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Abstract

Rationale
Areas near parks may present active travelers with higher risks than in other areas due to the confluence of more pedestrians and bicyclists, younger travelers, and the potential for increased numbers of motor vehicles. These risks may be amplified in low-income and minority neighborhoods due to generally higher rates of walking or lack of safety infrastructure.

Objectives
We pursued three research objectives: (1) to determine if pedestrian and bicycle crashes occur at higher rates in park-adjacent neighborhoods compared to the rest of the study area; (2) to identify if demographic characteristics predict active crash risk after controlling for population and the rate of active trips; and (3) to assess if there is an amplified effect of park proximity for active crash risk in low-income and minority neighborhoods after controlling for population and the rate of active trips.

Methods
With negative binomial regression modeling techniques, we used ten years of geolocated pedestrian and bicyclist crash data and a quarter mile (~400 meter) buffer around public parks to assess the risk of active travel near parks. We controlled for differential exposures to active travel risks using travel survey data.

Measurements
Quarter-mile network buffers were designated around parks from the Green Visions Plan for 21st Century California in 2249 census tracts. Crashes came from the 90,846 pedestrian and bicyclist injuries and fatalities from the Statewide Integrated Traffic Reporting System, and active travel was predicted using travel data from 9135 households that participated in the Southern California Association of Governments 2001 Travel and Congestion Survey. These data were combined with demographic and income data from the U.S. Census and traffic density predictions.

Results
The ratio of active crashes per 100,000 population within the quarter-mile park buffer to those outside is 1.52. The increased risk of crash for active travelers near parks remained after adjusting for varying rates of active travel in different census tracts. Minority and low-income residents of the study area are more likely to walk or bicycle than White and higher-income residents. This higher risk near parks is amplified in neighborhoods with high proportions of minority and low-income people. Higher traffic levels are highly predictive of active crashes.

Conclusions
Active travelers accessing parks may lack a safe route to places for play. The socioeconomic modification of active crashes near parks found in this study is supported by existing research showing disparities in park access and higher active travel risks in low-income and minority neighborhoods.

Introduction

Safe Routes to School and Safe Routes to Transit encourage physical activity and reduce the risks faced by pedestrians and cyclists accessing important public spaces (Safe Routes to School 2012, PlanYC 2011, and TransForm 2012). Parks, like schools and transit, are valuable public amenities that should be safe and accessible for active travelers. Ensuring that people have "Safe Routes to Play" could encourage physical activity and provide safe, equitable access to parks for pedestrians and bicyclists. To our knowledge, there is no existing research comparing the risks faced by active travelers near public parks and in other areas.

This study examines the risk of crash injury among active travelers near parks in Southern California by comparing crashes occurring within one-quarter mile of a park to crashes outside that buffer. We separately look at crashes near parks in low-income and minority neighborhoods, where rates of active travel and infrastructure provision may differ from the rest of the region.

Neighborhoods surrounding parks could pose a higher risk of crash injury or death for active travelers due to the type and volume of traffic. Children may be more likely to walk or bicycle to a neighborhood park than other destinations in the area and several studies suggest that proximity to a park is associated with increases in children's active travel behavior; however, other studies have found no significant association (Pont et al. 2009). Children have difficulty perceiving and understanding traffic risks and suffer pedestrian injuries at a higher rate than the adult population (American Academy of Pediatrics 2009).

In Southern California, many people live within a quarter-mile (ten to fifteen minute) walk or bicycle ride of a public park and the Mediterranean climate allows for year-round outdoor physical activity (Su et al. 2011). Parks with recreation facilities may attract higher volumes of motor vehicle traffic, thereby increasing the exposure of active travelers in the neighborhood to traffic (Byrne et al. 2009). It is also reasonable to conjecture that there may be a spatial-temporal relationship between active travel by children and adults as well as motor vehicle trips around parks. An after-school soccer tournament, for example, is likely to draw large numbers of neighborhood and regional traffic simultaneously.

Active travel near parks in low-income and minority neighborhoods may be riskier than travel near parks in other neighborhoods. Research suggests an elevated risk of crash injury for pedestrians and cyclists in low-income and minority neighborhoods (Laflamme et al. 2000). Child pedestrians in low-income census tracts in Manhattan were found to have a higher risk of traffic injury (Durkin et al. 2003). Low-income and minority neighborhoods have higher traffic densities, which increases the risk of pedestrian and cyclist crash (Houston et al. 2004). Higher active travel rates and greater motor vehicle volumes are important components of crash risk in any neighborhood. In Montreal, pedestrian and cyclist injuries are heightened in low-income neighborhoods, but this positive association is attenuated after accounting for higher numbers of pedestrians and cyclists exposed to greater volumes of motor vehicle traffic (Morency et al. 2011).

Parks in low-income or minority neighborhoods may be more congested, since these areas have a higher proportion of people to park-acres (Sister et al. 2010). Parks with a higher potential for congestion may have more active travelers and motor vehicles converging on the same space.

Objectives

In this context, we sought to address the following research objectives:

1. To determine if pedestrian and bicycle crashes occur at higher rates in park-adjacent neighborhoods compared to the rest of the study area.
2. To identify if demographic characteristics predict active crash risk after controlling for population and the rate of active trips.
3. To assess if there is an amplified effect of park proximity for active crash risk in low-income and minority neighborhoods after controlling for population and the rate of active trips.

We hypothesized that the risk of crash injury for pedestrians and bicyclists would be elevated near parks. We further hypothesized that park-adjacent neighborhoods in census tracts with a high proportion of low-income and minority residents would be more dangerous than park-adjacent neighborhoods in less disadvantaged census tracts.

Data and Methods

Overview

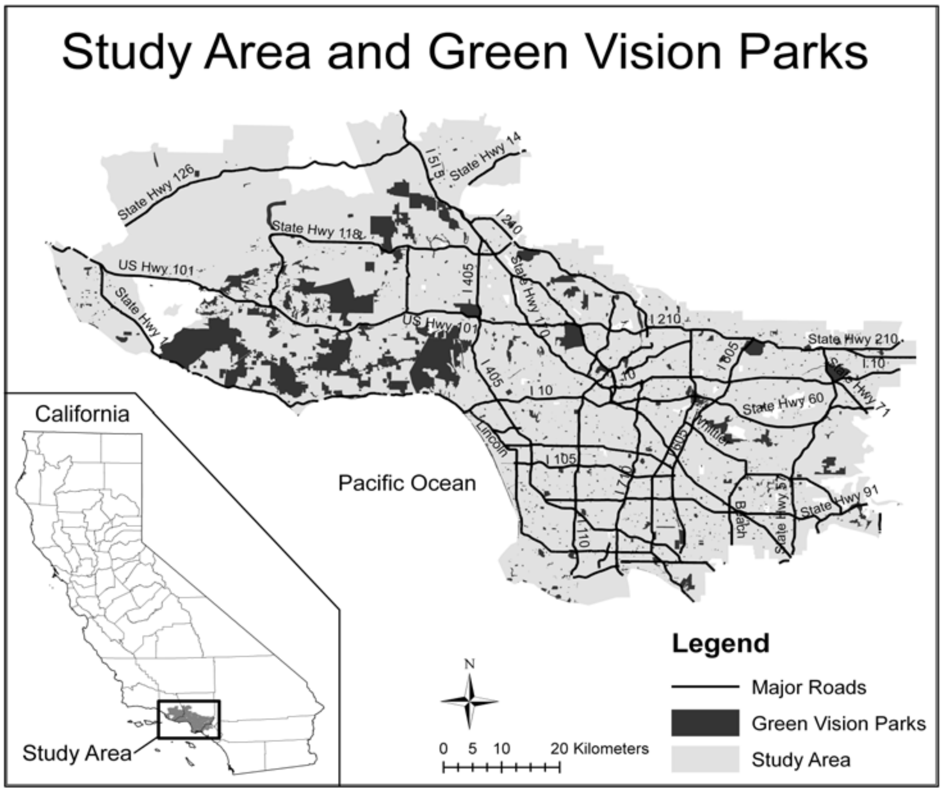
The risk of injury to active travelers is influenced by the behavior of drivers, pedestrians, and cyclists traveling there as well as any risks that may stem from the built environment (e.g., traffic calming devices). Two places with similar physical features and traffic volumes may see different levels of active travel, and therefore have different absolute numbers of crash injury and fatality but similar rates. We used estimates of active travel rates and vehicle traffic density within each census tract of our study area to better isolate the effects of park proximity, race/ethnicity, and income on active travel crash risk.

Study Area and Network Buffer

We studied the area in the Green Visions Plan for 21st Century Southern California (GVP). The GVP encompasses most of Los Angeles county and parts of Orange and Ventura counties; it includes five watersheds: Los Angeles River, Calleguas Creek, Santa Clara River, San Gabriel River, and the Santa Monica Bay. The GVP area contains 1672 parks. We removed three large parks in the northern part of the study area that are not representative of urban parks in the area (Angeles National Forest, Los Padres National Forest, and Vasquez Rocks Park) leaving 1669 parks. Parks in the GVP area were identified using a combination of field audits, available government digital maps, and private sector resources (see Sister et al. 2010 for details).

The GVP covers 2303 census tracts. We restricted the study area to those census tracts with reported travel survey data that could be used to estimate differential active travel exposure. The travel survey data is described below. Four additional census tracts within the GVP area were excluded from analysis for having zero residential population. The final analysis included 2249 census tracts covering 6097 km^2. Figure 1 shows the study area and the 1669 parks in the Green Vision Plan.

Figure 1



We designated areas within one-quarter mile of a park along the road network as park-adjacent. A quarter-mile network buffer is widely used in the urban park literature to define areas proximate to a park (e.g. Dill 2004; Sister et al. 2010; Su et al. 2011; Wolch et al. 2005). A quarter-mile also represents approximately a ten to fifteen minute walk or a short bicycle ride for children and adults accessing a park from their homes. The GVP parks and the quarter-mile network buffer were created using ESRI's ArcGIS and data from the ESRI Business Analyst

(ESRI, Redlands, CA) and TeleAtlas Dynamap 2000 (Lebanon, NH). Figures 2 and 3 illustrate the quarter-mile park buffer along a road network and active crash sites within a buffer.

Figure 2: Quarter-mile network buffer around Burns Park in Los Angeles

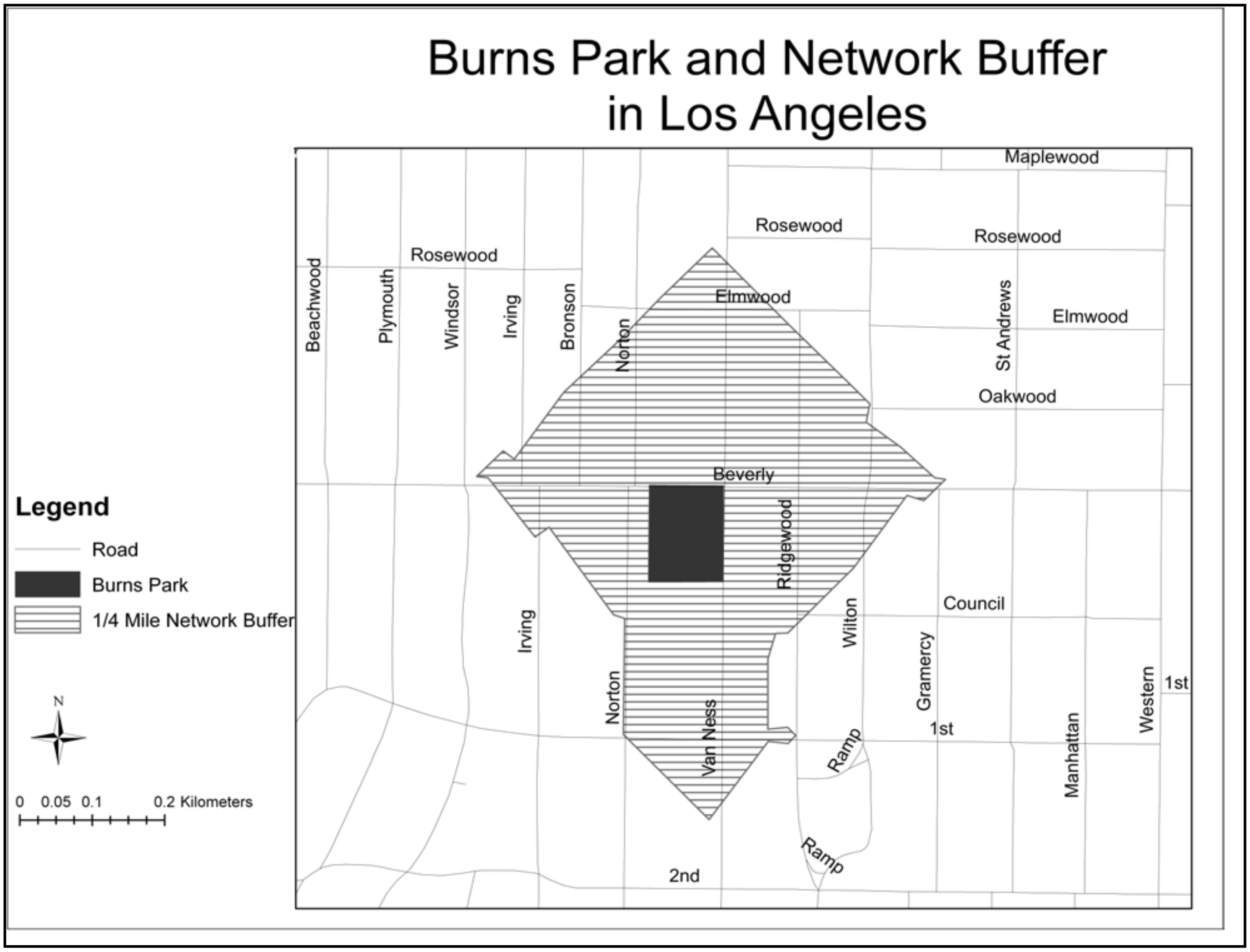
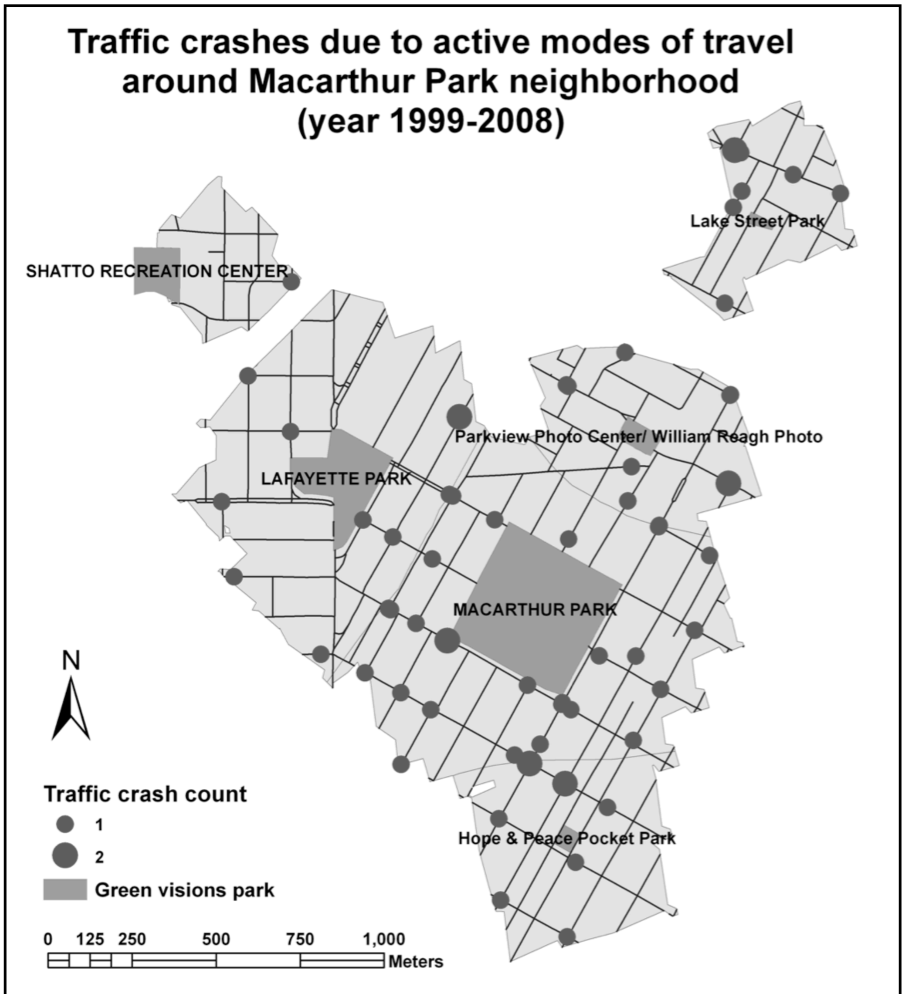


Figure 3: Quarter-mile network buffer in the MacArthur Park area of Los Angeles, with active crashes



U.S. Census Data

The 2249 census tracts in the study area include 10,694,153 people (2000 United States Census). We estimated the poverty level in each census tract using counts of households under the federal poverty level. The racial and ethnic composition of each census tract is from ESRI's Business Analyst, including counts of Hispanics, non-Hispanic Whites, Blacks, and Asians, and other races based on counts in 2000.

We assumed an even distribution of socioeconomic traits throughout the census tract. For example, a census tract of 100 Hispanic residents with 20% of its land area falling within a park buffer was assumed to have 20 Hispanic residents living within one-quarter mile of a park.

SWITRS Crash Data

We analyzed pedestrian and bicyclist crashes (hereafter "active crashes") that were reported in the Statewide Integrated Traffic Reporting System (SWITRS) between 2000 and 2009. The SWITRS database is produced and maintained by the California Highway Patrol using their own crash reports and collision reports from local government entities. The Safe Transportation Research and Education Center at the University of California, Berkeley geolocated these collisions in a GIS shapefile (Safe Transportation Research and Education Center 2012). We used this layer to determine which crashes occurred within our quarter-mile network buffer.

The SWITRS dataset includes 608,530 crashes that occurred within the study area between 2000 and 2009. Out of 1,311,736 parties involved in these crashes there were 896,359 injuries and 7,317 fatalities. Most active crashes involved more than one party (for example a pedestrian and a driver) and many involved multiple pedestrians, cyclists, and motor vehicle occupants.

Among active travelers there were 88,745 injuries and 2,361 deaths. Most pedestrians and bicyclists involved in a crash reported in the SWITRS database were injured or killed. Some 260 injuries to active travelers could not be spatially joined and were not included in the final analysis. Since we are interested in the risk of crash injury and it is likely that non-injurious crashes were never reported to the database, we included only injuries and fatalities in our analysis.

SCAG Travel Survey

The rate of active travel in each census tract was estimated using the 2001 Travel and Congestion Survey conducted by the Southern California Association of Governments (SCAG 2001). The SCAG survey collected travel diaries from 16,506 households in Southern California, and 9135 households were located within the GVP study area. Our analysis includes only the 2249 census tracts with a residential population and at least one recorded trip ending at a destination within the tract.

The SCAG travel survey did not contain enough observations to directly estimate the active travel rate in each census tract. We therefore smoothed the estimate of the active travel rate across the study area using the empirical Bayes and spatial empirical Bayes methods included in the Geoda geostatistical program (Anselin 2011). The empirical Bayes adjustment estimates the rate of active travel within each census tract using a combination of the regional average and the surveyed estimate within the tract. The surveyed rate of active travel is adjusted by the regional rate based on the number of observations in each census tract. As the number of surveyed trips increases, the observed rate is given greater weight. The spatial empirical Bayes estimate adjusts the surveyed rate according to the number of surveyed trips and the rate of active travel in nearby census tracts.

Traffic Density

We estimated vehicle kilometers traveled within each census tract using traffic volume and road network lengths within each tract both inside and outside the network buffer. Traffic volume counts from TeleAtlas for 2.04% of the road network in California were sorted into seven categories by road feature classification code (FCC) including primary road with limited access; primary road without limited access; secondary and connecting road; local, neighborhood, or rural road; vehicle trail; road ramp; and bicycle, pedestrian trail, or driveway. The median traffic count from each road size was assigned to the matching roads in the study area and mapped onto the ESRI Dynamap 2000 base map (Spatial Insights, Inc, Bethesda, MD). We estimated vehicle kilometers traveled by multiplying the estimated volume by the road segment lengths within the park buffer and outside the park buffer.

The models included vehicle kilometers traveled on primary and secondary roads classified as FCC A20-A39, but excluded limited access roads unlikely to have active travelers. We also excluded local and neighborhood roads that see highly variable levels of traffic and for which the estimates may not be reliable. A sensitivity analysis including FCC A15-A39, A15-A49, and A20-A49 showed similar results (see Appendix 1).

Predicting Crashes Inside and Outside the Park Buffer Using Negative Binomial Regression

We used negative binomial regression to analyze the count of active crashes. Active crashes are overdispersed, meaning the variance of crashes in a census tract exceeds the mean. The negative binomial regression model is more appropriate for these data than a standard Poisson model.

We used paired negative binomial regression models to compare the effect of race/ethnicity and poverty on the number of active crashes both within and outside the quarter-mile network buffer around a park. Active crashes are the dependent variable. The first pair of models also includes counts for Hispanic, Black, Asian, and other minority populations normalized to every 100 persons, which is within the distribution of data in the tracts. Due to collinearity between poverty and Hispanicity, coefficients for race/ethnicity are predicted separately from the coefficient for households in poverty. The second pair of models includes the count of residents in poverty normalized to every 100 persons. Both models include an estimate of vehicle kilometers traveled on major non-freeway roads normalized by 40,000, which is approximately the mean VKT at the census tract level. $Y_{i,j}$ is the predicted count of active crashes over a ten year period with *i* defined as 1 for areas within a quarter mile of a park and 2 for areas outside a park or the quarter-mile buffer in census tract *j*. The offset in both pairs is log(Active Rate*$\text{Population}_{i,j}$). The model for race/ethnicity is specified as follows:

$$\log(Y_{i,j}) = ß_0 + ß_1{*}\text{VKT}_{i,j} + ß_2{*}\text{CountHispanic}_{i,j} + ß_3{*}\text{CountBlack}_{i,j} + ß_4{*}\text{CountAsian}_{i,j} + ß_5{*}\text{CountOther}_{i,j} + \log(\text{Active Rate}{*}\text{Population}_{i,j})$$

Subtracting the offset element from the dependent variable, $\log(Y_{i,j})$, gives the following equation:

$$Y_{i,j}/(\text{Active Rate}{*}\text{Population}_{i,j}) = \exp(ß_0 + ß_1{*}\text{VKT}_{i,j} + ß_2{*}\text{CountHispanic}_{i,j} + ß_3{*}\text{CountBlack}_{i,j} + ß_4{*}\text{CountAsian}_{i,j} + ß_5{*}\text{CountOther}_{i,j})$$

The model for poverty is specified as follows:

$$\log(Y_{i,j}) = ß_0 + ß_1{*}\text{VKT}_{i,j} + ß_2{*}\text{CountInPoverty}_{i,j} + \log(\text{Active Rate}{*}\text{Population}_{i,j})$$

Subtracting the offset element from the dependent variable, $\log(Y_{i,j})$, gives the following equation:

$$Y_{i,j}/(\text{Active Rate}*\text{Population}_{i,j}) = \exp(ß_0 + ß_1*\text{VKT}_{i,j} + ß_2*\text{CountInPoverty}_{i,j})$$

The coefficients (ß) can be compared within each pair of models to see if the effect size for similar variables varies based on whether the crashes are within or outside the park buffer. The method used to compare coefficients is the random effects Q-test first described by Cochran (1954). The Q-test tells whether the difference in effect size of the variable of interest between park-adjacent and non park-adjacent models is significant at the 95% level (see Su et al. 2011 for detail on the Q-test).

Results

Study Area

Parks cover about 10.7% of the study area. 8.5% of the non-park area lies within the quarter-mile network buffer around parks. Table 1 describes the study area and network buffer.

Table 1: Characteristics of the 2249 census tracts in the study area

Geographic Area	Area	Percent of Total
Study area	6097 km^2	100.0%
Park area	650 km^2	10.7%
Quarter-mile network buffer area	462 km^2	7.6%

Census Data

The proportion of the population within each racial or ethnic group is similar inside and outside the quarter-mile park buffer. We assumed socioeconomic traits were equally distributed within and outside the buffer in each census tract; when examined across the entire study area, racial and ethnic groups live within a quarter-mile of a park in similar proportions to their share of the regional population. Whites are somewhat more likely to live near parks than minorities and Hispanics and households in poverty are less likely to live near parks than non-Hispanic and wealthier households. Table 2 shows the estimated number of residents across the study area in racial/ethnic, income, and age categories.

Table 2: Population within the study area estimated within and outside a quarter-mile park buffer

	Within a Quarter-Mile of a Park				Outside a Quarter-Mile of a Park			
Variable	**Percent**	**Count**	**Mean**	**Median**	**Percent**	**Count**	**Mean**	**Median**
Population	100.00%	1,534,699	682	401	100.00%	9,159,454	4073	3954
Hispanic	42.91%	658,602	293	92	43.56%	3,989,696	1774	1350
White (non-Hispanic)	33.92%	520,643	231	50	33.22%	3,042,971	1353	1052
Asian	11.23%	172,378	77	19	11.95%	1,094,173	467	280
Black	8.92%	136,922	61	8	8.24%	754,649	336	100
Other	3.01%	46,154	21	9	3.03%	277,965	124	104
In Poverty	17.62%	270,416	120	38	16.36%	1,498,811	666	505
Age 0 to 17	27.47%	421,592	187	102	27.93%	2,558,274	1138	1050
Age 18 to 64	62.68%	962,002	428	247	62.20%	5,697,389	2533	2436
Age 65+	9.85%	151,106	67	36	9.87%	903,792	402	352

Table 3 describes the racial/ethnic and income characteristics of the study area with the census tract as the unit of analysis. The study area population can also be summarized and described at the census tract level: the mean of the mean percent Hispanic in all the census tracts is 42.64%;

895 tracts are majority Hispanic; 734 majority White; 472 have no racial/ethnic majority, and 35 have a majority of residents living in poverty.

Table 3: Demographics by census tract

Variable	Mean	Min	Max	IQR	Tracts > 50%
Percent Hispanic	42.64%	0.00%	98.38%	52.71%	895
Percent White (non-Hispanic)	34.31%	0.03%	100.00%	54.03%	734
Percent Black	8.30%	0.00%	91.10%	5.31%	80
Percent Asian	11.74%	0.00%	81.75%	11.18%	68
Percent Other	3.00%	0.00%	15.32%	2.09%	0
Percent In Poverty	16.88%	0.00%	100.00%	17.94%	35

SWITRS Crash Results

Among all parties involved in a crash in the study area, active parties were more likely to be injured or killed than motor vehicle drivers and passengers. Pedestrians and bicyclists represent 7.0% of all parties involved in a crash and 10.1% of all parties who were injured or killed. The number of active parties injured or killed in a crash (pedestrian or bicyclist) ranged from a high of 9536 in 2000 to a low of 8717 in 2005.

The SWITRS crash reports from 2002 to 2009 include the race of each party involved in a crash. Party race is recorded as White, Hispanic, Black, Asian, Other, or Missing. All parties involved in an active crash in 2000 and 2001 are missing race data. 63,230 active crashes occurring between 2002 and 2009 have party race or ethnicity reported, as described in Table 4 below.

Minority pedestrians and cyclists make up a larger proportion of the active crash parties than their share of the study area population. The SWITRS crash database includes the race for most parties involved in a crash for the years 2002 to 2009. Among the crashes for which the race of the active traveler was documented, 27.0% of the active parties were White (non-Hispanic) and 73.0% were minority. This contrasts with the demographic makeup of the study area recorded in the 2000 Census, when 33.33% of the population was White (non-Hispanic) while the remaining 66.67% of the population was minority.

The breakdown of injuries and fatalities by age is found in Table 5 below. The percent of children ages 0 to 17 involved in an active crash (29.92%) is slightly higher than the percent of children in the population of the study area (27.86%). Children are much more likely to be injured than killed in an active crash. 30.41% of active travelers injured are children, while only 10.56% of those killed are between ages 0 and 17. This pattern reverses for senior citizens ages 65 and older, who account for 7.82% of injuries, 29.09% of fatal crashes and only 9.86% of the study area population.

Table 4: Active crashes by race/ethnicity, out of those crashes for which race/ethnicity was documented

	Count of Active Crashes	Percent of Active Crashes	Count of Active Fatalities	Percent of Active Fatalities	Count of Active Injuries	Percent of Active Injuries	Percent of Population in Study Area[1]	Percent of Population in Study Area[2]
Total	63,230	100.00%	1613	100.00%	61,617	100.00%	100.00%	100.00%
Hispanic	34,276	54.21%	835	51.77%	33,441	54.27%	43.47%	44.82%
White, non-Hispanic	17,069	27.00%	467	28.95%	16,602	26.94%	33.33%	34.36%
Black	9,244	14.62%	192	11.90%	9,052	14.69%	8.34%	8.60%
Asian	2,641	4.18%	119	7.38%	2,522	4.09%	11.84%	12.21%

Table 5: Active crashes by age, out of those crashes for which age was documented

	Count of Active Crashes	Percent of Active Crashes	Count of Active Fatalities	Percent of Active Fatalities	Count of Active Injuries	Percent of Active Injuries	Percent of Population in Study Area
Total	88,954	100.00%	2207	100.00%	86,747	100.00%	100.00%
Age 0-17	26,612	29.92%	233	10.56%	26,379	30.41%	27.86%
Age 18-64	54,914	61.73%	1,332	60.35%	53,582	61.77%	62.27%
Age 65-105	7,428	8.35%	642	29.09%	6,786	7.82%	9.86%

[1] Crash parties are put in one of four racial/ethnic groups: White (non-Hispanic), Hispanic, Black, and Asian. The 2000 Census includes eight racial/ethnic groups: White (non-Hispanic), Hispanic, Black, Asian, Hawaiian Pacific-Islander, American Indian or Alaska Native, Other Race, and Multiple Races. The latter four races represent 3.03% of the study area population. The first column sums to 96.98% of the study area population. The second column sums to 100% because it excludes the latter four races from the total population figure to better aid comparisons with the reported race and ethnicity characteristics of the crash parties.
[2] See footnote 1 above.

Active crashes are most common among Black and Hispanic residents and least common among Asians, as shown in Table 6. The rate of crashes is estimated per 100,000 residents per year for different demographic groups within and outside the quarter-mile network buffer.

Active crashes occur more frequently in the quarter-mile buffer around parks than in areas outside the park buffer. The total number of crashes in park adjacent areas is more than 50% higher than in areas farther away from parks. The increased rate of crashes within a quarter-mile network buffer of a park is found among all races, with a rate ratio ranging from 1.40 among Blacks to 1.70 among Whites.

Table 6: Active crashes per 100,000 per year[3]

	Active Crashes	Active Crashes Within a Quarter-Mile of a Park	Active Crashes Outside a Quarter-Mile of a Park	Ratio of Within Buffer to Outside Buffer
Total	87.2	122.9	81.1	1.52
Hispanic	92.2	128.5	88.0	1.46
White, non-Hispanic	59.9	95.6	56.4	1.70
Black	125.3	173.9	124.2	1.40
Asian	25.8	39.1	24.8	1.58
Age 0-17	89.3	131.3	84.8	1.55
Age 18-64	82.5	117.6	78.9	1.49
Age 65+	70.4	107.7	66.4	1.62

[3] The rate of total crashes per 100,000 population per year is based on crash data from 2000-2009 and population counts from the 2000 Census. The rate for the four racial groups is based on crash data from 2002-2009 and population counts from the 2000 Census. Population inside and outside the quarter-mile network buffer is estimated by multiplying the population by the proportion of non-park land area inside and outside the buffer within each census tract.

SCAG Results

The SCAG estimates of active travel are shown in Table 7. The SCAG survey captures all types of trips for any purpose. We estimated the rate of active travel within each census tract by finding the percent of walking or bicycling trips recorded by SCAG respondent households that were walking or bicycling trips. The rate of active travel across all census tracts is 9.61%, meaning 9.61% of surveyed trips terminating within one of the study census tracts were walking or cycling trips. The median active travel rate across census tracts was 5.0%. The rate varied from 0% in 826 tracts to 100% in 3 of the tracts.

The SCAG estimate is higher than the Census estimate of the active travel rate, which includes estimates of travel mode for commute trips emanating from a sample of households within each census tract. The Census counts only commute trips, thereby excluding any local trips including trips to a park.

In the final analysis we control for exposure to active travel by multiplying the local population count by the rate of active travel as estimated using the empirical Bayes method. This produces an exposure estimate in 2235 census tracts, which we used for the final analysis.

The spatial empirical Bayes adjustment produced several estimates of zero in census tracts near the edges of the study area. The empirical Bayes method estimated rates in all census tracts, and we used these rates for the final analysis. A sensitivity analysis of the spatial adjustment, the raw SCAG rate, and the rate of active travel among commuters sampled in the 2000 U.S. Census are included in Appendix 2. The choice of estimates has little effect on the final outcome.

Table 7: Active travel rates in the study area as a percentage of trips

Rate	Mean	Median	Interquartile Range	Census Tracts with an Estimate
SCAG surveyed rate	9.61%	5.00%	0.00-13.83%	1418
SCAG adjusted with empirical Bayes	9.78%	7.38%	4.73-12.37%	2235
SCAG adjusted with spatial empirical Bayes	10.09%	7.16%	3.85-13.17%	2171
U.S. Census sampled rate	3.93%	2.56%	1.33-4.57%	2126

Hispanic, Black, and other minority residents are more likely to report active travel methods than White (non-Hispanic) and Asian respondents. Table 8 shows the number of respondents in each racial/ethnic category and their reported active travel trips. Active travel is less common among White (non-Hispanic) and Asian respondents than it is among Hispanic, Black, and other minority respondents.

Table 8: Active travel trips by race/ethnicity

SCAG Respondents	Count of Respondents	Percent of Respondents	Count of Trips	Count of Active Trips	Percent of Trips that are Active
Total Respondents	10,050	100%	74,374	7098	9.54%
Hispanic	2060	20.50%	17,275	3126	18.10%
White (non-Hispanic)	5961	59.31%	42,763	2787	6.52%
Black	684	6.81%	4578	430	9.39%
Asian	552	5.49%	4158	257	6.18%
Other	274	2.73%	1882	157	8.34%
Race Missing	519	5.16%	3718	341	9.17%

Traffic Density Results

Major roads and traffic are more likely to be found near parks than outside the park buffer. 15.08% of major roadway kilometers (excluding freeways and residential roads) and 14.93% of vehicle kilometers traveled on these roads are within the quarter-mile park buffer, while only 7.6% of the study area land falls in this space. This may be partially explained by the disruptive effect parks can have on the street grid – streets may need to be bigger and carry more traffic around parks to avoid passing through the parks. The combined length of major roads both in parks and within the park buffer account for 18.88% of the road network, which is similar to the 18.3% share of land area covered by parks and the park buffer. Similarly, 18.69% of vehicle kilometers traveled in the census tract occur in parks or the buffer, which cover 18.3% of the land area.

Table 9: Vehicle kilometers traveled on roads classified FCC A20-A39

	Road Kilometers	Percent of Total	VKT (millions)	Percent of Total	Percent of Land Area in Study Area
Study area	8,149	100.00%	90.4	100.00%	100.0%
Park area	310	3.80%	3.40	3.76%	10.7%
Non-park area in the quarter-mile network buffer	1,229	15.08%	13.5	14.93%	7.6%
Non-park area outside the quarter-mile network buffer	6,609	81.10%	73.5	81.31%	81.7%
Parks and quarter-mile network buffer combined	1,539	18.88%	16.9	18.69%	18.3%

Negative Binomial Regression Results for the Within and Outside the Quarter-Mile Network Buffer Area

Dividing the study area into areas within the quarter-mile network buffer and outside the buffer reveals differences in the effects of race/ethnicity and poverty. The coefficients for traffic remain positive and strongly predictive of active crashes. In areas inside the park buffer, active crashes are more frequent in areas with higher counts of Hispanic and other minority residents as well as those in poverty. The results of the negative binomial regression analysis of paired models are found in Table 10.

Table 10: Negative binomial regression analyses for within and outside the quarter-mile network park buffer using demographic counts normalized to 100 persons and VKT normalized to 40,000

Model	Variable	Within a Quarter-Mile of a Park			Outside a Quarter-Mile of a Park			Difference
		Coefficient	Standard Error	p-value	Coefficient	Standard Error	p-value	Coefficient Difference
Race	Hispanic	0.085	0.009	<0.001**	-0.004	0.002	0.021*	0.089
	Black	0.041	0.021	0.057	0.012	0.004	0.001**	0.029
	Asian	-0.014	0.023	0.548	-0.019	0.004	<0.001**	0.005
	Other	0.957	0.148	<0.001**	-0.050	0.021	0.016*	1.007
	VKT	4.261	0.163	<0.001**	0.828	0.032	<0.001**	3.432
	Constant	-5.232	0.053	<0.001**	-2.695	0.053	<0.001**	
Poverty	Poverty	0.254	0.020	<0.001**	0.022	0.004	<0.001**	0.232
	VKT	4.459	0.168	<0.001**	0.870	0.033	<0.001**	3.588
	Constant	-5.082	0.049	<0.001**	-3.051	0.046	<0.001**	

* indicates significance at the 95% level
** indicates significance at the 99% level

The impact of proximity to parks is shown by the difference between coefficients from the two models. The significance of this difference at the 95% level was evaluated using Cochran's Q-test, as shown in Table 11. The prediction coefficients for traffic and the count of Hispanics, other minority residents, and residents in poverty in a census tract are significantly different between the in-buffer and out-of-buffer areas. There is an amplified effect of park proximity on crashes in areas with more Hispanic and other minority residents and households in poverty.

Table 11: Q-test of significant difference between coefficients, within-buffer minus outside of buffer

Model	Variable	Coefficient Difference	Q	p-value
Race	Hispanic	0.089	97.382	<0.001**
	Black	0.029	1.734	0.188
	Asian	0.005	0.044	0.834
	Other	1.007	44.623	<0.001**
	VKT	3.432	410.810	<0.001**
Poverty	Poverty	0.232	126.778	<0.001**
	VKT	3.588	424.103	<0.001**

* indicates significance at the 95% level
** indicates significance at the 99% level

The incidence rate ratios in Table 12 show the change in crashes if a census tract's demographic profile changed by 100 people in the stated demographic variable or 40,000 VKT. If the number of Hispanic people within a quarter mile of a park increased by 100, the expected number of crashes within that quarter-mile buffer would increase by about 8.9%. Similarly, if we compared two within-buffer areas in two different census tracts and one had 100 more Hispanics, the model predicts 8.9% more active crashes.

Table 12: Incidence rate ratios within and outside the quarter-mile network buffer using demographic counts normalized to 100 persons and VKT normalized to 40,000

Model	Variable	Within a Quarter-Mile of a Park				Outside a Quarter-Mile of a Park			
		Incidence Rate Ratio	Standard Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound	Incidence Rate Ratio	Standard Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Race	Hispanic	1.089	0.010	1.070	1.108	0.996	0.002	0.994	0.999
	Black	1.042	0.022	0.999	1.086	1.012	0.004	1.005	1.019
	Asian	0.986	0.023	0.943	1.032	0.981	0.004	0.975	0.988
	Other	2.603	0.385	1.948	3.480	0.951	0.020	0.913	0.991
	VKT	70.855	11.543	51.486	97.509	2.290	0.074	2.149	2.440
Poverty	Poverty	1.289	0.026	1.240	1.340	1.022	0.004	1.014	1.030
	VKT	86.373	14.483	62.179	119.981	2.388	0.079	2.237	2.548

In summary, these results indicate that a higher proportion of Hispanics, Blacks, residents of other race/ethnicities, or households in poverty, amplifies the effect of park proximity on active crash risk. In the study area, those areas within a quarter-mile of parks have a higher risk of active crash than areas away from parks. A higher proportion of Hispanics, other minority residents, or households in poverty within a quarter-mile of parks, further amplifies the higher risk of active travel crashes.

Discussion and Conclusions

In the Los Angeles region, pedestrians and bicyclists lack “Safe Routes to Play.” This research shows that pedestrians and bicyclists are injured or killed at much higher rates in park-adjacent neighborhoods than in areas farther away from parks, with a ratio per 100,000 population of 1.52. Furthermore, after adjusting for varying rates of active travel, there is an amplified effect of park proximity on active crashes in low-income, Hispanic, Black, and other minority neighborhoods.

Within the study area, minority households, except Asian households, walk and bicycle more than White households and minority and low-income neighborhoods have higher levels of active travel than primarily White and higher income neighborhoods. Sensitivity analyses using different methods to estimate the active travel rate and sensitivity analyses using VKT estimates from different road classifications show similarly significant and positive differences in the prediction coefficient for Hispanics, other minority residents, and households in poverty when comparing areas near parks to those away from parks.

Additional research is needed to investigate potential causes for the higher risks to active travelers near parks and the modification by underlying demographics. Children and the elderly, who are injured and killed near parks at a higher rate than adults 18 to 64, may engage in riskier pedestrian and bicyclist behavior or be more prone to injury because they move more slowly in the case of the elderly. Traffic is a strong predictor of crashes near parks, and the density of traffic near parks is higher than in other areas of the region. The placement and design of the streets near parks may increase the exposure of active travelers to motor vehicle traffic. Parks with recreational facilities and sports fields can serve as destinations for motor vehicle traffic, and they could act to bring pedestrians, bicyclists, and motor vehicles onto the same streets at the same time of day.

Disadvantaged neighborhoods might have less traffic-safety infrastructure, which could explain part of the effect modification from low-income, Hispanic, and other minority residents. Better estimates of active travel across the study area will improve estimates of this exposure.

Active travel free from crash risk has many health benefits. Multiple studies have linked the physical activity from active travel with reduced mortality (de Nazelle et al. 2011). Walking, jogging, and bicycling, can reduce the risk of cardiovascular disease, diabetes, breast and colon cancer, dementia, and depression (Woodcock 2009). People can increase their physical activity levels by incorporating active travel into their routines (de Nazelle et al. 2011) such as by walking to a park.

Park access and park proximity are associated with health in both adults and children and many of the health benefits stem from their likelihood to promote physical activity. Parks with features that support walking, jogging, and bicycling, such as paved and unpaved trails and wooded areas are associated with increased physical activity among adults (Kaczynski et al 2008). Lachowycz et al. (2011) found 33 studies showing a positive or potential association between greenspace and physical activity in a literature review of evidence linking greenspace and reduced obesity.

Children in California who were exposed to green spaces for more than twenty minutes a day were more than five times as likely to engage in moderate to vigorous physical activity compared to children who were exposed to no green spaces (Almanza et al. 2011). Parks are also associated with lower body mass in children. A longitudinal study of children in southern California found that improved access to parks and recreational programming is associated with reduced obesity

(Wolch et al. 2010). Among adolescents in Minneapolis and Saint Paul, lower access to parks was associated with a higher body mass index (Wall et al. 2012).

The benefits and opportunities provided by parks and active transportation, however, are not evenly shared. Residents of disadvantaged neighborhoods and communities of color face more congested parks and less access to recreation opportunities (Sister et al. 2010). Visitors to the parks that are located in poor and minority neighborhoods have higher exposure to and inhalation of criteria air pollutants compared to those visiting parks in wealthier and whiter neighborhoods (Su et al. 2011). Active travelers in poor and minority neighborhoods face a higher risk of crash injury (Laflamme et al. 2000).

This study shows that parks areas are more dangerous for active travelers than those areas away from a park and adds to the growing literature on disparities in parks access and active travel.

Traffic has a highly significant effect on active crashes both within and outside the quarter-mile park buffer. There are more road-kilometers and more vehicle kilometers traveled in the quarter-mile buffer area around parks, which heightens the risk of injury or death for active travelers. Traffic-calming measures and vehicle reduction strategies near parks similar to those used in the Safe Routes to School and Safe Routes to Transit programs could create a safer environment for those walking and bicycling to play. These interventions can be targeted to low-income and minority neighborhoods where the risks to active travelers are yet higher near parks.

Park access and active travel are both potential ways to increase physical activity levels in children and adults, yet residents of low income neighborhoods and communities of color face increased risk of injury or death due to traffic crashes. More research is needed on how to ensure that urban dwellers have a “Safe Route to Play.”

Appendix 1: Sensitivity Analysis of Estimating VKT Using Various Road Classifications

The following tables show the regression coefficient differences from within and outside the quarter-mile network buffer after adjusting for VKT on various types of roads. The final analysis uses VKT on roads classified as FCC 20-39. This excludes freeways, which are unlikely to have active travelers, and residential streets, which have unreliable traffic volume estimates.

Table A1-1: Significance of the difference between regression coefficients with VKT estimated on roads classified FCC A15-A39.

Model Using EB Rate	Variable	Coefficient Difference	Q	p-value
Race	Hispanic	8.83E-04	132.17	<0.001**
	Black	3.94E-04	24.63	<0.001**
	Asian	5.80E-05	0.06	0.081
	Other	1.19E-02	791.52	<0.001**
	Traffic on A15-A39 Roads	6.25E-05	151.46	<0.001**
Poverty	Poverty	2.51E-03	2664.43	<0.001**
	Traffic on A15-A39 Roads	6.79E-05	158.11	<0.001**

* indicates significance at the 95% level
** indicates significance at the 99% level

Table A1-2: Significance of the difference between regression coefficients with VKT estimated on roads classified FCC A20-A49.

Model Using EB Rate	Variable	Coefficient Difference	Q	p-value
Race	Hispanic	8.48E-04	253.26	<0.001**
	Black	2.22E-04	4.49	0.0341
	Asian	-8.85E-05	0.18	0.673
	Other	3.38E-03	23.89	<0.001**
	Traffic on A20-A49 Roads	7.46E-05	45.17	<0.001**
Poverty	Poverty	1.95E-03	104.16	<0.001**
	Traffic on A20-A49 Roads	7.53E-05	41.42	<0.001**

* indicates significance at the 95% level
** indicates significance at the 99% level

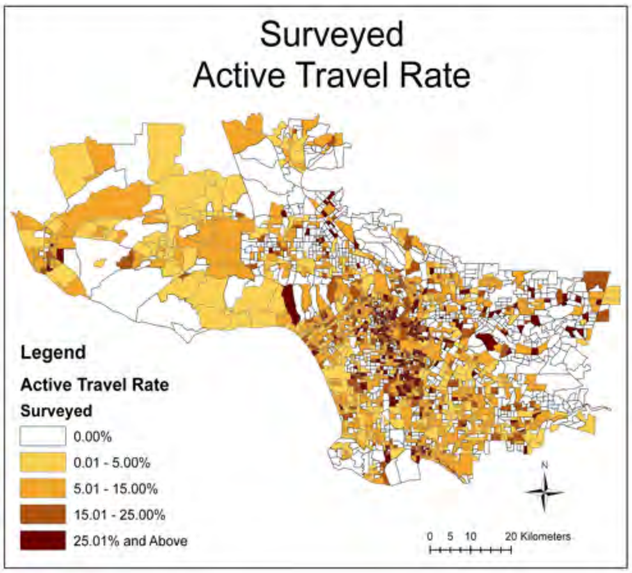
Table A1-3: Significance of the difference between regression coefficients with VKT estimated on roads classified FCC A15-A49.

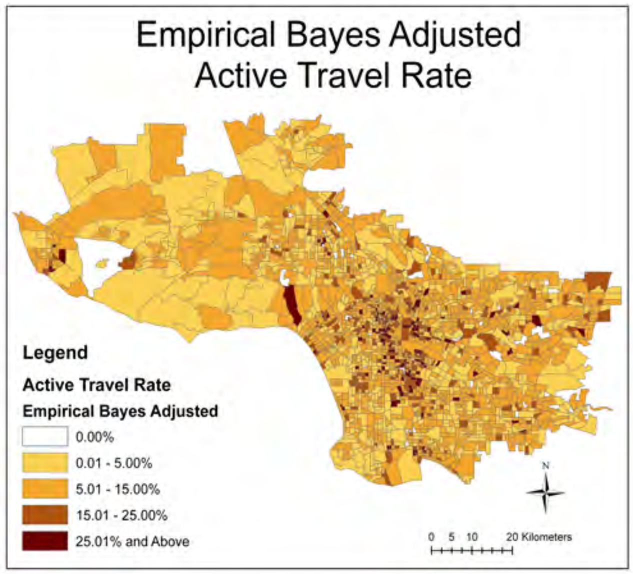
Model Using EB Rate	Variable	Coefficient Difference	Q	p-value
Race	Hispanic	8.60E-04	133.74	<0.001**
	Black	3.58E-04	18.18	<0.001**
	Asian	-6.00E-07	0.00	0.998
	Other	6.49E-03	167.11	<0.001**
	Traffic on A15-A49 Roads	5.23E-05	144.28	<0.001**
Poverty	Poverty	2.20E-03	800.11	<0.001**
	Traffic on A15-A49 Roads	5.68E-05	150.34	<0.001**

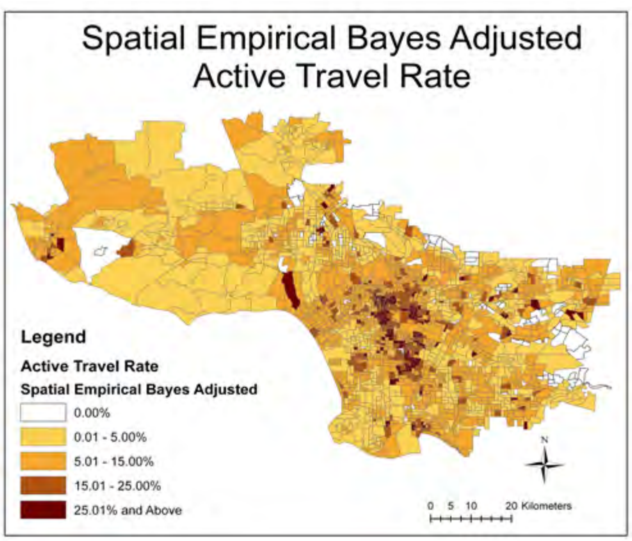
* indicates significance at the 95% level
** indicates significance at the 99% level

Appendix 2: Sensitivity Analysis of Various Estimates of Active Travel

This study used an estimate of active travel calculated using an empirical Bayes smoothing method on the raw rate of surveyed trips that were taken on foot or bicycle. The following maps show the active rate of travel estimated using the SCAG data as surveyed, as adjusted using empirical Bayes (used for this study) three other methods: and spatial empirical Bayes, and using reported commute mode from the 2000 U.S. Census. The tables below that show the regression coefficient differences and their significance tested with Cochran's Q-test







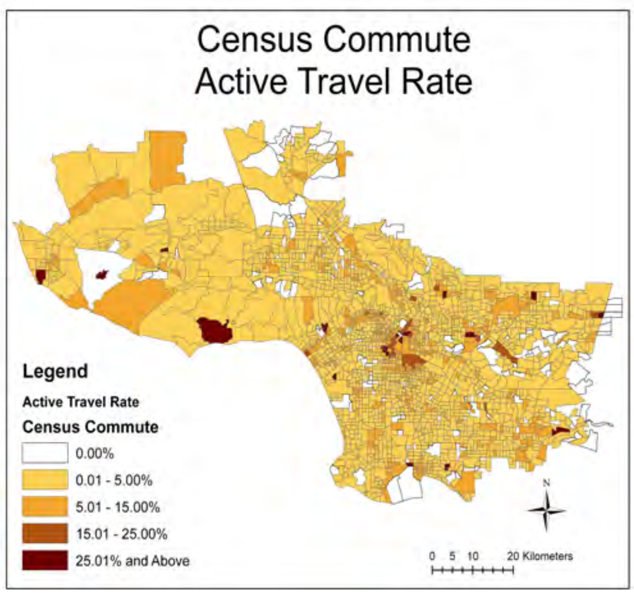


Table A2-1: Significance of the difference between regression coefficients with the exposure set as an estimate of active travel smoothed with the spatial empirical Bayes method times the census tract population

Model Using SEB Rate	Variable	Coefficient Difference	Q	p-value
Race	Hispanic	7.98E-04	321.44	<0.001**
	Black	2.17E-04	4.80	0.028
	Asian	1.85E-04	2.43	0.119
	Other	9.58E-03	15558.00	<0.001**
	Traffic on A20-A39 Roads	8.50E-05	14.40	<0.001**
Poverty	Poverty	2.11E-03	601.24	<0.001**
	Traffic on A20-A39 Roads	8.91E-05	15.14	<0.001**

* indicates significance at the 95% level
** indicates significance at the 99% level

Table A2-2: Significance of the difference between regression coefficients with the exposure set as the proportion of surveyed trips that were active times the census tract population

Model Using SCAG Rate	Variable	Coefficient Difference	Q	p-value
Race	Hispanic	6.88E-04	19.73	<0.001**
	Black	3.14E-04	8.94	0.003*
	Asian	8.00E-07	0.00	0.997
	Other	1.16E-02	478.32	<0.001**
	Traffic on A20-A39 Roads	8.87E-05	10.56	<0.001**
Poverty	Poverty	1.89E-03	2677.87	<0.001**
	Traffic on A20-A39 Roads	9.40E-05	11.03	<0.001**

* indicates significance at the 95% level
** indicates significance at the 99% level

Table A2-3: Significance of the difference between regression coefficients with the exposure set as the proportion of active commute trips reported in the 2000 U.S. Census times the census tract population

Model Using Census Rate	Variable	Coefficient Difference	Q	p-value
Race	Hispanic	5.89E-04	35.09	<0.000**
	Black	8.80E-04	6.88	0.009**
	Asian	5.53E-04	2119.72	<0.001**
	Other	1.12E-02	2828.55	<0.001**
	Traffic on A20-A39 Roads	7.19E-05	86.69	<0.001**
Poverty	Poverty	2.12E-03	744.10	<0.001**
	Traffic on A20-A39 Roads	8.83E-05	156.09	<0.001**

* indicates significance at the 95% level
** indicates significance at the 99% level

Appendix 3: Sensitivity Analysis of the Choice of Offset

The offset term in the negative binomial regression model can be estimated in several ways. In our final analysis we specified the offset as the empirical Bayes-smoothed active rate of travel times the population in each census tract. This gave an offset that estimated the relative number of active trips in a census tract based on the SCAG travel survey and the number of people residing in the tract. The following two tables show the resulting coefficient differences and their significance tested with Cochran's Q-test for two alternative offsets. The first is the mean active crash rate (total active crashes from 2000-2009 per capita) across the entire study area, which is 0.00849763. The second alternative offset is the expected active crash number, which was calculated as the study-wide crash rate per capita over a ten year period times the population in each census tract.

Table A3-1: Significance of the difference between regression coefficients with the offset defined as the active crash rate (0.00849763)

Model Using EBRate	Variable	Coefficient Difference	Q	p-value
Race	Hispanic	1.12E-03	176.73	<0.000**
	Black	4.46E-04	4.18	0.041*
	Asian	2.29E-04	1.18	0.277
	Other	8.59E-03	44.13	<0.001**
	Traffic on A20-A39 Roads	8.18E-05	461.32	<0.001**
Poverty	Poverty	3.02E-03	228.94	<0.001**
	Traffic on A20-A39 Roads	8.31E-05	488.48	<0.001**

* indicates significance at the 95% level
** indicates significance at the 99% level

Table A3-2: Significance of the difference between regression coefficients with the offset defined as the expected number of active crashes (census tract population times the active crash rate)

Model Using EBRate	Variable	Coefficient Difference	Q	p-value
Race	Hispanic	1.12E-03	176.73	<0.000**
	Black	4.46E-04	4.18	0.041*
	Asian	2.29E-04	1.18	0.277
	Other	8.59E-03	44.13	<0.001**
	Traffic on A20-A39 Roads	8.18E-05	461.32	<0.001**
Poverty	Poverty	3.02E-03	228.94	<0.001**
	Traffic on A20-A39 Roads	8.31E-05	488.48	<0.001**

* indicates significance at the 95% level
** indicates significance at the 99% level

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