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Suicide and Homicide More Common with Limited Urban Tree Canopy Cover

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Suicide and Homicide More Common with Limited Urban Tree Canopy Cover

Distribution of urban tree canopies is generally not uniform. Multiple variables have been shown to be associated with tree canopy cover, including violence, health, and general well-being. Herein we examine the relationship of tree cover with intentional deaths. Suicide, homicide, and tree cover data were examined by ZIP code for Louisville, a mid-sized city in Kentucky. Relationship between intentional death (suicide and homicide) and tree cover was examined with Poisson regression analysis. In both univariate and multivariate models, suicides ($P < 0.0001$ and $P = 0.0005$), homicides ($P < 0.0001$ and $P = 0.03$), and combination ($P = 0.0541$) were negatively associated with tree cover. In this exploratory study we have found that sparse canopy cover is associated with higher rates of intentional human death (both suicides and homicides). Given that suicides and homicides are relatively rare occurrences, these data suggest that larger samples be examined to confirm the relationship between intentional death and canopy cover.

Keywords

Canopy Cover; Homicide; Suicide; Trees; Tree Cover; Urban Canopy

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INTRODUCTION

Urban tree canopy cover has been demonstrated to be associated with several important aspects of human welfare and health. For example, trees mitigate the intensity of the heat island effect in cities which can have important health consequences (Loughner et al. 2012; Debbage and Shepherd 2015; Heaviside et al. 2017). But more specifically, trees themselves have been associated with better overall health (Maas et al. 2006), reduced mortality (Gascon et al. 2016; James et al. 2016), fewer adverse birth outcomes (Casey et al. 2016), improved mental health (Gascon et al. 2015), and lower rates of obesity (Bell et al. 2008), type 2 diabetes, high blood pressure, and asthma (Donovan et al. 2013; Ulmer et al. 2016) (however, specific tree species may increase allergenicity [Lovasi et al. 2013; Lai and Kontokosta 2019]). Some of these associations are disputed (Eisenman et al. 2019a, 2019b). These associations with human health seem to be specifically mediated by tree density, and not just green or open space (Ulmer et al. 2016; Reid et al. 2017). However, since the extent of urban tree canopy is associated with income (Iverson and Cook 2000; Schwarz et al. 2015; Krafft and Fryd 2016; Gerrish and Watkins, 2018), many of these observations may be indirect measures of socioeconomic variables (Schwarz et al. 2015), and so may not be related to trees, but be passive covariants of more influential variables (Vukojević et al. 2017; Elwadhi and Cohen 2020).

Green space has specifically been associated with reduced symptoms of depression and anxiety (Beyer et al. 2014; Araya et al. 2007). Additionally, tree cover has been associated with reduced violence against others and self (Kuo and William 2001; Kondo et al. 2017; Vaz et al. 2020).

A study in Portland, Oregon, examined violent crime before and after a tree planting project. The authors found that after the plantings, violent crime was lower in areas that had more trees, and that the effect was greater in poorer neighborhoods (Burley 2018). A similar study in Philadelphia in which vacant lots were cleaned, planted, and fenced, found that gun assaults were significantly reduced around the areas that underwent the plantings compared to control areas that remained neglected (Branas et al. 2011, 2016). An associational study in Philadelphia of 135 firearm victims and 274 community controls that mapped areas travelled by victims and the site where they were shot found that there was an inverse relationship between tree cover and gun violence (Kondo et al. 2017). This was true when victims were compared to local controls, and when the violent act was compared to earlier in the same day when the victim was not attacked (Kondo et al. 2017). As with the Portland study, the effect was greater in lower income areas (Kondo et al. 2017; Burley 2018). Similarly, in a study examining relationship between tree canopy and crime found that a 10% increase of tree canopy cover was associated with 10.3% reduction of battery and an 11.3% reduction of assault, robbery, and narcotics possession (Schusler et al. 2018). When the study is limited to economically similar inner-city neighborhoods, increased tree cover continues to be associated with reduced violence and overall crime (Kuo and William 2001).

Suicide, specifically, has been associated with tree cover in a geographic study of Toronto, Canada (Vaz et al. 2020). In that study suicide was both positively and negatively correlated with tree cover. The study measured canopy cover in two separate methods: Landscape Index (LSI) (Patton 1975), and Perimeter-area Fractal Dimension (PAFRAC) (Florio et al. 2019). LSI

provided a statistically significant negative correlation and PAFRAC provided a statistically significant positive correlation. The problem is that PAFRAC is notorious for providing false positive results (http://www.umass.edu/landeco/research/fragstats/documents/Metrics/Shape%20Metrics/Metrics/C23%20-%20PAFRAC.htm, accessed 7 May 2020). The authors simply concluded that tree cover was strongly associated with self-harm (Vax et al. 2020).

Interestingly, trees can be the instrument of suicide. In a study from Turkey, 48.9% of suicides over an eight-year period were completed by hanging (Dogan et al. 2015). About 10.8% of those who died by hanging, hung themselves on a tree branch (Dogan et al. 2015). Similarly, culture may have an impact. For example, in Japan people contemplating suicide may choose to go to the 'suicide forest,' Aokigahara Jukai Forest at the northwest base of Mount Fuji (Flaskerud 2014). About 30 people commit suicide there annually, and there appears to be cultural beliefs and myths that lead people to that location (Takahashi 1988). On the other hand, subjective calmness has been documented in university students who viewed photographs of urban scenes with trees and green space felt they were more restorative than urban scenes without vegetation (Hernández and Hidalgo 2005). Objective benefits include improved subjective sleep quality and increased sleep times associated with tree canopy cover in a study that used the Survey of the Health of Wisconsin database and canopy cover using National Land Cover Database (Johnson et al. 2018).

It is important to note that changes in violent crime or self-harm may or may not be related to trees. Urban tree canopy distribution may be related to other factors, including socioeconomic distribution, historical effects of "redlining," other aspects of investment into communities, and development. Controlling for all potential variables is ultimately impossible, and these variables may explain some of the variance in associational studies. Additional data also aid in understanding the nature of the relationships.

Trees have the potential of being a potent public health tool if they can contribute to better physical and mental health of urban residents. As this question continues to be explored, it is important to determine if some of the worst human outcomes –intentional death – can also be modified by trees. Suicide and homicide are extreme manifestations of psychiatric illness and human violence, and they both may be related at a core level (Pokorny 1965) – both being products of lethal aggression (Bills 2017) – we undertook an exploratory study of the relationship of both suicide and homicide to tree cover in an urban area.

METHODS

Data regarding trees in Jefferson County, Kentucky, were obtained from publicly available data provided by the US Geological Survey and are found online in the National Land Cover Database (NLCD) Percent Tree Canopy Collection for 2011. In this database each pixel is 30 m^2 (https://catalog.data.gov/harvest/object/362097c2-3090-4cda-8f04-d5a884c40aae/html/original, accessed 1 January 2021). This file came in the form of a raster which was converted from a percent per pixel basis to the average percent of all pixels in a Zone Improvement Plan (ZIP or zip) code. This provided the average percent tree canopy coverage per zip code. Data regarding suicides from 2007 to 2017 were obtained from the medical examiner's report to the Public Health and Wellness Department of the city of Louisville. The data were anonymous, and only included

the date of the suicide and the resident zip code. Data were provided for this project only with the caveat that "personal health information" or "identifying information" not be provided to the researchers. This was necessary to adhere to the requirements of the Health Insurance Portability and Accountability Act (HIPAA) of 1996 (https://aspe.hhs.gov/report/health-insurance-portability-and-accountability-act-1996, accessed 26 December 2020). This limited the analysis to zip codes only. Data regarding homicides were extracted from online crime data from 2007 to 2017 from the Louisville Metro Open Data portal. The data included the zip code in which the homicide took place. All data were imported into ArcGIS analytic mapping tool (https://www.esri.com/en-us/arcgis/about-arcgis/overview, accessed 26 December 2020) after conversion to shapefiles that used the coordinate system of a geographical zip code map of Jefferson County provided by the US Census Bureau. Rates of suicides and homicides were calculated in ArcGIS using the population data from 2014. Characteristics of each zip code were obtained from zipdatamaps.com (https://www.zipdatamaps.com/jefferson-ky-county-zipcodes, accessed 26 December 2020).

All suicide and homicide rates are expressed as per population of home zip code. Initially we performed simple correlation analysis. However, since the mortality data do not appear to have a normal distribution, they were also analyzed using a Poisson Regression model. Population size and income are reported scaled in thousands. We report rate, standard error (SE), 95% confidence interval (CI) and *P* values. The univariable model includes one variable at a time with intercept term. In the multivariable model, to study the association of canopy with mortality, annual income and race (expressed as Caucasian percent) along with an intercept term are included in the model. Results are considered significant at alpha = 0.05. The statistical analysis is performed using SAS System V9.4 (Cary, NC: SAS Institute Inc., 2003) (Walker and Shostak 2010).

RESULTS

Characteristics of each zip code included in this study are included in Table 1. The analyses of the data are presented in Table 2. In Jefferson County the annual suicide and homicide rates per 100,000 individuals were 14.44 ± standard error (SEM) 1.02 and 13.73 ± 3.486, respectively (based on annual rate of 462.0 suicides and 439.3 homicides in the county over the 11 years between 2007 and 2017). Suicides were negatively associated with tree cover ($r^2 = 0.213$, $P = 0.0077$) (Figure 1); as were homicides ($r^2 = 0.38$, $P = 0.0002$) (Figure2). Suicides were positively associated with homicides ($P = 0.02$). When results were graphed using Locally Weighted Scatterplot Smoothing (LOWESS), there appeared to be a threshold at approximately 20 – 30 % canopy coverage (Figures 1 and 2). To test this, we arranged both the suicide and homicide data at rates occurring below and above 20% and 30% canopy coverage threshold, respectively, and performed an unpaired t-test. Suicide rates below and above 20% canopy cover were significantly different (20.02 ± SEM 4.34 vs. 13.15 ± 0.61 suicides/100,000 people/year, t = 2.926, $P = 0.0065$). Similarly, homicide rates below and above 30% canopy cover were significantly different (24.25 ± SEM 5.93 vs. 3.211 ± 0.60, homicides/100,000 people/year, $P = 0.0014$).

Table 1. Study area (Jefferson County, Kentucky) zip codes and characteristics.

Zip Code	Canopy Cover (%)	Population	Area (square miles)	Average Adjusted Annual Income ($)	% African American/% Caucasian	Number Suicides	Number Homicides
40209	5.12	485	2	33,890	8.66/66.39	2	4
40202	7.42	6,468	2	142,570	55.98/28.1	18	16
40210	15.18	15,250	4	25,270	89.76/ 7.05	14	81
40203	17.33	18,347	3	30,690	59.68/34.68	45	121
40208	18.27	15,480	2	33,750	28.73/62.6	21	27
40213	18.77	15,834	13	45,180	17.61/70.58	25	22
40218	21.27	30,193	9	38,540	35.37/50.17	42	26
40215	24.23	22,342	4	30,110	33.06/52.69	31	47
40211	24.44	23,622	8	28,040	90.79/ 6.11	20	141
40217	24.48	13,077	2	47,810	7.20/88.52	24	8
40219	27.18	39,651	14	38,480	20.39/58.9	65	25
40220	28.09	33,941	8	58,490	17.48/73.15	51	9
40258	28.60	27,222	13	44,920	13.79/82.33	50	23
40216	29.22	40,844	16	39,300	33.84/59.34	68	35
40212	29.58	17,308	7	17,685	60.83/36.09	33	81
40242	29.93	11,334	3	68,110	10.35/78.61	16	1
40204	32.04	14,229	3	87,770	6.28/86.77	28	10
40222	33.22	21,221	7	114,580	6.16/81.61	29	8
40241	33.55	29,907	12	101,000	10.06/76.51	34	6
40205	34.78	24,068	7	110,770	1.8 /93.9	40	11
40243	35.33	10.569	4	70,760	5.1 /87.12	18	2
40206	36.47	19,277	7	83,080	8.76/85.03	29	9
40229	37.21	36,536	18	47,470	4.85/87.95	44	8
40245	38.06	31,941	35	122.410	9.48/78.68	24	4
40291	38.20	35,110	25	64,530	10.53/81.69	56	10
40214	39.19	45,756	16	14,170	14.9/65.86	74	49
40223	39.79	21,491	13	106,460	9.23/81.81	27	6
40059	41.80	17,785	32	210,580	3.41/89.75	12	1
40207	43.37	30,237	12	130,720	3.05/90.62	33	2
40299	47.19	38,952	50	74,950	7.34/83.87	53	7
40272	49.54	38,758	36	46,610	4.16/88.9	60	22
40118	67.20	9,767	9	38,540	35.37/50.17	17	4

Table 2A. Predictor of the different types of intentional death (suicide alone, homicide alone, or the two combined) in a univariable Poisson regression analysis.

Number of Suicides					
Variable	**Rate**	**SE**	**95% CI Lower**	**95% CI Upper**	***P*-value**
Canopy	0.0104	0.0024	0.0056	0.0151	<.0001
Population	0.0393	0.0027	0.034	0.0446	<.0001
Area in square miles	0.0154	0.0023	0.0109	0.0199	<.0001
Annual Income	-0.0032	0.0008	-0.0046	-0.0017	<.0001
Caucasian Percent	0.0038	0.0014	0.0011	0.0065	0.0051
Number Homicides					
Canopy	-0.0391	0.003	-0.0449	-0.0333	<.0001
Population	0.0036	0.003	-0.0022	0.0095	0.2226
Area in square miles	-0.0358	0.0043	-0.0442	-0.0275	<.0001
Annual Income	-0.0233	0.0014	-0.026	-0.0206	<.0001
Caucasian Percent	-0.0318	0.0012	-0.0341	-0.0295	<.0001
Number of Both					
Canopy	-0.010	0.0019	-0.0137	-0.0063	<.0001
Population	0.0236	0.002	0.0197	0.0275	<.0001
Area in square miles	-0.001	0.002	-0.0049	0.0029	0.6205
Annual Income	-0.0096	0.0007	-0.0109	-0.0082	<.0001
Caucasian Percent	-0.0141	0.0008	-0.0157	-0.0125	<.0001

Table 2B. Predictor of the different types of intentional death (suicide alone, homicide alone, of the two combined) in a multivariable Poisson regression analysis.

Number of Suicides					
Variable	**Rate**	**SE**	**95% CI Lower**	**95% CI Upper**	***P*-value**
Canopy	0.0091	0.0026	0.0039	0.0142	0.0005
Annual Income	-0.0049	0.0009	-0.0066	-0.0033	<.0001
Caucasian Percent	0.0056	0.0016	0.0024	0.0088	0.0007
Number Homicides					
Canopy	-0.0072	0.0033	-0.0137	-0.0007	0.0303
Annual Income	-0.0131	0.0014	-0.0159	-0.0103	<.0001
Caucasian Percent	-0.0253	0.0014	-0.0281	-0.0225	<.0001
Number of Both					
Canopy	0.0037	0.0019	-0.0001	0.0075	0.0541
Annual Income	-0.0063	0.0007	-0.0077	-0.0049	<.0001
Caucasian Percent	-0.0115	0.001	-0.0135	-0.0095	<.0001

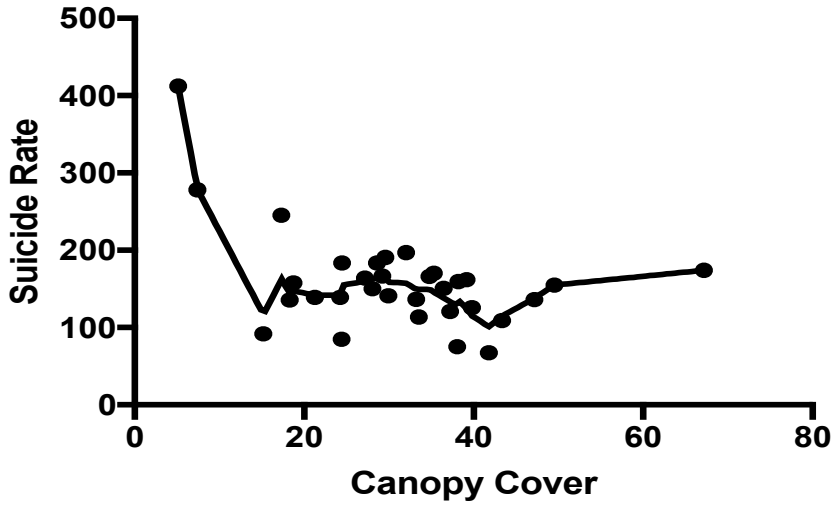

Figure 1. In this Locally Weighted Scatterplot Smoothing (LOWESS) graph, as tree canopy size decreases, the rate of suicide increases (r = -0.53, *P* = 0.0077) after approximately 20% canopy cover, there does not appear to be a relationship prior to that.

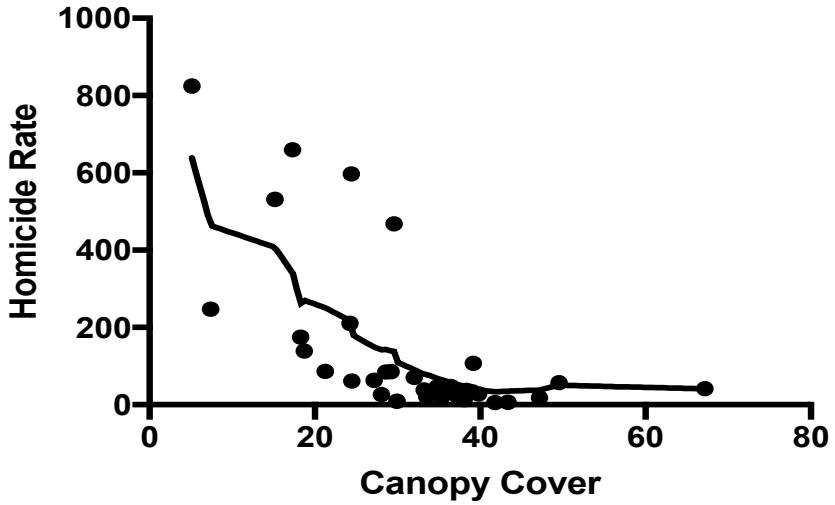

Figure 2. In this Locally Weighted Scatterplot Smoothing (LOWESS) graph, as tree canopy size decreases, the rate of homicide increases (-0.623, *P* = 0.0002) after approximately 30% canopy cover, there does not appear to be a relationship prior to that.

To address issues of multicollinearity, we performed modeling using the Poisson regression utilizing zip code zone area, population, race makeup, and wealth as covariables. Zip code area and population size accounted for the greatest difference in canopy cover between the different zip codes (Table 2). When those variables are excluded, there is a clear relationship between canopy cover and intentional death, suicide, and homicide (*P* = 0.05 - < 0.0001 for all, Table 2B).

Several secondary measures were also examined. Canopy cover was not associated with local wealth ($r^2 = 0.052$, $P = 0.21$). Race, measured as fraction of the population that is either African-American or Caucasian, was also associated with canopy cover. A negative association, or fewer trees, were associated with increasing fraction of African-American residents ($r^2 = 0.18$, slope = –0.823, 95% confidence interval [CI] = –1.48 to –0.0.16, $P = 0.016$), and a positive association for Caucasians ($r^2 = 0.21$, slope = 0.854, 95% CI = 0.23 to 1.47, $P = 0.009$). Race was not related to suicide for either African-Americans ($r^2 = 0.46$, $P = 0.99$) or Caucasians ($r^2 = 0.006$, $P = 0.66$). However, being victims of homicide was positively related to race among African-Americans ($r^2 = 0.46$, slope 0.08, 95% CI 0.045. to 0.107, $P < 0.0001$); and negatively related to race among Caucasians ($r^2 = 0.5$, slope –0.08, 95% CI –0.105. to –0.049, $P < 0.0001$). This appears to be mediated by poverty since income was not related to suicide ($r^2 = 0.061$, $P = 0.17$), but was related to homicide ($r^2 = 0.18$, $P = 0.015$). Similarly, wealth was positively correlated with percent of the population that is Caucasian ($r^2 = 0.22$, slope = 0.00025, 95% CI = 0.00008 to 0.0004, $P = 0.006$), and negatively correlated with the fraction of population that is African-American ($r^2 = 0.17$, slope = –0.0002, 95% CI = –0.0004 to – 0.00004, $P = 0.02$).

Community tree planting programs began in Louisville around 2013 and have planted 3,000 trees by 2019 (https://louisvillegrows.org/our-history/ accessed 1 January 2021). The data utilized for this study is from canopy cover in 2011, prior to the tree planting effort, but reflective of the time period being studied.

DISCUSSION

In this exploratory study we examined the relationship between suicides, homicides, and tree cover in a mid-sized city. We found a negative relationship between tree density and the rates of both suicide and homicide which persisted when we corrected for multiple variables with a multivariable Poisson Regression Analysis. Nonetheless, this is purely an association that does not examine any cause-effect relationship; although, it does support preexisting literature that documents both reduced violence and improved physical and mental health as a function of increased tree cover. We chose to examine intentional death by suicide and homicide because in psychodynamic formulations they can be seen as two sides of the same coin (Pokorny 1965; Bills 2019); both are forms of extreme human violence (Huesmann and Taylor 2006). But modern views of the two behaviors is that they are more distinct (Bähr 2013), with regional social and cultural variables being more important than biological or psychological ones (Bills and Li 2005). It is important to note, that beyond their shared cores of manifestation of human violence and their inverse association with trees, we do not feel that they are directly related.

Previous associational studies have shown that as canopy cover increases, there is an associated reduction in both violence towards others (Kondo et al. 2017; Escobedo et al. 2018; Schusler et al. 2018; Kuo and William 2001) and self-harm (Vaz et al. 2020). The relationship continues after control for socioeconomic variables (Escobedo et al. 2018; Kuo and William 2001). Additionally, examining violence in the same neighborhood before and after a tree-planting program reveals a notable reduction in violent crime (Burley 2018). Similarly, attempts to control for other variables in the suicide studies also appear to show an ongoing relationship (Vaz et al. 2020).

Within the limitations of our available data, we attempted to explore the relationship of suicide and homicide with canopy cover and socioeconomic status. We found that the average adjusted income was not associated with canopy cover. This finding increases the likelihood that the association seen with intentional deaths and the dearth of trees is not purely driven by socioeconomic status. Only being a victim of homicide was significantly related to reduced wealth; suicide showed no relationship with wealth. When we explored race, which is related to socioeconomic status (Myers 2009), we found that the rate of being a homicide victim dropped as the proportion of Caucasians increases and an inverse relationship with African-Americans.

In our data, the associations of canopy cover and suicide/homicide were not linear (Figures 1 and 2). The data are consistent with a threshold phenomenon, where, as the canopy cover drops below 20% for suicide and 30% for homicide, the rate of these violent deaths increases markedly.

There are significant limitations to the current study. The data were analyzed by zip code, which is associated with multiple uncertainties (Grubesic and Matisziw 2006; Grubesic 2008). Zip codes do not describe a geographic area, rather they are a collection of postal routes, and their original purpose was to smooth out postal delivery (Grubesic and Matisziw 2006; Grubesic 2008). Consequently, use of zip codes as geographic units can introduce unknown and unforeseen sources of error (Grubesic 2008). Some health care researchers feel that zip code data can be useful (Arrieta et al. 2008). We could not examine the question in any other fashion because the data regarding suicides were only available to us within zip codes. Additionally, this is an association study susceptible to multicollinearity errors (Kim 2019). For example, canopy cover is related to greater wealth of local residents (Iverson and Cook 2000; Schwarz et al. 2015; Krafft and Fryd 2016; Gerrish and Watkins 2018), which itself can be related to several health factors and crime (Schwarz et al. 2015). Furthermore, tree canopy cover can vary within the average area of a zip code of 12.375 square miles so that the number of trees does not actually describe the environment experienced by any particular individual. These preliminary observations will need to be replicated before being considered accurate. Finally, we found a possible threshold at about 20 – 30% canopy cover (Figures 1 and 2), below which loss of canopy cover increased both suicide and homicide. However, the vegetation database we used may lose resolution at < 10% vegetation cover, with an over-representation of pavement (Smith et al. 2011). All of these caveats need to be taken into account when interpreting these data.

CONCLUSION

We performed an exploratory examination of the relationship between tree cover and mental health outcomes as measured by suicide, and person-person violence as measured by homicide in a medium size Southern city with 37% canopy cover. We found that both suicide and homicide increase in association with reductions of canopy cover below 10% and 20%, respectively. Race and wealth appeared to covary with homicide, but wealth did not covary with suicide. These exploratory data suggest that tree cover or an associated variable may be associated with mitigation of intentional death in humans.

LITERATURE CITED

Araya, R., Montgomery, A., Rojas, G., Fritsch, R., Solis, J., Signorelli, A., & Lewis, G. (2007). Common mental disorders and the built environment in Santiago, Chile. *British Journal of Psychiatry*, 190, 394–401. doi: 10.1192/bjp.bp.106.024596

Arrieta, M., White, H.L./, & Crook, E.D. (2008). Using zip code-level mortality data as a local health status indicator in Mobile, Alabama. *American Journal of Medical Science*, 335(4), 271-274. doi: 10.1097/maj.0b013e31816a49c0

Bähr, A. (2013). Between "self-murder" and "suicide": The modern etymology of self-killing. *Journal of Social History*, 46(3), 620–632. https://doi.org/10.1093/jsh/shs119

Bell, J.F., Wilson, J.S., & Liu, G.C. (2008). Neighborhood greenness and 2-year changes in body mass index of children and youth. *American Journal of Preventative Medicine*, 35(6), 547-553.

Beyer, K.M., Kaltenbach, A., Szabo, A., Bogar, S., Nieto, F.J., & Malecki, K.M. (2014). Exposure to neighborhood green space and mental health: evidence from the survey of the health of Wisconsin. *International Journal of Environmental Research and Public Health*, 11(3), 3453-3472. doi: 10.3390/ijerph110303453

Bills, C.B. (2017). The relationship between homicide and suicide: A narrative and conceptual review of violent death. *International Journal of Conflict and Violence*, 11, 1-9. doi: 10.4119/UNIBI/ijcv.400

Bills, C.B., & Li, G. (2005). Correlating homicide and suicide. *International Journal of Epidemiology*, 34(4), 837-845. doi: 10.1093/ije/dyi079.

Burley, B.A. (2018). Green infrastructure and violence: Do new street trees mitigate violent crime? *Health Place*, 54, 43-49. doi: 10.1016/j.healthplace.2018.08.015

Casey, J.A., James, P., Rudolph, K.E., Wu, C.D., & Schwartz, B.S. (2016). Greenness and birth outcomes in a range of Pennsylvania communities. *International Journal of Environmental Research and Public Health*, 13(3), pii: E311. doi: 10.3390/ijerph13030311

Donovan, G.H., Butry, D.T., Michael, Y.L., Prestemon, J.P., Liebhold, A.M., Gatziolis, D., & Mao, M.Y. (2013). The relationship between trees and human health evidence from the spread of the emerald ash borer. *American Journal of Preventative Medicine*, 44(2), 139–145. doi: 10.1016/j.amepre.2012.09.066

Elwadhi, D., & Cohen, A. (2020). Social inequalities in antidepressant treatment outcomes: a systematic review. *Social Psychiatry and Psychiatric Epidemiology*, 55(10), 1241-1259. doi: 10.1007/s00127-020-01918-5

Eisenman, T.S., Churkina, G., Jariwala, S.P., Kumar, P., Lovasi, G.S., Pataki, D.E., Weinberger, K.R., & Whitlow, T.H. (2019). Urban trees, air quality, and asthma: An interdisciplinary review. *Landscape and Urban Planning*, 187, 47–59. https://doi.org/10.1016/j.landurbplan.2019.02.010

Eisenman, T.S., Jariwala, S.P., & Lovasi, G.S. (2019). Urban trees and asthma: A call for epidemiological research. *Lancet Respiratory Medicine*, 7, e19–e20. https://doi.org/10.1016/S2213-2600(19)30193-6

Escobedo, F.J., Clerici, N., Staudhammer, C.L., Feged-Rivadeneira, A., Bohorquez, J.C., Tovar, G. (2018). Trees and Crime in Bogota, Colombia: Is the link an ecosystem disservice or service? *Land Use Policy*, 78, 583-592. https://doi.org/10.1016/j.landusepol.2018.07.029

Gascon, M., Triguero-Mas, M., Martínez, D., Dadvand, P., Forns, J., Plasència, A., & Nieuwenhuijsen, M.J. (2015). Mental health benefits of long-term exposure to residential green and blue spaces: a systematic review. *International Journal of Environmental Research and Public Health,* 12(4), 4354-4379. doi: 10.3390/ijerph12049=04354

Gascon, M., Triguero-Mas, M., Martínez, D., Dadvand, P., Rojas-Rueda, D., Plasència, A., & Nieuwenhuijsen, M.J. (2016). Residential green spaces and mortality: A systematic review. *Environment International,* 86, 60-67.

Gerrish, E., & Watkins, S.L. (2018). The relationship between urban forests and income: A meta-analysis. *Landscape and Urban Planning,* 170, 293–308. https://doi.org/10.1016/j.landurbplan.2017.09.005

Grubesic, T.H. (2008). Zip codes and spatial analysis: Problems and prospects. *Socio-Economic Planning Sciences,* 42(2), 129-149.

Grubesic, T.H., & Matisziw, T.C. (2006). On the use of ZIP codes and ZIP code tabulation areas (ZCTAs) for the spatial analysis of epidemiological data. *International Journal of Health Geographics*. 5: Article number 58.

Huesmann, L.R., & Taylor, L.D. (2006). The role of media violence in violent behavior. *Annual Review of Public Health,* 27, 393-415. doi: 10.1146/annurev.publhealth.26.021304.144640

Iverson, L.R., & Cook, E.A. (2000). Urban forest cover of the Chicago region and its relation to household density and income. *Urban Ecosystems,* 4, 105–124. https://doi.org/10.1023/A:1011307327314

James, P., Hart, J.E., Banay, R.F., & Laden, F. (2016). Exposure to greenness and mortality in a nationwide prospective cohort study of women. *Environmental Health Perspectives,* 124(9), 1344-1352.

Kardan, O., Gozdyra, P., Misic, B., Moola, F., Palmer, L.J., Paus, T., & Berman, M.G. (2015). Neighborhood greenspace and health in a large urban center. *Science Reports*, 5, 11610. doi: 10.1038/srep11610

Kim, J.H. (2019). Multicollinearity and misleading statistical results. *Korean Journal of Anesthesiology,* 72(6), 558-569. doi: 10.4097/kja.19087

Kondo, M.C., South, E.C., Branas, C.C., Richmond, T.S., & Wiebe, D.J. (2017). The association between urban tree cover and gun assault: A case-control and case-crossover study. *American Journal of Epidemiology*, 186(3), 289-296. doi: 10.1093/aje/kwx096

Krafft, J.,& Fryd, O. (2016). Spatiotemporal patterns of tree canopy cover and socioeconomics in Melbourne. *Urban Forestry and Urban Greening*, 15, 45-52.

Kuo, F.E., & William, C.S. (2001). Environment and crime in the inner city: Does vegetation reduce crime? *Environment and Behavior*, 33(3), 343-367. doi: 10.1177/0013916501333002

Lai, Y., & Kontokosta, C.E. (2019). The impact of urban street tree species on air quality and respiratory illness: A spatial analysis of large-scale, high-resolution urban data. *Health and Place*, 56, 80-87. doi: 10.1016/j.healthplace.2019.01.016.

Lovasi, G.S., O'Neil-Dunne, J.P.M., Lu, J.W.T., Sheehan, D., Perzanowski, M.S., MacFaden, S.W., King, K.L., Matte, T., Miller, R.L., Hoepner, L.A., Perera, F.P., & Rundle, A. (2013). Urban tree canopy and asthma, wheeze, rhinitis, and allergic sensitization to tree pollen in a New York City birth cohort. *Environmental Health Perspectives,* 21(4), 494-500.

Maas, J., Verheij, R.A., Groenewegen, P.P., de Vries, S., & Spreeuwenberg. P. (2006). Green space, urbanity, and health: how strong is the relation? *Journal of Epidemiology and Community Health,* 60(7), 587-592.

Myers, H.F. (2009). Ethnicity- and socio-economic status-related stresses in context: An integrative review and conceptual model. *Journal of Behavioral Medicine,* 32(1), 9-19. doi: 10.1007/s10865-008-9181-4

Pedder, J. (1992). Psychoanalytic views of aggression: Some theoretical problems. *British Journal of Medical Psychology,* 65 (Pt 2), 95-106. doi: 10.1111/j.2044-8341.1992.tb01690.x

Pokorny, A.D. (1965). Human violence: A comparison of homicide, aggravated assault, suicide, and attempted suicide. *Journal of Criminal Law, Criminology and Police Science (*now *Journal of Criminal Law and Criminology),* 56(4), 488-497.

Reid, C.E., Clougherty, J.E., Shmool, J.L.C., & Kubzansky, L.D. (2017). Is all urban green space the same? A comparison of the health benefits of trees and grass in New York City. *International Journal of Environmental Research and Public Health,* 14(11), pii: E1411. doi: 10.3390/ijerph14111411

Schusler, T., Weiss, L., Treering, D., & Balderama, E. (2018). Research Note: Examining the association between tree canopy, parks and crime in Chicago. *Landscape and Urban Planning,* 170, 309-313.

Schwarz, K., Fragkias, M., Boone, C.G., Zhou, W., McHale, M., Grove, J.M., O'Neil-Dunne, J., McFadden, J.P., Buckley, G.L., Childers, D., Ogden, L., Pincetl, S., Pataki, D., Whitmer, A., & Cadenasso, M.L. (2015). Trees grow on money: Urban tree canopy cover and environmental justice. *PloS One,* 10(4), e0122051. doi: 10.1371/journal.pone.0122051

Smith, M.L., Zhou, W., Cadenasso, M., Grove, M., & Band, L.E. (2010). Evaluation of the National Land Cover Database for hydrologic applications in urban and suburban Baltimore, Maryland. *Journal of the American Water Resources Association (JAWRA),* 46(2), 429-442. doi: 10.1111⁄j.1752-1688. 2009.00412.x

Ulmer, J.M., Wolf, K.L., Backman, D.R., Tretheway, R.L., Blain, C.J.A., O'Neil-Dunne, J.P.M., & Frank, L.D. (2016). Multiple health benefits of urban tree canopy: The mounting evidence for a green prescription. *Health and Place,* 42, 54-62.

Vaz, E., Shaker, R.R., & Cusimano, M.D. (2020). A geographical exploration of environmental and land use characteristics of suicide in the greater Toronto area. *Psychiatry Research,* 287, 112790.

Vukojević, M., Zovko, A., Talić, I., Tanović, M., Rešić, B., Vrdoljak, I., & Splavski, B. (2017). Parental socioeconomic status as a predictor of physical and mental health outcomes in children – literature review. *Acta Clinica Croatica*, 56(4), 742-748. doi: 10.20471/acc.2017.56.04.23

Walker, G.A. & Shostak, J. (2010). *Common Statistical Methods for Clinical Research with SAS®, Examples 2nd Edition*. Cary, NC: SAS Institute Inc.