Exploring Racial Disproportionality in Traffic Stops Conducted by the Raleigh Police Department

FINAL REPORT

Prepared for

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Executive Summary

In 2016, RTI International conducted research using traffic stop data to evaluate the racial composition of the individuals in traffic stops conducted by the Raleigh Police Department (RPD). These data came from the traffic stop database maintained by the State of North Carolina. Following the publication of that report, RPD asked RTI to complete a more extensive review of racial disproportionality in the agency's traffic stops. Notably, the results reported herein differ from the previous analysis; this report (1) expands the analysis period, (2) disaggregates stops by the officers' assigned geographical areas, and (3) explores traffic stops conducted by patrol and nonpatrol units separately.

Data from January 2010 through June 2018 were analyzed using the "veil of darkness" (VOD) methodology first developed by Grogger and Ridgeway (2006). This methodology assumes that officers cannot always correctly determine a driver's race during periods of darkness. It takes advantage of the fact that the sun sets at different times throughout the year (e.g., sunset may occur at 6:00 p.m. in December and 9:00 p.m. in July). Using this framework, we can compare the race of drivers stopped during daylight with the race of drivers stopped during darkness. The analysis window is limited to those hours when it is sometimes light and sometimes dark throughout the year (roughly 5:30 p.m. and 9:00 p.m.).

During the study period, we found the following:

- No evidence of disproportionality at the city level.
- No evidence of disproportionality when considering only female drivers.
- No evidence of disproportionality when considering only male drivers.
- No evidence of disproportionality when considering individual districts.
- No evidence of disproportionality when considering only traffic stops conducted by officers assigned to patrol units.
- Some initial evidence of disproportionality when considering only traffic stops conducted by officers assigned to nonpatrol units; however, this result did not hold up under additional sensitivity testing, suggesting that other factors may have driven this result.
- Some evidence of disproportionality when considering the subset of traffic stops conducted by patrol officers making stops in the southwest district. Black female motorist were over-represented compared to white female motorists.

Introduction

In 2016, RTI conducted research using traffic stop data from a state-maintained database to evaluate the racial composition of the individuals in traffic stops conducted by the RPD. The RPD later asked RTI to complete a more extensive review of racial disproportionality among the agency's traffic stops. This document reports on the findings of this more in-depth evaluation. Notably, the results reported herein differ from the previous analysis; specifically, this report (1) expands the analysis period, (2) disaggregates stops by the officers' assigned geographical areas, and (3) explores traffic stops conducted by patrol and nonpatrol units separately.

In the previous report, we detailed the methodological challenges of analyzing traffic stop data for evidence of disproportionality. Externally benchmarked methods suffer from issues of internal validity, which makes studies using these methods questionable. Various other approaches have been developed to minimize the impact of external benchmarks. One such approach is the VOD method, which is based

on the logic that police officers are less likely to be able to ascertain the race of a motorist after dark than they are during daylight (Grogger & Ridgeway, 2006). The underlying assumption is that reduced lighting hinders the ability of officers to determine race. The existence of racial disproportionality can be assessed by comparing the race of drivers stopped during daylight with the race of drivers stopped after dark during the intertwilight period (roughly 5:30 p.m. to 9:00 p.m.). The analysis is limited to stops that occur in the late afternoon and early evening hours to reduce the variation in travel patterns that depend on time of day. Accordingly, the VOD method avoids the complex issue of controlling for the driver activity base rate.

Data

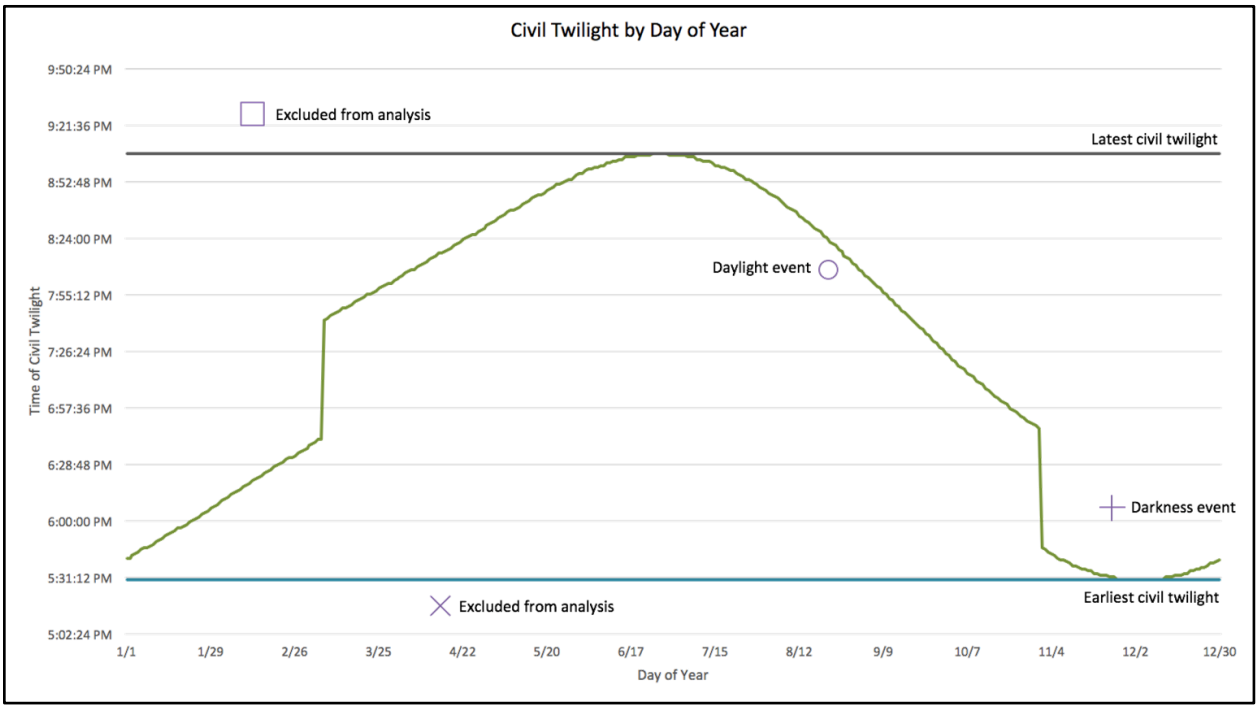
Data from 577,402 traffic stops conducted by the RPD from March 13, 2010 through June 2018 were analyzed. North Carolina state statute requires law enforcement agencies to document the demographic characteristics, stop characteristics, and stop outcomes of all traffic stops.[1] The stop data analyzed here were sourced directly from the RPD and included additional information (e.g., the district in which a stop occurred and the assignment to patrol or nonpatrol units) not included in the traffic stop data submitted to the state.

Analytical Method

To study the racial distribution represented in traffic stops in Raleigh, we used the VOD approach, which is based on the logic that police officers are less capable of determining the race of a motorist after dark than they are during daylight. Using this method, the existence of racial bias can be assessed by comparing the racial distribution of stops conducted during daylight to the racial distribution of stops after dark. The analysis is limited to stops that occurred during the intertwilight period (5:28 p.m. to 9:05 p.m. during the analysis period considered in this report) to reduce variation in travel patterns that are conditional on time of day. ***Figure 1*** depicts the intertwilight period.

[1] The North Carolina state legislature passed Senate Bill 76 in 1999 to require state law enforcement officers to collect traffic stop statistics. This requirement was later expanded to include local law enforcement officers. An amendment to the bill in 2009 specified that each law enforcement officer making a stop would be assigned an anonymous identification number by the officer's agency, and this number would be reported to the Division of Criminal Statistics along with other types of traffic stop data required by the bill.

Figure 1: Civil Twilight by Day of Year



☐ Events above the black line occurred *after* the latest civil twilight—always in the dark. These events are excluded.
X Events below the blue line occurred *before* the earliest civil twilight—always during daylight. These events are excluded.
O Events between the blue and black lines occurred after the earliest civil twilight and before the latest civil twilight. Events under the green curve occurred before civil twilight of that day and are considered daylight events.
\+ Events outside of the green curve occurred after civil twilight for that day and are considered darkness events.

The VOD method was developed and first employed by Grogger and Ridgeway in an analysis of traffic stops in Oakland, California, in 2006 (Grogger & Ridgeway, 2006) and Cincinnati, Ohio, in 2009 (Ridgeway et al., 2009). The method also has been used in studies focusing on the nature of traffic stops in Minneapolis, Minnesota (Ritter & Bael, 2009), Syracuse, New York (Worden, McLean, & Wheeler, 2010), San Diego, California (Burks, 2015), Durham, North Carolina (Taniguchi et al., 2017) and a variety of jurisdictions in the state of Connecticut (Ross, Fazzalaro, Barone, & Kalinowski, 2015). Evidence of racial disproportionality was identified using this method in Minneapolis, Durham, and several jurisdictions in Connecticut.

Like RTI's previous work in Durham, we incorporated one enhancement from most previous studies: We used a random intercepts model to control for differences between officers. Doing so recognizes inherent differences among officers in the percentages of black motorists they are likely to encounter. These differences may be caused by factors such as geographic deployment, unit assignment, or individual characteristics (e.g., unique decision-making processes). More details about the implications of this methodological enhancement can be found in Taniguchi et al. (2017).

One benefit of the VOD approach is the simple interpretation of results. A statistically nonsignificant daylight indicator suggests that daylight was not associated with the race of the stopped driver. Alternatively, a statistically significant, positive daylight indicator suggests that black motorists are more

likely to be stopped during times when visibility is higher. Evidence of racial bias is present if minority drivers are overrepresented during daylight hours compared with times of darkness.

We processed the RPD's traffic stop data for 2010–2018 and incorporated information on civil twilight, collected from a public database maintained by the U.S. Naval Observatory. Using the VOD method, we explored the following five relationships:

1. light visibility and race of the driver stopped;
2. light visibility and race of the driver stopped among female drivers only;
3. light visibility and race of the driver stopped among male drivers only;
4. light visibility and race of driver in different districts; and
5. light visibility and race of the driver stopped among different kinds of unit assignments.

Descriptive Statistics for Traffic Stops

This section describes the stop data used in this analysis. Descriptive statistics from all the stops in the time range (January 2010 through June 2017) are provided along with those for the subset of events that are used in the VOD analysis (intertwilight period).

Table 1 displays frequency distributions and percentages for the reasons for traffic stops. The first set of columns represents all 577,402 traffic stops that occurred in the time period studied. The shaded columns display frequency distributions and percentages for only the 72,191 traffic stops that occurred during the intertwilight period. Among the reasons for all traffic stops, the most likely was a vehicle regulatory violation (39.4% of all stops). Large percentages of stops were also identified for speed limit violations (15.3%) and vehicle equipment violations (14.8%). Perceptions of the driver being impaired, seat belt violations, and checkpoints were less common reasons for traffic stops (<2% each). Similar patterns were observed during the intertwilight period when, specifically, speed limit violations, vehicle regulatory violations, and vehicle equipment violations were the top three reasons for stops. One noteworthy difference is that speed limit violations made up a smaller percentage of stops during the intertwilight period than they do for all stops, whereas vehicle equipment and regulatory violations make up larger percentages of stops during the intertwilight period. Other motor vehicle violations are relatively common as well, comprising 9.2% of all stops and 11.5% of stops during the intertwilight period.

Table 1: Reasons for Stop

Reason	All stops (*N* = 577,402)		ITP stops (*n* = 72,191)	
	Frequency	Percent	Frequency	Percent
Checkpoint	284	0.05	11	0.02
DWI	6,884	1.19	286	0.40
Investigation	12,103	2.10	1,656	2.29
Other motor vehicle violation	53,213	9.22	8,305	11.50
Safe movement violation	38,083	6.60	5,051	7.00
Speed limit violation	162,742	28.19	11,075	15.34
Seat belt violation	13,712	2.37	1,280	1.77
Stoplight/sign violation	37,106	6.43	5,426	7.52
Vehicle equipment violation	66,169	11.46	10,663	14.77
Vehicle regulatory violation	186,974	32.38	28,418	39.37
Unknown	132	0.02	20	0.03
Total	577,402	100.00	72,191	100.00

Notes: DWI = driving while intoxicated; ITP = intertwilight period.

Table 2 shows descriptive statistics for reasons for the traffic stop by the officer's unit assignment. Shaded columns present results specifically during the intertwilight period. Only patrol and nonpatrol categories were provided, and over 80% of all traffic stops, both overall and during the intertwilight period, were conducted by officers assigned to the patrol unit. A lower percentage of stops conducted by officers in patrol units were for speed limit violations, and a higher percentage were for vehicle equipment and regulatory violations, than stops conducted by officers in nonpatrol units.

Table 2: Reasons for Stop by Officer Assignment

Reason for stop	Patrol				Nonpatrol				Total			
	All	%	ITP	%	All	%	ITP	%	All	%	ITP	%
Checkpoint	158	0.0	4	0.0	126	0.2	7	0.1	284	0.1	11	0.0
DWI	5,039	1.0	229	0.4	1,845	2.2	57	0.8	6,884	1.2	286	0.4
Investigation	11,887	2.2	1,447	2.2	1,216	1.4	209	2.9	12,103	2.1	1,656	2.3
Other motor vehicle violation	47,086	9.6	7,283	11.2	6,127	7.3	1,022	14.1	53,213	9.2	8,305	11.5
Safe movement violation	33,860	6.9	4,570	7.0	4,223	5.0	481	6.7	38,083	6.6	5,051	7.0
Speed limit violation	115,853	23.5	8,893	13.7	46,889	55.7	2,182	30.2	162,742	28.2	11,075	15.3
Seat belt violation	10,044	2.0	895	1.4	3,831	4.5	385	5.3	13,875	2.4	1,280	1.8
Stoplight/sign violation	34,313	7.0	5,051	7.8	2,793	3.3	375	5.2	37,106	6.4	5,426	7.5
Vehicle equipment violation	60,850	12.3	9,913	15.3	5,319	6.3	750	10.4	66,169	11.5	10,663	14.8
Vehicle regulatory violation	175,138	35.5	26,664	41.0	11,836	14.1	1,754	24.3	186,974	32.4	28,418	39.4
Unknown	89	0.0	15	0.0	43	0.1	5	0.1	132	0.0	20	0.0
Total	493,191	85.4%	**64,964**	**90.0%**	84,211	14.6%	**7,227**	**10.0%**	577,402		72,191	

Notes: ITP = intertwilight period; *N* for all stops = 577,402; *n* for ITP stops = 72,191; approximate column percentages are in parentheses.

Table 3 displays reasons for traffic stops by the time of day for stops that occurred during the intertwilight period. Although variation was found in the number of stops that occurred during each 30-minute increment, the distribution of reasons is constant over time except for seat belt and equipment

violations, which both decreased slightly throughout the night. The percentage of all stops that pertained to vehicle regulatory violations also varied slightly and peaked between 6:30 p.m. and 7:00 p.m. at 44%, but dropped to 35% of all stops after 8:30 p.m.

Table 3: Reasons for Stop by Time of Day during Intertwilight Period

Reason for stop	5:30–6:00	6:00–6:30	6:30–7:00	7:00–7:30	7:30–8:00	8:00–8:30	8:30–9:00	9:00–9:30	Total
Checkpoint	4	0	0	0	0	2	3	2	11
	(0)%	(0)%	(0)%	(0)%	(0)%	(0)%	(0)%	(0)%	(0)%
DWI	14	10	25	18	48	71	80	20	286
	(0)%	(0)%	(0)%	(0)%	(0)%	(0)%	(0)%	(1)%	(0)%
Investigation	109	91	141	168	331	361	376	79	1,656
	(2)%	(2)%	(2)%	(2)%	(2)%	(2)%	(2)%	(2)%	(2)%
Other vehicle violation	642	455	651	869	1,565	1,842	1,932	349	8,305
	(13)%	(11)%	(11)%	(11)%	(12)%	(12)%	(11)%	(11)%	(12)%
Safe movement violation	490	402	500	500	866	962	1,137	194	5,051
	(10)%	(10)%	(8)%	(6)%	(6)%	(6)%	(7)%	(6)%	(7)%
Speed limit violation	882	613	935	1,122	1,910	2,487	2,619	507	11,075
	(18)%	(15)%	(15)%	(14)%	(14)%	(16)%	(16)%	(15)%	(15)%
Seat belt violation	209	122	113	168	266	211	150	41	1,280
	(4)%	(3)%	(2)%	(2)%	(2)%	(1)%	(1)%	(1)%	(2)%
Stoplight/sign violation	411	307	409	556	959	1,206	1,315	263	5,426
	(8)%	(8)%	(7)%	(7)%	(7)%	(8)%	(8)%	(8)%	(8)%
Equipment violation	312	380	630	992	1,930	2,498	3,265	656	10,663
	(6)%	(9)%	(10)%	(13)%	(14)%	(16)%	(19)%	(20)%	(15)%
Vehicle regulatory violation	1,779	1,655	2,696	3,480	5,730	5,965	5,936	1,177	28,418
	(37)%	(41)%	(44)%	(44)%	(42)%	(38)%	(35)%	(36)%	(39)%
Unknown	0	2	1	4	3	3	7	0	20
	(0)%	(0)%	(0)%	(0)%	(0)%	(0)%	(0)%	(0)%	(0)%
Total	4,852	4,037	6,101	7,877	13,608	15,608	16,820	3,288	72,191
Percentage of total stops	(7)%	(6)%	(8)%	(11)%	(19)%	(22)%	(23)%	(5)%	

Notes: DWI = driving while intoxicated; All times are in the afternoon and evening (p.m.). *n* = 72,191; approximate column percentages are in parentheses. Percentages may not sum to 100 due to rounding.

Table 4 presents frequencies of stop reason by race of the driver. Races other than black and white comprised a small percentage of total traffic stops; Asian, Native American, and drivers with an unknown race, accounted for 4% of all stops, both overall and during the intertwilight period. Speed limit violations were the most common reason recorded for traffic stops for all races throughout the day, except among black and Native American drivers, among whom vehicle regulatory violation was the most common reason. During the intertwilight period, vehicle regulatory violation was the most common reason for conducting a traffic stop among drivers of all races.

Table 4: Reasons for Stop by Race of Driver

	Asian		Black		Native American		White		Unknown		Total	
Reason for stop	All	ITP	All	ITP	All	ITP	All	ITP	All	ITP	All	ITP
Checkpoint	3	0	94	5	0	0	177	6	10	0	284	11
	(0)%	(0)%	(0)%	(0)%	(0)%	(0)%	(0)%	(0)%	(0)%	(0)%	(0)%	(0)%
DWI	128	3	2,391	113	3	0	4,249	169	113	1	6,884	286
	(1)%	(0)%	(1)%	(0)%	(1)%	(0)%	(2)%	(1)%	(1)%	(0)%	(1)%	(0)%
Investigation	158	24	6,934	958	6	1	4,893	660	112	13	12,103	1,656
	(1)%	(2)%	(2)%	(3)%	(2)%	(2)%	(2)%	(2)%	(1)%	(1)%	(2)%	(2)%
Other motor vehicle violation	682	94	28,500	4,459	34	6	23,187	3,627	810	119	53,213	8,305
	(6)%	(7)%	(10)%	(12)%	(10)%	(11)%	(8)%	(11)%	(9)%	(12)%	(9)%	(12)%
Safe movement violation	1,186	160	16,996	2,163	23	3	19,003	2,626	875	99	38,083	5,051
	(11)%	(12)%	(6)%	(6)%	(7)%	(5)%	(7)%	(8)%	(10)%	(10)%	(7)%	(7)%
Speed limit violation	4,267	315	65,542	4,591	101	9	90,133	5,985	2,699	175	162,742	11,075
	(38)%	(23)%	(23)%	(12)%	(30)%	(16)%	(33)%	(18)%	(30)%	(17)%	(28)%	(15)%
Seat belt violation	180	7	7,362	772	6	2	5,871	469	293	30	13,712	1,280
	(2)%	(1)%	(3)%	(2)%	(2)%	(4)%	(2)%	(1)%	(3)%	(3)%	(2)%	(2)%
Stoplight/sign violation	1,169	178	15,961	2,345	18	4	19,145	2,782	813	117	37,106	5,426
	(10)%	(13)%	(6)%	(6)%	(5)%	(7)%	(7)%	(9)%	(9)%	(11)%	(6)%	(8)%
Vehicle equipment violation	1,265	227	38,313	6,114	37	8	25,449	4,157	1,105	157	66,169	10,663
	(11)%	(17)%	(14)%	(17)%	(11)%	(14)%	(9)%	(13)%	(12)%	(15)%	(11)%	(15)%
Vehicle regulatory violation	2,257	366	98,727	15,522	110	24	83,754	12,207	2,126	299	186,974	28,418
	(20)%	(27)%	(35)%	(42)%	(33)%	(42)%	(30)%	(37)%	(23)%	(29)%	(32)%	(39)%
Unknown	0	0	0	0	0	0	0	0	132	20	132	20
	(0)%	(0)%	(0)%	(0)%	(0)%	(0)%	(0)%	(0)%	(1)%	(2)%	(0)%	(0)%
Total	11,295	1,374	280,820	37,042	338	57	275,861	32,688	9,088	1,030	577,402	72,191
Percent of total stops	(2)%	(2)%	(49)%	(51)%	(0)%	(0)%	(48)%	(45)%	(2)%	(1)%		

Notes: DWI = driving while intoxicated; ITP = intertwilight period. Approximate column percentages are in parentheses. *N* for all stops = 577,402; *n* for ITP stops = 72,191. Percentages may not sum to 100 due to rounding.

Table 5 displays descriptive statistics for sex and race of drivers for all stops and for stops that occurred during the intertwilight period. Traffic stops more commonly involved male drivers than female drivers. The racial distribution of all traffic stops and traffic stops occurring in the intertwilight period was relatively consistent. Drivers that were black or white were fairly equally represented and comprised over 90% of all drivers stopped. Most drivers were stopped by RPD in the SED or NOD district.

Table 5: Race, Sex, and Location of People Stopped

	Overall (*N* = 577,402)		ITP Stops (*n* = 72,191)	
Characteristic	Frequency	%	Frequency	%
Sex				
Male	353,240	61.18	44,479	61.61
Female	223,991	38.79	27,690	38.36
Unknown	171	0.02	22	0.03
Total	577,402	100.00	72,191	100.00
Race				
Asian	11,295	1.96	1,374	1.90
Black	280,820	48.64	37,042	51.31
Native American	338	0.06	57	0.08
Unknown	9,088	1.57	950	1.32
White	275,861	47.78	32,688	45.28
Total	577,402	100.00	72,191	100.00
District				
DTD	91,676	15.88	10,495	14.54
NED	64,669	11.19	7,985	11.06
NOD	113,571	19.67	13,354	18.50
NWD	81,479	14.11	9,591	13.29
SED	131,624	22.80	19,331	26.78
SWD	84,986	14.72	10,264	14.22
Unknown	9,397	1.63	1,171	1.62
Total	577,402	100.00	72,191	100.00

Notes: DTD = downtown district; ITP = intertwilight period; NED = northeast district; NOD = north district; NWD = northwest district; SED = southeast district; SWD = southwest district.

Table 6 displays cross-tabulations for traffic stops by sex of driver and reason recorded for stop. Male drivers were more or as likely as female drivers to be stopped for most reasons. Women were more likely to be stopped for speed limit violations overall (but not during the intertwilight period) and vehicle regulatory violations.

Table 6: Reason for Stop by Sex of Driver

	All Stops (*N* = 577,402)				ITP Stops (*n* = 72,191)			
	Frequency				Frequency			
Reason	Male	Female	Unknown	Total	Male	Female	Unknown	Total
Checkpoint	194	91	0	284	6	5	0	11
	(1%)	(0%)	(0%)	(1%)	(0%)	(0%)	(0%)	(0%)
DWI	5,023	1,861	0	6,884	214	72	0	286
	(1%)	(1%)	(0%)	(1%)	(1%)	(0%)	(0%)	(4%)
Investigation	8,516	3,583	4	12,103	1,174	482	0	1,656
	(2%)	(2%)	(2%)	(2%)	(3%)	(2%)	(0%)	(3%)
Other motor vehicle violation	35,167	18,034	12	53,213	5,442	2,862	1	8,305
	(10%)	(8%)	(7%)	(9%)	(12%)	(10%)	(5%)	(12%)
Safe movement violation	24,609	13,472	2	38,083	3,235	1,816	0	5,051
	(7%)	(6%)	(1%)	(7%)	(7%)	(7%)	(0%)	(7%)
Speed limit violation	93,807	68,921	14	162,742	6,823	4,252	0	11,075
	(27%)	(31%)	(8%)	(28%)	(15%)	(15%)	(0%)	(15%)
Seat belt violation	9,702	4,010	0	13,712	919	361	0	1,280
	(3%)	(2%)	(0%)	(2%)	(2%)	(1%)	(0%)	(2%)
Stoplight/sign violation	22,900	14,206	0	37,106	3,410	2,016	0	5,426
	(6%)	(6%)	(0%)	(6%)	(8%)	(7%)	(0%)	(8%)
Vehicle equipment violation	42,507	23,660	2	66,169	6,529	4,134	0	10,663
	(12%)	(11%)	(1%)	(11%)	(15%)	(15%)	(0%)	(15%)
Vehicle regulatory violation	110,815	76,154	5	186,974	16,727	11,690	1	28,418
	(31%)	(34%)	(3%)	(32%)	(38%)	(42%)	(5%)	(39%)
Unknown	0	0	132	132	0	0	20	20
	(0%)	(0%)	(77%)	(0%)	(0%)	(0%)	(91%)	(0%)
Total	353,240	223,991	171	577,402	44,860	27,842	22	72,191
	(61%)	(39%)	(0%)		(62%)	(38%)	(0%)	

Notes: DWI = driving while intoxicated; ITP = intertwilight period; approximate column percentages are in parentheses. Percentages may not sum to 100 due to rounding.

Veil of Darkness

The overall model suggests that daylight was not significantly associated with driver race when considering only drivers recorded as white and black (***Table 7***). The odds of the driver's being black were not higher when the stop occurred during daylight than when the stop occurred during darkness.[2] Based on this model, we conclude no evidence of disproportionality in traffic stops during the time period analyzed, when considering the entire city.

Table 7: Overall Veil of Darkness Analysis

Model specification	*n*	Odds Ratio
Model 1—white vs. black drivers	69,730	1.0

Notes: Results presented as odds ratios. Models also controlled for day of week, year, and time of stop. These coefficients are omitted for brevity. Models were specified as generalized linear mixed models where officer ID was treated as a random effect.

Race–Sex Interaction

Models were respecified to explore the effect of driver's sex on the relationship between available lighting and driver race (***Table 8***). The VOD method was applied to the subsample for males only and for females only. We found no significant relationship between daylight and driver race among male or female drivers. These models suggest no disproportionality for black male or black female drivers, relative to white male or white female drivers, during the analysis period.

Table 8: Veil of Darkness Analysis Subset by Sex

Model specification	*n*	Odds Ratio
Model 2—Male only	42,826	1.0
Model 3—Female only	26,904	1.0

Notes: Results presented as odds ratios. Models also controlled for day of week, year, and time of stop. These coefficients are omitted for brevity. Models were specified as generalized linear mixed models where officer ID was treated as a random effect.

Analysis by District Assignment

Analyses were disaggregated by the district assignment of the officer making the traffic stop (***Table 9***). These models explore the possibility of disproportionality within smaller geographic units that may be washed out by only evaluating agency-wide patterns. Models were specified for the all drivers, for male drivers only, and for female drivers only. There was no significant relationship between driver race and the variable indicating daylight/darkness regardless of the officer's district assignment or driver sex. Therefore, we found no evidence of racial disproportionality in traffic stops when disaggregated by geographical area.

[2] A likelihood ratio test was performed to test the time control-only model (day of week, year, and time of stop indicators) against the fully fitted model that added the dark/light indicators. Models including the day/light indicator resulted in a statistically significant improvement in model fit.

Table 9: Veil of Darkness Analysis Subset by Officer District Assignment

	All		Male Drivers Only		Female Drivers Only	
Model specification	*n*	Odds Ratio	*n*	Odds Ratio	*n*	Odds Ratio
Model 4—DTD	10,193	1.1	6,477	1.1	3,716	1.1
Model 5—NED	7,757	1.0	4,802	1.0	2,955	1.0
Model 6—NOD	12,886	1.0	7,628	1.0	5,258	1.0
Model 7—NWD	9,139	1.0	5,432	1.0	3,707	1.0
Model 8—SED	19,104	1.0	11,763	1.0	7,341	1.0
Model 9—SWD	9,519	1.1	6,035	1.0	3,484	1.1

Notes: DTD = downtown district; NED = northeast district; NOD = north district; NWD = northwest district; SED = southeast district; SWD = southwest district. Results presented as odds ratios. Models also controlled for day of week, year, and time of stop. These coefficients are omitted for brevity. Models were specified as generalized linear mixed models where officer ID was treated as a random effect. Models 4 through 9 only include patrol officers assigned to the six indicated districts.

Analysis by Patrol Designation and Unit Assignment

Analyses were disaggregated to explore the potential disproportionality in traffic stops conducted by officers assigned to patrol and officers assigned to nonpatrol units (e.g., gang suppression, traffic, investigations; ***Table 10***).

Table 10: Veil of Darkness Analysis Subset by Patrol Designation

	All		Male Drivers Only		Female Drivers Only	
Model specification	*n*	Odds Ratio	*n*	Odds Ratio	*n*	Odds Ratio
Model 10— Patrol	62,741	1.00	38,365	0.98	24,376	1.01
Model 11— Nonpatrol	6,989	1.18**	4,461	1.24**	2,528	1.10
Model 11.1— Nonpatrol (with month)	6,989	1.02	4,461	1.03	2,528	1.03
Model 11.2— Nonpatrol (30 days +/-DST)	2,256	0.94	1,407	0.92	849	0.93

Notes: DST = daylight savings time. Results presented as odds ratios. Models also controlled for day of week, year, and time of stop. These coefficients are omitted for brevity. Models were specified as generalized linear mixed models where officer ID was treated as a random effect. **$p < 0.01$.

Results from the subsample of traffic stops conducted by patrol units indicated that the odds of daylight stops involving a black driver were not statistically different than the odds during darkness (Table 10, Model 10), suggesting no evidence of disproportionality. This finding was consistent when disaggregating by male or female drivers. No evidence of disproportionality was found for traffic stops conducted only by patrol officers.

Findings involving officers assigned to nonpatrol were more complex with initial models indicating racial disparity. Among nonpatrol officers, the odds of a driver involved in a traffic stop being black during daylight hours were 18% higher (24% higher for the male only subset) than the odds of a driver being black during darkness (Model 11).

These significant model results prompted a round of sensitivity analysis to explore the robustness of these findings under different model assumptions. Two additional models were specified (Model 11.1 and

11.2). Model 11.1 was respecified to include monthly indicator variables. Adding monthly variables helps to explore potential seasonality in the relationship between driver characteristics and light level. A second model (Model 11.2) was respecified to restrict analysis to cases that occur within 30 days of daylight saving time. Limiting analysis to this subset of cases takes advantage of a "natural experiment" that occurs during the shift to daylight saving. It minimizes driver variation that may exist due to changes in seasonal driver patterns, and is generally considered to be the strongest test of disproportionality.

In both models (11.1 and 11.2), the relationship between driver's race and light level did not remain significant when specified for all drivers or for only male drivers. We have no definitive explanation for why results do not maintain once controlling for seasonality. One explanation may be that nonpatrol units are modifying traffic stop activity depending on the time of year. Given that the results in Model 11 did not hold up during sensitivity analysis, it would be inappropriate to draw conclusions about racial disproportionality among nonpatrol units.

Table 11 further disaggregates the analysis by the officer unit assignment or location of stop for patrol officers. Results reported in Table 9 will differ from those reported in Table 11. Table 9 reports on the traffic stops conducted by officers assigned to each district. Table 11 reports on traffic stops *conducted* in each district if the stop was conducted by an officer assigned to the patrol division. Evidence of racial disproportionality was found in only one model. The odds of a black female driver being stopped was 17% higher compared to white female drivers in the southwest district. The relatively small number of cases makes it difficult to conduct sensitivity testing on this subset of cases.

Table 11: Veil of Darkness Analysis Subset by Officer Unit Assignment or District of Stop

	All		Male Drivers Only		Female Drivers Only	
Model specification	*n*	Odds Ratio	*n*	Odds Ratio	*n*	Odds Ratio
Model 12— DWI Enforcement	318	0.82	216	0.79[2]	102	0.73[1]
Model 13— DTD	9,179	1.03	5,789	1.00	3,390	1.05
Model 14— Gang Suppression	615	1.50[1]	484	1.18[1]	131	2.91[2]
Model 15— K-9 and Mounted	855	1.12	531	1.23	324	1.11
Model 16— North	10,216	0.92	6,032	0.92	4,184	0.92
Model 17— NED	7,060	0.96	4,342	1.00	2,718	0.92
Model 18— NWD	9,378	0.99	5,572	0.98	3,806	0.99
Model 19— Other	492	1.21	313	1.39	179	1.10
Model 20— SED	17,243	1.02	10,483	1.00	6,760	1.05
Model 21— SWD	9,479	1.07	6,029	1.03	3,450	1.17*
Model 22— Special Enforcement	1,771	1.19	1,172	1.17	599	1.22
Model 23— Traffic	3,123	1.17[1]	1,863	1.25	1,260	1.08[1]

Notes: DTD = downtown district; NED = northeast district; NOD = north district; NWD = northwest district; SED = southeast district; SWD = southwest district. Other includes administrative positions and other assignments that did not have enough traffic stops to analyze independently.

[1]Models exclude day of week controls due to lack of traffic stops on some days of the week.

[2]Models exclude day of week controls and officer-level random intercept due to low event count.

*p < 0.05 **p < 0.01.

Interagency Comparison

Other cities similar in size to Raleigh, including Greensboro, Fayetteville, and Durham, have had similar claims of racial disproportionality (Baumgartner & Epps, 2012; LaFraniere & Lehren, 2015). As reported in Taniguchi et. al. (2017), VOD methodology was used to explore racial disproportionality in traffic stop data maintained by the state (Fayetteville and Greensboro) or by the agency (Durham). The results from Taniguchi et. al. (2017) are presented in ***Table 12*** for comparison purposes.

Table 12: Comparison City Analysis

	Durham		Fayetteville		Greensboro	
Model	*N*	OR	*N*	OR	*N*	OR
Model 6—Overall	19,801	1.12**	30,733	1.02	37,125	0.99
Model 7—Males only	12,516	1.20**	18,133	1.02	21,796	1.05
Model 8—Females only	7,285	0.99	12,600	1.00	15,329	0.89**

Notes: Results presented as odds ratios (OR). Models also controlled for day of week, year, and time of stop. Model fit tests for the analysis of traffic stops in Greensboro and Durham indicated a statistically significant improvement in model fit when a quadratic term for time of stop was also included in the model. Assessments for Fayetteville indicated that quadratic terms did not improve model fit, and therefore those models controlled for time of stop as a linear term only. Coefficients for all control variables omitted for brevity. Models were specified as generalized linear mixed models where officer ID was treated as a random effect. **$p < 0.001$.

Limitations

First, the VOD method is sensitive to factors that reduce the correlation between presumed visibility and darkness. For example, street lighting may alter the ability of officers to detect the race of drivers in darkness (Horrace & Rohlin, 2014), or adverse weather conditions may cause dark conditions earlier than expected based on civil twilight. Under both of these conditions, the exclusion of this ancillary information biases results toward null findings, and the inclusion of these ancillary data should strengthen the ability to detect a relationship between visibility and driver race. The results presented here are thus a *conservative* estimate of the impact of lighting on the race of driver stopped.

Second, the VOD addresses only the question of racial bias that may be occurring during the intertwilight period. Because the method requires variations in light conditions during the same times, this methodology cannot assess racial bias in time periods when it is always day (e.g., 3:00 p.m.) or always dark (e.g., 11:30 p.m.). Although these results are suggestive, it would be inappropriate to extrapolate findings to times outside of our analysis window.

Third, the VOD approach explores only the patterns of traffic stops and the racial composition of the drivers. It does not explore the reasons, causes, or other factors that can influence the officer's decision to make a traffic stop. Relatedly, the VOD approach does not inform about other important stop characteristics, including the length of the stop, the outcome, or decisions to search. Moreover, this approach does not consider the impact of passengers on the decision to stop.

Discussion

The VOD approach to analyzing traffic stops is powerful because it does not need an external benchmark to model the driving population at risk. Instead, VOD uses natural variation in light levels occurring over time throughout the year to identify periods when it is dark at some times of the year and light during

other times (e.g., 7:30 p.m. in July will be light, whereas 7:30 p.m. in December will be dark). This natural variation creates changes in the ability of officers to determine driver race, while avoiding the issue of comparing different times that may have different driving populations at risk. For these reasons, the VOD approach has received widespread and increasing acceptance in the criminal justice field in recent years.

The results of these analyses were complex. Overall, when considering the entire traffic stop activity by RPD, there was no evidence of racial disproportionality. Disaggregating by male and female motorist did not change this result. Further disaggregation was performed to test for disproportionality by unit assignment and location of stop. The analysis of traffic stops conducted by patrol, when disaggregate by district assignment found no evidence of disproportionality (Models 4-9). However, traffic stops conducted by officers in non-patrol assignments (Model 11) showed some evidence of over-representation of black male drivers. These results did not maintain after conducting several sensitivity tests (Models 11.1 and 11.2). Further disaggregation was performed (Models 12-23). One model indicated the presence of racial disproportionality: black female drivers were more likely to be stopped compared to white female drivers for traffic stops that occurred in the southwest district. The low number of traffic stops prevented us from exploring this result any further.

Note that the proportion of black drivers stopped during darkness is not the key indicator of disproportionality. It is assumed that the lack of available lighting during the dark hours prevents officers from reliably determining the race of the driver before initiating the traffic stop. The overrepresentation of black motorists during darkness may be driven by the natural differences in the driving population, differences in the driving population at risk of being stopped (i.e., differences in driving behaviors), or differences in police deployment strategies that influence risk of being stopped (i.e., officers being assigned to high-crime areas that correlate with larger minority populations). The differences between black and non-black driver risk during darkness highlights why analyses that have focused on the difference between the racial compositions of those stopped and the racial compositions of the jurisdiction's population are highly problematic and potentially misleading.

Recommendations

The results of these analyses demonstrate the importance of capturing additional contextual details in the traffic stop dataset. Our analyses demonstrate that organizational unit is a key factor in exploring racial bias. Future work could leverage the detailed stop location information that is recorded by RPD to better specify models (Grogger & Ridgeway, 2006) or to control for features of the built environment (Horrace & Rohlin, 2014).

Finally, the RPD should be recognized for its willingness to conduct a thorough and rigorous analysis of its traffic stop data in an effort to promote transparency. To that end, the RPD should continue to analyze traffic stop data in the future. RTI's RTI-STAR tool is available free of charge to any agency that collects the requisite traffic stop data to analyze evidence of racial bias. Conducting such an analysis on an annual basis will enable RPD to provide transparency to the community it serves into the future.

Appendix 1—References

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