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Climate Change and Levels of Violence in Socially Disadvantaged Neighborhood Groups

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ABSTRACT *The current study examines the link between climate change and neighborhood levels of violence using 20 years of monthly climatic and crime data from St. Louis, MO, USA. St. Louis census tracts are aggregated in neighborhood groups of similar levels of social disadvantage, after which each group is subjected to time series analysis. Findings suggest that neighborhoods with higher levels of social disadvantage are very likely to experience higher levels of violence as a result of anomalously warm temperatures. The 20 % of most disadvantaged neighborhoods in St. Louis, MO, USA are predicted to experience over half of the climate change-related increase in cases of violence. These results provide further evidence that the health impacts of climate change are proportionally higher among populations that are already at high risk and underscore the need to comprehensively address climate change.*

KEYWORDS *Climate change, Violence, Neighborhood dimensions, Social disorganization, Routine activities*

INTRODUCTION

Violent crime is a serious health issue that unevenly affects the American population and exacts a large impact on the quality of life and health of residents as well as imposes a large financial burden on health care providers.[1–3] Neighborhood conditions are cited in the criminological literature as one of the more consistent and pervasive factors in predicting high levels of violence.[4–7]

The National Institutes of Health[8] recently called attention to the relevance of climate change and described a large number of possible negative health effects of climate change. The climate change literature suggests that economically disadvantaged populations may experience a larger health impact,[9–14] but no study to date has examined if climate change also influences neighborhood levels of violence.

Several recent epidemiological studies have touched on the relationship in an indirect fashion. For example, one study suggests that health impacts of climate change may be heightened in high-crime neighborhoods because residents may keep doors and windows shut during extremely hot days, but this study does not address interpersonal violence.[10] Another epidemiological study found a relationship between climatic conditions and sexual assaults, but did not examine if neighborhood conditions influenced this relationship.[14]

The following study uses 20 years of monthly data from St. Louis, MO, USA to examine the likely relation between climate change and violent crime in a range of

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neighborhoods. Previous research on the link between climatic conditions and violence has predominantly focused on the impact of seasonality.[15–28] It is well-documented that violent crimes generally increase during the warmer months of the year, but debate continues on the causes. Some studies explain the link between violence and warmer climatic conditions as a result of a heat–aggression link that has been observed in laboratory experiments.[29–35] It is hypothesized that unusual heat levels may trigger irritation and discomfort and thereby heighten aggression.

Other studies suggest that there is an indirect connection between violence and warmer conditions. In these studies, levels of violence fluctuate throughout the year as people change their routine activities.[20,25,27,28] Pleasant weather, for instance, brings victims and offenders in closer proximity, as more people are out and about, resulting in a higher level of violence, particularly robberies and assaults.[17,18,28]

The theoretical foundations of both routine activities theory and heat–aggression theories remain largely untested. In order to see if changing routine activities impact violence levels during warmer weather, one would actually need to estimate how people's routine activities change. Particularly at the weekly or monthly levels, these data are simply not yet available. Researchers, however, argue that the specific temperature–violence curve can provide an approximation of the dilemma. Routine activities theorists point out that, while violence increases during pleasant weather, people are less likely to commit acts of violence when it is too hot (curvilinear relationship). Heat–aggression perspectives often argue that the link between violence and temperature is simpler: more heat, more irritation, and consequently, more violence (linear relationship).

Rotton and Cohn[28] and Anderson, Bushman, and Groom[29] are currently the only empirical studies that have quantitatively measured the relation between *climate change* and interpersonal violence in the USA. Both studies found a positive relationship between increasing average temperatures and levels of violence. Rotton and Cohn[28], in particular, provided a specific enumeration of climatic influences on violence, suggesting a small but significant positive correlation between higher average temperatures and higher levels of violent crime. Several other studies have examined the connection between climate change and interstate and civil conflicts, but the results of these studies are not always supportive of a climate change–violence connection, plus state level violence is quite distinct from interpersonal violence.[36–40]

The currently available studies focusing on climate change and interpersonal violence in the USA[28,29] suffer from two flaws. One, they use annual data to estimate the impact of climate change on levels of violence. This is problematic as recent climate research shows that the impact of climate change (increasing temperatures) is not equally distributed throughout the year.[13,41,42] Particularly in the USA, winter temperatures have recently increased far more so than summer temperatures.[38,41] Two, several recent studies have found that levels of violence in disadvantaged neighborhoods may be more affected by seasonal variations in temperature.[16,43] By extension, some neighborhoods may be at greater risk of increased violence as a result of climate change, but no study has yet addressed this issue. Criminologists have, however, produced a large body of work illustrating the relevance of neighborhood conditions in producing or controlling crime.[4–6,45,46] Particularly instructive is the research on social disorganization theory, which has provided ample evidence for the role that economic disadvantage and neighborhood stability play in controlling levels of violence.

In short, there is a need to understand how climate change may differently impact violence in communities with varying levels of socioeconomic resilience. Based on the common research findings that crime is higher during pleasant weather and crime being higher in socially disadvantaged neighborhoods, one would predict that socially disadvantaged neighborhoods are likely to experience higher increases in violence as a result of climatic changes.

The primary goal of this study is to estimate the potential effects of climate change on levels of violence in different types of neighborhoods. While being inherently descriptive and exploratory, this study cannot confidently settle the theoretical debate on the root causes of the heat–violence link. Nonetheless, the "Discussion" section will discuss some of the theoretical implications of this study.

METHODS

In order to examine the potential link between climate change and violence, monthly data are collected from several public sources. Violent crime data are obtained from the Saint Louis Metropolitan Police Department's Uniform Crime Report database. All reported homicides, rapes, aggravated assaults, and robberies with complete location and date information between January 1, 1990 and December 31, 2009 are used for the current analysis. Temperature data for Lambert St. Louis Airport during the same period are obtained from NOAA's National Climate Data Center.[47] Control variables are constructed using Census and Bureau of Labor Statistics.[48]

Figure 1 shows the average monthly temperature anomalies (1990–2009) for both the USA and St. Louis. Overall monthly temperatures in St. Louis are 1.15 °F above the long-term means (1970–2000), but January temperatures have averaged 3.4 °F above normal. This seasonal trend in climate change in St. Louis closely mirrors the

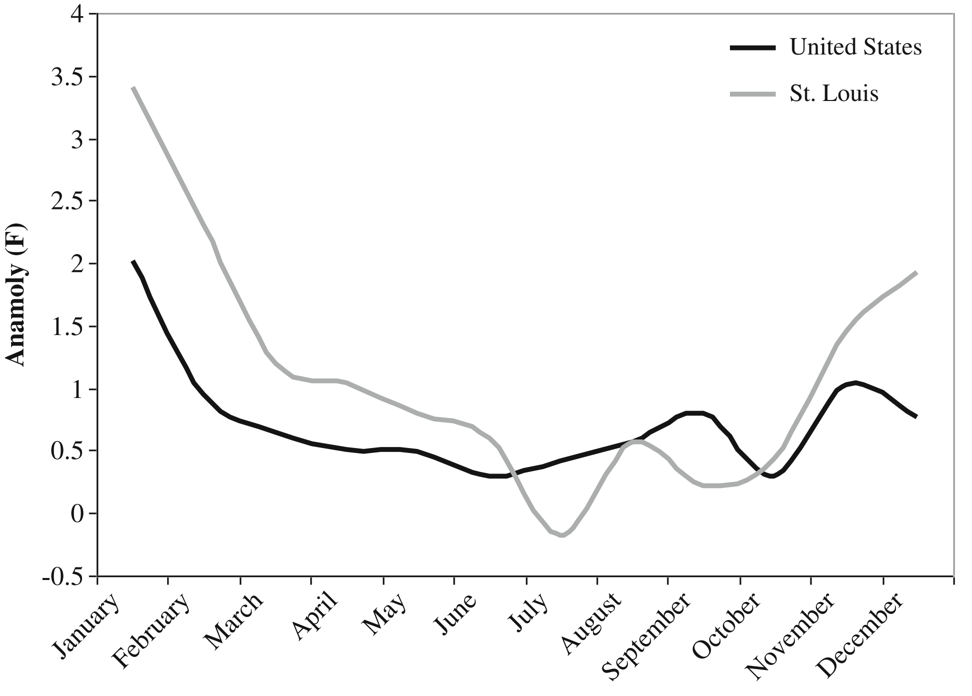

FIGURE 1. Monthly temperature anomalies St. Louis and USA, 1990–2009.

trend of climate change in the USA during the same period, albeit at slightly higher levels.[42]

Crime rates in St. Louis are higher than in most of the USA, but trends in this city mirror those of the USA. For good reasons, St. Louis has been featured in many prior criminological studies that sought to generalize findings.[49–53] Richard Rosenfeld, a leading expert of trends in violence, even suggests that St. Louis can be used to estimate national trends in homicides.[51] Figure 2 illustrates this pattern and shows that St. Louis mirrors national trends quite well. This is quite typical for larger cities in the USA, as national trends in violence are driven to a large extent by young urban males who live in inner city communities.[54]

It appears paradoxical to expect a positive relationship between climate change and violence when annual rates of violence are decreasing, but temperatures trend upward. Nonetheless, Figure 3 provides an illustration for this hypothesis. Just because annual levels of violence recede does not mean that the decline is balanced throughout the year.

Warmer than normal summers do not appear to equal higher than normal levels of violence. Violence during the winter months, however, appears to be more sensitive to temperature shifts. Figure 3 suggests that colder winters see a deeper decline in violence, whereas warmer winters see a comparative increase in violence. Given the climatic anomalies displayed in Figure 1, we may thus argue that climate change likely influences violence levels by changing the amplitude of crime trends, particularly during the colder months of the year. In effect, climate change may be reducing the normal seasonal fluctuations in violence, which means that a declining trend in violence (including summers) is partially offset by warmer winters.

In order to approximate the relationship between climate change and violent crime in St. Louis neighborhoods more specifically, 20 years of monthly reported violent crime data (approximately 200,000 cases) were geocoded in ArcGis 9.3. This provides a match rate of nearly 96 % to a specific census tract. It would have been ideal to examine census tracts individually, but violent crimes do not occur frequently enough at this level of aggregation and thus pose issues of non-normality. For instance, some of the least disadvantaged neighborhoods report fewer than 100

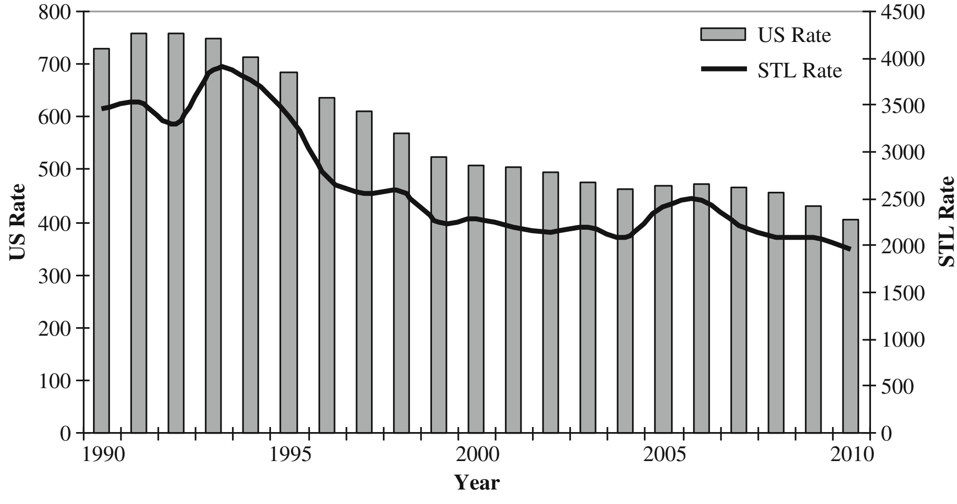

FIGURE 2. Rates of violence St. Louis and USA, 1990–2010. Source for US data: Bureau of Justice Statistics: http://bjs.ojp.usdoj.gov/ucrdata/; accessed July 20, 2012.

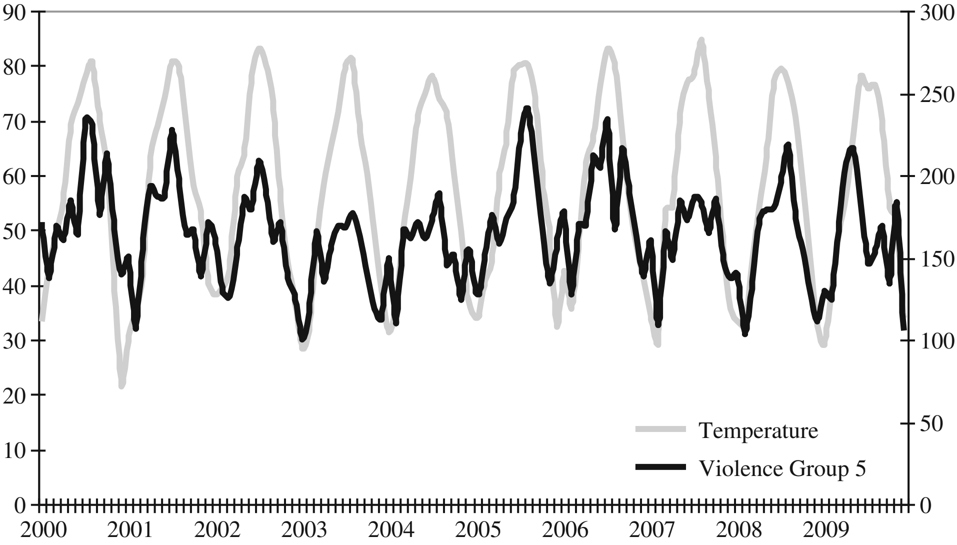

FIGURE 3. Monthly trends of temperature and violence in St. Louis' most disadvantaged neighborhoods.

violent incidents during the 240 monthly observations, creating a problematic low count distribution that cannot be appropriately modeled in time series analysis procedures.[55,56] While some researchers argue that the level of aggregation matters, this is most often a problem in studies that are interested in a highly theoretical issue.[57] The current study is, however, simply interested in finding out if places with lower levels of social control are more impacted by climatic changes.

Using groups of census tracts rather than individual census tracts can be also beneficial because it averages out highly localized processes, such as turf wars and highly active individuals that can severely skew results for individual census tracts. Groups of census tracts are also a more preferable comparison units than cities in which the socioeconomic, cultural, and climatic conditions are likely not comparable.

The current study aggregates census tracts into 5 groups (22 tracts per group) by ordering census tracts on their level of social disadvantage using commonly used census indicators including poverty level, percent vacant homes, proportion of young Black males, female-headed households, high school dropouts, unemployment levels, and proportion of rental units (for a fuller explanation, see Appendix 1). A similar approach is taken by Kubrin and Weitzer, who divided St. Louis census tracts into quartiles to examine retaliatory homicides (Table 1).[50]

RESULTS

In order to test the hypothesis that climate change is having a larger deleterious effect on violent crimes in socially disadvantaged neighborhoods, regression models are constructed for each neighborhood group (group 1 is least disadvantaged, group 5 is most disadvantaged). The dependent variable for the study is the log-transformed sum of reported aggravated assaults, robberies, rapes, and homicides occurring per month per neighborhood group (N=240, 12 months×20 years). By creating a log-transformed dependent variable, the coefficients for the independent variables are easily interpretable as they roughly refer to percent change.

TABLE 1 St. Louis neighborhood groups: social disadvantage indicators and crime

	St. Louis[a]	Group 1	Group 2	Group 3	Group 4	Group 5
Total population	348,189	79,123	80,731	75,940	58,000	54,273
Percent homes vacant	17.798	5.921	12.353	19.099	22.543	28.116
Percent Black males, 15–24 years old	3.990	0.269	2.471	4.420	6.131	6.839
Percent female-headed households	49.647	22.130	42.909	57.814	62.023	70.128
Percent high school dropout	14.220	10.312	14.480	12.742	12.411	23.093
Percent unemployed	13.039	4.724	7.383	11.957	17.224	25.683
Percent rental units	43.416	29.994	46.337	46.529	45.954	47.655
Percent below the poverty line	26.309	9.191	19.236	26.821	34.020	43.146
Average violent crime rate per 100,000	2,831	494	1,703	3,175	4,327	5,059

[a]Numbers may not add up to 100 % due to rounding and three census tracts with a small population that were dropped from the five groups

The main independent variable ("Tempanomaly") provides a proxy for climate change and is measured as the actual monthly temperature anomalies, a commonly used measure of climate change.[13,38,41] The measure is created by subtracting the monthly values of the long-term (30 years) mean from the actual monthly temperatures. While one may object that monthly temperature anomalies do not capture climate change as a larger process, the point is exactly that recent climate change has not been equitable month to month. Substantial seasonal variation in climate change has been observed in the USA, with winter months especially seeing warmer than average temperatures.[13,41,42] Michael Mann recently argued that climate change should be measured on the scale of decades.[43] With 20 years of data in the current study, one can hardly make the claim one is measuring such a fundamental process. Nonetheless, temperature anomalies as measured in the current study can generate an estimate of the current impact of climate change on violence. Whether specific monthly temperature anomalies are the direct outcome of climate change or whether they are the outcome of normal weather variability is not critical. Violent individuals are unlikely to care whether a 60-degree-day in January is the outcome of climate change or natural variability; they just know it is pleasant out. As long as we can uncover the relationship between above or below normal temperature and violence, we can estimate—if we know the current effect of climate change on temperature—what the probable impact of climate change on levels of violence is.

Because previous research has indicated strong seasonality effects on violence that are the outcome of normal seasonal variation in temperatures, the 30-year average monthly temperature ("Seasonality") for St. Louis is incorporated as a control variable. This variable thus captures typically expected seasonal fluctuations in temperature and violence. Given the importance of economic factors in previous criminological research, an economic component is integrated in the analysis. The variable CPI represents the monthly US consumer price index. This measure captures a degree of economic growth as products tend to get more expensive as affluence spreads throughout society (other economic variables—including unemployment and regional home sales—were examined but failed to yield significant results and are thus excluded from the final model reported here). "Monthcontrol" captures the variation in the monthly number of days. This is an important variable as the colder months in the year are shorter. Finally, the log of the population is used as a control factor to account for estimated changes in the overall population of St. Louis.

Data ordered in time units (months in this case) often exhibit temporal autocorrelation. Serial dependence in the error term violates a key assumption of ordinary least squares analysis and, therefore, must be addressed.[55,56] In order to correct for this problem and create a time series that is stationary, the analysis first identifies underlying trends and includes these trend coefficients as a control in the model. All models reported (see Table 2) also include the results of the Portmanteau test of white noise after these trend adjustments are included in the final models.

Findings for the "Monthcontrol" variable show the importance of correcting for the number of days in a month as the variable is highly significant in each neighborhood group. Its impact is relatively consistent across neighborhood groups, suggesting that violence increases around 6 % for each additional day. The population control measure is also significant in all the neighborhood groups, but particularly those with high levels of social disadvantage. This likely suggests that the population decline of St. Louis in the last two decades took place especially in more disadvantaged neighborhoods.

The variable CPI exhibits an interesting relationship to levels of violence in neighborhood groups. Whereas the citywide coefficient is significant and negative (−0.602), the coefficients grow more negative as the level of disadvantage of a neighborhood group increases. This suggests, consistent with prior criminological research,[4] that macroeconomic growth can have an important relationship to violence, depending on specific neighborhood contexts.

What is further evident from all models is that a strong seasonality component is present in all neighborhood groups. The seasonality component of the models does not allow us to distinguish if higher violence during warmer months is the direct result of expected seasonal temperature variation or whether this is the result of exogenous factors connected to seasons (such as school closings). Citywide results suggest that violence increases 0.638 % on average for each degree Fahrenheit increase in monthly average temperatures. Considering that average temperatures fluctuate about 50 °F between the coldest (January) and warmest (August) months, this finding suggests that a typical August should experience almost 32 % more violence than an average January.

The correlation coefficients of seasonality are a bit more diverse when examining neighborhood groups, ranging from a low of 0.429 in the more affluent neighborhoods (group 1) to a high of 0.724 in the most severely disadvantaged neighborhoods (group 5). This suggests that residents of disadvantaged neighborhoods are likely at higher risk of increased violence during seasonally warmer months. The most disadvantaged group of neighborhoods experience approximately 36 % more violent crimes in the warmest month compared to the coldest month, whereas the least disadvantaged group of neighborhoods typically sees an uptick of about 21 %. This indicates that socially disadvantaged neighborhoods experience greater variability in violent victimization during the course of a normal year and is consistent with prior research.[11,44]

When examining temperature anomalies—our proxy measure for climate change—an even more divergent pattern emerges. For instance, when a typical month is a single degree Fahrenheit warmer than the expected seasonal temperature, violence in St. Louis rises on average by 0.739 %. This citywide average appears to be mostly generated in

TABLE 2 Time series regression results (standard errors in parentheses)

	St. Louis[a]	Group 1	Group 2	Group 3	Group 4	Group 5
Model	ln(1,0,1)(1,0,0)	ln(1,0,1)(0,0,0)	ln(1,0,1)(0,0,0)	ln(1,0,1)(0,0,0)	ln(1,0,1)(1,0,0)	ln(1,0,1)(1,0,0)
	Q=31.884	Q=45.182	Q=42.661	Q=31.423	Q=38.766	Q=42.465
Q value (lag 40)	Sig=0.816	Sig=0.264	Sig=0.357	Sig=0.823	Sig=0.526	Sig=0.365
Month control	5.879***	6.026**	5.787***	5.797***	5.603***	6.233***
	(0.005)	(0.018)	(0.010)	(0.001)	(0.009)	(0.008)
Population Control	184.255*	40.528	123.777	162.778*	239.423*	249.221*
	(0.825)	(0.927)	(0.730)	(0.756)	(0.988)	(0.870)
CPI	−0.602***	0.039	−0.469**	−0.497*	−0.640*	−0.743***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Seasonality	0.638***	0.429***	0.457***	0.674***	0.652***	0.724***
	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)
Tempanomaly	0.739***	0.450	0.471	0.659*	0.728**	1.070***
	(0.001)	(0.005)	(0.003)	(0.002)	(0.002)	(0.002)

*P<0.05, **P<0.01, ***P<0.001

[a]Please note that all coefficients in this table are multiplied by 100 to assist interpretation

the three most socially disadvantaged neighborhood groups (group 3=0.659, group 4=0.728, and group 5=1.070). What is particularly disconcerting is the greater overall number of violent crimes occurring in these neighborhoods to begin with, magnifying the impact of this coefficient.

For example, neighborhood group 5 averages 4,576 reported violent incidents per year. Average monthly temperatures during the research period have increased by 1.15 °F. If we assume this 1.15 °F difference to be attributable to climate change, it would mean that, during the research period, a typical year would experience 1.23 % (1.070×1.15 °F) more violent crimes or about 56 actual violent incidents. In the other four neighborhood groups, the connection between climate change and violence suggests that violent crimes during an average year likely increase by 21 (group 4), 18 (group 3), 8 (group 2), and 2 (group 1). If this analysis reflects actual changes, the group of most disadvantaged neighborhoods in St. Louis (group 5) likely experiences more than half of the climate change-related increases in violence (56 out of 105), whereas the 2 groups with the lowest levels of disadvantage appear to receive only a small nonsignificant slice (<10 %).

What is more, given that climate change-induced temperature anomalies increased particularly during the colder months, the likely impact on violence for disadvantaged neighborhoods should be particularly pronounced during Januaries where temperature anomalies have averaged 3.4 °F in the last two decades. This would suggest an average uptick of 3.6 % in violence during a typical January in the most disadvantaged group of neighborhoods.

The analysis thus reveals that, after controlling for typical factors and expected seasonality, temperature anomalies remain correlated to levels of violence in disadvantaged neighborhoods. The most disadvantaged neighborhoods in St. Louis are likely experiencing a double whammy. During typical years, violence is already proportionally higher during the warmer months (due to seasonality), but climate anomalies are particularly likely to increase levels of violence during the winter months.

If this found relationship between climate anomalies and levels of violence in fact displays a true causal connection, future climate change may (depending on extent and timing) reduce seasonal fluctuations in violence particularly in socially disadvantaged neighborhoods by lifting up levels of violence during the cooler seasons and bringing them more in line with the typical higher levels of violence during warmer months. In other words, the amplitude of the typical seasonal fluctuations in violence may be reduced to where levels of violence are more constant throughout the year (see Appendix 2 and especially the comparison of St. Louis to New Orleans).

DISCUSSION

Several limitations of the current study should be pointed out and lead to some caution in the interpretation of the findings until further research becomes available. For one, St. Louis is a relatively poor city with a high crime rate. While temperature and climate change patterns mirror that of the USA, social and crime indicators do not always. Nonetheless, inner city communities are important drivers of overall violent crime rates, and St. Louis is reflective of this group of communities.[50,51,53] Findings for the current study are likely generalizable to some extent to many other similar cities across the USA (see Appendix 2). Given the extremely high concentration of social disadvantage in St. Louis, the strength of the climate change coefficient ("Tempanomaly") is perhaps lower in other cities, but the positive direction of the climate change coefficient can likely be found in most socially disadvantaged locations in the USA. Given the disproportionate impact of extremely disadvantaged neighborhoods on overall levels of violence in the USA, the St. Louis estimates may approximate the impact that climate change is exerting on US violence rates.

Another methodological issue is the reliability of the dependent variable as a measure of actual violence. Police agencies rely on residents to report violent crimes; hence, the measure in this study is a measure of reported violence, not necessarily measuring all incidents of violence. A clear caveat for the current study is the fact that reporting of violence may increase as temperatures are warmer than normal. Routine activities theory could explain that, during pleasant weather, people spend more time outside and thus more likely to witness a violent crime.

Another potential issue in the current study is the exclusion of relevant exogenous variables. One may argue that more independent variables should have been included in the current analysis. Unfortunately, relevant monthly data are not as widely available. Knowing the fluctuations in the proportion of young men, for instance, may likely have yielded additional insights, but this information was not available at the city or neighborhood level.

A final issue relates to the underlying causes of the found link between climate change and crime. The current study cannot definitively establish why neighborhood differences exist in correlations between our climate change proxy and levels of violence. Nonetheless, some of the reported findings are theoretically intriguing. For one, the results partially invalidate heat–aggression theories as there appears to be a difference in the impact of weather/climate on violence levels in neighborhood groups. Psychological perspectives on heat and crime implicitly propose that the theories apply to everyone equally; the current results question that argument and suggest that neighborhood factors at the very least mediate the impact of heat. Secondly, heat–aggression theories argue that heat is the underlying cause of higher violence. The current findings do not completely dismiss this idea (seasonal temperature differences remain highly correlated to violence), but this study does suggest that violence may also increase when temperatures go from normal to above normal, particularly during the coolest months of the year. It is difficult to conceive how a 40-degree-day in January leads to heat-induced irritation and aggressive acts.

Whereas heat–aggression theories may not be as appropriate to explain the found patterns in this study, routine activities arguments could be employed to provide somewhat of an ad hoc explanation. Disadvantaged inner city communities like those in St. Louis are characterized by a lifestyle in which many events often take place in public outdoor places.[45,46,53] Pleasant or at least tolerable weather conditions during the winter months may allow violence-prone individuals to resume their activities earlier in the year, thus boosting violence during those normally cool months. This could even affect indoor domestic assaults because these incidents often occur between related individuals who do not live together. Tolerable weather makes travel easier for residents in economically distressed communities as car ownership is often far below typical levels. A greater number of individuals on the street would likely create a greater pool of both potential offenders and victims. Unfortunately, these explanations for the found patterns could not be directly tested for this study, which remains a typical problem with the routine activities theory.

CONCLUSION

The current study examines the relation between climate change and levels of violence in different groups of neighborhoods. Using data from St. Louis, MO, USA, the findings indicate that climate change is likely having a greater impact on levels of violence in disadvantaged communities than levels of violence in more affluent communities. After controlling for confounding factors, the most disadvantaged group of communities in St. Louis typically experience an average 1 % monthly increase in violent crimes for each degree increase in anomalous temperatures. In fact, results show that the 20 % of most disadvantaged neighborhoods are predicted to absorb over 50 % of climate change-related increases in violence. On the other hand, the least disadvantaged neighborhoods in the study display no significant correlation between violence and temperature anomalies. Combined, these results suggest that those already at higher risk for a plethora of health issues connected to climate change are also likely to experience higher levels of violent victimization.

APPENDIX 1: NEIGHBORHOOD GROUPING METHODOLOGY

In order to create similar neighborhood groups, census data from 2000 (the midpoint in the series) are collected for all 113 census tracts in the city of St. Louis (3 tracts are excluded because their population was below 500) using the Neighborhood Change Database (Neighborhood Change Data Base [computer program]. Washington: The Urban Institute; 2004).

Next, a social disorganization index is developed for each census tract using seven measures of structural disadvantage. These seven measures include the percentage of people below the federal poverty threshold, the unemployment rate, the rate of high school dropouts, the percentage of female headed households, the proportion of young Black males (15–24 years old), the percentage of properties that are rental units, and the percentage of homes that are vacant. Reliability analysis on the elements of the index yields a Cronbach's alpha of 0.804, suggesting substantial similarity between the individual elements to justify grouping them. Previous neighborhood studies have used similar indexing techniques to measure extreme disadvantage in neighborhoods.[7,49,50]

The 7 census measures are subsequently standardized and aggregated to create a social disorganization rank score for the remaining 110 census tracts. In order to promote normally distributed dependent variables, a choice is made to group the census tracts into 5 equal groups of 22 to allow for further study. Group 1 is the least disadvantaged group, whereas group 5 is the most disadvantaged group of census tracts. This strategy creates enough monthly counts of violence in the least disadvantaged groups to conduct further analysis.

As Table 1 in the article body indicates, some variability in the total population between the neighborhood groups exists. Considering that violent crime counts are actually higher in the groups of neighborhoods with the lowest population, this should not pose an issue for analysis. The five groups display the expected connection between higher levels of social disadvantage and higher levels of violence. The poverty rate in group 1 (9.191 %), for instance, is well below that of group 5 (43.146 %). What is particularly noteworthy is the large difference in the percentage of young Black males (15–24 years old) in the groups. Group 1 only contains 0.269 % of this high-risk group, whereas group 2 has 10 times as many at-risk youth (2.471 %). This illustrates the continuing racial divide in St. Louis where socially disadvantaged neighborhoods tend to be predominantly African American.

Group 1 (see Table 1) with the lowest levels of disadvantage also has the lowest levels of violent crime. Subsequent groups show increasing crime rates and increasing levels of disadvantage. In fact, group 5 has a violent crime rate more than 10 times that of group 1 (5,059 vs. 494). This indicates that separating distinct neighborhood groups using the disadvantage measure likely captures the essence of socially disorganized neighborhoods and their (in)ability to control crime.[4–6]

APPENDIX 2: ADDITIONAL ANALYSIS COMPARISON SITES

One of the reviewers brought up an important issue. How do other places stack up to the findings in St. Louis? While it is difficult to locate monthly data by neighborhoods, a quick comparison of four additional cities (Cleveland (NIBRS)[*], New Orleans (UCR), Boston (UCR), and Phoenix (UCR)[†]), reveals more support for the general idea in this paper (see Table 3). The city in the analysis most comparable to St. Louis is New Orleans, followed by Cleveland. New Orleans also has extremely disadvantaged neighborhoods and an exceptionally high level of violence. Perhaps one of the key differences is that New Orleans has a substantial population of affluent residents in the downtown area, which may explain the slight difference in the "Tempanomaly" variable. What is interesting is that the climate change proxy variables of St. Louis and New Orleans are fairly close (0.739 and 0.651) despite the differences in time period examined. What is of further interest is the fact that New Orleans' seasonality pattern is smaller than that of all other places. This is not odd because New Orleans has less annual temperature variation than all other places as its climate is subtropical (winters are relatively pleasant). Cleveland also shares many similarities with St. Louis, but unfortunately, only 5 years of data were available at present; this likely underestimates the coefficients for seasonality and climate change. The other two cities (Boston and Phoenix), which were selected here because they house a more affluent population, display smaller coefficients for both seasonality and climate change.

The results of this brief comparison thus fall in line with the results of our neighborhood comparison. The advantage of the neighborhood group approach is that the socioeconomic, cultural, and climatic conditions are kept relatively constant within one city, whereas this is probably not as clear-cut when comparing cities.

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[*]Collected from the National Archive of Criminal Justice Data. National Incident-Based Reporting System, 2004–2009: Extract Files. ICPSR33601-v1. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor].

[†]Collected from monthly UCR counts collected by Michael Maltz. Available at http://cjrc.osu.edu/researchprojects/hvd/usa/ucrfbi/. Last accessed November 20, 2011.

TABLE 3 St. Louis and comparison sites

	St. Louis 1990–2009	Cleveland 2004–2009[a]	New Orleans 1990–2004[b]	Boston 1990–2004[b]	Phoenix 1990–2004[b]
Model	ln(1,0,1)(1,0,0)	ln(1,0,1)(1,0,0)	ln(1,0,1)(0,0,0)	ln(1,0,1)(1,0,1)	ln(1,0,2)(0,0,0)
	Q=31.884	Q=22.365	Q=31.454	Q=31.595	Q=50.524
Q value (lag 40)	Sig=0.816	Sig=0.989	Sig=0.831	Sig=0.826	Sig=0.123
Month control	5.879***	6.472***	4.353***	5.273***	2.388***
	(0.005)	(0.014)	(0.009)	(0.007)	(0.005)
Population control	184.255*	63.582	229.091	110.206	34.439*
	(0.825)	(0.604)	(2.315)	(1.060)	(0.133)
CPI	−0.602***	Not estimated[c]	−1.475***	−1.278***	Not estimated[c]
	(0.002)		(0.004)	(0.002)	
Seasonality	0.638***	0.479***	0.226*	0.462***	0.321***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)
Tempanomaly	0.739***	0.560**	0.651*	0.525**	0.575***
	(0.001)	(0.002)	(0.003)	(0.002)	(0.002)
Average temperature	57.467	51.186	69.124	51.479	74.787
Per capita income	16,108	17,258	21,003	23,353	19,833
2000 family poverty rate[d]	20.8 %	22.9 %	23.7 %	15.3 %	11.5 %
2000 high school completion	27.5 %	33.2 %	23.4 %	24.0 %	22.9 %
Single parents as percent of all households	12.6 %	15.3 %	14.3 %	9.4 %	7.7 %

*$P<0.05$, **$P<0.01$, ***$P<0.001$

[a]Cleveland temperature data: Tempanomaly 2004–2009 was calculated from deviation of long-term mean 1973–2000

[b]Boston, New Orleans, and Phoenix temperature data 1990–2004. Long-term mean was based on period 1964–1984. Anomalies were calculated as actual minus long term mean value

[c]Could not be estimated because of high cross-correlation with the population variable

[d]Census data from http://quickfacts.census.gov/qfd/index.html, downloaded July 18, 2012

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