) of homicides occurred in urban counties (population greater than 100,000), and 23.8 percent occurred in rural areas (Table 2). Three cases with missing records accounted for the remaining 0.5 percent of victims.

Table (2): Total homicides in urban and rural areas for victims

Area	Total Homicides in Urban and Rural Area	Percentage Result
Urban	438	75.7
Rural	142	23.8
Total	580	99.5

Maps

ID

Based on the record of victims, homicides occurred in 12 out of 87 counties: Hennepin, Sherburne, Carlton, Washington, Hubbard, Anoka, St. Louis, Pine, Cass, Olmsted, Wadena, and Dodge (yellow in Figure 3). Thirty-four additional counties were found to have homicides. Research found no homicides occurred in the remaining counties (Figure 3). Most of the homicides happened in urban areas (Figure 4). A majority of victims in urban areas compared to rural areas suggests population density remains a relevant factor with victims suggesting areas with more people provide more opportunities for crimes.

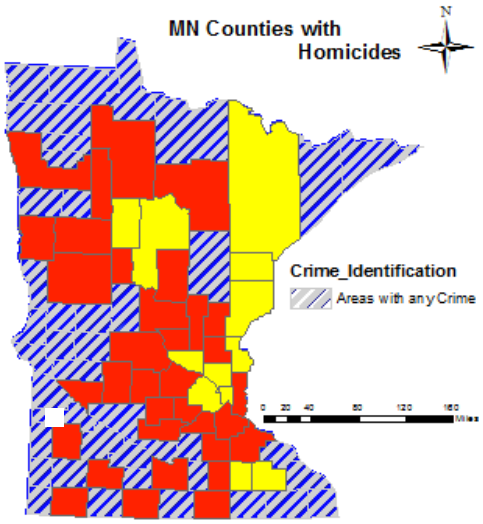

Figure (3): Homicide analysis within counties.

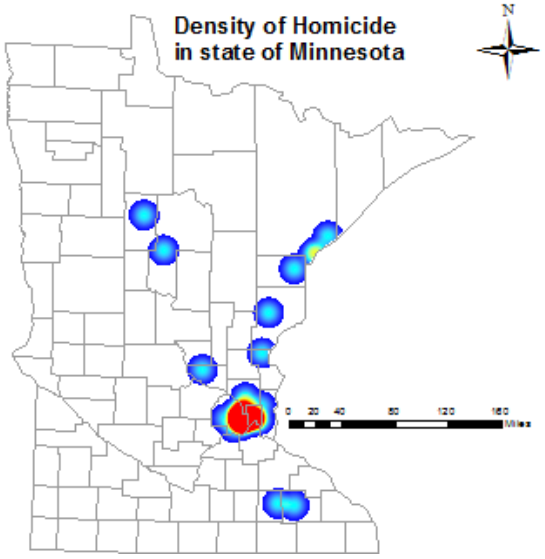

Figure (4): Homicide density depiction within the state of Minnesota. Areas of red indicate a higher density of homicides.

Victim Sex

Exploring the role of gender identity, of either the victim, the offender, or of both parties, and the specific implications related to homicide cases have become

Increasingly important in today's social climate (McClellan, 2008). Victim sex was classified into four categories within the database: male, female, transgender, and missing or unknown. Research focused on the number of males and females for homicide, because numbers in male and female victim categories were greater than transgender and missing cases categories. In addition, the number of transgender victims was not adequate for exploratory statistical analysis. There were two victims recorded as transgender and one case where the victim's sex was missing. Figure 5 shows overall victim sex results.

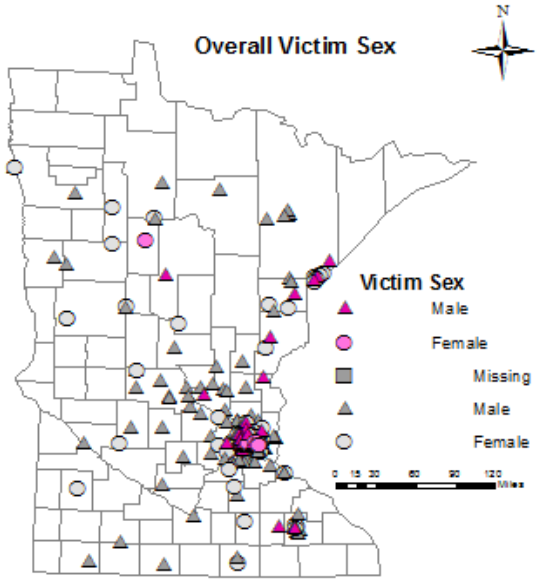

Figure (5): Victim sex for homicide throughout Minnesota.

There were 56 cases of homicide recorded. Out of the 56 cases, 50 cases were male and six cases were female (Figure 6). As illustrated in Figure 5, most victims were in urban areas. Of the six cases reported for female victims, five cases happened in urban areas and one case occurred in a rural area. Figure 7 shows that there were 522 homicides. Of the 522 homicides that occurred, 384 victims were male, 137 were female, and there was one missing or unknown case.

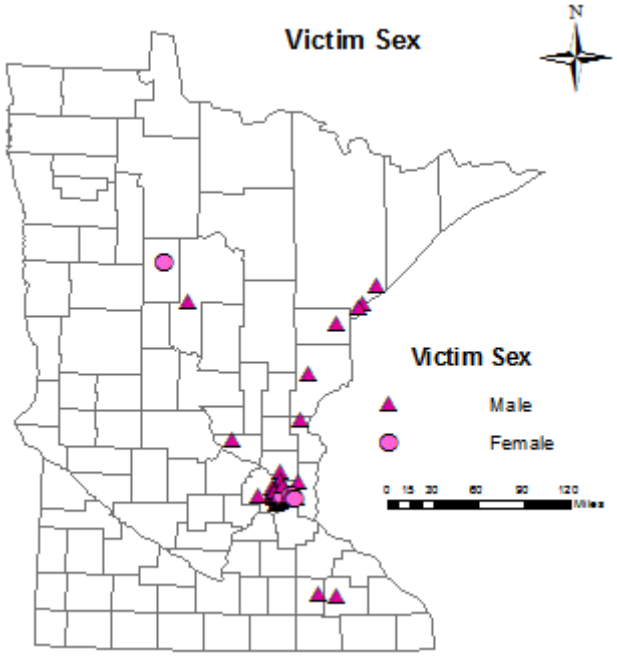

Figure (6): victim's sex within Minnesota

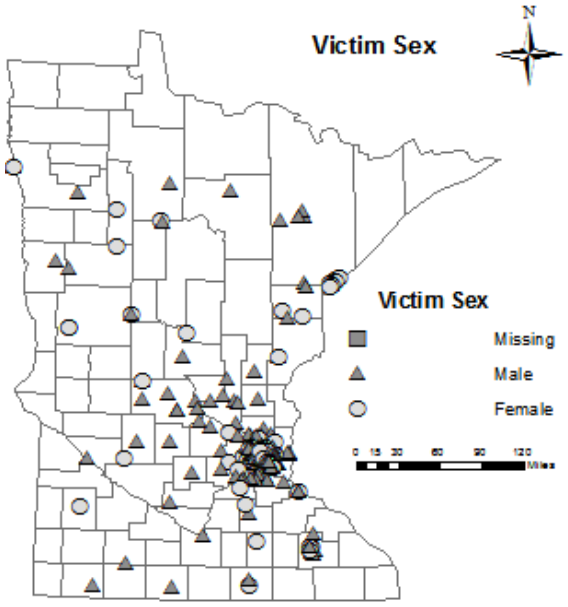

Figure (7): victim's sex within the state.

Table 3 indicates the sex of victims. Approximately 75 percent of homicide victims were males and 25 percent were females.

Table (3): Victim sex for homicide.

Victim Sex	Number of Victims	Percentage Result
Male	444	74.5
Female	133	25.0
Transgender	2	0.3
Missing	1	0.2
Total	580	100.0

Victim Race

To analyze the race of the victim, nine categories were identified: White, Black, Asian, Latino, Hispanic, Native-Alaskan, East-Indian, Unknown/Missing, and Other. Table 4 and 5 illustrate the categorization of victim race. The distribution of races according to Table 4 shows that 46.6 percent of the victims were white and 33.9 percent were black. According to Avakame (1998), findings show white individuals ages 46 to 64 were more likely than other members of the community to be the victims of personal violence. The number of victims in each racial group varied. There were 35 cases discovered among the group "Missing." These missing cases were never identified; however, they are shown on the map. Figure 8 illustrates race for victims. Thirty out of 58 victims were white and 5 victims were black. Of 522 cases, 242 victims were white, and 194 victims were black. Other races included: Asian (15), Latino (16), and Native-Alaskan (29) (Figure 9). White and those in the “missing” category of victims had the highest rates among other groups distributed throughout the state (Figure 10).

Table (4): Victim race for homicide

Victim Race	Number of Race	Percentage Result
White	272	46.6
Black	199	33.9
Native-Alaskan	31	5.0
Asian	16	3.7
Latino	16	2.7
Unknown/Missing	16	2.7
Other	6	1.0
Hispanics	3	0.5
East-Indian	2	0.4
Total	580	100.0

Table (5): Number of homicides by victim status and race

Races	Grand Total
White	272
Black	199
East-Indian	2
Hispanic	3
Latino	16
Missing	35
Native Alaskan	31
Asian	16
Other	6
Total	580

Most homicides occurred in Hennepin, Sherburne, Carlton, Washington, Hubbard, Anoka, St. Louis, Olmsted, and Dodge counties (Figure 10). Hatched orange counties contained homicides, and the remaining counties had no homicide records (no color). Whites and blacks were among the highest percentage of homicide victims compared to other races. From 1996 to 2012, approximately 62% of homicide against whites and 48% of homicide against blacks involved an offender armed with a weapon. Between 2000 and 2012 most homicides with one victim and one offender were interracial or mixed. Offenders who were intimate or sexual partners with their victim such as current or past spouses, boyfriends, or girlfriends, including same sex relationships, accounted for comparatively fewer homicides among blacks (9%) than whites (15%) from 1996 to 2005 (Drake, 2004).

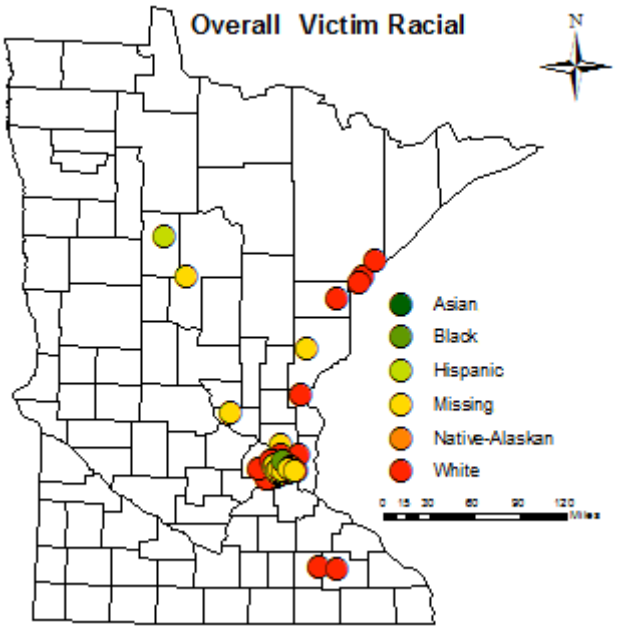

Figure (8): victim race within the state

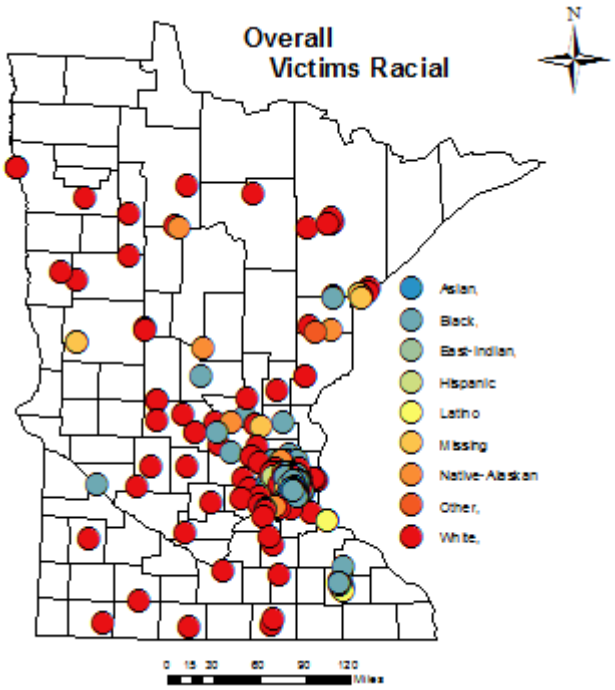

Figure (9): victim race within the state

Due to the majority of victims in the white or black race category, analysis focused on these two groups. To portray where homicide occurred for whites and blacks in Minnesota relative to overall population, the ratio per 100,000 people was determined. For instance, to determine the number of white victims relative to the overall white population, the equation used was: ([White or Non-White])/ White)*100000.

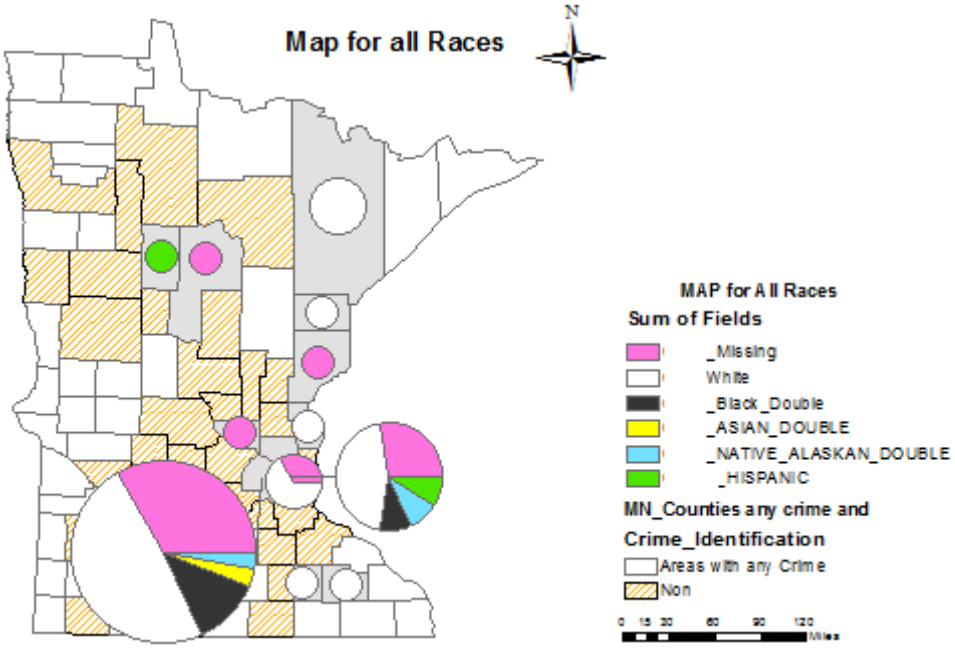

Figure (10): Victim race by county

Figure 11 and 12 show white and black to total white and black population. Highest rates of white victims (between 7 to 16 cases per 100,000) occurred within the following counties: Hennepin, Ramsey, Pine, Sibley, Kanabec, Cottonwood, Wadena, Becker, Beltrami, Clearwater, and Polk. In comparison, highest rates of black homicide victims per 100,000 black persons (12 to 16 per 100,000) occurred within the counties of Polk, Clearwater, Chisago, Dodge, and Wadena.

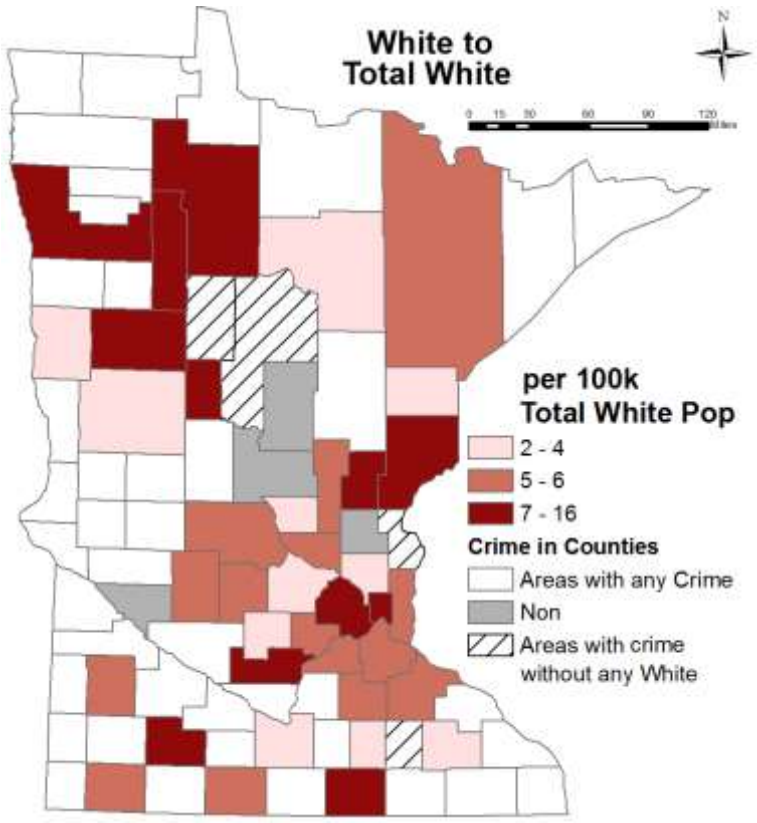

Figure (11): White victims to total white population

Less than one black homicide per 100,000 black residents occurred within Anoka and Hennepin counties (Figure 14). One to 2 cases of black homicides per 100,000 black residents occurred within Wright and Isanti counties. Two or more (up to 16 cases) of black homicides per 100,000 black residents occurred within Mille Lacs, Morrison, and Renville counties. Black homicide occurred in Dodge and Chisago counties. No white or black homicides occurred in four counties: Hubbard, Cass, Sherburne and Pine (Figure 13 and 14).

Prior analyses suggested a) the number of white/black victims per 100,000 were white/black citizens (Figure 11 and 12), and b) the number of white/black victims per 100,000 were white/black citizens (Figures 13 and 14). To compare the number of white /black and white/black victims per county, these two numbers were divided by a/b.

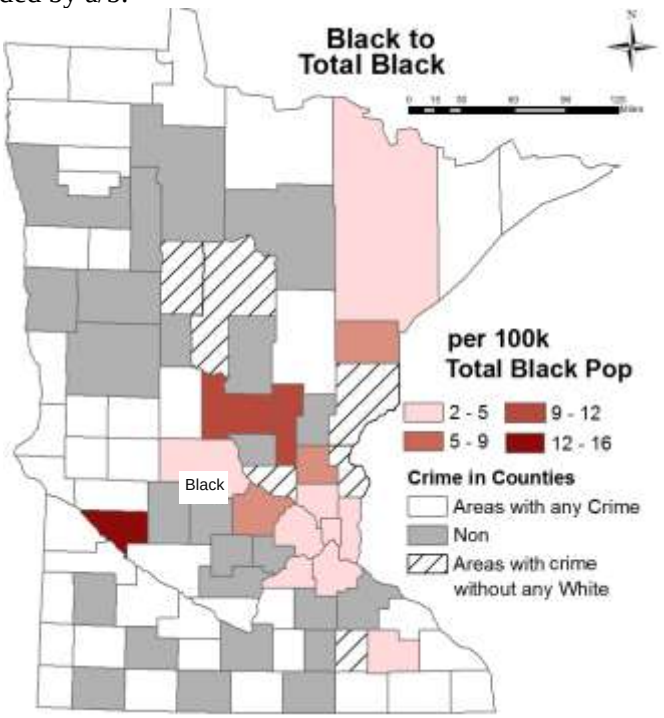

Figure (12): Black victims to total black population

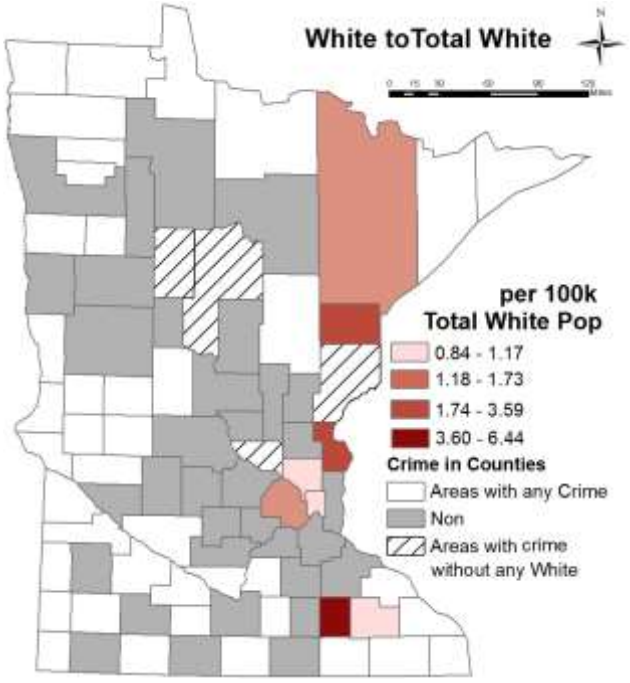

Figure (13): White victims to total white population

Figures 15 (white) and 16 (black) illustrate ratio. According to Figure 16, the ratio of white was less than one in Carlton County. There were between one and two white victims for every one victim in in Olmsted County.

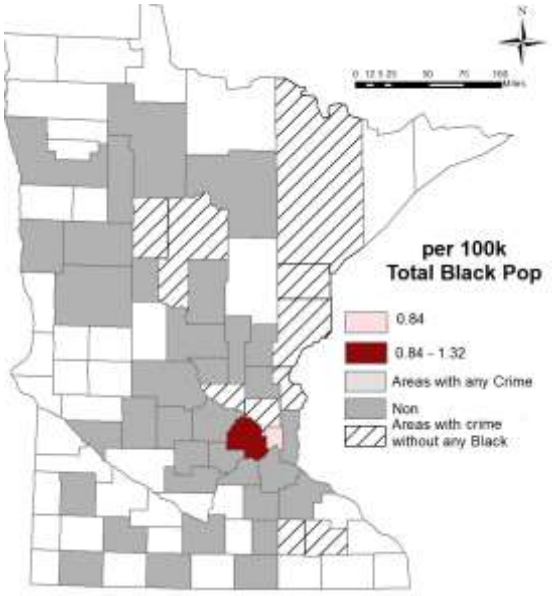

Figure (14): Black victims to total black per 100,000 population black residents of the county

A ratio of white to white between two and four occurred within St. Louis County and Anoka County. Highest ratios of white to white occurred in Hennepin County and Ramsey County. There were only two counties for which a black to black ratio could be reported since Hennepin and Ramsey were the only two counties with black victims. The ratio for Hennepin County was 31 black, and the ratio for black victims in Ramsey County was 36 to on black
(Figure 16).

Race by Region

Homicides against blacks and whites occurred in highly populated areas in Minnesota, including cities and suburbs. About half (53%) of white homicides in 2005 happened in counties with populations of at least 100,000 people. A third (33%) of black homicides occurred in counties with populations of 100,000 or greater. From 1993 to 2012, the rate of homicide victimization for both blacks and whites in rural areas were smaller than for blacks and whites in urban areas and somewhat larger than for those in suburban areas (Figure 17).

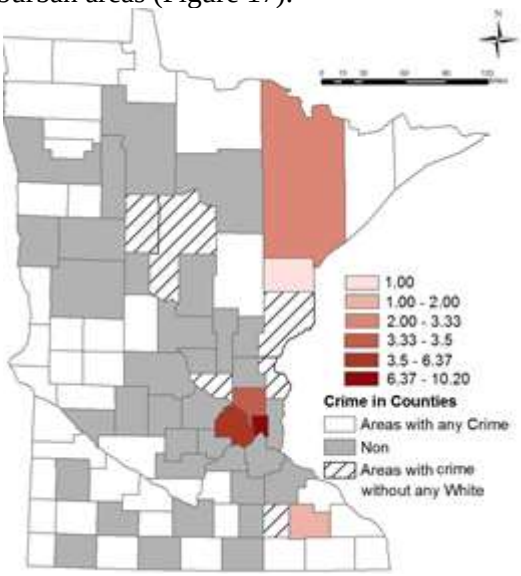

Figure (15): White homicide ratio

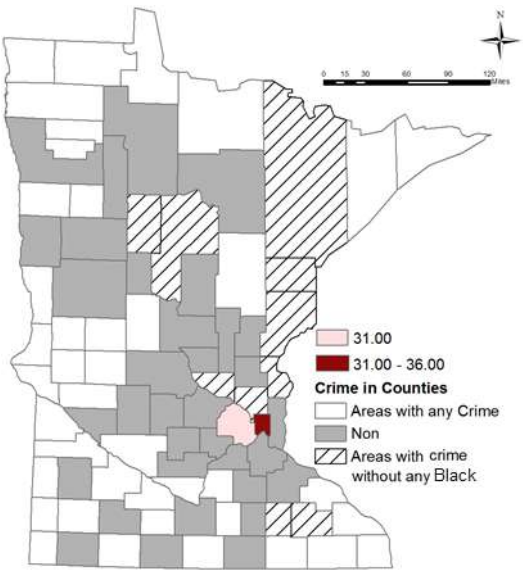

Figure (16): Black homicide ratio

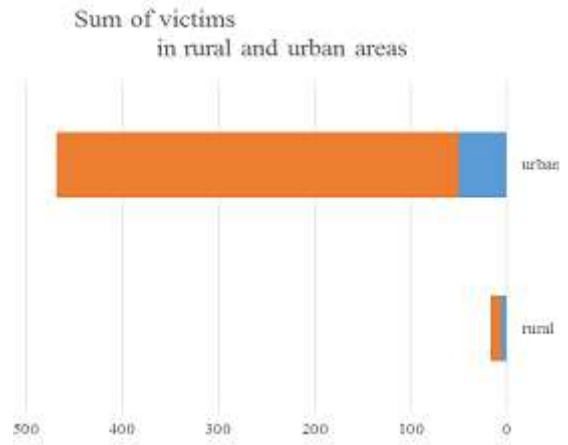

Figure (17): Sum of homicide victims in both rural (population <100,000) and urban (population => 100,000) areas

Table 6 illustrates total population in both rural and urban areas, sum of whites, sum of blacks, sum white, sum black, sum of crimes, and the percentage in rural and urban areas. Population data was collected by the Federal Bureau of Investigation and the Census Bureau. Urban was considered counties with population greater than 100,000.

Table (6): Total population and white and black victims in rural and urban areas

Measure	Rural	Urban
Total Population	221966	2158114
Total White Population	169045	1880722
White Victims	0	27
White Victims	5	172
Total Black Population	778	85971
Black Victims	0	5
Non- Black Victims	1	172
Total Homicides	17	468
Total Victims	7	51
Total Victims	5	172
Percentage of Victims	42%	11%
Percentage of Victims	59%	89%

Weapon

Between 1996 and 2005, about 35% of all homicide cases in Minnesota involved offenders with a weapon. Drake (2004) found homosexual males kill their partners more frequently than lesbians. In cases of homicide, it is more likely for the homicidal event to occur near or within the victim's domain, with men utilizing more personal, hands-on methods of death and women choosing to kill using weapons found at the scene, such as a knife (Snook, Cullen, Mokros, and Harbort, 2005). Weapons included firearms, knives, and other objects used as a weapon.

Drake (2004) found black and white victims were 80% more likely than American Indians and Hispanics to face an offender with a weapon. They were 20% more likely than Asians to confront an offender with a weapon (Drake). Blacks were murdered with firearms in approximately 77% of homicides against them in 2005, contrasted with 60% of white homicide victims (Drake). Eleven different weapon categories were analyzed, eight of which were recognizable; the other three groups of weapons were missing, other, or not found. Weapons analyzed included asphyxiation, bludgeon, and neglect, which accounted for a smaller portion of weapons compared to other categories. The most common means of killing according to results were shooting with firearm and stabbing with a knife. Table 7 summarizes the number of homicides attributed to each weapon.

Figures 18 and 19 illustrate distribution of weapon usage within the state of Minnesota for victims. The majority of homicides committed using firearms and knives occurred within the counties of Hennepin,

Ramsey, Anoka, Wright, Goodhue, Stearns, Meeker, Kandiyohi, and Chippewa. Other weapons, including blunt, bludgeon, and personal, were more prevalent in St. Louis, Carlton, Pine, Chisago, Morrison, Lyon, and McLeod counties.

Table (7): Weapons used in homicide for victims

Weapon	Frequency	Percent
Firearm	266	44.6
Knife	91	16.1
Missing	60	11.9
Personal	48	8.1
Bludgeon	47	7.9
Other	46	7.7
Not Found	9	1.5
Ligature	6	1.0
Blunt Object	4	0.7
Asphyxiation	2	0.3
Neglect	1	0.2
Total	580	100.0

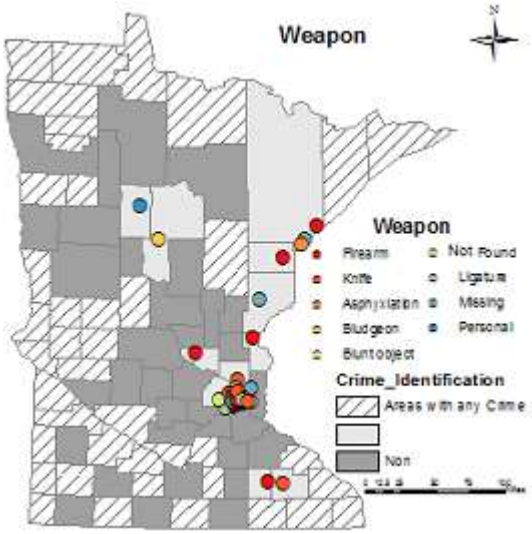

Figure (18): Weapons used for homicides

Analysis of weapons usage for the 58 victims found firearms were used in 11 cases, knife used in 15 cases, blunt object and bludgeon used in 4 cases, asphyxiation used in one case, ligature used in six cases, and ten cases where the weapon information was missing.

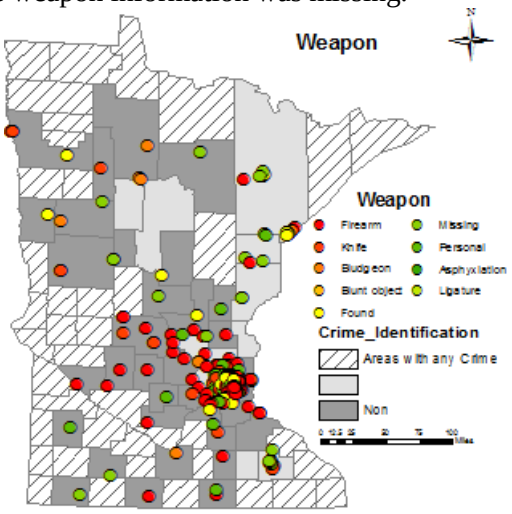

Figure (19): Weapons used in homicides

In cases with victims, firearm was used in 255 cases, knife used in 76 cases, and bludgeon used in 42 cases. In 33 cases the weapon was recorded as personal and 78 cases were missing weapon information. Figure 20 shows the comparison of weapon usage.

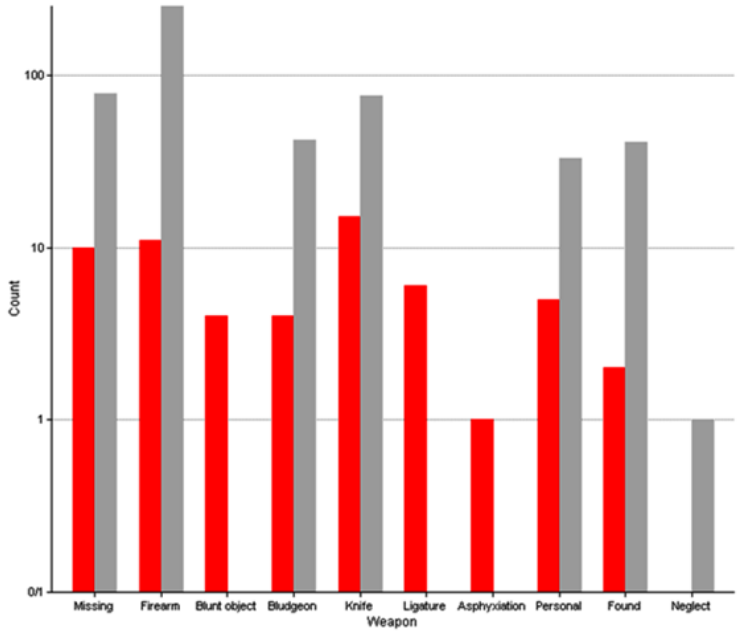

Figure (20): Weapon usage distribution. Weapon types from left to right: Missing, Firearm, Blunt object, Bludgeon, Knife, Ligature, Asphyxiation, Personal, Found, and Neglect

Cause of Death

Cause of death is the illness or detriment responsible for the deadly succession of consequences. There are several elements identified as being "typical" of a homicide, including a partially clothed or nude male victim, death occurring outside the domain of the offender, signs of overkill or arson are present but a firearm was not the cause of death, and the victim is found in a sleeping area of a home that shows no signs of forced entry (Drake, 2004).

According to the Messner (1999), in 2010, homicide was the 5th major cause of death for individuals in the state of Minnesota; guns accounted for 70 percent of those deaths. Between the years 1996 to 2010 in Minnesota, one of the most common causes of death for people was homicide, and 83 percent of those homicides were committed with a gun (Drake, 2004). Eight different causes of deaths were analyzed for victims (Table 8).

Table (8): Cause of death for victims.

Cause of Death (COD)	Number of Victims	Percentage
Shot	283	53.0
Cut-Slashed	113	16.8
Bludgeoned	74	12.4
Other, Undetermined	56	9.4
Strangled	26	4.4
Stabbed, Beaten	25	3.5
Asphyxiation	2	0.3
Drowned	1	0.2
Total	580	100

Figure 22 depicts cause of death throughout the state of Minnesota. Of the 58 cases, 23 victims were killed as a result of being cut-slashed, 11 victims were killed as a result of a shooting, and 8 cases were undetermined. Beaten, bludgeon, asphyxiation, and drowned were other causes of death, listed in order of frequency. Out of 522 cases of victims, 257 victims were shot, 79 victims were killed as a result of cut-slashed, and 68 victims had an undetermined cause of death. Asphyxiation, strangled, beaten and other were also recorded (Figure 22).

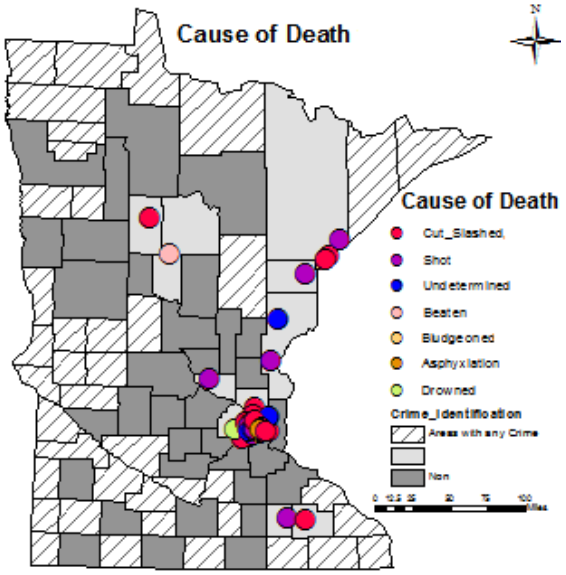

Figure (22): Cause of death for homicides

Figure 23 illustrates cause of death among victims. As seen in Figure 23 and Table 8, the majority of victims were killed as a result of being shot.

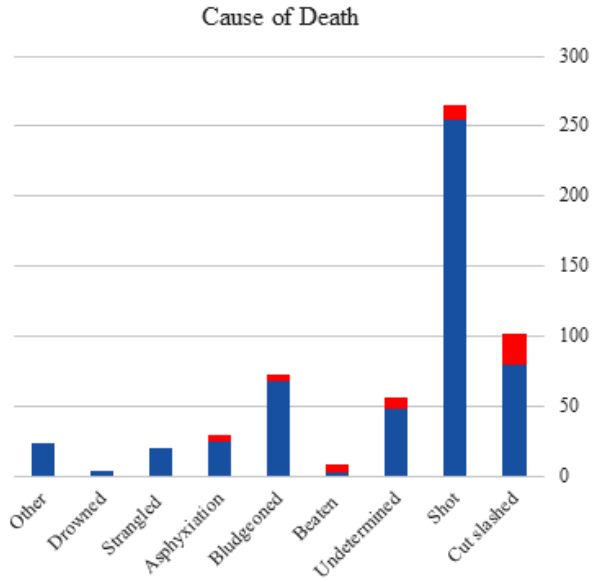

Figure (23): Cause of death for homicide victims

White Race, Firearm, and Knife Analysis

White race and firearm were among the highest percentage in each of their categories. White victims and firearm weapons were analyzed in more depth due to their prevalence in the results. Firearm weapons, and the associated cause of death (shot), had the highest percentage in its category. 266 victims were shot. Of the 266 cases were victims. Two counties, Hennepin and Ramsey, were selected for additional analysis due to their population and concentration of homicide.

Two objectives were identified for further investigation: first, to determine the total number of white victims who were killed by firearms and knives and second, to analyze the number of white victims killed in Hennepin and Ramsey County compared to other counties. Figure 24 illustrates the number of white a victims killed in Minnesota, including 7 cases of white victims killed by firearms and 88 cases of white victims killed by firearms. Of the 7 white victim cases, 3 were killed as a result of firearm in Hennepin County and the other four victims were killed by firearm in St. Louis, Chisago, Dodge, and

Carlton counties. In comparison, the majority of homicides with white victims killed by firearms occurred in Hennepin, Ramsey, Dakota, Anoka, Sherburne, Washington, and Stearns counties (Figure 25). Despite its overall population, no white victims were killed by firearms in Olmsted County.

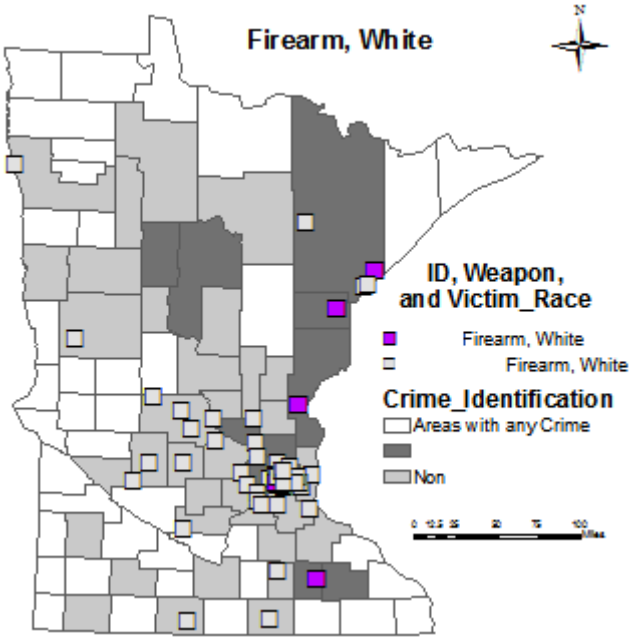

Figure (24): White homicide victims killed by firearm

Another analysis was conducted regarding the relationship between white victims and the weapon of knife. Knife placed second after firearm in the weapon category.

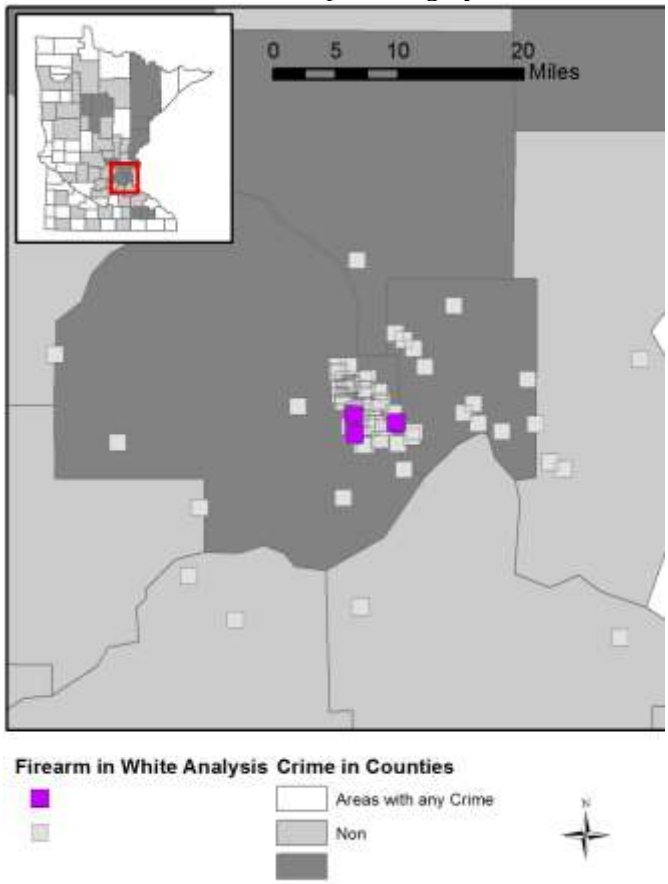

Figure (25): The comparison of white homicide victims killed by firearms in Hennepin and Ramsey counties

Figure 26 depicts the 91 white victim locations. One case occurred in Olmsted County. Of 39 cases of white victims, 11 cases occurred in Hennepin County, 15 cases in Ramsey County, 4 cases in Dakota County, and 2 cases each in Anoka, Polk and Stearns counties. Only 1 case occurred within Olmstead, Carver, Rice, Clearwater, and Goodhue counties. Of the 91 victims killed using a knife, 48 victims were white. Of these 48 cases, 39 cases were white victims and the other 9 victims were white. Figure 27 illustrates those 8 out of 9 cases of white victims occurred in Hennepin County.

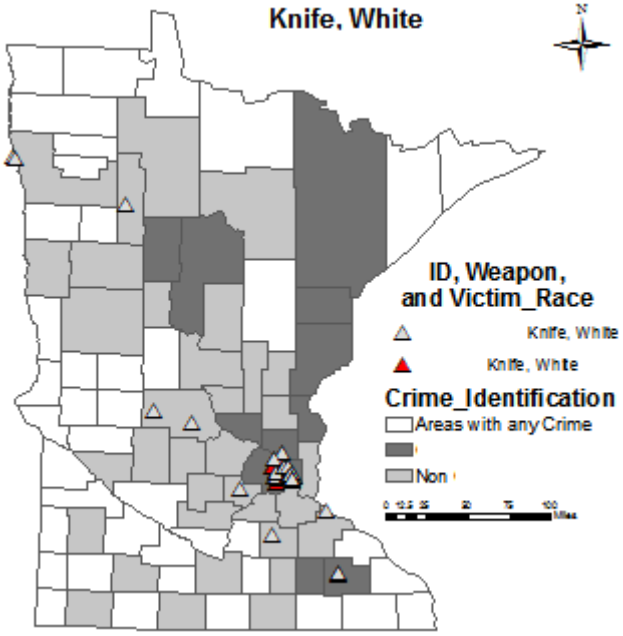

Figure (26): White homicide victims killed by knife

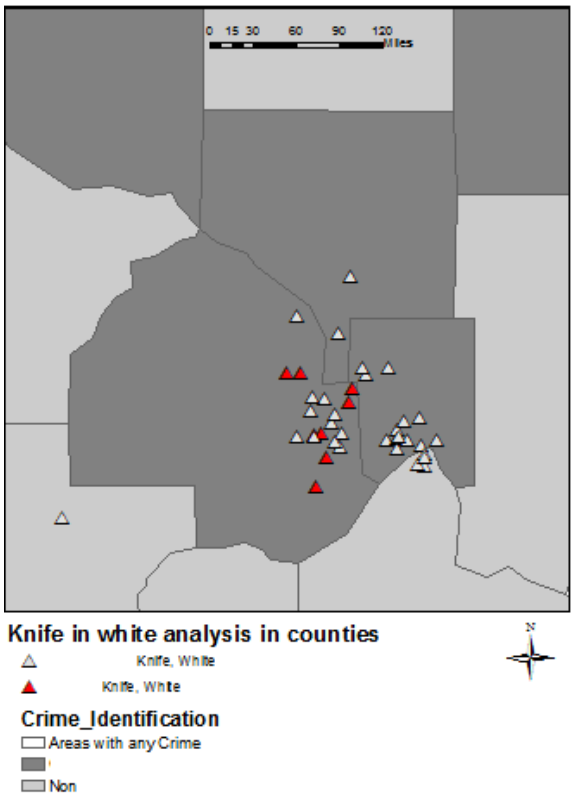

Figure (27): The comparison of white homicide victims by knife in Hennepin and Ramsey counties

Discussion

The study of crime and law enforcement determine long-term patterns of activity and assist in problem solving as well as research and evaluation of responses and procedures. One of the most vital factors of analyzing homicide is to precisely acknowledge and mark cases. Law enforcement officials frequently do not investigate or document the sexual tendency of victims or offenders. The main purpose of recording identification is to facilitate research of this sub-category of homicide. For this study, each key element (ID, race, sex, weapon, and cause of death) was analyzed to identify patterns and trends, including which weapon was most used and which race were the majority of victims.

These findings could be of interest for the families of victims, states, counties, and areas with high rates of homicide. Descriptive studies such as this one may help organizations such as police departments, counties, states, and FBI to plan for a better and comprehensive plan to better understand the nature of these types of crimes.

Suggestions for Future Study

Obtaining more information on the human ecology, human psychology, and sociology of populations, social functions, distribution, etc., would allow future researchers to establish a multistage spatial analysis involving proximity, density, and distance between the occurrences of the crime. It might portray a clearer correlation between crime and place and would examine and expand the outcomes of this study. Statistical analysis techniques such as regression and correlation analysis may allow researchers to better predict crime likelihood and crime patterns with a larger analysis. Illustrating the variation of crime over time would also assist researchers in evolving and testing their hypotheses for better crime reduction strategies.

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