ELSEVIER

Social Science & Medicine 59 (2004) 405–414

SOCIAL SCIENCE & MEDICINE

www.elsevier.com/locate/socscimed

Traffic stress, vehicular burden and well-being: A multilevel analysis

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Abstract

This study examined whether health is associated with individually perceived traffic stress and as well as ecologically measured vehicular burden using multi-level analysis.

Data from the Chinese American psychiatric epidemiologic study ($N = 1503$) are linked to data from the 1990 Census in the United States. Hierarchical linear modeling was used to analyze the cross-sectional relationship between traffic stress, neighborhood conditions, depression and health status. Perceived traffic stress is associated with both general health status and depression in multivariate multilevel models, such that persons reporting traffic stress had lower health status and more depressive symptoms. Further, there is an interaction between vehicular burden and traffic stress for both health outcomes. Persons who lived in areas with greater vehicular burden and who reported the most traffic stress also had the lowest health status and greatest depressive symptoms. These findings suggest that traffic stress may represent an important factor that influences the well-being of urban populations, and that studies which examine factors at only one level (either individual level only or ecological level only) may underestimate the effect of the social environment.

Keywords: Neighborhoods; Multilevel; Environment; Minorities; Traffic; USA

Introduction

Urban and suburban centers rely upon their transportation infrastructure for the well-being of their populous. Roads allow for the development of populated areas, facilitating the exchange of commerce and ideas (Abu-Lughod, 1991). Automobile ownership provides mobility, potential enjoyment from the vehicle and driving experience, and may confer and reflect social status (Parsons, Tassinary, Ulrich, Hebl, & Grossman-Alexander, 1998). Transportation also aids in the accessibility of preventive health services (Lovett, Haynes, Sunnenberg, & Gale, 2002) and can be one of the rallying points from which to help develop community coalitions and social capital (World Health Organization, 2000; Brugge, Leong, & Lai, 2002a; 2002b).

At the same time, transportation and one of its undesired consequences—traffic—pose potential challenges to the public's health. There are some obvious hazards, including unintentional injuries, pollution, "road rage" and drive-by-shootings (Centers for Disease Control, 2002; Krug, Sharma, & Lozano 2000; Wong et al., 1990; Bentham, 1986; Fong, Frost, & Stansfeld, 2001; Parker, Lajunen, & Summala, 2002; WHO, 2000; Winston et al., 2002; Batten, Penn, & Bloom, 2000; Koren, Arnon, & Klein, 1999; Hasselberg, Laflamme, & Weitoft, 2001). Less apparent are the indirect effects of transportation, including the displacement of city residents and racial segregation due to the construction of highways (Sugrue, 1996), the role of roads as a vector in the transmission of communicable diseases

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doi:10.1016/j.socscimed.2003.10.027

(Singhanetra-Renard, 1993), and the stresses and annoyances due to traffic noise (Babish, Fromme, Beyer, & Ising, 2001; Ouis, 2001). Finally, transportation and traffic may impede preventive actions and health care, by limiting access to health services and discouraging physical exercise (Lovett, Haynes, Sunnenberg, & Gale, 2002; Cvitkovich & Wister, 2001; Macintyre & Ellaway, 1998). The Centers for Disease Control (2002) recently reported that perceived traffic danger was the second leading barrier to children walking and biking to school in the United States. Similarly Balfour and Kaplan (2002) found that traffic was the most commonly cited neighborhood problem among elderly persons and further, that elderly persons living in neighborhoods characterized by heavy traffic and other neighborhood problems had greater functional deterioration over 1 year of followup. These observations suggest that a constellation of experiences due to transportation and traffic impact well-being (WHO, 2000).

We examine some of these issues in Los Angeles. Los Angeles is one urban center where the use of automobiles is widespread, necessitated by urban sprawl and a minimal public transportation system. Use of cars is so normative here that people sometimes ask, "need a ride to your car?" Thus, Los Angeles presents an ideal place to examine the issues of transportation and traffic. Los Angeles may be unique in several aspects of the urban experience, including its ethnically diverse community (Davis, 1992; Ong, Bonacich, & Cheng, 1994), but issues related to travel and transportation are common in many areas, urban or not. For example, in the year 2000, 88% for the US population, aged 16 or over, drove themselves or carpooled to work, compared with 86% for Los Angeles (US Census Bureau, 2002). Outside of the United States, the World Health Organization (2000) recently articulated that health concerns related to traffic and transportation have become a worldwide phenomenon and will likely become more of an issue in the future (for examples, see Lovett, Haynes, Sunnenberg, & Gale, 2002; Forjuoh & Li, 1996). Finally, others have suggested that the organization of Los Angeles may reflect the trends in other global cities, including transnational economic ties and diverse burgeoning immigration (United Nations Centre for Human Settlements, 2001).

This study is situated in a broader literature focused on understanding the relationship between places and health. Neighborhood factors, such as poverty, are discussed quite often, but several have critiqued the literature for not clearly specifying the potential mechanisms whereby places may impact health (Macintyre, Ellaway, & Cummins, 2002; Mitchell, Gleave, Bartley, Wiggins, & Joshi, 2000; Diez-Roux, 1998, 2000; Pickett & Pearl, 2001; Kaplan, 1996; Yen & Syme, 1999). This study attempts to address this issue by investigating perceptions of stress due to traffic and transportation (hereafter called "traffic stress") among residents of Los Angeles. Traffic stress may result from the hassles of driving and parking, the potential for unintentional injuries, and pecuniary hardships and inconveniences of vehicle maintenance and purchase. This stress is seen not merely an intrapsychic phenomenon, but arises from an interaction between an individual and her/his environment. When stress exceeds the ability to cope with the stress, illness occurs (Lazarus & Folkman, 1984). However, the stress literature has been criticized as being overly individualized, with inadequate attention given to environmental factors, both theoretically and analytically (Pearlin, 1989; Aneschensel, 1992).

Given this background, the present study seeks to examine both individual perceptions of traffic stress, as well as objectively measured environmental characteristics related to traffic. One of the pertinent environmental characteristics related to perceptions of traffic stress is the presence of vehicles in the neighborhood. It is suggested that the vehicular burden of the neighborhood interacts with individual perceptions to produce illness. This is because stressful objective conditions (vehicular burden) will weigh more heavily upon individual perceptions of (traffic) stress than less stressful objective conditions to produce differential patterns of illness. This reasoning is the basis for hypothesizing a statistical interaction between traffic stress and vehicular burden.

In addition to traffic stress, an individual's perceptions of their environment may be associated with illness. There is some suggestion that perceptions of neighborhood problems themselves are associated with poor health (Steptoe & Feldman, 2001; Balfour & Kaplan, 2002; Booth, Owen, Bauman, Clavisi, & Leslie, 2000; Mitchell et al., 2000). Therefore, this study also seeks to examine whether it is perceptions of the environment per se, as well as neighborhood economic conditions, that may account for any potential relationship between traffic stress and health.

Methods

The data come from the Chinese American Psychiatric Epidemiologic Study (CAPES). The CAPES study is only summarized as it has been described previously (Gee, 2002; Takeuchi et al., 1998). Thirty-six census tracts were selected from 1652 tracts in Los Angeles, based on income and race characteristics. This sampling design was used in order to identify persons of Chinese descent in a cost-efficient manner. In 1993, 16,916 households within 36 census tracts in Los Angeles were screened to produce 1747 completed interviews with Chinese Americans. The response rate among eligible participants was 82%. Of these respondents, 1503 were reinterviewed 15 months later. This study uses the reinterview data because it contained several variables of interest. Respondents were also linked to census tract data from the 1990 US Census of the Population, allowing for analysis of neighborhood level factors.

Dependent variables

Stress is associated with a variety of physical and mental health outcomes. Following Sooman and Macintyre's (1995) approach, we focus on general measures of mental health and global self-perceived health. General health status was measured with a five-item scale derived from the Medical Outcomes Study Short-Form 36 (SF-36). The range was 0–100, with higher scores indicating better health status. This scale is widely used and has been correlated with several health outcomes (Ware, 1993). Depressive symptoms was measured with the depression subscale from the Revised Symptom Checklist 90 (SCL-90-R) (Derogatis, 1994). The ranges were 0–2.9 for depression, with higher scores indicating more depressive symptoms. It is emphasized that the two outcome variables are of opposite directions, such that positive well-being is indicated by higher scores on general health status and lower scores on depression.

Independent variables

Traffic stress was measured with a Likert-response scale asking respondents how much they were bothered within the last month by: (a) traffic; (b) auto maintenance; (c) accidents. The reliability of this three-item scale was moderate (Cronbach's alpha = 0.58). The moderate alpha may have been due to the few number of items, since alpha increases with the number of items in a scale. The range was 3–11, with higher values indicating greater concerns.

Because traffic stress could actually be due to more general characteristics of the environment, a measure of the *perceived environment* was included. This measure consisted of four questions asking about concerns over the physical conditions of the neighborhood, noise, pollution and crime. The reliability of this scale was good (cronbach's alpha = 0.69). The range was 4–16, with higher values indicating greater concerns.

Previously identified predictors of general health and distress among Chinese Americans (Gee, 2002; Takeuchi et al., 1998) were included as covariates. These included education, family income, occupational status, gender, acculturation (measured with a 14-item scale), and social support (measured with a six-item scale). Social class (education, income occupation) can be seen as potential mediators, and social support can be viewed as a potential buffer. Gender is included because men and women may differ in perceptions of traffic stress, use of vehicles, and reported health. Acculturation is also included as a potential mediator between stress and health, although the literature is still equivocal as to whether acculturation is protective or health aversive (Escobar, Hoyos, & Gara, 2000; Kaplan, Chang, Newsom, & McFarland, 2002).

CAPES respondents were linked to census-tract data from the 1990 US Census. The first neighborhood variable was neighborhood poverty, operationalized as the percent of persons meeting the federal poverty threshold. Although numerous ways of measuring neighborhood economic status have been proposed, this variable was chosen based on Krieger, et al. (2002) empirical observation that neighborhood poverty is among the most robust of several neighborhood socioeconomic indicators. The second was a measure of the vehicular burden, operationalized as the percent of persons age 16 or older who drive or take public transportation to work in a given census tract. This measure did not examine the number of vehicles per road mile.

Analysis

Bivariate analysis and hierarchical linear modeling (HLM) were performed to examine the association between traffic stress, perceived environment, and other covariates. The data are hierarchically arranged, with individuals nesting within census tracts. HLM is a multivariate technique suited for this type of design, not only because it accounts for autocorrelation due to clustering, but also because HLM was built from a theoretical base designed to examine multilevel factors (Raudenbush & Bryk, 2002). Analyses were weighted to account for differential probabilities of selection. The intercept, traffic stress, and perceived environment variables were modeled as random effects. The analytic plan was to perform a series of HLM models, with initial models including previously identified individual level predictors of health and depression, building to final multivariate multilevel models. In order to examine the hypothesis that the association between health and traffic stress was influenced by neighborhood-level factors related to transportation and traffic, the final models included census tract poverty and vehicular burden as possible predictors of the slope of traffic stress. In notation:

$$Y_{ij} = \beta_{0j} + \beta_{1j}X_1 + \beta_{2j}X_{2j} + \cdots + \beta_{Qj}X_{Qij} + r_{ij},$$
where $r_{ij} \sim N(0, \sigma^2)$

and

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(\text{vehicular burden}) + \gamma_{02}(\text{poverty}) + u_{0j},$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11}(\text{vehicular burden}) + \gamma_{12}(\text{poverty}) + u_{ij},$$

where Y_{ij} is the outcome for the ith individual in the jth census tract. Here, X_1 is the measure of traffic stress, and X_Q refers to other covariates. The error terms u_{0j} and u_{0j} are assumed multivariate normal with means of zero, and variances τ_{00} and τ_{11} and covariance τ_{01}.

The most important thing to note is that while traffic stress is hypothesized to predict health, the slope of traffic stress (β_{1j}) is itself a function of the neighborhood variables, vehicular burden (γ_{11}) and poverty (γ_{12}). This allows for an examination of the hypothesis that individually perceived traffic stress may be influenced by objective neighborhood conditions. See Diez-Roux (2000) and Raudenbush and Bryk (2002) for further discussions of these models. In a similar fashion, cross-level interactions were also examined for perceived environment, vehicular burden and poverty. Additionally, exploratory analyses examined interactions between gender and traffic stress, but were not statistically significant. Analyses were conducted with versions 8.2 of SAS and 5.04 of HLM.

Results

Table 1 describes the characteristics of the 1503 CAPES respondents. Respondents are fairly healthy and well educated, but there is also a sizable low-income population. Almost a third earn less than $20,000 a year in household income. On average, respondents report a fairly low level of stress due to traffic or neighborhood conditions.

The intraclass correlation coefficients for general health status, depression, traffic stress and perceived environment are 0.03, 0.07, 0.15 and 0.16, respectively. This means, for example, that 16% of the variance in the report of perceived environment is between census tracts, with the remainder of the variance accounted for by within-person factors. This suggests that while neighborhoods appear to account for relatively little of the health differences between individuals, neighborhoods may explain part of the differences in reports of environmental conditions.

Table 2 shows the characteristics of CAPES respondents by neighborhood characteristics. For this table, vehicular burden and neighborhood poverty are split at their median. Compared to respondents living in areas in the lower median of vehicular burden, those living in the upper median (greater vehicular burden) have higher health status, fewer depressive symptoms, greater acculturation, and are more likely to be employed. Although contrary to expectation, the positive health status among persons living in areas with higher vehicular burden, compared to those living in areas with lower vehicular burden, disappeared in multivariate analyses (see below). Also, respondents living in areas with greater poverty (upper median) have lower health status, more depressive symptoms, lower social support, and are less acculturated.

Table 1
Characteristics of respondents ($n = 1503$) and neighborhoods ($n = 36$)

General health status, mean (SD)	70.37	(18.95)
Depression, mean (SD)	0.20	(0.32)
Traffic stress, mean (SD)	4.04	(1.44)
Perceived neighborhood, mean (SD)	5.47	(1.90)
Acculturation, mean (SD)	2.09	(0.71)
Age, mean (SD)	38.86	(11.48)
Social support, mean (SD)	3.25	(0.48)
Female, no. (%)	797	53.00
Education, no. (%)		
0–11 years	288	19.2
High school	277	18.5
Some college	308	20.5
College graduate	628	41.8
Income, no. (%)		
> $10,000	120	8.0
$10,000–$19,999	348	23.2
$20,000–$34,999	354	23.6
$35,000–$49,999	254	16.9
$50,000–$69,999	234	15.6
$70,000 and above	193	12.8
Employed, no. (%)	972	64.7
% Neighborhood poverty, mean (SD)	13	(8.4)
% Public transportation, mean (SD)	6	(6.0)
% Drive to work, mean (SD)	88	(11.0)

Tables 3 and 4 show the hierarchical linear models for depression and general health status, respectively. For each outcome, Column A displays simple bivariate associations, while Columns B through E are multivariate. Column B shows the base model that simultaneously includes income, education, gender, age, employment and acculturation. Column C includes traffic stress and perceived neighborhood simultaneously. Column D includes all of the individual level factors from Columns B and C. Finally, Column E adds the census tract variables of poverty and vehicular burden to the slopes of the intercept, perceived neighborhood, and traffic stress. Each outcome is discussed in turn.

Table 3 shows the results for depressive symptoms. Column A shows that most of the covariates were significantly associated with depression in the expected directions. For example, social support is negatively associated with depression, indicating that persons with more social support had fewer depressive symptoms. Traffic stress and perceived neighborhood are both positively associated with depressive symptoms. Also, the data show a positive association between depression and neighborhood poverty and a negative association with vehicular burden. This indicates that poverty is

Table 2
Characteristics of respondents, by neighborhood vehicular burden and poverty

	Vehicular burden[a]			Neighborhood poverty[b]		
	Lower median	Upper median	p-value	Lower median	Upper median	p-value
General health status	68.10[c]	72.12	**	72.26	68.17	**
Depressive symptoms	0.22	0.20	**	0.18	0.23	*
Traffic stress	3.91	4.13		4.09	3.97	
perceived neighborhood		5.48		5.43	5.66	
Age	38.30	38.38		38.44	38.24	
Social support	3.21	3.25		3.28	3.18	**
Acculturation	1.90	2.17		2.20	1.88	***
% Working	58.81	67.44	**	65.86	60.92	
% Female	48.37	52.03		51.73	48.88	

*$p<0.05$; **$p<0.01$; ***$p<0.001$.
[a] The upper median for vehicular burden indicates a greater percent of vehicles in a census tract, compared to the lower median.
[b] The upper median for neighborhood poverty indicates a greater percent of individuals in a census tract living in poverty, compared to those in the bottom median.
[c] All numbers are means.

Table 3
Hierarchical linear models of depressive symptoms

	Bivariate	Multivariatate			
	A	B	C	D	E
	Coeff SE	Coeff. SE	Coeff. SE	Coeff. SE	Coeff. SE
Intercept	0.2045 (0.010) ***	0.1639 (0.021) ***		0.1772 (0.022) ***	0.1773 (0.020) ***
Female (vs. male)	0.0538 (0.018) **	0.0398 (0.017) *		0.0411 (0.018) *	0.0429 (0.019) *
Age	0.0013 (0.001)	0.0014 (0.001) †		0.0018 (0.001) *	0.0019 (0.001) *
Education					
0–11 grade	0.0805 (0.029) **	0.0463 (0.025) †		0.0502 (0.026) *	0.0445 (0.027)
High school	−0.0062 (0.028)	−0.0348 (0.023)		−0.0393 (0.024)	−0.0430 (0.025) †
Any college	1.0	1.0		1.0	1.0
Family income					
< \$19,999	0.0958 (0.024) ***	0.0869 (0.027) **		0.0842 (0.027) **	0.0777 (0.027) **
\$20,000–\$34,999	0.0742 (0.030) *	0.0794 (0.028) **		0.0788 (0.028) **	0.0744 (0.029) **
\$35,000 and more	1.0	1.0		1.0	1.0
Social support	−0.1660 (0.026) ***	−0.1915 (0.030) ***		−0.1731 (0.034) ***	−0.1740 (0.035) ***
Employed (vs. not)	−0.0712 (0.022) **	−0.0490 (0.023) *		−0.0692 (0.023) **	−0.0704 (0.023) **
Acculturation	0.0138 (0.020)	0.0877 (0.017) ***		0.0777 (0.018) ***	0.0757 (0.018) ***
Perceived neighborhood	0.0201 (0.006) **		0.0036 (0.005)	0.0028 (0.004)	0.0029 (0.005)
Traffic stress	0.0420 (0.008) ***		0.0398 (0.008) ***	0.0365 (0.010) ***	0.0345 (0.010) **
Effect on slope of traffic stress					
Poverty in tract (%)					0.0011 (0.001)
Vehicular burden (%)					0.0018 (0.001) *
Effect on slope of perceived neighborhood					
Poverty in tract (%)					0.0001 (0.001)
Vehicular burden (%)					0.0003 (0.000)
Effect on slope of intercept					
Poverty in tract (%)	0.0038 (0.001) ***				0.0023 (0.001)
Vehicular burden (%)	−0.0022 (0.001) **				0.0010 (0.001)

†$p<0.1$; *$p<0.05$; **$p<0.01$; ***$p<0.001$.

linked with a greater likelihood of depression, but also, that respondents living in areas with a greater vehicular burden have fewer depressive symptoms. Column B shows the multivariate association between the individual level factors only, excluding perceived neighborhood and traffic stress. The associations between these

Table 4
Hierarchical linear models of general health status

	Bivariate			Multivariatate			
	A			B	C	D	E
	Coeff.	SE		Coeff. SE	Coeff. SE	Coeff. SE	Coeff. SE
Intercept	70.51	(0.74)	***	70.39 (1.34) ***		70.02 (1.38) ***	69.79 (1.42) ***
Female (vs. male)	−5.11	(1.20)	***	−2.66 (0.97) **		−2.65 (1.01) **	−2.73 (1.02) **
Age	−0.39	(0.05)	***	−0.29 (0.05) ***		−0.30 (0.05) ***	−0.31 (0.05) ***
Education							
0–11 grade	−11.41	(1.51)	***	−3.88 (1.22) **		−4.10 (1.24) ***	−3.55 (1.28) **
High school	−3.98	(1.45)	**	0.45 (1.51)		0.51 (1.53)	0.85 (1.56)
Any college							
Family income							
<$19,999	−8.36	(1.33)	***	−3.00 (1.20) *		−3.02 (1.22) *	−2.57 (1.31) *
$20,000–$34,999	−3.09	(1.69)	†	−1.15 (1.52)		−1.03 (1.51)	−0.66 (1.58)
$35,000 and more							
Social support	8.13	(1.30)	***	5.64 (1.09) ***		5.12 (1.17) ***	5.14 (1.19) ***
Employed (vs. not)	7.24	(1.50)	***	5.35 (1.42) ***		5.91 (1.48) ***	6.04 (1.50) ***
Acculturation	6.76	(0.84)	***	1.65 (0.76) *		1.73 (0.79) *	1.87 (1.78) *
Perceived neighborhood	−0.13	(0.33)			0.04 (0.40)	0.01 (0.31)	−0.04 (0.34)
Traffic stress	−0.44	(0.34)			−0.49 (0.44)	−1.01 (0.47) *	−1.02 (0.46) *
Effect on slope of traffic stress							
Poverty in tract (%)							0.00 (0.05)
Vehicular burden (%)							−0.11 (0.05) *
Effect on slope of perceived neighborhood							
Poverty in tract (%)							0.00 (0.04)
Vehicular burden (%)							0.03 (0.03)
Effect on slope of intercept							
Poverty in tract (%)	−0.2436	(0.074)	**				−0.15 (0.09)
Vehicular burden (%)	0.1743	(0.104)					−0.01 (0.10)

†$p<0.1$; *$p<0.05$; **$p<0.01$; ***$p<0.001$.

individual level factors and depression remain consistent with those shown in Column A. Column C includes traffic stress and perceived neighborhood simultaneously. Traffic stress remains significantly associated with depression, but perceived neighborhood becomes non-significant. Column D indicates that the findings for traffic stress and perceived neighborhood seen in Column C remain robust controlling for other individual level covariates. Finally, Column E shows that the observations from Column D remain after controlling for the neighborhood indicators. Interestingly, poverty and vehicular burden are no longer significantly associated with the slope of the intercept and were also not associated with the slope of perceived neighborhood or traffic stress. Other analyses (not shown) indicate that the bivariate relationship between neighborhood poverty and vehicular burden noted in Column A were explained by controls for individual social class. However, there is a significant cross-level interaction between traffic stress and vehicular burden ($p = 0.04$). Fig. 1 graphs the interaction from Column E, illustrating that individuals who report traffic stress have more depressive symptoms, but also that depressive symptoms are even higher for those who report traffic stress and live in areas with high vehicular burden.

Table 4 shows the regression analyses for general health status. The bivariate analyses in Column A shows that the associations between individual level variables and general health status conform to expectations. For example, persons of higher income have better health status than those of lower income. Perceived neighborhood, traffic stress and vehicular burden are not associated with health status. Column B, which simultaneously controls for all of the individual factors except traffic stress and perceived neighborhood, shows results that are consistent with Column A. Column C, which includes perceived neighborhood and traffic stress simultaneously, shows no significant association of either variable with health. However, Column D suggests a suppressor effect for traffic stress, such that addition of the other individual level variables changed traffic stress from non-significant to significant. The direction of the association is as expected, such that persons reporting more traffic stress has significantly

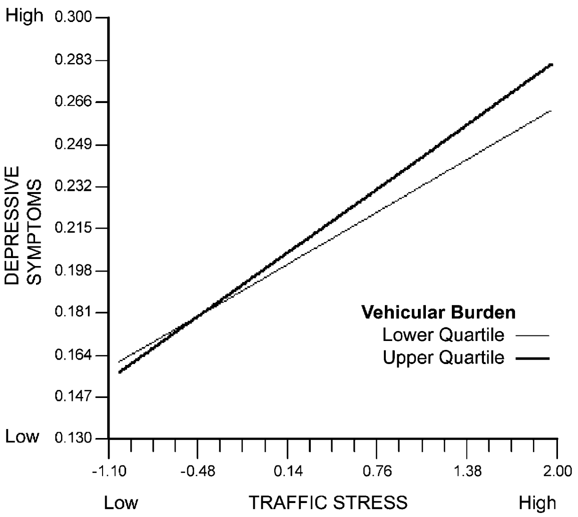

Fig. 1. Interaction between traffic stress and vehicular burden on depressive symptoms.

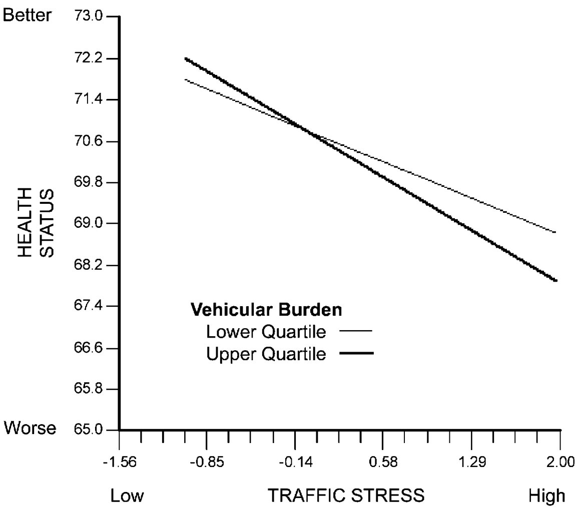

Fig. 2. Interaction between traffic stress and vehicular burden on general health status.

lower health status. Column E includes neighborhood poverty and vehicular burden. Neighborhood poverty is not associated with health status either directly via the intercept, nor indirectly via perceived neighborhood and traffic stress. However, again, the data indicate a significant cross-level interaction between traffic stress and vehicular burden for general health ($p = 0.05$). Fig. 2 illustrates the interaction from Column E, showing that persons reporting higher traffic stress had lower general health, but further, that persons who live in census tracts with greater vehicular burden and who report high levels of traffic stress, have the lowest levels of general health.

Discussion

This study sought to examine whether stress due to traffic and travel was associated with well-being. The data suggest that concerns over traffic, vehicle maintenance, and accidents were stressors faced by persons living in Los Angeles, and that these stressors are associated with lowered health status and greater depressive symptoms. Consistent with other studies, individual social class, acculturation, gender, age and neighborhood poverty are associated with health outcomes (e.g. Gee, 2002; Cubbin, LeClere, & Smith, 2000; Diez-Roux, 1997; Geronimus, Bound, & Waidman, 1999). However, these factors do not account for the relationship between traffic stress and the health outcomes in multivariate, multilevel models.

Additionally, the analyses show an interaction between individually perceived traffic and objective neighborhood conditions for both health outcomes. Although traffic stress is associated with decreased well-being (i.e. lower health status and higher depression) for all respondents, persons who reported traffic stress and who lived in neighborhoods with a high vehicular burden have significantly lower well-being than those living in areas with lower vehicular burdens. That is, the effect of traffic stress on health is worse for persons living in environments with more vehicle use, compared to those living in areas with less vehicle use.

These results are consonant with multilevel frameworks of health (Diez-Roux, 2000) as well as theoretical models that suggest that environmental stressors are influenced by individual's appraisals of them (Lazarus and Folkman, 1984). Further, the consistency in findings between two different health indicators derived from two different scales (the SF-36 and the SCL-90-R) bolsters our confidence in these results.

We operationalized vehicular burden as the combination of persons driving or taking public transportation to work. Because our concern was in the total burden on the roadways, we believe this way of operationalizing this concept makes sense in Los Angeles since (1) the public system largely means the buses (in the 1990s, there was no subway system) which share the same roads as automobiles and (2) relatively few individuals use public transportation (6%). However, studies in other places, especially areas where the public system in practice ameliorates the burden on the streets, may wish to examine public transportation separate from driving.

This finding also supports the observation that "the properties of individuals ... which are used in many multilevel models are themselves shaped by the properties of the locality used in the same models" (Macintyre et al., 2002, p. 129). Although not completely addressing this concern, one way of understanding the effects of context on individual factors is through examination of interactions between individual and macro-level covariates. Because characteristics of large spatial units, such as census tracts, are fairly distal to the individual, significant findings between neighborhoods and individuals in multivariate analyses are even more remarkable.

Although perceived neighborhood is associated with depression in bivariate analyses, perceived neighborhood becomes non-significant once traffic stress is included in the model. This suggests that traffic stress may explain some of the association between the perceived environment and health reported by other studies (Steptoe & Feldman, 2001; Balfour & Kaplan, 2002; Booth et al., 2000; Mitchell et al., 2000). Alternatively, it may be that the perceived neighborhood is inadequately measured. Other studies have shown an association between the perceived neighborhood and health, but do not include a measure of traffic stress or incorporate issues of traffic and transportation into their measure of the perceived environment. Future studies are encouraged to measure these two concepts distinctly in order to examine the potential contribution of general environmental stress and traffic stress.

Some readers may be dismayed by the finding that relatively little of the variation in health appears across census tracts. Based on similar findings, some have concluded that individual factors are far more important than neighborhood factors (Brooks-Gunn, Duncan, Leventhal, & Abner, 1997). This study demonstrates that it is not a simple dichotomy between individual and context, but that it is necessary to consider both levels. It is also important to put these "small numbers" in population perspective. Thus, while only 7% of the variation in depression may be attributed to tract-level variation, this number multiplied by the population of a city may potentially lead to important consequences in terms of the distribution of health resources and the potential risks to individuals. The present data, however, are insufficient to provide any population based estimates.

Several caveats should be mentioned. First, the cross-sectional design precludes firm conclusions as to the causal direction between variables. For example, although we presume that persons living in stressful conditions develop illness, it is possible that ill persons choose to live in stressful neighborhoods or that illness influences one's report of stress. Similarly, although we assume that traffic stress causes mental and physical illness, it is possible that perceptions of traffic stress arise among individuals who are not well. Answers to these concerns will be better resolved through longitudinal studies.

Second, the limited number of census tracts raises questions as to the representativeness of the tracts. However, CAPES tracts compare favorably to those in Los Angeles and the general US population. For example, in 1990, persons living in CAPES neighborhoods spent 26.9 min driving to work, compared to 26.5 min for LA County as a whole, and 22.5 min for the US population (US Census Bureau, 2002). Additionally, the limited number of tracts reduces the statistical power of the ecological level analyses (Diez-Roux, 2000), suggesting that findings for neighborhood factors may have erred on the more conservative side.

Third, it is unclear how the experiences of Chinese Americans in Los Angeles generalize to other populations. As one check, CAPES respondents' general health scores (mean = 70.4) were similar to those of US national norms (mean = 72.0) (Ware, 1993). Although focusing on Chinese Americans raise questions as to generalizability, that potential limitation is also a strength because it controls to some extent for unmeasured characteristics related to ethnicity. That said, future research should examine traffic stress in other populations and make explicit comparisons between advantaged and disadvantaged populations.

Fourth, the moderate Cronbach's alpha for traffic stress indicates that the reliability of the measure could be further improved (alpha often increases with the number of items in a scale). One reviewer questioned our inclusion of auto maintenance in the scale, suggesting that the low reliability may arise because maintenance is a poor measure of traffic stress. In fact, removing maintenance drops the alpha to 0.40. However, we have opted to include maintenance because the hassles of driving may be magnified if one has to do so in a poorly conditioned car and needs to spend time and money to maintain their automobile. Nontheless, future studies should develop more sophisticated measures.

Fifth, we measured the vehicular burden of the census tracts from which respondents lived, but this does not capture their experiences of vehicular burden in areas outside of their local neighborhoods. A more detailed examination requires data on their commuting experiences to work and other places, which we do not have. Examination of driving experiences may be an especially important distinction between respondents of lower and higher social class. Although we controlled for employment, income education and neighborhood poverty, it is possible that these measures inadequately capture class differences. Sixth, there is a potential time lag between the 1995 CAPES data and the 1990 Census that may question the ecological measures (Blakely & Woodward, 2000). However, examination of county-level census data suggests stability over time. For example, 1990, 70.1% of persons in LA drove to work alone in 1990, compared to 70.4% in 2000 (US Census Bureau, 2002). Granted these caveats, the use of both census data and self-reports, the consistency in the direction of their relationships with health, and the use of multilevel analysis give us some faith in the overall findings.

While many automobile commercials highlight the joys of driving a new car on a country road, this is not likely the experience of the typical commuter. Many studies have documented the negative consequences of driving, such as road rage and post-traumatic stress disorder after an automobile injury (Winston et al., 2002; Batten et al., 2000; Koren et al., 1999; Mayou et al., 2002). A few others have suggested that road conditions impact the association between driving and stress (Parsons, Tassinary, Ulrich, Hebl, & Grossman-Alexander, 1998). However, the consequences of traffic and transportation are broader than the interaction between drivers and pedestrians. The transportation system affects the well-being of an entire community. Smog is one obvious problem. Further, roads contribute to the configurations of neighborhoods and allow for access of both resources as well as of potential hazards. However, less obvious are the effects of transportation and traffic on feelings of general well-being among community residents. This study seeks to encourage discussion and future research on that very issue.

Acknowledgements

We thank Larissa Larsen, Wendy Lin and several anonymous reviewers for their helpful comments and Beth Talbot for her assistance in preparing this manuscript. This study was funded by a grant from the National Institutes of Mental Health (#47460) to David Takeuchi.

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