Independent Expert Review of the Data, Analysis, and Conclusions of "Part E: Multivariate Analysis of Use of Force Cases" of the *Use of Force by the Toronto Police Service* report

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Scope and Nature of the Review

I have been retained by the Ontario Human Rights Commission (OHRC) to provide an independent expert review of the data, analysis, and conclusions of "Part E: Multivariate Analysis of Use of Forces Cases" of the *Use of Force by the Toronto Police Service* report ("the original report").

For the review of the data, analysis, and conclusions of the original report, I looked at the raw data transferred to me from the OHRC in Statistical Package for Social Sciences (SPSS). Subsequently, I imported the SPSS data file into R to see if the error in R, noted by Dr. Ayobami Laniyonu, surrounding the reading of "rich text formats" occurred, and whether it resulted in the miscoding of civilian race in the data in R. I then corrected the miscoding in R of civilian race, re-ran the multivariate multi-level negative-binomial regression analyses and produced the tables associated with said analyses (Tables E1 through E6). I compared these new tables to the tables from the original analyses. I verified the conclusions and also corrected parts of the conclusions where necessary, as they pertained to the discussion of the ratios from the original tables.

Review of the Choice of Analytic Technique and Approach

Part E of the original report presents results of several multi-level, negative binomial regression models of police use of force. The choice of analytic technique for these types of data is appropriate. Multi-level models refer to statistical techniques used in cases where parameters vary at more than one level of analysis, often at the individual- and aggregate-levels. In these data, use of force incidents vary at the individual level (meaning, characteristics associated with the individual incident itself, e.g., characteristics of the case or the civilian, such as civilian race) while contextual variation occurs at the level of patrol zones (meaning, characteristics of the patrol zone which may also influence the likelihood of use of force incidents, e.g., the violent crime rate of the patrol zone as a proxy for the potential danger officers may face within particular areas of the city, median household income and proportion of single-mother households as an estimate of economic disadvantage/social disorganization within patrol zones). In other words, this technique allows for the analysis of use of force to take into account both the variation at the individual-level while also accounting for structural or community-level characteristics at the level of patrol zones.

The use of negative binomial regression models is also appropriate. Negative binomial models are used for "count" data that are over-dispersed and/or zero-inflated (see Osgood 2000)[1]. Over-dispersion refers to a situation when a distribution of counts has a variance that is greater than its mean. This is often the case with the distribution of discrete events in a given setting

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[1] D. Wayne Osgood. 2000. "Poisson-Based Regression Analysis of Aggregate Crime Rates." *Journal of Quantitative Criminology* 16(1): 21-43.

where there is zero-inflation. Zero-inflation refers to where there are excess zeros ('0") to denote the absence of an event in many cases. As such, negative binomial regression models have been commonly used to model discrete crime events such as homicides (see Piza 2012)[2] and use of force events (see Edwards, Lee, and Esposito 2019; Gelman, Fagan, and Kiss 2007; Geller and Fagan 2010; references included in the original report) in criminological research.

In employing negative binomial regression models, there is usually an exposure variable or an "offset", which essentially allows the counts to be viewed as rates. The use of race-specific population of each patrol zone as the "offset" is appropriate since use of force against particular racial groups will be expected to be higher in patrol zones where more members of that group reside.

The analytic approach used in Part E of the report allows for an examination of whether the observed racial disparities in the risk of experiencing police use of force persist after controlling for possible effects of patrol zone characteristics at the aggregate level, including the violent crime rate, median household income, and proportion of single-mother households.

Nature of the Error

According to Dr. Ayobami Laniyonu who performed the multivariate analyses in Part E of the original report, there was a coding error which occurred in the process of transferring the data from SPSS (Statistical Package for the Social Sciences) to R (an open-source programming language for statistical analysis and graphics). R has much more sophisticated and advanced capabilities than SPSS and is therefore preferred for more complex statistical analyses, such as the multi-level analyses and negative binomial regression techniques, needed for the data in Part E. For this reason, it is understandable why the data were transferred from SPSS to R. In the process of this data transfer process, there was an error. The racial background of civilians was initially coded as a string variable in rich text format. However, R can experience glitches with reading rich text formats. (This is a noted problem as indicated by numerous threads on stackoverflow.com, a popular online community for computer programmers and coders.)

Here, I describe how I independently ascertained that this was indeed the source of the error. First, I reviewed the raw data in SPSS that was transferred to me from the OHRC, paying close attention to how the variable of civilian race was coded. In these SPSS data files (for example, minor use of force dataset (003).sav-2022-8-19 22.44.16.), the variable for civilian race is defined as a string variable with text entered as data, e.g., "1. White". Given the input of text as the entered data (as opposed to a number/value that stands in for a name/category without actually entering the name/category out in text), this would be data in "rich text format". I then imported the SPSS data files into R. During this importation process, I received an error message from R about the reading of rich text formats in the SPSS data file. Using the General Occurrence number (which allows me to locate the same case in both the SPSS files and in the R files), I visually compared how civilian race in the SPSS datafile compared to what was read into R. In so doing, consistent with what Dr. Ayobami Laniyonu's account, I found that, in the R data files, White civilians were incorrectly coded as Black civilians; Black civilians were incorrectly coded as belonging to some other racialized minority groups; civilians of other racialized minority groups were incorrectly coded as individuals where race could not be identified; and persons whose race could not be identified were coded as White.

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[2] Eric L. Piza. 2012. "Using Poisson and Negative Binomial Regression Models to Measure the Influence of Risk on Crime Incidence Counts." Rutgers Center on Public Security.

This is why the odds ratios from the regression models showing the extent of overrepresentation of Black civilians in use of force cases were so much higher in the original report (e.g., upwards of 50 for the full model in Table E1). Recall that White civilians were incorrectly coded as Black civilians and persons whose race could not be identified were coded as White. White civilians would constitute a fairly large group whereas persons whose race could not be identified would constitute a very small group. It is no wonder that when White civilians' experiences of use of force was compared to a very small group of those whose race could not be identified that the comparison resulted in ratios so large.

By using the correct coding of the groups in R, I have reviewed and replicated Tables E1 through E6, the odds ratios discussed based on these tables, as well as conclusions drawn from them in Part E.

Corrected Series of Tables

Here, I present a series of Tables E1 through E6 produced by my own independent analysis using R of the data transferred to me from the Ontario Human Rights Commission. I have used the same incremental building of regression models used by Dr. Ayobami Laniyonu. Model 1 examines the risk that Black civilians and civilians belonging to other racial minority groups in a patrol zone will experience police use of force, compared to White civilians in the same patrol zone, given their share of the population. Model 2 estimates racial disparity while controlling for average violent crime rates for the study period. Model 3 estimates racial disparity while controlling for median household income. Model 4 estimates racial disparity while controlling for the proportion of single-mother headed households in the patrol zone. Finally, Model 5 presents the full model, estimating racial disparity while controlling for the violent crime rate, median household income, and single-mother headed households. Since Model 5 controls for the full set of co-variates, only the results from Model 5 will be discussed.

The tables I present here are essentially and substantially the same as the corrected series of tables from Dr. Ayobami Laniyonu.

Original **Table E1:**

Table E1: Predictors of SIU cases in Toronto by race and patrol zone factors

	Model 1	Model 2	Model 3	Model 4	Model 5
Race (White set as reference group)					
Black	49	48	49	51	50
Other racial minority	14	13	14	15	14
Patrol zone factors					
Violent crime rate (log)	—	1.9	—	—	4.1
Median household income (log)	—	—	1	—	0.94
% Single mother households	—	—	—	0.96	0.89

Note: Negative binomial models of SIU cases in Toronto patrol zones. Effect of race is relative to White reference group. Cell values give effect of a unit change on odds of force. Values in bold Values in bold are those where 95% credible intervals do not overlap with 1.

Corrected **Table E1: Predictors of SIU cases in Toronto by race and patrol zone factors**

	Model 1	Model 2	Model 3	Model 4	Model 5
Race (White as reference group)					
Black	**4.09** (2.88-5.81)	**3.56** (2.50-5.03)	**3.89** (2.75-5.46)	**4.25** (2.94-6.13)	**3.97** (2.81-5.52)
Other	**0.64** (0.43-0.93)	**0.59** (0.41-0.86)	**0.62** (0.41-0.89)	**0.64** (0.44-0.96)	**0.61** (0.42-0.88)
Patrol zone factors					
Violent Crime Rate (log)	-	**3.61** (2.56-5.04)	-	-	**3.35** (2.36-4.87)
Median household income (log)	-	-	**0.28** (0.09-0.82)	-	0.6 (0.2-1.6)
%Single mother households	-	-	-	0.97 (0.92-1.02)	**0.94** (0.90-0.98)

Note: Negative binomial models of SIU cases in Toronto patrol zones. 95% credible intervals are given in parentheses. Effect of race is relative to White reference group. Cell values give effect of a unit change on risk of force. Values in bold are those where 95% credible intervals do not overlap with 1.

Controlling for patrol zone factors, in the original Table E1, the odds that a Black civilian will experience injury or death related to use of force resulting in a SIU investigation is about 50 times the risk for White civilians. However, in the corrected Table E1, the risk for the same type of event for Black civilians is about 4 times the risk for White civilians.

Controlling for patrol zone factors, in the original Table E1, the odds that a civilian of other racial minority groups will experience injury or death related to use of force result in a SIU investigation is about 14 times the risk for White civilians. However, in the corrected Table E1, the risk for the same type of event for other racial minority groups is about 0.6 times the risk for White civilians (i.e., about 40% lower than White civilians, in other words).

Original **Table E2:**

Table E2: Predictors of lower-level use of force cases in Toronto, by race and patrol zone factors

	Model 1	Model 2	Model 3	Model 4	Model 5
Race (White set as reference group)					
Black	47	39	47	42	37
Other racial minority	7	5	7	8	6
Patrol zone factors					
Violent crime rate (log)	—	5	—	—	5
Median household income (log)	—	—	0.29	—	0.67
% single mothers	—	—	—	.94	.99

Note: Negative binomial models of lower-level use of force cases in Toronto patrol zones. Effect of race is relative to White reference group. Cell values give effect of a unit change on odds of force. Values in bold are those where 95% credible intervals do not overlap with 1.

Corrected **Table E2: Predictors of low-level use of force cases in Toronto by race and patrol zone factors**

	Model 1	Model 2	Model 3	Model 4	Model 5
Race (White as reference group)					
Black	**5.35** **(4.20-6.75)**	**5.09** **(4.01-6.42)**	**5.21** **(4.09-6.53)**	**5.33** **(4.16-6.76)**	**5.23** **(4.12-6.53)**
Other	**0.57** **(0.43-0.76)**	**0.57** **(0.43-0.75)**	**0.57** **(0.43-0.74)**	**0.58** **(0.43-0.75)**	**0.57** **(0.43-0.75)**
Patrol zone factors					
Violent Crime Rate (log)	-	**5.72** **(3.95-8.44)**	-	-	**4.91** **(3.29-7.33)**
Median household income (log)	-	-	**0.11** **(0.03-0.38)**	-	0.34 (0.10-1.04)
%Single mother households	-	-	-	1.00 (0.94-1.06)	**0.94** **(0.90-0.98)**

Note: Negative binomial models of low-level use of force cases in Toronto patrol zones. 95% credible intervals are given in parentheses. Effect of race is relative to White reference group. Cell values give effect of a unit change on risk of force. Values in bold are those where 95% credible intervals do not overlap with 1.

Controlling for patrol zone factors, in the original Table E2, the odds that a Black civilian will experience low-level use of force is about 37 times the risk for White civilians. However, in the corrected Table E2, the risk for the same type of event for Black civilians is about 5 times the risk for White civilians.

Controlling for patrol zone factors, in the original Table E2, the odds that a civilian of other racial minority groups will experience low-level use of force is about 6 times the risk for White civilians. However, in the corrected Table E2, the risk for the same type of event for other racial minority groups is about 0.6 times the risk for White civilians (i.e., about 40% lower than White civilians, in other words).

Original Table E3:

Table E3: Predictors all use of force cases in Toronto by race and patrol zone factors

	Model 1	Model 2	Model 3	Model 4	Model 5
Race (White set as reference group)					
Black	**53**	**45**	**53**	**47**	**55**
Other racial minority	**9**	**7**	**8**	**9**	**13**
Patrol zone-level factors					
Violent crime rate (log)	—	**5**	—	—	**3.6**
Median household income (log)	—	—	—	.94	**0.90**

Note: Negative binomial models of lower-level use of force cases in Toronto patrol zones. Effect of race is relative to White reference group. Cell values give effect of a unit change on odds of force. Values in bold are those where 95% credible intervals do not overlap with 1.

Corrected **Table E3: Predictors of all use of force cases in Toronto by race and patrol zone factors**

	Model 1	Model 2	Model 3	Model 4	Model 5
Race (White as reference group)					
Black	**4.98** **(4.01-6.18)**	**4.70** **(3.83-5.79)**	**4.89** **(3.93-6.00)**	**5.00** **(3.98-6.14)**	**4.88** **(3.96-5.98)**
Other	**0.60** **(0.47-0.77)**	**0.59** **(0.46-0.75)**	**0.60** **(0.47-0.75)**	**0.60** **(0.47-0.77)**	**0.59** **(0.47-0.75)**
Patrol zone factors					
Violent Crime Rate (log)	-	**4.87** **(3.65-6.45)**	-	-	**4.34** **(3.24-5.72)**
Median household income (log)	-	-	**0.16** **(0.06-0.44)**	-	**0.40** **(0.17-0.93)**
%Single mother households	-	-	-	0.99 (0.94-1.04)	**0.94** **(0.91-0.97)**

Note: Negative binomial models of all use of force cases in Toronto patrol zones. 95% credible intervals are given in parentheses. Effect of race is relative to White reference group. Cell values give effect of a unit change on risk of force. Values in bold are those where 95% credible intervals do not overlap with 1.

Controlling for patrol zone factors, in the original Table E3, the odds that a Black civilian will experience use of force is about 55 times the risk for White civilians. However, in the corrected Table E3, the risk for the same type of event for Black civilians is about 5 times the risk for White civilians.

Controlling for patrol zone factors, in the original Table E3, the odds that a civilian of other racial minority groups will experience use of force is about 13 times the risk for White civilians. However, in the corrected Table E3, the risk for the same type of event for other racial minority groups is about 0.6 times the risk for White civilians (i.e., about 40% lower than White civilians, in other words).

Original **Table E4:**

Table E4: Predictors of SIU cases in Toronto by race and patrol zone factors, (patrol zones from 51 and 52 Divisions omitted)

	Model 1	Model 2	Model 3	Model 4	Model 5
Race (White set as reference group)					
Black	69	57	69	67	58
Other racial minority	16	13	16	17	15
Patrol zone-level factors					
Violent crime rate (log)	—	3.8	—	—	3.8
Median household income (log)	—	—	0.4	—	0.71
% single mother households	—	—	—	0.92	0.9

Note: Negative binomial models of low level use of force cases in Toronto patrol zones. Effect of race is relative to White reference group. Cell values give effect of a unit change on odds of force. Values in bold are those where 95% credible intervals do not overlap with 1.

Corrected **Table E4: Predictors of SIU cases in Toronto by race and patrol zone factors, excluding Divisions 51 and 52**

	Model 1	Model 2	Model 3	Model 4	Model 5
Race (White as reference group)					
Black	**4.05 (2.72-5.92)**	**3.56 (2.47-5.24)**	**3.89 (2.57-5.72)**	**4.15 (2.78-6.05)**	**4.00 (2.69-5.87)**
Other	0.68 (0.44-1.01)	**0.64 (0.42-0.96)**	0.65 (0.42-1.00)	0.68 (0.44-1.03)	**0.65 (0.44-0.97)**
Patrol zone factors					
Violent Crime Rate (log)	-	**2.88 (1.86-4.38)**	-	-	**3.18 (2.01-4.96)**
Median household income (log)	-	-	0.54 (0.20-1.44)	-	0.53 (0.14-2.08)
%Single mother households	-	-	-	0.99 (0.94-1.03)	0.93 (0.88-0.98)

Note: Negative binomial models of SIU cases in Toronto patrol zones (excluding Divisions 51 and 52). 95% credible intervals are given in parentheses. Effect of race is relative to White reference group. Cell values give effect of a unit change on risk of force. Values in bold are those where 95% credible intervals do not overlap with 1.

Controlling for patrol zone factors (excluding patrol zones 51 and 52), in the original Table E4, the odds that a Black civilian will experience injury or death related to use of force resulting in a SIU investigation is about 58 times the risk for White civilians. However, in the corrected Table E4, the risk for the same type of event for Black civilians is about 4 times the risk for White civilians.

Controlling for patrol zone factors (excluding patrol zones 51 and 52), in the original Table E4, the odds that a civilian of other racial minority groups will experience injury or death related to use of force result in a SIU investigation is about 14 times the risk for White civilians. However, in the corrected Table E4, the risk for the same type of event for other racial minority groups is about 0.6 times the risk for White civilians (i.e., about 40% lower than White civilians, in other words).

Original **Table E5:**

Table E5: Predictors of lower-level use of force cases in Toronto by race and patrol zone factors (patrol zones in 51 and 52 Divisions omitted)

	Model 1	Model 2	Model 3	Model 4	Model 5
Race (White set as reference group)					
Black	**33**	**32**	**32**	**34**	**30**
Other	**6**	**5**	**5**	**5**	**5**
Patrol zone-level factors					
Violent crime rate (log)	—	**2.6**	—	—	**2.5**
Median household income (log)	—	—	.37	—	.81
% single mother households	—	—	—	1.5	.9

Note: Negative binomial models of low level use of force cases in Toronto patrol zones. Effect of race is relative to White reference group. Cell values give effect of a unit change on odds of force. Values in bold are those where 95% credible intervals do not overlap with 1.

Corrected **Table E5: Predictors of low-level use of force cases in Toronto by race and patrol zone factors, excluding Divisions 51 and 52**

	Model 1	Model 2	Model 3	Model 4	Model 5
Race (White as reference group)					
Black	**5.17** (3.98-6.67)	**4.84** (3.71-6.34)	**5.05** (3.89-6.61)	**5.11** (3.90-6.68)	**5.00** (3.78-6.50)
Other	**0.57** (0.41-0.76)	**0.56** (0.41-0.77)	**0.56** (0.41-0.76)	**0.56** (0.40-0.77)	**0.56** (0.40-0.76)
Patrol zone factors					
Violent Crime Rate (log)	-	**4.79** (3.04-7.39)	-	-	**5.00** (3.18-7.86)
Median household income (log)	-	-	**0.26** (0.07-0.89)	-	0.48 (0.13-1.90)
%Single mother households	-	-	-	1.02 (0.97-1.08)	0.95 (0.90-1.00)

Note: Negative binomial models of low-level use of force cases in Toronto patrol zones (excluding Divisions 51 and 52). 95% credible intervals are given in parentheses. Effect of race is relative to White reference group. Cell values give effect of a unit change on risk of force. Values in bold are those where 95% credible intervals do not overlap with 1.

Controlling for patrol zone factors (excluding patrol zones 51 and 52), in the original Table E5, the odds that a Black civilian will experience low-level use of force is about 30 times the risk for White civilians. However, in the corrected Table E5, the risk for the same type of event for Black civilians is about 5 times the risk for White civilians.

Controlling for patrol zone factors (excluding patrol zones 51 and 52), in the original Table E5, the odds that a civilian of other racial minority groups will experience low-level use of force is about 5 times the risk for White civilians. However, in the corrected Table E5, the risk for the same type of event for other racial minority groups is about 0.6 times the risk for White civilians (i.e., about 40% lower than White civilians, in other words).

Original **Table E6:**

Table E6: Predictors of all use of force cases in Toronto by race and patrol zone factors (patrol zones in 51 and 52 Divisions omitted)

	Model 1	Model 2	Model 3	Model 4	Model 5
Race (White set as reference group)					
Black	38	38	38	39	46
Other	7	7	7	7	13
Patrol zone-level factors					
Violent crime rate (log)	—	2.3	—	—	3.7
Median household income (log)	—	—	.53	—	1.02
% single mother households	—	—	—	1.01	.9

Note: Negative binomial models of low level use of force cases in Toronto patrol zones. Effect of race is relative to White reference group. Cell values give effect of a unit change on odds of force. Values in bold are those where 95% credible intervals do not overlap with 1.

Corrected **Table E6: Predictors of all use of force cases in Toronto by race and patrol zone factors, excluding Divisions 51 and 52**

	Model 1	Model 2	Model 3	Model 4	Model 5
Race (White as reference group)					
Black	**4.88 (3.86-6.20)**	**4.52 (3.59-5.68)**	**4.78 (3.82-6.03)**	**4.86 (3.82-6.18)**	**4.70 (3.70-5.95)**
Other	**0.61 (0.47-0.81)**	**0.59 (0.46-0.77)**	**0.61 (0.47-0.79)**	**0.61 (0.47-0.49)**	**0.59 (0.45-0.78)**
Patrol zone factors					
Violent Crime Rate (log)	-	**4.09 (2.96-5.61)**		-	**4.46 (3.21-6.08)**
Median household income (log)	-	-	**0.35 (0.13-0.95)**	-	0.53 (0.20-1.33)
%Single mother households	-	-	-	1.01 (0.96-1.05)	**0.94 (0.91-0.98)**

Note: Negative binomial models of all use of force cases in Toronto patrol zones (excluding Divisions 51 and 52). 95% credible intervals are given in parentheses. Effect of race is relative to White reference group. Cell values give effect of a unit change on risk of force. Values in bold are those where 95% credible intervals do not overlap with 1.

Controlling for patrol zone factors (excluding patrol zones 51 and 52), in the original Table E6, the odds that a Black civilian will experience use of force is about 46 times the risk for White civilians. However, in the corrected Table E6, the risk for the same type of event for Black civilians is about 5 times the risk for White civilians.

Controlling for patrol zone factors (excluding patrol zones 51 and 52), in the original Table E6, the odds that a civilian of other racial minority groups will experience use of force is about 13 times the risk for White civilians. However, in the corrected Table E6, the risk for the same type of event for other racial minority groups is about 0.6 times the risk for White civilians (i.e., about 40% lower than White civilians, in other words).

Conclusions

As a result of this independent review, the analysis shows that Black people are markedly more likely to experience all types of police use of force compared to their White counterparts. These gross racial disparities remain after statistically controlling for patrol zone characteristics, including violent crime rate, median household income, and proportion of single-mother households. This is consistent with the conclusions drawn in the original report. However, the extent of racial disparity is smaller in the corrected analysis than the original report. Instead of 30-58 times the risk of experiencing use of force experienced by Black civilians compared to White civilians, as noted in the original report, the results of this corrected analysis show that Black civilians are 4-5 times more likely to experience use of force relative to their White counterparts.

However, for civilians of other racial minority groups, the conclusions from the corrected analysis are substantially different from those drawn in the original report. In the original report, civilians of other racial minority groups were 5-14 times *more* likely to experience use of force compared to their White counterparts, controlling for patrol zone characteristics, including violent crime rate, median household income, and proportion of single-mother households. In the corrected analysis, civilians of other racial minority groups are about 40% *less* likely than their White counterparts to experience use of force, controlling for patrol zone characteristics.

As noted in the original report, similar limitations and words of caution are warranted. These results do not provide conclusive evidence that individual police officers are engaged in individual acts of racial discrimination in their decisions to use force. More narrowly, the results demonstrate that racial disparities in police use of force against Black civilians cannot be explained by differential distribution of Black civilians in patrol zones with higher rates of violent crime or by other patrol zone-level factors.

Another limitation is more systemic in nature. It is typical in the majority of American studies to statistically control for race-specific arrest rates and/or race-specific police contact rates (see Gelman, Fagan, and Kiss 2007; reference in original report). The availability of this kind of data would allow for the estimation of racial disparities in police use of force compared/relative to arrest or the likelihood of police-citizen contact/interaction. This would also help to further contextualize the findings and provide some explanation as to the observed racial disparities (see Tregle, Nix, and Alpert 2019; reference in the original report).

The findings for Black civilians from the corrected analysis are also consistent with racial bias arguments and also further underscore the need for race-based police statistics.