

International Journal of Criminal Justice

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Effect of marijuana legalization policies on youth marijuana use: A logistic model comparison analysis of demographic characteristics

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Abstract

During the last two decades, many U.S. states have legalized marijuana use, and the effect of this policy on youth marijuana use has emerged as a critical concern for policymakers and academic studies. However, the empirical findings from previous studies are not consistent and even conflict with each other. This study hypothesizes that these discrepancies should be caused by demographic differences in youth marijuana use. For the data analysis, we employed nationally representative survey data, “Continuing Study of American Youth - 12th-Grade Survey,” from 2012 to 2020 and examined the temporal changes in youth marijuana use by gender and race groups. We also introduced logistic regressions to clarify the effect of legalization after controlling for personal and contextual characteristics. The results show that as more states have legalized recreational marijuana, marijuana use among female youths has increased significantly, while that of males has not changed. Recreational marijuana use also positively influences white and black youths; however, its impact on Hispanic youths is negative. With these findings, we conclude that different attitudes, perceptions, and circumstances should cause distinctive

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Received 5 July 2023; Revised 9 December 2023; Accepted 20 December 2023

INTERNATIONAL JOURNAL OF CRIMINAL JUSTICE, Vol. 5 Issue 2, December 2023, 3-27

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effects of marijuana legalization across gender and race groups. Future studies should consider these demographic differences in youth marijuana use for more effective intervention efforts.

Keywords: Recreational Marijuana Legalization, Youth Marijuana Use, Gender Difference, Racial Difference

Introduction

Over the last two decades, state legislatures have rapidly changed the legal aspect of medical and recreational marijuana consumption in the U.S. (Carnevale et al., 2017; Hinckley et al., 2022; O'Grady et al., 2022). As of July 2022, 18 states and the District of Columbia fully legalized both medical and recreational marijuana use, and the other 21 states have legally allowed the use of marijuana for medical purposes. Currently, only eleven states entirely prohibit marijuana consumption; however, eight of these states have initiated low-dose Cannabidiol (CBD) oil or Tetrahydrocannabinol (THC) use programs, leaving only three states without any public marijuana access (DISA, 2022). In sum, more than 40% of the American population resides in areas where both recreational and medical marijuana is publicly available, and an additional 36% have legal access to medical marijuana use, while marijuana is still classified as a Schedule I controlled substance¹ at the federal level (Carnevale et al., 2017; DEA, 2022).

One of the most critical concerns about this lawful availability of marijuana is the increase in youth marijuana use. (Lachance et al., 2022; O'Grady et al., 2022). Studies on marijuana consumption effect have revealed that early marijuana use is significantly associated with anti-social behaviors, lower academic achievement, and later involvement in other illegal drugs (Lynskey & Hall, 2000; Meier et al., 2015; Schaefer et al., 2021; Silins et al., 2014). For instance, Silins and colleagues (2014) have found that those who use marijuana daily before 17 retain significantly lower odds of high school completion and degree attainment while showing substantially higher odds of marijuana dependence, use of other illicit drugs, and suicide attempts. One recent study also showed that youths with heavy marijuana use retained unbalanced brain development, disrupted brain functions, and decreased intelligence functioning and IQ compared to those who do not consume marijuana (Lees et al., 2021). Therefore, it is crucial to examine and understand the effect of marijuana legalization on youth marijuana use.

1 Substances that are not currently accepted for medical use and retain a high potential for abuse (DEA, 2022)

While many empirical studies have investigated this research question, their findings are not coherent and even conflict with each other (Lachance et al., 2022; O’Grady et al., 2022). In their meta-analysis of 32 academic studies (11 higher quality and 21 lower quality), Lachance and colleagues (2021) revealed that 40% of higher-quality studies presented an increase in youth/young adult marijuana use after legalization, while 55% did not report any change, and 5% reported a decrease. Another systematic review study examined 22 research articles on youth marijuana use after legalization and presented that seven studies identified an increase, ten found no change, and six reported a decrease (O’Grady et al., 2022).

The current study posits that these inconsistent findings should partially originate from distinctive marijuana use patterns across gender and race groups after marijuana legalization. Previous studies revealed that males and females, as well as different racial groups, retained significantly disparate behaviors, perceptions, and attitudes to marijuana use (Assari et al., 2019; Goncy & Mrug, 2013; Lac et al., 2011; Preston, 2006; Wallace et al., 2003). Therefore, different gender and race youth groups should experience the distinct effect of recreational marijuana legalization. However, the differentiating impact of marijuana legalization on youth marijuana use by gender and race has not been thoroughly examined in previous studies. This study intends to fill this gap by analyzing the representative youth survey data, the Monitoring the Future: A Continuing Study of American Youth (12-Grade Survey), from 2012 to 2020 with logistic model comparison analyses by gender and race groups. The findings and implications of this study, as well as limitations, are discussed for future studies.

Legalization Effect on Youth Marijuana Use

Theoretical Framework

As for the causal link between marijuana legalization and youth marijuana consumption, studies have presented two types of theoretical frameworks: (1) the increase in availability and accessibility and (2) the

change in youth attitude and risk perception (Lachance et al., 2022; Ousey & Maume, 1997). The argument about the increase in availability and accessibility posits that recreational marijuana legalization should enhance the availability and accessibility of marijuana products to youths even though it is still illegal for them to purchase or consume marijuana products (Lachance et al., 2022). The theoretical notion of “availability” indicates that marijuana is available in more diverse forms so that youths can consume marijuana products conveniently. The theoretical concept of “accessibility” means that marijuana products are more accessible at many locations; therefore, youths can obtain these products in an easier manner. Studies on youth cigarette and alcohol consumption have already proved that the density and proximity of retailers significantly impact youth consumption (Campbell et al., 2009; Henriksen et al., 2008). In the same vein, it is hypothesized that the availability of legal retailers of marijuana products should positively influence youth marijuana consumption (Orenstein, 2021). Furthermore, the availability of marijuana in diverse forms should also increase youth accessibility to marijuana products (Lachance et al., 2022). For example, recreational marijuana legalization has allowed various forms of marijuana products, such as edibles, drinkables, and vapes (Borodovsky et al., 2016). Some companies have introduced marijuana gummies, chocolate bars, and snacks, which should be more familiar to youths (Barker, 2022). These various forms should elevate youth accessibility to marijuana products and increase youth marijuana consumption (Lachance et al., 2022).

The other theoretical argument about marijuana legalization’s effect on youth consumption is the change in youth attitude and risk perception (Brooks-Russell et al., 2019; Danseco et al., 1999; Hughes et al., 2016; Keyes et al., 2016; Lachance et al., 2022). Studies have revealed that attitude and risk perception of marijuana use are significantly associated with marijuana consumption (Danseco et al., 1999; Hughes et al., 2016; Keyes et al., 2016). Based on these findings, studies have theorized that marijuana legalization normalizes marijuana use for youths and lowers their risk perception, as observed in cigarette and alcohol consumption (Fries & Grube, 2013; Khatapoush & Hallfors, 2004). Correspondingly, studies have posited that marijuana legalization policies should alleviate youth’s negative attitude and

risk perception, which, in turn, increase their use of marijuana. While some studies have found that medical marijuana legalization does not influence youth attitudes and perceptions (i.e., Friese & Grube, 2013; Khatapoush & Hallfors, 2004), other studies have empirically supported this theoretical argument (Danseco et al., 1999; Hughes et al., 2016; Keyes et al., 2016).

Gender Variation in Legalization Effect

Despite inconsistent findings across studies on the marijuana legalization effect on youths, one noteworthy and consistent finding is that the legalization policy has significantly increased females' marijuana consumption (Bae & Kerr, 2020; Brooks-Russell et al., 2019; Doran et al., 2021; Lachance et al., 2022; Miller et al., 2017; Paschall et al., 2021). In their analysis of National College Health Assessment Survey data, Bae and Kerr (2020) revealed that recreational marijuana legalization significantly impacted female students. Brooks-Russell and colleagues (2019) also examined youths' perceptions and use of marijuana and found a significant increase in marijuana use among female students, while male students reported a decrease. Through analyzing three-year panel data surveying 563 young adults in California, Doran and colleagues (2021) also showed that women reported increasing use of marijuana following legalization, but men reported a decrease. As for the theoretical explanation of these disparities between male and female youths, studies have suggested that the emergence of new marijuana products, such as candy bars, gummies, and chocolate snacks, should attract more diverse consumers, including female youths (Lachance et al., 2022). In general, women perceived a higher risk of using marijuana and consumed marijuana less than men (Park et al., 2022). However, these new types of marijuana products should reduce women's disapproval of marijuana use. Therefore, the effect of these marijuana products should be differentiated by gender in terms of intensity and psychoactive effect (Lachance et al., 2022).

Racial Variation in Legalization Effect

Contrary to the findings about gender disparities, studies on racial disparities have presented inconsistent effects of marijuana legalization. Some studies have found no significant difference across racial groups (Brooks-Russell et al., 2019), other studies have revealed a significant increase in Black and Hispanic racial groups (Miller et al., 2017), and other studies have presented the higher odds of using marijuana in White youths (Coley et al., 2021; Paschall et al., 2021). For example, Miller and colleagues (2017) analyzed the marijuana consumption of college students before and after recreational marijuana legalization and found that there is a relatively large increase in the likelihood of marijuana use for black and Hispanic students. In their study, the likelihood of marijuana use among Black and Hispanic students increased by 15.8 and 14 percentage points after legalization, respectively. This change represents an 88-percent increase in recent users for Black students and a 93-percent increase for Hispanic students (Miller et al., 2017). On the contrary, Paschall and colleagues (2021) analyzed the California Healthy Kids Survey from 2010–2011 to 2018–2019 and found a strong positive effect of recreational marijuana legalization on the marijuana use frequency of white students compared to other minority groups.

Hypotheses of Current Study

Based on these findings from previous studies, the current study hypothesizes that the effects of recreational marijuana legalization should show different temporal trajectories between gender and race groups. More specifically, this study intends to examine the following hypotheses.

1. As more states legalize the recreational use of marijuana, female youths show different trajectories of marijuana consumption from males after controlling for the change in their personal and contextual characteristics.
2. As more states legalize the recreational use of marijuana, African American youths show different trajectories of marijuana consumption from Whites after controlling for the change in their personal and contextual

characteristics.

3. As more states legalize the recreational use of marijuana, Hispanic youths show different trajectories of marijuana consumption from Whites after controlling for the change in their personal and contextual characteristics.

Methods

Data

For the examination of the proposed hypotheses, this study employs nine-year survey datasets, “Monitoring the Future: A Continuing Study of American Youth - 12th-Grade Survey (MFCSAY)” from 2012 to 2020. This MFCSAY survey is conducted by the Institute for Social Research at the University of Michigan and supported by the National Institute on Drug Abuse. Since 1975, this nationwide representative survey has investigated the trends of American youths’ illegal drug use and their perception of the drug use risk annually (Miech et al., 2020; Park, 2022). For the sampling process, the MFCSAY study selected geographical areas from the Sampling Section of the Survey Research Center and identified high schools in the selected geographical regions (Park, 2022). Individual senior students from the identified high schools are randomly selected and surveyed for their experience of illegal drugs, as well as their school experience and demographic backgrounds (Miech et al., 2020). We employed the MFCSAY datasets because these datasets provide nationally representative information about youth marijuana use by gender and race groups.

Variables

Marijuana Use. For the measurement of the main dependent variable, *youth marijuana use*, this study employs an MFCSAY survey question, “how many occasions (if any) have you used marijuana (grass, pot) or hashish (hash, hash oil) during the last 12 months?” Respondents were given choices of “(1)

0 occasions, (2) 1 – 2 times, (3) 3 – 5 times, (4) 6 – 9 times, (5) 10 – 19 times, (6) 20 to 39 times, and (7) 40 times or more.” For the purpose of analysis, this study dichotomizes these choices into a binary variable, such as (1) the respondent did not use marijuana during the last 12 months and (2) the respondent used marijuana during the last 12 months (= non-reference category) and introduces this variable into logistic regression. Therefore, the dependent variable in this study should indicate the likelihood of using marijuana.

Marijuana Legalization. To examine the effect of recreational marijuana legalization, this study operationalizes a variable, *Marijuana Legalization*, as the cumulative number of states that have legalized recreational marijuana each year from 2012 to 2020. Table 1 shows the list and the number of states in the U.S. that have legalized recreational marijuana from 2012 to 2020. When there is a time gap of more than a year between the enactment of legalization and the actual sales of recreational marijuana, this study introduces the year of the actual sales for the standard of recreational marijuana legalization. For example, The State of Vermont enacted the legalization of recreational marijuana in 2018; however, the sales of recreational marijuana are still illegal due to the absence of an administrative regulation process. The District of Columbia also legalized recreational marijuana in 2014; however, the sales of recreational marijuana are not legally allowed as of July 2022 because politicians prevent the District of Columbia from establishing an independent regulatory board. Therefore, the State of Vermont and the District of Columbia are excluded from the measurement of recreational marijuana legalization in this study.

Table 1. The List and Number of States Legalizing Recreational Marijuana (2012 – 2020)

Year	State	Number of States	Cumulative Number
2012		0	0
2013		0	0
2014	Colorado, Washington	2	2
2015	Oregon	1	3

Year	State	Number of States	Cumulative Number
2016	Alaska	1	4
2017	Nevada	1	5
2018	California, Massachusetts	2	7
2019	Michigan	1	8
2020	Illinois, Maine	2	10

Parental Control. Studies have revealed that youths are more likely to use marijuana when they perceive a lower level of parental control (Caldwell & Darling, 1999; Lac & Crano, 2009). For example, in their meta-analysis of 17 empirical studies, Lac and Crano (2009) found that the level of parental monitoring retained a significant negative effect on youth marijuana use. To reflect this finding in the analysis, the current study identified whether or not respondents lived with their father and/or mother with the questions in the MFCSAY survey. The variable, Parental Control, is coded as (1) 0 = living with no parent, (2) 1 = living with one parent, and (3) 2 = living with both parents. This study hypothesizes that youths living with more parents should be under a higher level of parental control.

Socio-economic Status. Socio-economic status has also been presented as a significant determinant of youth marijuana use in previous studies (Lemstra et al., 2008; Miller & Miller, 1997). In addition, Clendennen et al. (2021) revealed that the change of socio-economic change during the COVID-19 pandemic era significantly influenced youth marijuana use, and other studies argued that youth socio-economic status could be a possible confounding factor in the effect of marijuana legalization (Rogeberg, 2013). However, the employed data in this study, the MFCSAY survey, did not directly investigate the socio-economic statuses of respondents. Therefore, this study introduces a proxy measure of the variable, *Socio-Economic Status*, as the education levels of both parents. The MFCSAY survey included two questions, “What is the highest level of schooling your father/mother completed?” and provided choices of (1) 1 = Grade School, (2) 2 = Some Highschool, (3) 3 = Highschool Graduation, (4) 4 = Some College, (5) 5 = College Graduation, (6) 6 = Graduate School. This study adds both parents’

education levels and introduces the variable *Socio-Economic Status*.

Delinquency. Since the earlier studies, delinquent behaviors have been found to be significantly associated with youth marijuana use (D'Amico et al., 2008; Dembo et al., 1992; Huizinga & Elliott, 1981; Lynskey & Hall, 2000). To control for the effect of youth delinquency on marijuana use, the current study employs one proxy question from the MFCSAY survey, "During the last four weeks, how many whole days of school have you missed because you skipped or "cut"?" Respondents were given seven choices such as (1) 1 = None, (2) 2 = 1 day, (3) 3 = 2 days, (4) 4 = 3 days, (5) 5 = 4-5 days, (6) 6 = 6-10 days, (7) 7 = 11+ days. This study hypothesizes that the more students have missed school due to skipping or cutting, the more likely they are to be involved in delinquent behaviors (Yukse & Solakoglu, 2016).

School Achievement. Studies have shown that students' achievements at school are significantly related to their marijuana use (Meier et al., 2015; Silins et al., 2014). To consider the association between school achievement and marijuana use, the current study employs the question about respondents' grades at school. Respondents are given choices from D (= 1) to A (= 9) with nine categories; therefore, the higher value indicates better school achievement.

Demographic Variable. Two demographic characteristics of youths are introduced to examine the main research hypotheses in this study: gender and race. The gender of each youth is measured as a dichotomized variable (1 = Male), and the race is operationalized into three categories: white, black, and Hispanic. For the purpose of analysis, the *Race* variable is recoded into two dummy variables (0 = white). Table 2 shows descriptive statistics of all the variables in the current study, and Table 3 presents the gender and race frequency distribution.

Table 2. Descriptive Statistics of Variables

Variable	Valid N	Freq.	%	Mean	SD.
Marijuana Use (1 = Yes)	105,943	38,898	34.6		
Legalization	112,375			3.86	2.99
Parental Control	106,134			1.61	0.60
Socio-economic Status	94,500			7.93	2.46

Variable	Valid N	Freq.	%	Mean	SD.
Delinquency	100,359			1.69	1.30
School Achievement	103,805			6.68	1.89
Gender (1 = Male)	102,790	50,262	48.9		
Race	89,406				
White		57,684	51.3		
Blck		12,420	11.1		
Hispanic		19,302	17.2		

Table 3. Gender and Race Frequency Distribution

	White		Black		Hispanic		Total
	Freq.	%*	Freq.	%*	Freq.	%*	
Female	28,072	50.1/63.9	6,165	53.1/14.0	9,663	52.3/22.0	43,900
Male	27,914	49.9/66.2	5,454	46.9/12.9	8,799	47.7/20.9	42,167
Total	55,986	/65.0	11,619	/13.5	18,462	/21.5	86,097

* Column % / Row%

Analytical Plan

To clarify gender and racial disparities in the effect of recreational marijuana legalization on youth marijuana use, the current study employs logit-based logistic regression with model comparison approaches. In the first stage, this study conducts separate logistic analyses for each gender, race, and gender x race group and compares results to each other. In the second stage, this study runs the same analysis with the whole sample and compares it with the results from each group.

Results

Gender Variation in Youth Marijuana Use

First, this study has examined the annual changes in the numbers of marijuana-using youths by gender from 2012 to 2020 and presented the results in Table 3. Overall, the average number of marijuana-using youths is higher

for males (38.3) than for females (34.6). However, the temporal distributions show that the difference between males and females gets smaller as more and more states have legalized recreational marijuana. For example, the percentile differences between females and males are 32.7 vs. 41.2 in 2012 and 32.9 vs. 40.1 in 2013 when no state sold marijuana legally. But, these notable differences became 36.4 vs. 36.8 in 2019 and 35.3 vs. 36.4 in 2020 when around 20% of states sold marijuana legally. These descriptive findings indicate that the number of marijuana-using female youths has increased as more states legalize recreational marijuana use, while that of male youths decreases. Furthermore, the result from the Chi-square tests shows that these discrepant distributions are significant ($p < .001$).

Table 4. Annual Change in Marijuana-using Youths by Gender from 2012 to 2020

		2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Female	N	2,156	1,984	2,080	2,141	1,844	2,255	2,286	2,321	660	17,727
	%	32.7	32.9	34.1	34.4	33.7	37.0	35.5	36.4	35.3	34.6
Male	N	2,721	2,381	2,178	2,159	2,041	2,165	2,159	2,181	604	18,628
	%	41.2	40.1	38.7	37.2	37.0	37.9	37.8	36.8	36.4	38.3

Chi-square = 101.867 ($p < 0.000$)

In the second step, this study runs the full model by introducing the gender variable in the model. This model examines the effect of recreational marijuana legalization while controlling for the average difference between the two genders. The result from this full model analysis is presented in Table 4. The results from this analysis show that recreational marijuana legalization significantly increases the likelihood of youth marijuana use after controlling for gender differences ($b = 0.009$, $p < .01$). The gender difference in the likelihood of using marijuana is also significant ($p < 0.01$), and the slope of .111 indicates male youths retain the higher log odds of using marijuana by .111.

Table 5. Full Logistic Regression Analysis of Marijuana Use (N = 105,943)

	B	S.E.	Exp(B)
Legalization	.009**	.003	1.009
P. Control	-.221**	.015	.802
SES	.028**	.004	1.028
Delinquency	.322**	.007	1.380
Achievement	-.178**	.005	.837
Gender (1 = Male)	.111**	.017	1.118
Black	-.208**	.027	.812
Hispanic	-.179**	.024	.836
Nagelkerke R ²		0.097	

*p < .05. **p < .01

In the third step, the current study has run separate logistic regressions for male and female youths and examined the effect of legalization after controlling for individual characteristics. The findings from these analyses are presented in Table 5. These analyses have shown that recreational marijuana legalization significantly impacts female youth marijuana use positively ($b = 0.274$, $p < 0.01$), while it is not significant for males ($b = -.010$, $p > .05$). The exponential b value of female marijuana use (1.029) indicates that as one state legalizes recreational marijuana, the odds ratio of female marijuana use increases by 1.029. Besides this difference, the effects of other explanatory variables are consistent between male and female youths. Both genders are less likely to use marijuana as parental control and school achievement increase and more likely to consume when socio-economic status and delinquency involvement escalate. For the analysis of racial differences, both genders show that black and Hispanic youths are significantly less likely to use marijuana than white.

Table 6. Logistic Regression of Marijuana Use by Gender

	Female (N = 52,528)			Male (N = 50,262)		
	B	S.E.	Exp(B)	B	S.E.	Exp(B)
Legalization	.274**	.028	1.029	-.010	.004	.990
Parental Control	-.277**	.021	.758	-.162**	.022	.857
SES	.031**	.005	1.031	.025**	.005	1.026
Delinquency	.324**	.009	1.383	.320**	.010	1.377

	Female (N = 52,528)			Male (N = 50,262)		
	B	S.E.	Exp(B)	B	S.E.	Exp(B)
Achievement	-.192**	.007	.826	-.168**	.006	.846
Black	-.274**	.038	.761	-.139**	.039	.870
Hispanic	-.253**	.033	.777	-.104*	.033	.902
Nagelkerke R ²		0.100			0.089	

*p < .05. **p < .01

Racial Variation in Youth Marijuana Use

For the analysis of racial variation, this study has examined the annual changes in youth marijuana use by race from 2012 to 2020. The result from this analysis is presented in Table 6. As expected, this result shows racial variations in the effect of recreational marijuana legalization on youth marijuana consumption. As given in the full model, the total average marijuana use is found to be higher for white youths than for black and Hispanic youths. However, while marijuana consumption by white and black youths has shown increases from 2012 to 2020, those of Hispanic youths have decreased. The Chi-square test result shows that these racial disparities across given years are significant at the .001 significance level.

Table 7. Annual Change in Marijuana-using Youths by Race from 2012 to 2020

		2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
White	N	3,072	2,624	2,440	2,427	2,203	2,517	2,555	2,527	612	20,977
	%	37.3	36.0	37.4	36.0	35.6	39.2	38.5	36.9	35.4	37.0
Black	N	448	496	517	591	512	541	446	421	131	4,103
	%	33.5	37.5	36.0	33.1	35.6	35.2	36.9	36.3	37.8	35.5
Hispanic	N	738	754	783	773	703	854	947	842	248	6,642
	%	39.8	38.4	35.1	35.7	36.4	36.1	33.4	34.5	32.8	35.8

Chi-square = 170.170 (p < 0.000)

In the second stage of the racial disparity examination, this study has run three separate logistic regressions for each race and analyzed the effect of legalization. The results from these analyses are presented in Table 7. As observed in the examination of annual changes, there are significant positive

relationships between the number of states with legalization and marijuana use for white and black youths ($b = .014$, $p < .01$ and $b = .018$, $p < .05$ correspondingly). However, legalization negatively impacts Hispanic youth marijuana use ($b = -.016$, $p < .05$). The exponential b values of these analyses indicate that as one state legalizes recreational marijuana, the log odds of white and black youths decrease by .014 and .018 correspondingly, but that of Hispanic youth decreases by .016. In addition to these discrepancies, the socio-economic status of black youths is found to retain a non-significant influence on marijuana use, while those of white and Hispanic youths are significant. The effects of all other variables are consistent across races and also with those from the full model.

Table 8. Logistic Regression of Marijuana Use by Race

	White (N = 57,689)			Black (N = 11,570)			Hispanic (N = 18,549)		
	B	S.E.	Exp(B)	B	S.E.	Exp(B)	B	S.E.	Exp(B)
Legalization	.014**	.003	1.014	.018*	.009	1.018	-.016*	.006	.984
P. Control	-.238**	.019	.788	-.154**	.039	.857	-.191**	.033	.826
SES	.026**	.005	1.026	.007	.011	1.007	.042**	.007	1.043
Delinquency	.340**	.009	1.405	.29**	.019	1.336	.292**	.013	1.340
Achievement	-.182**	.006	.834	-.174**	.013	.84	-.164**	.010	.849
Gender (1=M)	.082**	.020	1.085	.162**	.049	1.176	.196**	.038	1.216
Nagelkerke R ²		0.098			0.087			0.101	

* $p < .05$. ** $p < .01$

Discussion

In this study, we intend to examine gender and racial disparities in youth marijuana use as more states have legalized recreational marijuana use. Previous studies on youth marijuana use have argued that different gender and racial groups should have distinctive attitudes and risk perceptions, which lead to distinguishing patterns of marijuana use across gender and racial groups (Brooks-Russell et al., 2019; Danseco et al., 1999; Hughes et al., 2016; Keyes et al., 2016; Lachance et al., 2022). Other studies also posit that the accessibility and availability of marijuana products after legalization influence

gender and racial groups in a distinctive manner and cause unique patterns across these groups (Lachance et al., 2022; Orenstein, 2021). Based on these theoretical frameworks, we have hypothesized that recreational marijuana legalization should impact youth marijuana use differently across gender and racial groups. To examine the hypothesis, we have employed the MFCSAY survey data from 2012 to 2020, which has investigated the trends of American youths' illegal drug use and their annual perception of the risk of drug use. For the data analysis, the logistic regression with model comparison approaches, as well as temporal descriptive examination, are introduced.

The results from these analyses support our hypothetical arguments. Each gender and race group shows a distinctive trajectory, which is significantly different from those of other groups. As for the gender difference, the overall average marijuana use is higher for male youths than for females. However, the temporal examination of annual frequencies presents that marijuana use by female youths has continuously increased while that by males has not changed prominently. Due to these different patterns, the annual frequency difference between female and male youths has decreased and become nearly identical to each other in 2020, when 20% of states have legalized the selling of recreational marijuana. In the following logistic regressions with model comparisons, we have found that the number of states legalizing recreational marijuana significantly influences the likelihood of using marijuana for female youths but not for males after controlling for other personal characteristics. This finding is consistent with the temporal examination and supports the argument that recreational marijuana legalization positively influences female youth marijuana consumption but not that of males.

This finding of gender difference supports the theoretical argument of “accessibility and availability” and “risk perception” (Lachance et al., 2022; Ousey & Maume, 1997). The theoretical argument of “accessibility and availability” postulates that the availability of diverse forms of marijuana products, such as edibles, drinkables, and vapes, allow female youths to access and use marijuana more easily, while males are relatively less influenced by these new forms (Borodovsky et al., 2016; Lachance et al., 2022). The

increase in female youth marijuana use in our findings is consistent with these theoretical arguments. The “risk perception” theory also postulates that marijuana legalization policies should alleviate youth’s negative attitude and risk perception about marijuana consumption. Our finding implies that the legalization of recreational marijuana has changed the attitude and risk perception of youths female youths more than those of male youths.

The distinctive trajectories of youth marijuana use are also found in the analyses by racial groups. The temporal analysis of youth marijuana use by racial groups has presented that the marijuana uses of white and black youths have increased as more states have introduced recreational marijuana use; however, that of Hispanic youths has decreased during the same periods. The logistic regressions by racial groups also showed that there are positive relationships between legalization and marijuana use for white and black youths after controlling for personal characteristics; however, this relationship is found to be negative for Hispanic youths. We propose that these discrepancies should be caused by different attitudes and cultural backgrounds across racial groups. We suggest that future studies should investigate these differences with a detailed investigation of distinctive cultural and social effects on youth attitude and risk perception by racial groups. Considering racial discrimination issues in marijuana-related law enforcement in the U.S., the consideration of cultural and social differences across racial groups can also provide appropriate and fair criminal justice policies on drug enforcement (Vitiello, 2019).

One noteworthy finding from the full model analysis is that legalization retains a significant positive effect on youth marijuana use when we have merged the data. This positive relationship is significant ($p < .01$); however, the exponential b value is 1.009, which indicates the odds of using marijuana increase only by 0.009 per one-state legalization. We posit that this limited overall change is caused by the offset across gender and racial group differences and provides a cue to understand the inconsistent findings from previous studies (see Lachance et al., 2022; O’Grady et al., 2022). That is, the differentiated effect of recreational marijuana legalization across gender and racial groups has generated inconsistent results in previous studies based on

the composition of respondents in the sample. Therefore, future studies should consider these discrepancies in their examination of the marijuana legalization effect and try to clarify the complex causal mechanism across different gender and race youth groups. Moreover, marijuana-related policymakers and law enforcement agencies should also consider these gender and racial discrepancies in the effects of marijuana legalization and introduce more tailored prevention policies for specific gender and racial groups. Our findings show that it is critical to reduce the accessibility and availability of marijuana for youths by regulating diverse forms of marijuana products and introducing educational approaches to perceive the risk of youth marijuana use properly.

Conclusion

The findings of this study support that the legalization of recreational marijuana influences youth marijuana use. Moreover, we have found that this influence should be distinctive across different gender and racial groups. While its impact on male youths is not significant, this legalization increases marijuana use among female youths significantly. We have also found that white and black youths are positively influenced by legalization; however, its effect on Hispanic youths is negative. These findings are coherent with the theoretical framework that posits the effects of different attitudes, perceptions, availability, and accessibility on youth marijuana use. Previous inconsistent findings on the legalization effect should have originated from these differentiating effects across gender and racial groups; therefore, it is critical to consider youths' demographic differences in the study of their marijuana consumption. We suggest future studies examine these differentiating effects across various youth groups so that our societies can initiate more effective intervention efforts against youth marijuana use.

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Police visibility and fear of crime: Results of a study in Malatya, Turkey

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Abstract

Despite mixed research findings, increasing police visibility has long been assumed to reduce crime and citizen fear of crime. Surveying 1,175 respondents from Malatya, a midsize city in Turkey, this paper examines the effects of citizens' perceptions of police visibility and success on fear of crime during the daytime and at night. Consistent with some previous research, ordered logistic regression analyses revealed that perceived police visibility had no effect on citizens' fear of crime. However, perceived police success significantly reduced fear of crime at night. Consistent with previous research, females were more likely than males to fear crime during the day, and this effect increased exponentially at night. Previous personal crime victimization was a strong predictor of fear of crime during daytime but not at night, and reading local newspapers increased fear of crime during daytime only, suggesting that victims of personal crimes are more likely to limit their exposure to nighttime contexts. Limitations and implications for future research are discussed.

Keywords: Police Visibility, Fear of Crime, police-citizen contacts, victimization, Turkey

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Received 28 August 2023; Revised 20 December 2023; Accepted 27 December 2023
INTERNATIONAL JOURNAL OF CRIMINAL JUSTICE, Vol. 5 Issue 2, December 2023, 29-58
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Introduction

Causes and consequences of citizen fear of crime have been a subject of interest in criminological research for several decades, and police visibility has often been a variable of interest (Akyuz et al., 2023; Bennett, 1994; Bilach et al., 2022; Box et al., 1988; Brown, 2016; Cho, 2020; Collins, 2016; Cordner, 1986; 2010; Dolu & Uludag, 2010; Eck & Rosenbaum, 1994; Ferraro, 1995; Henig & Maxfield, 1978; Holmberg, 2002; Karakus et al., 2010; Kelling et al., 1974; Kim et al., 2021; Koseoglu, 2021; Moore & Trojanowicz, 1988; Oliver, 1998; Pate et al., 1986; Polat & Gul, 2009; Pfuhl, 1983; Ratcliffe et al., 2011; Salmi et al., 2004; Schnelle et al., 1977; Sipahi, 2021; Skogan, 1986; Trojanowicz, 1983; Warr, 2000; Winkel, 1986). Fear of crime is defined as “...an emotional response of dread and anxiety to crime or symbols that a person associates with crime” (Ferraro, 1995, p. 23) and “...a complex construct that is used to describe a range of both psychological and social reactions to perceived threats of crime and/or victimization.” (Collins, 2016, p. 21) Even though there are many other definitions of fear of crime, there is no consensus on the definition (Borovec et al., 2019; Cordner, 1986; 2010; Kim et al., 2021; Kula, 2015).

Fear of crime is a personal and subjective matter, and it can cause severe psychological, physiological, and sociological problems that may exceed the tangible costs of actual crime incidents (Alfaro-Beracoechea et al., 2018; Dolu et al., 2010; Macassa et al., 2017). Fearful residents might stay indoors during the day or at night or avoid going out altogether. This leads to installing special locks, security alarms, video surveillance, and metal bars, opting for living in gated communities, and even owning guns. Isolation and paranoia, in turn, may harm social cohesion, trust, and the effectiveness of informal social controls (Brooks, 1974; Mesko et al., 2008; Ross & Jang, 2000; Skogan, 1986).

Police visibility has a “...significant symbolic importance to many citizens...” (Pfuhl, 1983, p. 500) and it is defined and discussed in previous studies in the forms of police presence (Pfuhl, 1983), police stations (Boivin & de Melo, 2023), house calls (Winkel, 1986), moving citations (Wilson & Boland, 1978), warning citations (Currey et al., 1983), helicopter patrolling

(Gerrell et al., 2020; Schnelle et al., 1978), bike patrolling (Prine et al., 2001), car patrolling (Kelling et al., 1974; Schnelle et al., 1977) or car patrolling activities such as traffic control, parking control, response to a call, response to disturbances, and driving for emergencies (Salmi et al., 2004), and even deployment of an unoccupied police vehicle (Simpson et al., 2023), foot patrolling (Bilach et al., 2022; Kelling et al., 1981; Piza, 2018; Ratcliffe et al., 2011; Trojanowicz, 1983), or other activities such as chatting with citizens, providing information (Salmi et al., 2004), police-community newsletter, -meeting, and -station, citizen contact patrol, recontact victims, and reducing the “signs of crime” efforts (Pate et al., 1986).

Police visibility is assumed to reduce citizens’ fear of crime, as a commonly stated goal of policing is public safety through order maintenance. Lower crime rates and faster response times have been traditional, easily quantifiable measures of police effectiveness; however, more subjective measures that have emerged with community policing include fear reduction and citizen satisfaction with the police (Brooks, 1974; Greene & Taylor, 1988; Trojanowicz, 1983).

The present study aims to examine whether there is a relationship between police visibility—patrolling uniformed police officers and police vehicles—and citizen fear of crime during daytime and at night in the neighborhoods of a midsize city in Turkey. After reviewing the literature, we will explain the methods and share the findings before the discussion and conclusion sections.

Literature Review

Police visibility is defined and conceptualized differently in various studies in the literature, as introduced briefly in the previous section. However, we will review the most relevant ones (i.e., the connection with the fear of crime) that fall within the scope of the current study and the most common police visibility forms, such as foot and car patrolling and their activities, and police-community contacts.

Foot patrol and car patrol as police visibility

Although citizen fear of crime is subjective and, in many cases, not correlated with the actual risk of victimization, police visibility has long been thought to have a positive influence on public perception of safety. This assumption was challenged by the well-cited Kansas City Preventive Patrol Experiment (KCPPE), which was "...possibly the most influential policing experiment" (Hope, 2009, p. 125) and a "...landmark study in policing." (Weisburd et al., 2023, p. 544). Random assignment of either no police presence except responding to calls, normal patrol, or double or triple the amount of regular patrol produced no significant difference in crime rates or citizen fear of crime (Kelling et al., 1974). In a recent study, Weisburd and his colleagues identified and analyzed the original official crime data from the KCPPE and found evidence of crime prevention benefits for preventive patrol but reminded to read the findings with caution (Weisburd et al., 2023, p. 552):

In the case of burglary, our analyses show a statistically significant result in favor of preventive patrol at the 0.05 level. All of the effects in our analysis of proactive versus control conditions are in the direction of deterrence, and many of these achieve statistical significance at the 0.10 level...The impact of the experiment on violent crime comparing the proactive to control conditions was a relative reduction in crime of 17%; for burglary, the estimate of the relative reduction was 13%. For crime overall, the relative reduction in the proactive condition was 7%.

When the Kansas City Response Time Analysis Study of 1977 showed the ineffectiveness of rapid response (Kansas City Police Department, 1977) and was successfully replicated in four other U.S. cities, law enforcement began to question basic assumptions about its time-honored tenets of motorized patrol and rapid response (Spelman & Brown, 1981). More proactive police interventions became popular after the Kansas City experiments (Roberg, 1976).

The Newark Foot Patrol Experiment (Kelling, 1981; Kelling et al., 1981) randomly assigned either car patrol or foot patrol to eight demographically similar areas and found no difference in crime rates but less citizen fear of crime in areas with foot patrol, and an increase in citizen fear of crime in these same areas when foot patrol stopped at the end of the experiment. Experiments in several Dutch cities, such as Hoogeveen and Amsterdam, also revealed that increased police presence through foot patrols and intense contact with citizens led to a decrease in citizens' fear of crime (Winkel, 1986).

The Neighborhood Foot Patrol Program (NFPP), conducted in 14 Flint, Michigan, neighborhoods between January 1979 and January 1982, showed that the citizens felt safer after the foot patrol program, especially when the officers were well-known and highly visible (Trojanowicz, 1983). It is also reported that the program reduced criminal activities and crime rates and that protection for women, children, and the elderly had been increased.

Another study, the Philadelphia Foot Patrol Experiment, conducted during the Summer of 2009, found that foot patrols in violent crime hotspots significantly reduced violent crime levels. After three months of additional randomized foot patrol beats, a reduction of 23% in violent crime was recorded (Ratcliffe et al., 2011). The authors conceptualized the foot patrols as a "certainty-communicating device" as they "...may communicate an increased level of certainty that crimes will be detected, disrupted, and/or punished" (p. 819).

Borovec et al. (2019) conducted a study in Croatia to examine the relationship between police visibility and feeling of safety. They used fear of crime, perception of crime risk and frequency, and perception of incivilities as predictors for the feeling of safety, and found that whereas patrolling the neighborhood on foot patrol more frequently reduced the perception of incivilities and crime risk and frequency, patrolling by car frequently increased them in addition to increasing fear of crime. On the other hand, frequent patrols, regardless of foot or car, have a positive impact on reducing fear of crime and perception of crime risk and frequency when dealing with persons disrupting public order in the neighborhood.

A study conducted in Denmark showed that increased patrolling both on foot and by car also increased fear of crime among citizens. The author concluded that citizens perceived extra police presence as signaling crime-related situations (Holmberg, 2002). Another Scandinavian research suggested that increased police presence in a neighborhood might appear to residents as a symptom of crime rather than a preventive (Salmi et al., 2004). In the same vein, Fernandes (2018) found that police arrests increased the fear of violent crime victimization in Seattle. Further, police arrests of violent crimes increased the fear of crime more when the individuals had a victimization history and were females. She also found that greater physical disorder increases the fear of crime, as well.

Police-citizen contacts as police presence

With the acceptance of community policing in the U.S. in the 1980s, police presence evolved beyond foot patrol and reacting to calls by increasing police-citizen contacts in proactive and creative ways. Two experiments of the same project, one in Houston and the other in Newark, were developed and implemented between 1983 and 1984 (Brown & Wycoff, 1987; Pate & Skogan, 1985; Pate et al., 1986; Wycoff & Skogan, 1985).

The Citizen Contact Patrol experiment in Houston was developed and implemented by young, hand-picked patrol officers who rejected the broken windows thesis that fear of crime arose from social and physical disorder (Wilson & Kelling, 1982). The experiment's designers thought that Houston citizens were suffering *anomie* due to social distance from neighbors, police, and city government, and a corresponding lack of information about neighborhood crime. Interventions were contacting citizens, re-contacting victims, neighborhood newsletters, establishing a neighborhood storefront "cop shop" with outreach programs to the community, and community organizing. Of the five carefully planned and implemented programs, only the citizen contact program and the storefront office program reduced fear of crime; both of these programs, however, had little or no effect on Blacks and renters, who seemed unaware of the programs (Brown & Wycoff, 1987; Pate

et al., 1986; Wycoff & Skogan, 1985).

The Newark Fear Reduction Task Force instituted similar but unique programs in Newark to increase the quantity and quality of police-community contacts and reduce fear of crime (Pate & Skogan, 1985; Pate et al., 1986). Interventions were neighborhood newsletters, the “signs of crime” program, and a coordinated community policing program. Among all, the coordinated community policing program applications significantly impacted the reduction of fear of personal victimization and worry of property crime.

The impact of community policing on citizen fear of crime was assessed in 1998 by the Twelve Cities Survey, which showed that community policing increased satisfaction with the police and citizen crime prevention behaviors, but did not decrease citizen fear of crime (Scheider et al., 2003). Moreover, citizen crime prevention behavior did not affect fear of crime in six cities but increased fear of crime in the other six. The authors speculated that concrete activities aimed at preventing crime may increase concerns about personal victimization (Scheider et al., 2003).

Hinkle and Weisburd (2008) examined the effects of a two-pronged approach of “broken windows” crackdowns on neighborhood disorder, along with police targeting of minor crime “hotspots.” They found that reducing perceived social disorder and observable physical disorder reduced fear of crime. However, citizens living in targeted hotspot areas felt 27% less safe than those in non-targeted areas.

Police visibility, fear of crime and its predictors

Fear of crime and its predictors have been the focus of some studies in the United Kingdom (Bennett, 1994; Box et al., 1988), South Korea (Brown, 2016; Cho, 2020; Kim et al., 2021), Turkey (Akyuz et al., 2023; Karakus et al., 2010; Ozascilar et al., 2019; Polat & Gul, 2009; Sipahi, 2021), and Northern Cyprus (Koseoglu, 2021), as well. In the United Kingdom, data from the British Crime Survey showed that citizens who thought the police were doing a good job were less fearful of crime (Box et al., 1988), but a survey of

four residential areas in Birmingham and London showed that this effect disappeared in multivariate analysis (Bennett, 1994).

Kim et al. (2021) conducted research in South Korea using the Korean Crime Victim Survey (KCVS) data and found that people with direct and vicarious victimization experiences have more fear of crime. Also, the perceived signs of disorder in neighborhoods increased the fear of crime. In another study in South Korea, Cho (2020) found that when police made arrests, violent crime rates went down. Further, residents' fear of crime reduced with the police patrol, whereas it increased in disorderly public places. Therefore, he suggested, "...police visibility and response capability are important in reducing fear of crime among residents" (p. 794). He also found that the level of patrolling and disorder policing is positively associated with the satisfaction of the people with the police.

Polat and Gul (2009) conducted surveys on a large random sample in Erzincan, a city in the eastern region of Turkey with roughly a quarter million people. They examined the association of police visibility and fear of crime. There was an inverse relationship between police visibility and fear of crime, but only 24% of interviewees reported that visible police made them feel safer (Polat & Gul, 2009).

Sex differences in fear of crime. Concerning gender differences and fear of crime, Scheider et al. (2003) and Hinkle and Weisburd (2008) found that social disorder made U.S. women 79% and 154% more fearful than men, respectively, and Bennett (1994) found that British women were 34% more fearful of crime than men. In the first two U.S. studies, police presence aggravated the fear of crime; in the latter British study, confidence in the police had no effect on the fear of crime. Weitzer and Kubrin (2004) found that women were 19% more likely than men to fear crime in both models of their study of media influence. Some studies in South Korea (Brown, 2016; Kim et al., 2021) and Turkey (Karakus et al., 2010; Koseoglu, 2021; Turk et al., 2023) also found that women have more fear of crime than men.

News and fear of crime. Shin and Watson (2022) conducted research in Chicago and found that local news, particularly radio and TV, negatively

impacted residents' fear of crime. Another research done in the U.S. suggested a higher fear of crime for citizens who get their news from local TV (Weitzer & Kubrin, 2004). A study on the media effect on fear of crime conducted in households in California showed that women had consistently significantly higher levels of fear of crime than men (Callanan, 2012). Further, she found that television news and crime-based reality shows had more impact on both perception of neighborhood crime and fear of crime than newspapers or crime dramas. And yet another study found that social media creates the fear of sexual crimes (Turk et al., 2023).

Studies of police visibility and citizen fear of crime have mixed results. Police presence in these studies has varied from mere car patrol to intensive police-citizen contacts associated with community policing to hotspots and other specifically targeted interventions. Vulnerable populations with a higher baseline fear of crime and perhaps less trust in police, such as women, social minorities, and, to some extent, the elderly, may react negatively to a heightened police presence. In some societies, minorities are more likely to be victims of crime, however, so they may find comfort in a substantial police presence (Bennett & Flavin, 1994).

Methods

This section provides information about the data study setting, context, and data collection and analysis, followed by the dependent, independent, and control variables.

Study setting and context. This study adds to policing research in Turkey, a nation of over 85 million people (Turkish Statistical Institute, 2023). Although mainstream criminology has shown increased interest in comparing criminal justice systems in recent years, relatively little Turkish research has been published outside of this country (Shahidullah, 2013; Dammer & Albanese, 2014). Self-reported personal crime victimization during 2005 was 17.9% in Istanbul, versus an average of 21.5% for 33 major world cities, including New York, in which 23.3% of citizens reported being victims of

personal crime (Dammer & Albanese, 2014).

The police in Turkey are highly centralized and organized under a top-down, hierarchical structure as a national police force. About 300,000 sworn officers serve in 81 provincial police departments that are directly attached to the Turkish National Police Headquarters in Ankara (Turkish Statistical Institute, 2023). Provincial police have considerable discretion in doing their job, but all policy comes from headquarters to be implemented in the provinces.

Current research was part of a research initiative funded by the Malatya Police Department to identify the role of police visibility on citizen fear of crime. As a midsize and ancient city, dating back to the earliest agriculture in the Fertile Crescent, Malatya is a typical Turkish city that represents all colors of Anatolian culture and national characteristics. For this reason, the authors of this paper selected Malatya for this research.

Data collection and analysis. A total of 67 questions with Likert scale answers were included in the questionnaire designed to measure the respondent demographics, attitudes and reactions toward crime, satisfaction with and expectations of the police, and perceptions of the effects of media, social, and physical environments. The survey was field-tested on both citizens and criminal justice professionals.

A total of 1,500 individuals aged 16 or over were randomly selected from the community, and 1173 (78.1%) participated in the survey. Teachers from the Malatya Department of Education administered the surveys via face-to-face interviews, and data were collected during four weeks from May to June 2008. Two staff from the Malatya Police Training Center assisted the authors in coding and entering data.

We used ordered logistic regression analysis since the independent and dependent variables were measured with ordinal scales. We checked for model specification errors using the *linktest* function of Stata and found that the goodness of fit was acceptable, and there were no misspecification errors in the analysis. We have also run multicollinearity and heteroskedasticity tests and found no problems.

Dependent variables. There is considerable controversy among social scientists about how to measure and analyze citizens' fear of crime (Scheider et al., 2003; Brown & Wycoff, 1987). Furstenburg (1971) found that research subjects appear more fearful of crime if survey questions are general and posit crime as a public issue, but less fearful if surveyed about crime as a judgment of personal safety. This response bias to vague questions is especially strong for demographic groups with unrealistically high expectations of personal victimization, such as females and, to a certain extent the elderly (LaGrange & Ferraro, 1987), and may be intensified by survey questions containing words with emotional impact such as this example from the General Social Survey: "Is there an area right around here—that is, within a mile—where you would be afraid to walk alone at night?" (LaGrange & Ferraro, p. 378). We used a measure of self-perceived safety consistent with the U.S. National Crime Victimization Survey (Hinkle & Weisburd, 2008) and the British Crime Survey (Bennett, 1994).

Citizen fear of crime during the day and nighttime are the dependent variables in this study (see Table 1). Respondents were asked, "How safe do you feel when you walk alone in your neighborhood during daytime/nighttime?" Respondent choices were (1) *very safe*, (2) *safe*, (3) *somewhat unsafe*, (4) *unsafe*, (5) *very unsafe*. As seen in Table 1, the nighttime fear of crime is greater than the daytime fear of crime.

Table 1. Descriptive Statistics

Variable	Min.	Max.	<i>M</i>	<i>SD</i>
Dependent				
Fear of crime during nighttime	1	5	3.18	1.311
Fear of crime during daytime	1	5	2.28	1.128
Independent				
Police visibility	1	5	2.98	1.440
Police response time	1	5	3.13	1.052
Citizens' perception of police success	1	5	3.36	1.030
Control				
Age	16	79	29.18	12.004
Female	0	1	0.55	0.497
Age x female interaction term	0	75	16.22	16.860
Income	1	5	2.56	1.190

Variable	Min.	Max.	M	SD
Education	1	5	2.91	0.872
Marital status (married)	0	1	0.41	0.492
Property crime victimization	0	1	0.24	0.426
Personal crime victimization	0	1	0.11	0.315
Watching news on national TV	1	5	3.41	1.192
Watching news on local TV	1	5	2.41	1.088
Read news in national newspapers	1	5	2.57	1.256
Read news in local newspapers	1	5	1.95	1.114
Know people in neighborhood	1	5	3.53	1.182
Length of residence in neighborhood	1	5	3.29	1.373
Economic status of neighborhood	1	5	3.04	0.657
Sufficient streetlights	1	5	3.09	1.129

Independent variables. Police visibility was measured by the question, “How frequently do you see a uniformed police officer or a police car in your neighborhood?” Respondent choices were (1) not at all, (2) one or two times in a year, (3) one or two times in a month, (4) one or two times in a week, (5) almost every day. Our research findings show that the police visibility variable has a mean score of 2.98, which means that citizens saw a uniformed police officer or police car once or two times a month.

Citizens’ subjective assessments of police response time and success were measured with similar five-point scales. Inadequate response times can have tragic consequences and generate much worse publicity for police departments, especially in domestic violence cases. As discussed earlier, response time is no longer a variable of interest for many police researchers; however, it was included here because of a lack of research on Turkey. For the question, “Do you agree that the police are responding to calls for service in a reasonable time?” respondents were given five choices: (1) *strongly disagree*, (2) *disagree*, (3) *somewhat agree*, (4) *agree*, (5) *strongly agree*. As reported in Table 1, the mean score of response time is 3.13. In other words, citizens believe that police responses are more or less within reasonable time limits.

Citizen perceptions of police success have been examined in previous research (Brown & Wycoff, 1987; Hinkle & Weisburd, 2008; Scheider et al.,

2003). According to Hunter (1978), whose work underpinned the broken windows theory (Wilson & Kelling, 1982), citizen fear of personal victimization rises when local agencies fail to provide formal social control. Our measure of police success was relative: “How successful do you see the police compared to past years in fighting crimes?” Respondent choices were (1) *far worse than before*, (2) *worse than before*, (3) *no difference*, (4) *better*, and (5) *far better than before*. Our survey results show that citizens’ perception of police success has a mean score of 3.36, which means there is not much difference compared to the past but a slight inclination for improvement.

Control variables. Since our focus in this paper is on police visibility and related variables, we have considered demographic variables (age, sex, income, education), victimization variables (personal crime victimization, property crime victimization), socioeconomic-environmental variables (economic status of neighborhood, sufficiency of lighting in the streets, length of residence in neighborhood, knowing people in neighborhood), and media variables (watching news from local/national TVs and reading news from local/national newspapers) as control variables.

The mean age of the sample was 29.19, close to the mean age of Turkey’s general population, 28.5, at the time of data collection, according to the 2010 Turkish Census (Turkish Statistical Institute, 2023). Fifty-five percent of the sample was female, slightly more than the percentage of males in the general population, 50.2% at the time of the survey.

Education was measured on a Likert scale: (1) *No schooling*, (2) *8 years of mandatory education (elementary & middle school)*, (3) *high school*, (4) *university degree*, (5) *postgraduate education*. The mean value (2.91) points to high school education. Monthly income is measured with a Likert scale in Turkish Liras (TL): (1) *Less than 500 TL*, (2) *between 501-1000 TL*, (3) *between 1001-1500 TL*, (4) *between 1501-2000 TL*, (5) *more than 2000 TL*. The mean value is 2.59 (between 501-1000 TL), which is around the national average monthly income at the time of research.

Personal and property crime victimization variables ask whether the

respondents themselves or anyone in their families were victimized in the last two years. Both variables are binary: (0) *not being victimized*, (1) *being victimized*. 11% of respondents reported that they or one of their family members were victims of personal crimes within two years prior to the survey, whereas 24% of respondents reported property crime victimization within their family during the same period.

All the news variables, namely watching news on national TV, watching news on local TV, reading news from national newspapers, and reading news from local newspapers, are all measured the same way: (1) *less than once a month*, (2) *a couple of times a month*, (3) *a couple of times a week*, (4) *most days of the week*, (5) *every day*. The mean value of these four media consumption variables is around 2 or above.

The question for knowing people in the neighborhood was, “Do you think that people generally know each other in your neighborhood? (1) *Definitely disagree*, (2) *disagree*, (3) *partly agree*, (4) *agree*, (5) *definitely agree*. The mean value for this question is 3.53, and the median value is 4. This means that respondents agree that people in their neighborhood generally know each other.

For the length of residence in the neighborhood, the respondents were asked how long they had been living in their community, and the answers were (1) *less than 1 year*, (2) *1–5 years*, (3) *5–10 years*, (4) *10–15 years*, (5) *more than 15 years*. The mean (3.29) indicates that participants of this study had been living in their neighborhood for at least 5 to 10 years.

Economic status of the neighborhood is also measured with a Likert scale that is composed of the following options: (1) *very poor neighborhood*, (2) *poor neighborhood*, (3) *neither poor nor rich*, (4) *wealthy neighborhood*, (5) *very wealthy neighborhood*. The mean value is 3, indicating that the respondents' average economic status is neither poor nor wealthy.

Sufficiency of the streetlights is measured as follows: (1) *totally insufficient*, (2) *insufficient*, (3) *somehow sufficient*, (4) *sufficient*, (5) *totally sufficient*. The mean value (3.09) shows that people feel the lighting in the city streets is more or less sufficient.

Results

Ordered logistic regression analysis in Table 2 shows that respondents' perceptions of police visibility, response time, and success had no significant effect on citizens' fear of crime during the daytime. It may seem surprising to some that the age of the respondents had no significant effect on fear of crime. However, LaGrange and Ferraro (1987) have shown that elderly people's emotions may be more in tune with their actual risk of criminal victimization than many criminologists have assumed, especially if research questions are specific and not vague or charged with emotional language. However, gender, income, personal crime victimization, reading national and local newspapers, knowing people in the neighborhood, and living in a wealthier neighborhood were statistically significant. The most substantial aggravating effects on citizen fear of crime in the daytime were being female (3.185 odds ratio, $p = .001$) and previous personal victimization (1.890 odds ratio, $p = .003$). Put differently, females were over three times more likely to fear crime than males, and previous victims of personal crime were almost twice as likely to fear crime as non-victims.

Table 2. Fear of Crime in Daytime

Independent Variable	OR	SE	$p > z $
Police visibility	0.953	0.042	0.280
Police response time	1.034	0.071	0.626
Citizens' perception of police success	0.879	0.063	0.074
Age	1.006	0.008	0.448
Female	3.185*	1.063*	0.001*
Age x female interaction term	0.984	0.010	0.132
Income	0.875*	0.051*	0.025*
Education	1.144	0.098	0.119
Marital status (married)	1.173	0.190	0.326
Property crime victimization	1.135	0.172	0.404
Person crime victimization	1.890*	0.408*	0.003*
Watching news on national TV	0.989	0.056	0.851
Watching news on local TV	0.996	0.064	0.952
Read news from national newspapers	0.867*	0.051*	0.016*
Read news from local newspapers	1.174*	0.079*	0.018*

Independent Variable	OR	SE	$p > z $
Know people in neighborhood	0.786*	0.048*	0.000*
Length of residence in neighborhood	0.960	0.046	0.414
Economic status of neighborhood	0.704*	0.080*	0.002*

Note: $N = 894$. Wald $\chi^2(18) = 74.96$, $p > \chi^2/2 = 0.000$. Pseudo $R^2 = 0.038$. The dependent variable is fear of crime during daytime. To measure this variable, the following question was asked: How safe do you feel when you walk alone in your neighborhood during the daytime? (1) Very safe, (2) Safe, (3) Somewhat safe, (4) Unsafe, (5) Very unsafe. Because the dependent variable was an ordinal-level variable, ordered logistic regression was used.

* $p < .05$.

Respondents living in neighborhoods with high economic status are more likely to fear being victimized when walking alone during the daytime (0.704 odds ratio, $p = .002$). In other words, those who live in wealthier neighborhoods have 0.704 times the odds of feeling unsafe when walking alone during the daytime compared to those who live in less wealthy and poorer neighborhoods.

Interestingly, knowing people in the neighborhood also increases fear of crime during daytime (0.786 odds ratio, $p = .000$). Those who live in communities where people know each other well are 0.786 times the odds of feeling unsafe when they walk alone during daytime compared to others who live in neighborhoods where people do not know each other well.

Even though respondents from Malatya said they were more likely to watch the news on national TV than on local channels and more than read newspapers on local and national levels, it did not have any impact on their fear of crime. Getting news from local TV channels did not significantly affect the respondents' fear of crime, either.

Whereas reading news from a national newspaper increased the fear of crime during daytime (0.867 odds ratio, $p = .016$), it did not have the same impact at nighttime, as shown in Tables 2 and 3. However, getting news from local newspapers positively affected the fear of crime during daytime (1.174 odds ratio, $p = .018$) and nighttime (0.816 odds ratio, $p = .016$). Reading local news is the only news variable that increases fear of crime both daytime and nighttime. These findings are as expected as one might expect that local crime stories would make citizens more fearful than national stories because they

are closer to home.

In changing the focus of fear of crime from day to night (see Table 3), citizen perception of police success becomes significant and reduces citizen fear of crime by a modest amount (.843 odds ratio, $p = .017$). Females are nine times more likely to experience fear of crime during nighttime (9.179 odds ratio, $p = .000$). What is even more striking here is that females' fear of crime seems to be tripled from 3.185 odds ratio during daytime to 9.179 odds ratio during nighttime.

Table 3. Fear of Crime at Night

Independent Variable	OR	SE	$p > z$
Police visibility	1.014	0.045	0.752
Police response time	0.955	0.065	0.505
Citizens' perception of police success	0.843*	0.060*	0.017*
Age	1.008	0.008	0.327
Female	9.179*	3.030*	0.000*
Age x female interaction term	0.975*	0.009*	0.015*
Income	0.889*	0.053*	0.049*
Education	0.901	0.076	0.219
Marital status (married)	0.894	0.145	0.494
Property crime victimization	1.183	0.177	0.261
Person crime victimization	1.280	0.272	0.246
Watching news on national TV	0.984	0.057	0.781
Watching news on local TV	1.101	0.070	0.132
Read news from national newspapers	1.014	0.058	0.804
Read news from local newspapers	0.853*	0.056*	0.016*
Know people in neighborhood	0.960	0.056	0.496
Length of residence in neighborhood	0.927	0.044	0.121
Economic status of neighborhood	0.833	0.094	0.107
Sufficient streetlights	0.864*	0.053*	0.020*

Note: $N = 891$. LR $\chi^2 (19) = 199.80$. $p > \chi^2_2 = 0.000$. Pseudo $R^2 = 0.071$. The dependent variable is fear of crime at night. To measure this variable, the following question was asked: How safe do you feel when you walk alone in your neighborhood at night? (1) Very safe, (2) Safe, (3) Somewhat safe, (4) Unsafe, (5) Very unsafe. Because the dependent variable was an ordinal-level variable, ordered logistic regression was used.

* $p < .05$.

The inverse relationship between income and fear of crime is virtually unchanged in going from daytime in Table 2 to nighttime in Table 3. Surprisingly, the robust effect of previous personal victimization on fear of crime during the day disappears in the context of night. Reading local newspapers, however, consistently increases fear of crime during the daytime (1.174 odds ratio, $p = .018$ in Table 2) and at night (.853 odds ratio, $p = .016$). Further, the social solidarity indicator of knowing people in the neighborhood mitigates the fear of crime during the day (.786, $p = .000$ in Table 2) but has no effect at night in Table 3. Similarly, living in a neighborhood of higher economic status reduces fear of crime in the daytime but not at night. Some of these unexpected findings may reflect respondents' conscious decisions to limit their exposure to nighttime environments. We also see that citizen impressions of the adequacy of street lighting reduce fear of crime by a small amount.

The age-sex (female) interaction term does not affect fear of crime during the day in Table 2 but becomes significant at night in Table 3 ($p = .015$). It means that females of older ages are no different than younger females and males of all ages regarding daytime fear of crime. However, females of older ages are more worried about being a victim of crime during the night than younger females and males of all ages. To visually show why the interaction term is significant in the daytime model but not in the nighttime model, we have created the following two figures (see Figure 1 and Figure 2). The x-axis represents the age of the respondents, the y-axis represents their fear of crime at night, and the different lines represent the average fear of crime for both sexes at each age. The interaction plots below are used to determine whether there is a significant interaction effect between sex and age on fear of crime at night. Since the lines are parallel and follow the same trend in the daytime fear of crime model, it suggests that the relationship between age and fear of crime is consistent for both sexes. On the other hand, since the lines deviate significantly from each other in the second graph, it indicates a significant interaction effect in the fear of crime at night.

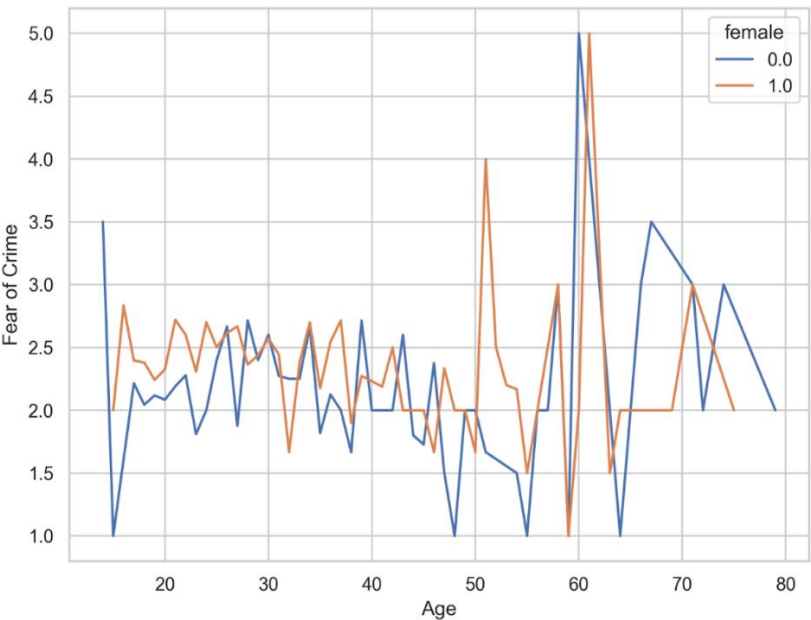


Figure 1. Interaction Plot between Sex and Age on Fear of Crime during Daytime

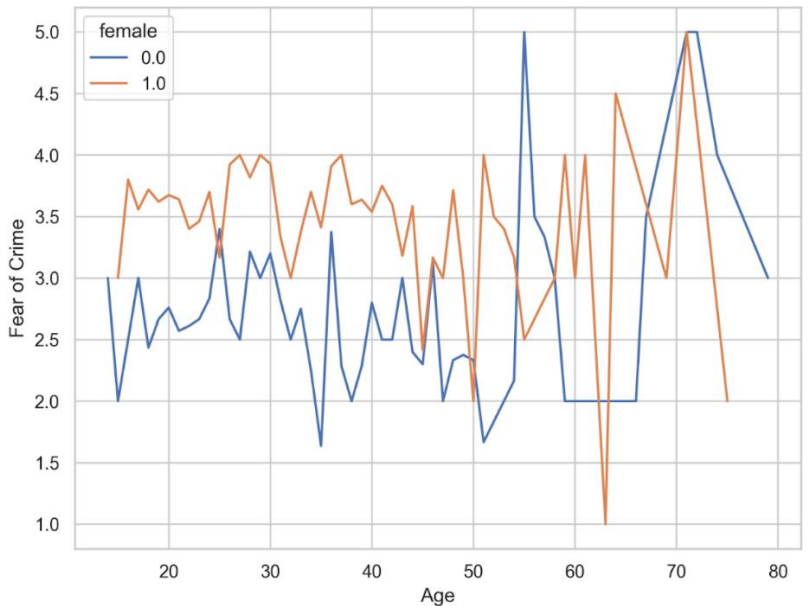


Figure 2. Interaction Plot between Sex and Age on Fear of Crime during Nighttime

Discussion and Conclusion

The current study of police visibility and fear of crime in Malatya, Turkey, attempts to contribute to the global literature on policing and fear of crime. This is the first empirical study of the influence of traditional measures of police visibility and effectiveness on citizens' fear of crime in Turkey and contributes to a small body of research that looks at citizens' fear of crime during the day and at night. Contrary to some previous studies (Borovec et al., 2019; Brown & Wycoff, 1987; Cho, 2020; Kelling et al., 1981; Kim et al., 2021; Pate et al., 1986; Polat & Gul, 2009; Turk et al., 2023), citizens' subjective perceptions of police visibility and response time did not affect fear of crime during either day or at night. It is a common police practice in Turkey to always keep the emergency lights on at night to increase police visibility. As with the color-coded threat levels for terrorist attacks implemented by the Department of Homeland Security in the U.S., citizens may simply ignore overused stimuli or reject their credibility (Grant & Terry, 2012). If police presence increases some citizens' fear of crime, as noted in several studies (Fernandes, 2018; Holmberg, 2002; Salmi et al., 2004; Scheider et al., 2003), then the visual overload produced by police cars' emergency lights is likely to aggravate such apprehension. In addition, more judicious use of emergency lights on police cars may increase the probability that citizens will yield the right-of-way during a real emergency or give a wider berth to officers ticketing moving violations or rendering assistance on the side of the road.

Citizens subjective perceptions of police success reduced fear of crime only at night in this study, so perhaps this variable is more important when one's environment is less predictable. Citizens may be more sensitive to the possibility of criminal victimization and feel more vulnerable at night. In such a context, feeling that the police are doing a good job may increase citizens' comfort (Kim et al., 2021; Weitzer & Kubrin, 2004).

Sufficient street lighting had a modest but significant mitigating effect on fear of crime (see Table 3). Well-maintained streetlights are more likely to positively impact citizens' perception of safety, a finding that has important implications for policing practices and collaboration with local authorities.

Respondents' criminal victimization in the past has a doubling effect on fear of crime during the daytime but it had no effect at night. This finding may reflect a conscious decision of victims of crime to take precautionary measures and restrict their nighttime activities to avoid a similar risk again. In contrast, prior property crime victimization did not affect fear of crime at night or fear of crime in the daytime. Compared to personal crime victimization, property crime victimization may represent a less direct threat to citizens. This finding contrasts the previous research (Brown, 2016) in which victimization of burglary increased the fear of crime. Burglary, while not a violent crime, can significantly impact victims. Since everyone's house is the most trusted, secure, and sacred place in their lives, burglary violates people's sense of safety and privacy. Most definitely, burglary incidents can also lead to significant financial losses. As a result, victims of burglary would likely experience higher levels of fear of crime than other forms of property crime. Victims of burglary may be more likely to worry about being targeted again, while victims of other property crimes may be less worried about being targeted again. This difference may be because burglary is a crime that specifically targets a specific place that is supposed to be the most secure in one's life, while other property crimes may be more random. Additionally, victims of burglary may experience a greater sense of loss of control and vulnerability, as their home or place of business has been violated. This can lead to increased levels of fear and anxiety.

Reading local newspapers increased the fear of crime during the day and at night, whereas reading national newspapers increased it only during the daytime. On the other hand, getting news from local or national TV channels did not significantly affect the respondents' fear of crime. Our findings support previous research with some similarities and differences. For instance, one research done in the U.S. suggested a higher fear of crime for citizens who get their news from local TV (Weitzer & Kubrin, 2004), and another study found that local news on radio and TV rather than newspapers had an impact on fear of crime (Shin & Watson, 2022). Yet, another study found a similar impact with television news and crime-based reality shows rather than newspapers or crime dramas (Callanan, 2012). However, none of them differentiated whether daytime or night mattered.

Knowing one's neighbors decreases fear of crime during the day but not at night, which is consistent with citizens consciously limiting their exposure to crime at night. LaGrange and Ferraro (1987) point out that most people generally, not just women and the elderly, are in their homes during nighttime hours, so the nighttime question becomes more hypothetical.

The most dramatic effect in the entire study is, being female made Malatya respondents over three times more fearful of crime during the day (see Table 2) and over nine times more fearful of crime at night (see Table 3). Comparing gender effects in previous research gives an idea of the magnitude of the above effects. Our findings support the previous studies (Bennett, 1994; Brown, 2016; Hinkle & Weisburd, 2008; Scheider et al., 2003; Turk et al., 2023; Weitzer & Kubrin, 2004) that females have more fear of crime than males. Since the reasons and sources of fear of crime were not the scope of the current study, further studies should explore why females have more fear of crime in Turkey's context.

Even though it is commonly assumed that more police visibility and reduced response time increase feelings of security, this study could not find empirical support for either argument. This suggests that police practices as implemented and their interpretation by citizens may be distinct phenomena. Thus, common policies like increasing police visibility should more often be independently evaluated to determine whether they create expected results.

Limitations

We acknowledge some limitations to our study that have implications for future research. As this study was designed as cross-sectional research conducted in only one city in Turkey, there is a need for further research in other parts of Turkey to test the validity of the findings presented here. Although Malatya was carefully chosen as a typical Turkish city using multiple factors, future research should try to replicate this study in other parts of Turkey and elsewhere. Cross-sectional data may be biased by a highly publicized crime event or a dramatic change in police policy. However, we are not aware of any such contaminating factors, longitudinal research is

certainly desirable. Since the previous studies that sampled fear of crime in daytime versus nighttime (Gallup, 1982; Bennett, 1994) did not use this differential as a unit of analysis, we especially recommend more studies of this variable.

Police visibility and effectiveness in this study were measured by respondents' subjective impressions, not actual police hours worked or specific law enforcement strategies implemented. More objective measures of police visibility and implementation of different strategies in randomly selected neighborhoods may show the assumed inverse relationship between police visibility and fear of crime that was not obtained in the current study. Citizens' perception of police success had a separate effect from police visibility in reducing fear of crime at night, which casts further doubt on the assumption that police visibility alone can reduce fear of crime. Especially in developing nations, police may be seen as ineffective, corrupt, and abusive. Another possible explanation for the insignificance is that citizens' perceptions of police success and visibility are highly correlated. To test the hypothesis, we ran an ordered logistic regression model with resident ratings of police success as the dependent variable. As the public perception of police presence (police visibility) increased, the ratings of police success also increased. The public ratings of police success may mediate the impact of police visibility.

Studies of police visibility and fear of crime seem to ask more questions than they answer. What types of police visibility best benefit the people, reduce fear of crime, make the individuals feel much safer, and how much visibility is enough? Yet, do cultural aspects matter in determining the balance between police visibility and fear of crime?

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Searching for Brazilian serial killers' home using a geographical offender profiling software

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Abstract

Geographical offender profiling proposes that it is possible to predict the likely area where serial killers live by analyzing where and how they committed their crimes. This information could be used by police to prioritize suspects and make better use of their resources. Based on findings from years of research on the field, a software was developed to assist in this endeavor: Dragnet. While there have been tests of this software's applicability internationally, only one was conducted in Brazil but with a small sample. The present study sought to verify Dragnet's accuracy with a larger sample of Brazilian serial killers. Data was collected from police and court records of two capital cities. The sample consisted of 66 serial killers whose crime location and home address were available. In 84.9% of the cases the offender's home was within the area predicted by the software, and in 63.6% of the cases it was within the top areas suggested. While they show promise, these results are discussed as to how they could be improved and the importance of a qualitative analysis, considering factors that may influence offender's mobility. Future research projects are suggested to address these issues.

Keywords: Dragnet, Geographical Profiling, Offender Profiling, Psychology.

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Received 14 April 2024; Revised 15 December 2023; Accepted 30 December 2023

INTERNATIONAL JOURNAL OF CRIMINAL JUSTICE, Vol. 5 Issue 2, December 2023, 59-91

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Introduction

While some crimes happen at unknown or virtual locations, most of them are committed at a specific place: a person is kidnapped from the street, a house is burgled, a victim is approached by an offender on their way home from work, drug trafficking takes place in the parking lot of a supermarket. Information on where crime occurs can help police forces identify hotspots (geographical areas where most of the crimes are being committed) and act accordingly to reduce criminality in the area. Some examples include adding more police officers to survey that area, making changes to the environment, or even assisting potential victims to be safer when moving around that area. Although this approach focused on crime prevention is important, geographical information can also prove useful when investigating crimes as proposed by geographical offender profiling (geoprofiling). This is a field of research and practice, which aims to identify the location of serial offenders' unknown base of operation by analyzing how and where they committed their crimes (Lino, 2021). This spatial analysis technique considers the known locations of crimes committed by the same offender to determine the most probable area where they live, reside, or work (Rossmo & Rombouts, 2016).

There are dozens of scientific publications focused on providing a deeper understanding of the theoretical grounds that support a connection between crime locations and offenders' base, as well as empirical evidence of this link. Building upon Environmental Criminology theories and scientific evidence that dates as far back as 1932, geoprofiling now consists of a solid strategy to assist criminal investigations (Lino & Matsunaga, 2018). Some countries, such as the United Kingdom and Germany have expert Geographical Profilers working in police forces, whose main job is to generate geographical profiles and provide investigative recommendations (Knabe-Nicol & Alison, 2011).

Technological advances have also made the development of computerized decision-support tools possible. These tools are available to assist practitioners who wish to generate a geographical profile. Geoprofiling and, consequently, these decision support tools were developed to focus criminal investigation

efforts on identifying the base of serial offenders (a broad definition to encompass offenders who commit multiple crimes in a series). Due to this focus, they are significantly different from how other Geographic Information Systems (GIS) are used. GIS are routinely used to manage massive amounts of data from criminality in general, identify hotspots, visualize which types of crimes are committed in a specific place and at a specific time, identify crime patterns and trends, etc. However, they have not been designed to identify a serial offender's base (Butorac & Marinović, 2017).

Among the various types of serial offenders, serial killers have gained much attention in recent decades, mostly due to media portrayal in podcasts, TV series, movies, and novels. It has sparked the interest of both researchers and practitioners who wish to better understand these offenders and how to improve investigations to identify and stop their series of murders. Despite that, in Brazil, there is still a huge gap in our understanding of serial killers. There are nearly 47,000 murders each year, and only around 40% of them are solved, which hinders our ability to verify if there are active serial killers and who they might be (Fórum Brasileiro de Segurança Pública, 2022; Instituto Sou da Paz, 2022). The low clearance rates highlight the need for police forces to improve how they conduct their investigations and use every tool available at their disposal. Using geographical offender profiling software could prove useful in directing police resources to identify and imprison these offenders, which would bring justice to the families of the victims and increase residents' feelings of safety. However, before blindly using geoprofiling software, it is necessary to test whether it would assist an investigation. Therefore, the main goal of the present study was to verify the effectiveness of "Dragnet", a geographical profiling software, in identifying the home of serial killers in Brazil.

Theoretical Bases of Geographical Profiling

The main theoretical base that supports the application of Geographical Offender Profiling is the Crime Pattern Theory. It was developed by Brantingham and Brantingham in 1984 to explain how crimes are not random.

They are linked to how victims and offenders use and move around an area's environmental backcloth. There are two relevant concepts to help understand victims' and offenders' movement: nodes, which are the places where they spend most of their time during the day (home, work, pub, etc.), and paths, which refer to the routes they take to move between nodes (roads, streets, highways).

Furthermore, Crime Pattern Theory builds on knowledge from Cohen and Felson's (1979) Routine Activity Approach, which suggests that offenders will choose places to commit their crimes according to their routine activities. During their daily activities, offenders will undoubtedly move around the city, they must leave their homes to go to work, grocery shopping, and take part in leisure activities in places such as the beach, pool, bars, cinema, etc. As a result of their movement between nodes on a regular base, offenders develop detailed knowledge of that specific area, which is referred as "awareness space" (Brantingham & Brantingham, 1984). It represents their mental map, the locations they are familiar with, the presence of potential victims, and sources of risk for getting caught. A serial burglar who leaves his home to work every day will follow similar paths, during his trips he will become aware of his surroundings. He will learn which neighborhoods are wealthier and present more chances of higher financial gain, how many potential witnesses are in the streets around the time he is commuting, as well as which house appears to be less risky to target. According to this knowledge, he may opt to come back at a different time to attempt to rob the place (Lino & Matsunaga, 2018).

According to Crime Pattern Theory, geoprofiling is possible because offenders will most likely attack places that have some significance to where they live. First, offenders' awareness space is decisive in identifying potential targets. Offenders may be unaware of potential targets because they do not move around that area. The burglar from the last example may not attack other more suitable targets, which are less risky and produce high financial gain because he is unaware that they exist, since he does not travel to that area of the city. Second, awareness space is developed according to our routine activities, therefore, the crime location is connected to offenders' daily

activities and routines. For that reason, as van der Kemp (2021, p.37) suggests: “Predicting the anchor points of the offender based on where he committed his crimes is, in essence, the reversal of the prediction of where an offender commits his crimes that follows from the Crime Pattern Theory.”

Another relevant theory that further supports geographical offender profiling is the Rational Choice approach, which suggests that offenders make rational decisions when considering how and where to commit a crime (Cornish & Clarke, 2016). It is expected that offenders will choose a victim, time, and place where they perceive their chances of being successful as higher than the probability of failure. They will weigh the pros and cons of committing a crime in that location, before deciding whether to move forward with their criminal actions. Indeed, research on robbers has highlighted their ability to assess the potential benefits and risks of attacking a specific target, as well as how to reduce the risks to optimize their chances of success (Morrison & O'Donnell, 1996).

In line with the Rational Choice approach, the Least Effort Principle, originally proposed by Zipf (1949), helps us understand offenders' movement to generate geographical profiles. This principle suggests that humans will attempt to do the least effort necessary to achieve their objectives. In the context of human movement, it means that we are likely to take shorter paths to reach our goals. Considering that criminals are also humans, bound by the same principles as everyone else, they will choose a location closest to their home to commit their crimes as long as they can find suitable victims and achieve their criminal objectives.

Taking these three theoretical approaches together, we can deduce that offenders actively decide where they will commit their crimes. However, this decision is bounded by cognitive and situational factors, such as the least effort principle and their knowledge of the area (awareness space). Accordingly, their awareness space will be constructed based on their routine activities. As a result, offenders do not commit crimes in random places, they have a pattern, which has a direct link to who they are, how they perceive the environment, how they move around the city, how they make their decisions, and, most importantly, where they may live (Rossmo & Rombouts, 2016).

Geographical Offender Profiling Empirical Base

Empirical research has been conducted to test the theoretical bases of geoprofiling and whether it is possible to fathom the link between a crime and its offender's base in an investigative useful way. The main body of empirical evidence is currently on the journey to crime of offenders, which is essentially how far from their homes they travel to commit a crime.

Nearly a century ago White (1932) conducted the first study analyzing how far burglars traveled to commit their crimes. Ever since then, multiple studies have replicated it using samples from different countries and various types of crimes. The main finding is that offenders do not usually travel far from their homes to commit their crimes (Martineau & Beauregard, 2016). In practice, researchers have found that criminals follow an exponential distance decay function (Figure 1). They will commit most of their crimes close to their home but the further they move away from it, the fewer crimes they are likely to commit (Willmott, Hunt, & Mojtahedi, 2021).

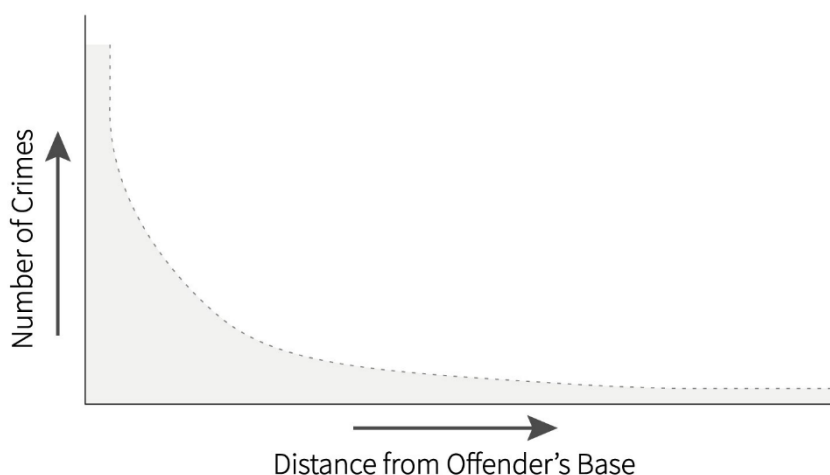


Figure 1: Example of an exponential distance decay.

It has also been identified that some offenders' and crime characteristics influence the distance traveled. Violent and interpersonal crimes are committed much closer to an offender's home when compared to property crimes or crimes motivated by financial gains. Levine and Lee (2012) found that, in the UK, violent criminals traveled on average 2.3km, while offenses motivated by financial gain had longer distances between the offender's home and crime location (2.9km). This relationship between the type of crime and distance traveled has also been found in the USA, where violent criminals traveled on average 2.1km less than property criminals (Ackerman & Rossmo, 2015). Similar findings were also identified in Canada, where violent criminals traveled a mean distance of 4.9km, while property criminals traveled on average 7.6km to commit their crimes (Wang, Lee & Williams, 2019).

Another important development in geoprofiling came from the work of Canter and Larkin (1993), who proposed the Circle Hypothesis (Figure 2). It is hypothesized that serial offenders will most likely have their base within their criminal range (a circular area created using the distance of the two farthest crimes of the series as the diameter). From this, serial offenders could be divided either as marauders or commuters. The first are serial offenders who leave their base searching for victims, attack them, and return home, they would have their base within their criminal range. The other type travels from their home to a different area, commits their crimes there, and travels back home, in this case, offenders' base and criminal range do not overlap.

The first study that proposed the Circle Hypothesis found that 87% of 45 serial rapists were marauders (Canter & Larkin, 1993). Additionally, Meany's (2004) study with 136 serial offenders showed that 93% of serial sex offenders, and 90% of serial arsonists were marauders. Eventually, empirical testing of the Circle Hypothesis has shown that it can work as a rather relevant 'rule of thumb', as it provides a good estimative when conducting a geographical offender profile of violent serial criminals (Willmott et al., 2021).

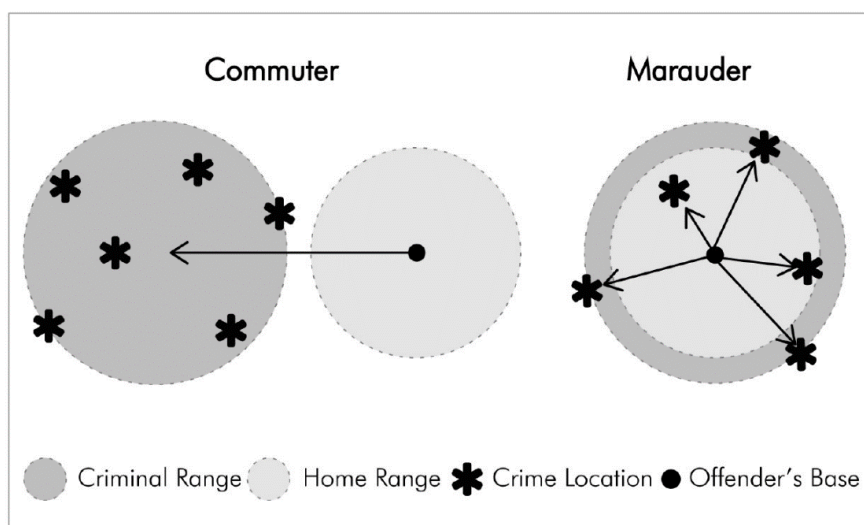


Figure 2: Example of the Circle Hypothesis

Individual factors such as offender's age have also been shown to be related to their journey to crime. Empirical evidence suggests that older offenders tend to travel longer distances to commit their crimes (Xiao, Liu, Song, Ruiter & Zhou, 2018). This could be explained by the fact that they may have a larger awareness space that has been built from years of moving around the city. Considering financial hindrance from younger populations that do not have a paid job and are dependent on others to fend for themselves, it could also be that older offenders have easier access to modes of transportation that facilitate travel and have more freedom to travel in search of a suitable victim without having to justify to others (e.g., parents or school) where they have been.

Similarly, offender's gender and race have also been found to be related to different patterns of movement. Most research has suggested that female offenders tend to travel shorter distances, while white offenders in the US have been found to travel longer distances when compared to African Americans and Hispanics (Ackerman & Rossmo, 2015; Xiao et al., 2018). A proposed explanation is that women and people from lower socioeconomic groups,

which is usually the case for non-white ethnicities in the US, have smaller activity spaces and thus, smaller awareness spaces.

Geographical Offender Profiling Software

Based on these advances in the field that allowed for the identification of how a crime location may be linked to an offender's base, and with the increased use of technology to assist humans in their everyday activities, computer software have been developed to assist geographical profilers and investigators. There are at least three different geoprofiling software available: Dragnet (Canter, Coffey, Huntley & Missen, 2000), Rigel Analyst (Rossmo, 2000), and CrimeStat (Levine, 2000). All three function in a very similar way: the user marks on the software where the crimes occurred, and the software uses algorithms based on distance decay functions to generate a heatmap. The heatmap indicates the degree of likelihood that the offender lives in that specific area, which varies from high to low probability. An example of Dragnet's output is presented in Figure 3 and should be interpreted as follows: red is the highest probability, grey is the lowest probability, and black squares are crime locations.

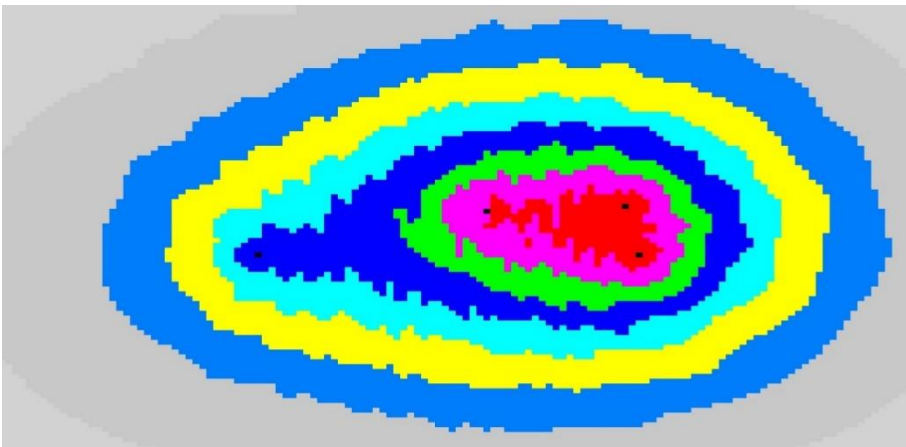


Figure 3: Example of a heatmap generated by Dragnet.

Although there are multiple computerized tools to assist a geographical offender profile, due to their similarities, they often achieve similar results (Berezowski, MacGregor, Ellis, Moffat & Mallett, 2021; Rich & Shively, 2004). Therefore, since the present study aims to assess the effectiveness of a computer software designed for geographical offender profiling, we will focus on only one of them: Dragnet.

It is important to note that the use of any geographical profiling software is not without its limitations. They are only useful when there is a series of crimes to analyze (Beauregard, Proulx & Rossmo, 2005), limiting their use to serial offenders. Additionally, the results require the interpretation from a human judge (geographical profiler or investigator), for example, to verify if it is possible for the offender to live in the prioritized area (Willmot et al., 2021).

Geographical Offender Profiling and Serial Killers

Many studies on geoprofiling have been conducted to analyze its applicability to serial killers. One set of research aims to verify the journey to crime of this type of offender. Considering that violent offenders travel shorter distances between their homes and crime locations, it is expected that serial killers will behave similarly. However, the mean distance traveled by these offenders is quite high. Lundrigan and Canter (2001) found that British serial killers traveled a mean distance of 18km, while serial killers from the USA traveled 40km on average. Snook, Cullen, Mokros, and Harbort (2005) found similar results in Germany, where serial killers traveled on average 16.8km.

The fact that serial killers have different reasons for committing their offenses when compared to one-time murderers is one of the proposed explanations for this difference. While murders are often the result of arguments that escalate to physical aggression, serial killing is usually more planned and targeting a specific type of victim. Thus, if serial killers wish to attack a specific target (e.g., children) they must travel to a location where the target is available (e.g., primary schools), which may not always be close to their home. Furthermore, hard-to-solve crimes, which usually require a lot of planning and preparation from the offender, have been linked to longer

journey to crime distances (Santilla, Laukkanen & Zappalà, 2007; Warren et al., 1998). Finally, serial killers' motivation may also play a role in the long distance traveled. These offenders are often sexually motivated and single sexual murderers have been found to travel very long distances to commit their crimes (nearly 30km on average), while sex offenders in general travel short distances (under 4km on average) (Martineau & Beauregard, 2016).

The longer distances traveled do not imply that geographical profiling of these offenders is impossible or even inaccurate. Serial killers have been found to have similar decision-making when moving around an area's environmental backcloth. As a result, they have similar patterns to other violent criminals as proposed by the Circle Hypothesis. Hodge and Canter (1998), for example, found that 86% of 126 US serial killers were marauders, Lino, Calado, Belchior, Cruz and Lobato (2018) identified that 66.7% of a sample of Brazilian serial killers were marauders, and Barreda's (2021) sample of 41 serial killers included 77.6% of marauders.

Tests of Dragnet's applicability on samples of serial killers have also shown good results. Canter et al. (2000) found that 51% of the serial killers analyzed had their home/base within 5% of the area suggested by Dragnet. Lino et al. (2018) found that in 66.7% of the serial killer cases analyzed, the offender's home was within one of the top two highest probability areas predicted by Dragnet. These findings suggest that Dragnet may be a useful solution to assist hard-to-solve serial killing cases.

Methods

Data was collected from two Brazilian cities: Salvador, the state capital of Bahia, which has approximately 2,857,000 habitants (around 3,900 habitants/km²), and Belo Horizonte, the state capital of Minas Gerais, with approximately 2,500,000 habitants (around 7,000 habitants/km²). In Salvador, there were 1,289 murders in 2016, while in Belo Horizonte there were 615 in the same year (Fórum Brasileiro de Segurança Pública, 2017). Regarding murder investigative success, there is no information about the cities, only

about their state. 58% of the murders committed in Minas Gerais in 2019 were solved, while in Bahia only 24% of them were solved (Instituto Sou da Paz, 2022). These differences may be because the largest criminal organizations in Brazil were created in the southeast area (where Minas Gerais is situated) but have recently moved to other areas of the country (such as Bahia) (Fórum Brasileiro de Segurança Pública, 2022). However, it could also be the result of financial investment, since Minas Gerais' Gross Domestic Product is more than twice that of Bahia, which directly influences the amount of money available to invest in better policing and to improve habitants' quality of life (Instituto Brasileiro de Geografia e Estatística, n.d.).

Police and court records were searched to identify serial killers. There are several proposed definitions for serial killers, however, the present study considers a serial killer as a person who unlawfully killed at least three victims in separate events, with a cooling-off period between them. This definition is in line with both the classical proposal by Douglas, Ressler, Burgess, and Hartman (1986) and recent developments in the field as proposed by Fridel and Fox (2018). The period considered for data collection varied according to each city due to the reliability of data and access granted by the institutions. As a result, data collected from Salvador ranged between 2011 and 2017, while in Belo Horizonte it ranged from 1999 and 2017.

A data collection protocol was created to ensure that every relevant information was extracted and considered for future analysis. Considering that the focus of the paper is on the effectiveness of a geographical profiling software, considerable emphasis was given to the geographical coordinates and information, such as the street address of where the crime occurred and where the offender lived. Independent variables that could provide greater insight into the applicability and effectiveness of Dragnet's performance were included in this protocol: offenders' gender, race, how many murders the offender committed, age at first murder, and the distance between crime location and offenders' home as measured by a straight line (as the crow flies).

Using the information about where the crimes took place for each series of murders, Dragnet was used to generate a heatmap for each one of them. The standard negative exponential function of the software was used since there

were no significant differences to other functions when tested on a sample of serial killers (Canter, et al., 2000; Canter & Hammond, 2006). After the results from this software were available, the home location for each serial killer was manually added using an image editor software. This allowed for verification of whether the home of the offender responsible for that specific series of crimes was within the area predicted by Dragnet, and how close it was to the top priority area.

Considering that Dragnet has eight different colors that range from grey to red (least to most likely area to find offender's home/base), the effectiveness of the software was categorized into four types, equal to that proposed by Lino et al. (2018): Ideal (offender's home within the red area), Fit (offender's home within the pink area), Weak (offender's home within the green, navy blue, light blue, yellow or dark blue area), Harmful (offenders' home within the grey area). However, due to the small sample size expected in each of the four groups, a new dependent variable named "Dragnet's Effectiveness" was created from these results to allow for more robust analyses. It was a dichotomous variable where a value of "0" was given when Dragnet was either Weak or Harmful, and a value of "1" was given when the result was Fit or Ideal.

Following this process, two types of statistical analysis were conducted. First, descriptive analyses were used to characterize the sample of serial killers and how well Dragnet could predict their home base. Second, Spearman's Rho correlations were conducted to analyze the association between the dichotomous variable "Dragnet's Effectiveness" and the independent variables. This research was submitted and approved by the Ethics Committee of the State University of Paraíba.

Results

In total, 66 serial killers were identified, which had enough information about the offender and crimes committed to allow the use of a geographical profiling software such as Dragnet. There were 20 serial killers in Salvador,

who had murdered 86 victims, the remaining 46 serial killers were identified in Belo Horizonte, and they were responsible for the murder of 248 victims. The mean age when these serial killers started their series was 20.47 (SD = 4.24) and only one of them was a female. A considerable part of the data regarding race was missing (43.9%) but analyses of the information available showed that 56.8% were black, 27% were brown-skinned (*pardo*, in Brazilian Portuguese), and 16.2% were white. Information about formal education was even more lacking, only 28.8% of the files had details of whether offenders had finished elementary or high school. Detailed information on sociodemographic data is presented in Table 1.

Table 1: Sociodemographic variables

Variable	n	Valid Frequency
Serial Killers per City		
Belo Horizonte	46	69.7%
Salvador	20	30.3%
Gender		
Male	65	98.5%
Female	1	1.5%
Race ^a		
Black	21	56.8%
Brown-skinned	10	27%
White	6	16.2%
Formal Education ^b		
Unfinished Elementary School	4	21.1%
Finished Elementary School	12	63.2%
Finished High School	3	15.8%

a: 43.9% of missing data.

b: 71.2% of missing data.

Regarding their crime series, offenders usually committed four murders (45.5%). Only 9.1% had killed the minimum number of victims to be considered a serial killer (3 victims), while 2 offenders were each responsible for the murder of 12 people (3%). In total, only 9.1% had killed at least eight victims and could be considered “prolific” serial killers according to the classification proposed by Fridel and Fox (2018). The serial killers traveled

on average 2.36km (median = 0.65km) from their home to the crime scene, with a minimum distance traveled of 0.03km and a maximum of 21.74km. Table 2 and Figure 4 present detailed data on serial killers’ crime information and distance traveled.

Table 2: Serial killers’ crime information

Variable	Mean (SD)	Median	Minimum	Maximum
Number of victims	5.06 (1.86)	4	3	12
Age of first murder	20.47 (4.24)	20	14	34
Distance travelled	2.36km (4.33)	0.65km	0.03km	21.74km

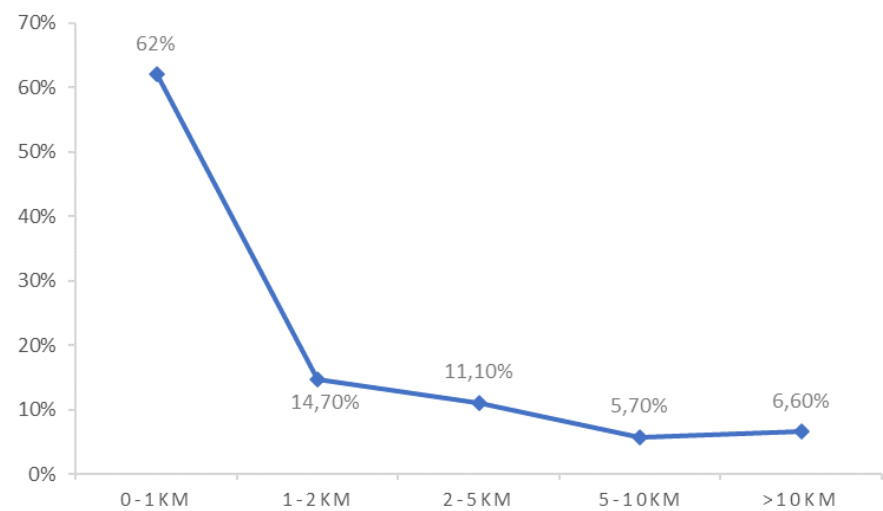


Figure 4: Distance traveled from offenders’ base to commit murder.

Most of the serial killers displayed a marauder offending pattern (66.7%). Finally, Dragnet’s results were as follows: 45.5% of serial killers had their home base within the red area, thus being categorized as an Ideal result, 18.2% were identified as a Fit result, while 21.2% of the results were Weak and 15.1% were considered Harmful. As a result, Dragnet achieved high effectiveness in 63.6%

of the cases and low effectiveness in 36.4% of the cases. Figures 5 and 6 provide examples of Dragnet's High Effectiveness and Low Effectiveness, respectively. In those figures, the offender's base is represented by the white circle. Table 3 details offenders' geographical movement patterns and Dragnet's results.

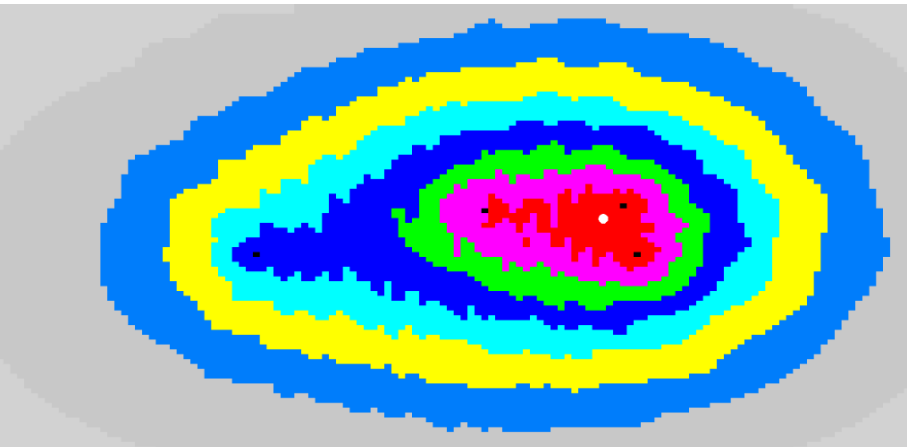


Figure 5: Example of Dragnet's High Effectiveness.

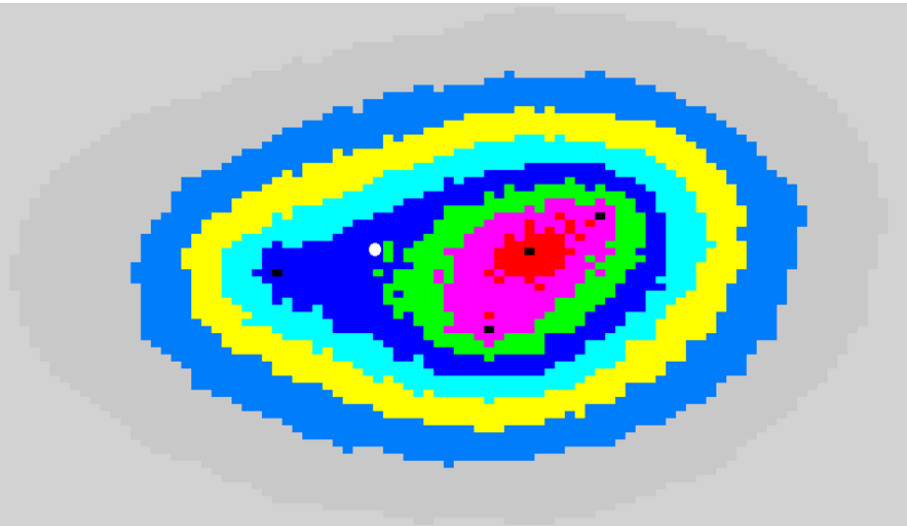


Figure 6: Example of Dragnet's Low Effectiveness

Table 3: Serial killers' movement pattern and Dragnet's results

Variable	n	Valid Frequency
Movement pattern		
Commuter	22	33.3%
Marauder	44	66.7%
Dragnet's results		
Ideal	30	45.5%
Fit	12	18.2%
Weak	14	21.2%
Harmful	10	15.2%
Dragnet's effectiveness		
High effectiveness	42	63.6%
Low effectiveness	24	36.4%

Correlation analyses were conducted to measure whether the dependent variable “Dragnet’s Effectiveness” was related to any of the independent variables. A significant and positive correlation was found between Dragnet’s results and the marauder offending pattern ($r = 0.535$, $p < 0.01$), with a negative correlation of equal strength to the commuter offending pattern ($r = -0.535$, $p < 0.01$). A negative significant correlation was found between Dragnet’s results and the mean distance traveled to commit a murder ($r = -0.250$, $p < 0.05$).

There were no other significant correlations ($p > 0.05$) when analyzing “Dragnet’s Effectiveness” and the other independent variables, such as gender, race, age on the first murder, and number of victims. Offenders’ formal education was not considered for correlation analysis because more than 70% of the data was missing, which could lead to inaccurate results (Fraenkel & Wallen, 2009). A new dichotomous variable was also created to allow for the analysis of prolific serial killers (i.e., those who had killed at least eight victims). It was named “Prolific” with the following values: 0 = “non-prolific offender” and 1 = “prolific offender”. However, there were no significant correlations identified between this new variable and the dependent variable “Dragnet’s Effectiveness” ($p > 0.05$). Table 4 details the full correlation matrix.

Table 4: Full correlation matrix

	1	2	3	4	5	6	7	8	9	10	11
1. Dragnet's Effectiveness	1										
2. Marauder	.535 ^a	1									
3. Commuter	-.535 ^a	-1.000 ^a	1								
4. Mean distance travelled	-.250 ^b	-.438 ^a	.438 ^a	1							
5. Number of victims	.058	.220	-.220	.082	1						
6. Prolific	.020	.112	-.112	.111	.525 ^a	1					
7. Male	-.094	-.088	.088	-.029	-.120	.039	1				
8. Black	.057	-.119	.119	.164	.162	-.191	^c	1			
9. Brown-skinned	-.117	.098	-.098	-.097	-.159	.274	^c	-.697 ^a	1		
10. White	.065	.041	-.041	-.103	-.026	-.073	^c	-.504 ^a	-.268	1	
11. Age at first murder	.004	-.057	.057	.083	-.150	-.206	.114	-.098	.132	-.028	1

a: Correlation is significant at the 0.01 level (2-tailed)

b: Correlation is significant at the 0.05 level (2-tailed)

c: Unable to calculate because at least one of the variables is constant. There was no data on the single female participant.

Discussion

Studies on Brazilian serial killers are extremely scarce. The available information on the biggest database in the world on serial killers (Radford/FGCU Serial Killer Database) includes only 29 Brazilian serial killers, even though it considers any time or location where the crimes took place in Brazil, and a minimum victim threshold of two, instead of three (Aamodt, Leary & Southard, 2020). This is less than half of the serial killers that have been analyzed in the present study, even though only two cities were considered, and the definition of serial killers was much stricter. Therefore, it is extremely likely that a country as big as Brazil has at least as many serial killers as the USA, widely known as the country with the most serial killers.

Comparing the data from Brazil and that of the Radford/FGCU Serial Killer Database, allow us to verify up to which point international details on

serial killers are also found in Brazil. Worldwide, serial killers appear to be mostly men, with only 10.7% of them being women (Aamodt, Leary & Southard, 2020). In Brazil, this is also true, but the proportion seems to be much more prominent, considering that out of the 66 serial killers identified, only one of them was a woman, equivalent to 1.51% of the sample, or around 10x less than the proportion of female serial killers worldwide. While this information may lead us to think that Brazilian females are less likely to commit serial murder than females from other countries, it is also possible that the explanation for this difference resides in investigative results. Female serial killers are more likely than their male counterparts to kill using poison. Male serial killers, on the other hand, are more likely to kill using firearms and have unusual behaviors, such as necrophilia, torture, rape, and mutilation of the body (Aamodt, Leary & Southard, 2020). These differences may make it more likely for police forces to identify male perpetrators because they would leave more forensic evidence (e.g., sperm, DNA on victim's body), while women serial killers would be more difficult to detect since they would leave less identifiable traces that could link them to the murders.

Race of serial killers is another topic usually considered when characterizing these offenders. In the USA, half of the serial killers are white, while 40.4% are African American (Aamodt, Leary & Southard, 2020). The sample analyzed in the present study did not have information on the ethnicity of nearly half of the serial killers, preventing an accurate comparison. However, the available information points to a significantly different direction, given that 16.2% of the offenders were white, and over half were black. These results should be considered with caution, not only due to the lack of representative data but also due to cultural differences.

Brazil is known to be a country with mixed races, with less clear differences between White, Black, and Brown-skinned people than other countries from North America or Europe. Furthermore, black people in Brazil are more likely to live in areas where infrastructure, formal education, and basic human rights are lacking (Instituto Brasileiro de Geografia e Estatística, 2021; Oliveira & Souza, 2015). This could be linked to increased involvement with criminality, including crimes against the person such as homicide. A

national report showed that the proportion of white victims of murder caused by firearms was 10.6/100,000 white habitants, while for black victims it was 27.4/100,000 black habitants (Waiselfisz, 2016). Therefore, it is probable that the high proportion of black serial killers in this sample is a symptom of much deeper socioeconomic problems in Brazil.

It appears that Brazilian serial killers begin their crime series much younger than in other countries. The average age for a serial killer at the start of their series was 28 when looking at the serial killer database (Aamodt, Leary & Southard, 2020), while in Brazil they started 8 years earlier. The high levels of criminality, especially homicide, in Brazil may serve as a catalyst for earlier involvement in crime. There were around 47,000 murders in Brazil in 2021, there are geographical areas dominated by drug traffic cartels where dispute for territory leads to dozens of murders in the area (Fórum Brasileiro de Segurança Pública, 2021; 2022). This exposure to violence likely affects people from a very young age, desensitizing them to acts of aggression and resorting to violence to solve interpersonal conflicts. Three other factors may also be influencing this young age of offending. Aamodt, Leary, and Southard (2020), found that male and Black serial killers, as well as those that killed in relation to organized crimes, were younger at the beginning of their murder series. The sample analyzed in this paper consisted mostly of men and (possibly) black offenders, and the high number of drug-related murders in Brazil suggests that this motivation is also prevalent among Brazilian serial killers, a fact already identified by Lino and Lobato (2019).

The number of victims each offender killed shows that there were “regular” serial killers as well as “prolific” serial killers, those that killed more than seven victims (Fridel & Fox, 2018). These were only a small part of the sample, which indicates that the police have been able to prevent future murders from happening by arresting these individuals early in their series. While this is a fact to be praised, since serial killers cause terror and are responsible for taking multiple lives, it is likely that many more serial killers have not yet been identified by the police. Recent reports show that only 37% of the murders in Brazil are solved by the police, which means that around 29,600 of them remain unsolved each year (Instituto Sou da Paz, 2022). If we

consider, hypothetically, that merely 1% of the unsolved murders are due to serial killers (296 murders per year), and that each of them killed four people (the average number of victims identified in the present study), there would be 74 serial killers active in a year in Brazil. Whilst it is important to praise police for their work in the capture of these serial killers, it is also necessary to identify the perpetrator of the thousands of other murders that happened and correctly verify how many serial killers are active in a year in Brazil.

In this sense, Dragnet showed promising results that it could work as an effective decision-support tool in the investigation of serial killers in Brazil. It could accurately direct police resources in around 63% of the time (when the offender's base was within the first or second most likely area predicted by the software). Although one can argue that this percentage of accuracy is not good enough to defend its use in active investigations, in only 15% of the cases the offender's home was not within the area predicted by Dragnet. Even though the offender's home was not always within the highest area of probability predicted, should police forces work their way through the other areas suggested by Dragnet, they would find the home of the offender in 85% of the cases.

The results found in the present study are similar to those with another sample of Brazilian serial killers, where Dragnet accurately predicted the offender's home in 66.67% of the cases (when the offender's base was within the first or second most likely area predicted by the software) and had the offender's base within any of the predicted area 86.67% of the time (Lino et al., 2018). Faria (2020) found similar results testing the Rigel Analyst software using a sample of Brazilian serial offenders in general. In 85% of the cases, a known address of the serial offender was present in an area predicted by the geoprofiling software. These findings suggest that any geographical profiling software currently available would have around 85% accuracy in identifying a Brazilian serial offender's base within the heatmap generated, with a decrease in accuracy when considering the highest probability area suggested by the software.

For that reason, it is important to improve the software's effectiveness. Identifying which factors could contribute to a higher level of accuracy is one

possible way of improving Dragnet's effectiveness. Attempts to identify these factors using the data collected in the present study were less promising than expected. Correlation analyses identified only two factors that were significantly related to Dragnet's accuracy: offenders' movement pattern (marauder vs commuter) and offenders' short journey to crime distances. Other independent variables collected and discussed earlier, such as race, gender, age of first murder, and number of victims were not correlated to Dragnet's effectiveness.

Considering that Dragnet uses an exponential distance decay function to measure and create the heatmap, it is not surprising that the farther offenders travel from home, the less likely the software is to identify where they live. This was expected because the environmental theories that support the geographical offender profiling (and consequently Dragnet's calculations) propose that offenders do not travel far from home because of their awareness space, routine activities, and decision-making focused on minimum effort (Brantingham & Brantingham, 1984; Cohen and Felson, 1979; Cornish & Clarke, 2016). This theoretical perspective has also proven to be true under empirical scrutiny, given that most offenders travel short distances to commit their crimes (Martineau & Beauregard, 2016), which has also been found to be true for serial offenders in Brazil (Faria & Diniz, 2020; Lino et al., 2018)

This finding further suggests that if police forces have reason to believe that the offender would not travel far from home, Dragnet could be even more reliable. There are numerous studies on journey to crime that have established links between offender characteristics or offending behavior and distance traveled. Lino et al. (2018) have found that serial killers who use surprise as the method to approach/attack their victims are more likely to travel shorter distances. Andresen, Frank, and Felson (2014) have identified an inverted "U" shaped relationship between age and distance traveled. In other words, very young and older adults tend to travel shorter distances to crime when compared to young adults between 18 and 29 years of age. This type of information can be collected directly or inferred from the crime scene and could help police better discern when and how to use Dragnet, increasing its effectiveness. Therefore, it is not simply a matter of knowing simple "rules of

thumb” but understanding the underlying principles and theories of geographical profiling, the cognitive and social constraints on offender’s decision-making, and being in touch with the available evidence to make the most of a geoprofiling software (Knabe-Nicol and Alison, 2011).

The link between offenders’ movement patterns (marauder/commuter) and Dagnet’s results found in the present study had already been identified by Lino et al. (2018), which suggests that this software’s applicability is constrained depending on how the offender searches for his victims and uses his base/home. In Brazil, most of the serial killers are marauders. However, it is not as dominant as it has been found in other countries, such as the USA (86% of marauders serial killers; Hodge & Canter, 1998) or from an international sample of multiple countries (77.6% of marauders; Barreda, 2021). If the link identified in the present research is also present in international samples, it is possible that Dagnet could have reduced accuracy in Brazil when compared to other countries.

The fact that Dagnet is more suitable for marauder offenders is not surprising due to what is already known about offenders’ decision-making and movement patterns. When Canter and Larkin (1993) first proposed the Circle Hypothesis, they based their assumptions on environmental criminology research, which suggested that offenders would act somewhat close to their homes due to the security provided by their familiarity with the area. In other words, offenders will act close to their homes because it is the least effort required but also because they are familiar with the area due to their routine activities. Furthermore, as Canter and Larkin (1993) suggest, the marauder model has a closer relationship between his home and crime locations when compared to the commuter model. Thus, Dagnet, which has been created as a computerized development of the Circle Hypothesis, is more effective when analyzing the most common offending model identified in previous research: the marauders (Canter, et al., 2000).

This connection between Dagnet’s good results with marauders raises the question if police forces should invest in acquiring and training police officers to use geographical profiling software, or whether they should simply teach them the circle hypothesis. In other words, train them to look for

suspects living within the criminal range of the series of crimes. Bennell, Snook, Taylor, Corey, and Keyton (2007) tested this using a sample of police officers who were tasked with identifying the home location of serial burglars. They found that officers who were taught about the circle hypothesis were significantly better at predicting the offender's home base when compared to CrimeStat's results. Considering that Dragnet follows the same underlying principles as CrimeStat, it is possible that the results would be similar if Dragnet were the chosen geoprofiling software used for analysis by the researchers.

On the other hand, as Knabe-Nicol and Alison (2011) highlight, the work of producing a geographical offender profiling is more than putting "Xs" on a map. It consists of being able to identify the most relevant information collected in the investigation that could have inferential or predictive value, an attempt to identify criminal behavior and offenders' choices throughout their criminal act, such as how they chose the victim or location or why they decided to attack at a specific time. Another important piece of expertise required to produce a geoprofile is knowledge of the available scientific evidence on geographical offender profiling. It would make investigators aware of situations when software may not be favorable or how to best interpret its findings. This necessary knowledge is directly linked to the results of the present study, which has identified some situations where Dragnet has its best results.

Practical Implications

The need for better investigative practices in Brazil when it comes to murder, and serial murder is clear. The clearance rates for these types of crimes are far from ideal. The present research provides scientific evidence for the use of a new investigative tool to assist in the investigation of serial killings. Dragnet's accuracy was not perfect, but it was suitable for use in most cases. Therefore, during an active serial killer investigation, where police either have no suspects or too many suspects, knowledge of where this offender may live can prove fruitful. If there are currently no suspects, police

can use the heatmap generated by Dragnet to conduct house-to-house inquiries and identify anyone who could be linked to the killings. In a situation where there are too many suspects, the ones that live in high-probability areas predicted by Dragnet could be prioritized. Therefore, it allows police to use their resources more effectively, using science and evidence-based practices to increase their chances of apprehending the suspect faster while spending less money. It is important to note that a geographical profile produced from Dragnet is not supposed to be used as evidence of guilt or innocence but as a decision support tool to help police direct their efforts. It is not meant to replace traditional investigations but to act as another tool in the investigators' toolbox.

On the other hand, some precautions must be taken to ensure that Dragnet's use is optimal. Dragnet will have the best results when the offender is a marauder or when the journey to crime distances are shorter. Thus, officers must consider other factors when deciding whether and how to use this software. For example, if the police have reason to believe that an offender travels short distances because he is a teenager, Dragnet is more suitable. However, if the police have reason to believe that the offender is not from the area (e.g., the offender stands out from the people that circulate in the area where the crimes are committed), they are advised to use Dragnet with caution, since it is likely that the offender is not a marauder, and Dragnet's effectiveness is suboptimal.

Considering these issues, it is suggested that a geographical offender profiling software (Dragnet) can be used in active serial killer investigations in Brazil. However, any investigators who wish to produce geographical profiles need to go through proper training, since it requires thorough knowledge of the underlying theories, principles, and empirical evidence on the subject. Even though it may seem like a big effort, the results can have a cascade effect and improve murder clearance rates and public safety. First, if a serial killer is identified and Dragnet is used, the police will have more chances to conclude the investigation more quickly and spend fewer resources. Second, if this serial killer is arrested, multiple murder investigations will have been solved, increasing clearance rates, and there will probably be fewer

homicides because a serial offender has been stopped. Third, because of more effective investigations, police forces will have more resources (e.g., number of investigators available, quicker forensic analyses) and, therefore, more chances to solve other murders that may or may not have been committed by serial killers. Fourth, arresting serial killers and improving murder clearance rates will also lead to better perceptions of public safety by the community, improving quality of life and the relationship between police and the community.

Limitations and Future Directions

Despite the promising findings and potential applications, the present research also had limitations. One of those is outside of researchers' grasp, which relates to the low murder clearance rates and inaccuracy of police crime data. Less than half of the homicides in Brazil are solved, Minas Gerais had better clearance rates than Bahia, but it still fell below 60%. As a result, there is a plethora of data that is inaccessible and could represent a different group of serial killers, those that are not caught. This is a common limitation to any research in Investigative Psychology and Offender Profiling, which is constrained by what the police and courts have available. Similarly, out of those cases in which the serial killer was caught, some data that could prove useful to better understand Dragnet's effectiveness were missing, such as offenders' race, previous convictions, previous home addresses, etc. The fact that only one of the serial killers was a female also prevented detailed analyses of how gender could be related to offenders' movement and Dragnet's effectiveness.

Another limitation refers to research generalizability. The sample consisted of serial killers from only two cities, although the results were similar to studies in another Brazilian city, Brazil is a massive country, with many states and regions, each with its own culture, police force, and movement patterns. Further, considering the method used to assess Dragnet's accuracy in the present paper, it was possible to compare to other studies conducted in Brazil, but it did not directly compare to studies in other

countries.

Identifying those limitations is an important step to direct future research. Colleagues who wish to further explore the subject are invited to seek other independent variables that were unavailable or missing and could prove useful. Those include but are not limited to offenders' criminal history, past home addresses, work address, modus operandi, and victimology. It would also be beneficial to verify Dragnet's applicability on a sample of female serial killers to compare with the results presented in this paper and other research conducted in Brazil. One of the main findings of the present paper refers to Dragnet's improved accuracy when the offender is a marauder, thus, research that builds on current knowledge to identify whether the offender is a commuter or marauder based on crime scene evidence and criminal behavior will greatly advance the field. Finally, Dragnet was developed to assist in the investigation of serial crimes, it is important to test its applicability on other types of crimes, such as serial rape or serial burglary, which could potentially provide evidence of its use in different investigative scenarios.

Conclusion

The present study set out to verify the effectiveness of Dragnet, a geographical profiling software, in the identification of Brazilian serial killers' homes. Results showed promise as in most of the cases the offender's home was within the area predicted by the software, and in 6 out of 10 cases, it would be within the most likely areas predicted. This supports the use of such software in assisting police investigations when searching for serial killers. However, it is important to note that it should not be used without a qualitative analysis and interpretation that considers other aspects of the crime and offender that may increase or decrease the software's effectiveness.

The data collected also allowed for an analysis of Brazilian serial killers that had not yet been done and published in English. This study has shown that Brazilian serial killers start their crimes much younger when compared to international ones, fewer women are involved in this type of criminal activity,

and the race of these offenders is quite different in proportion. Explanations of these discrepancies are suggested according to the specificities of criminality and police investigation in Brazil.

Although these findings encourage the use of Dragnet to assist investigations of serial killings, there is still much that can and needs to be improved as we expect greater accuracy to optimize even further police efforts. It has been shown that there are individual differences among Brazilian and foreign serial killers, but do they also affect how offenders move, and how effective geographical profiling software are? It is important to generate as much evidence as possible on influencing factors of Brazilian serial killers' movement patterns and how these may impact Dragnet's efficacy.

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Printed in Seoul, Korea
31 December, 2023

ISSN 2713-5152

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