Demographic and Economic Characteristics of Bicyclists Involved in Bicycle–Motor Vehicle Accidents

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The purpose of this study is to compare the demographic and economic characteristics of bicyclists involved in bicycle–motor vehicle accidents in the large urban area of Dade County, Florida. This comparison is done in an attempt to discern meaningful statistical relationships between those characteristics and the accidents. For this project, police reports of bicycle–motor vehicle accidents occurring in the Miami metropolitan area from January 1, 1990, to December 31, 1991, were collected. The data from these 1,777 accidents were subjected to two reviews. The first was a general comparison of accident patterns between black and nonblack bicycling accident victims. A second review tabulated accidents and accident rates by census tract, which were then compared with 14 economic and demographic characteristics for each census tract using a stepwise linear regression technique. The results of this analysis indicate that economic factors (particularly the percentage of poor households within a neighborhood) play an important role in the prediction of areas with high bicycle accident rates. Limited evidence, in the form of a comparison in accident rates by age between all bicyclists and black bicyclists, suggests that this is probably the result of increased bicycle use. The study concludes that bicycle planners should give greater attention to neighborhoods of lower-than-average affluence, particularly where extreme poverty exists and where transit availability is inferior. It appears likely that rather than being the transportation method of choice, the bicycle is often the mode of last resort.

A central concern of planners and engineers working in the field of bicycle planning is the evaluation of bicycling accidents. Although studies indicate that collisions involving a motor vehicle are a minority of all bicycling accidents, such incidents account for most of the serious injuries to and deaths of bicyclists (*1–3*). Although research into bicycle–motor vehicle accidents has often referenced at least some demographic characteristics of the accident victims, these studies have usually included only age and gender. No known study has systematically evaluated a wider array of economic or demographic variables.

The purpose of this study is to compare the incidence of bicycle accidents between neighborhoods in a large urban area with a selected list of economic and demographic characteristics of those neighborhoods. This comparison is done in an attempt to discern meaningful statistical relationships between those characteristics and the accidents.

There is a need for such information. The characteristics of bicycle accident victims are important for three reasons. First, there is reason to believe that the demographic and economic makeup of these victims may reveal important information about the characteristics of bicycle users. Any factor that tends to increase bicycle use among a population group can be expected to increase the exposure of that group to bicycle accidents. In other words, anything that leads a population group to bicycle more can be expected to increase its incidence of bicycling accidents.

For example, in a theoretical evaluation of the economics of the bicycle as a means of commuter transport, Everett (*4*) concluded that the bicycle as compared with the automobile is a utility-maximizing form of transport only in those cases where the trip length is very short or the income of the commuter is very low. Although the cost of operating a bicycle is small, the bicycle travels more slowly than an automobile under most conditions, resulting in a higher cost when value-of-time considerations are factored in. A study of commuting trips to the downtown area of Davis, California (*5*), indicated that there is a marked tendency for managerial employees to prefer automobiles rather than nonmotorized modes of transportation, regardless of the employees' age or their distance of commute. Sales, clerical, and blue-collar employees, on the other hand, exhibited a propensity to commute by nonmotorized modes, again assuming that age and commuting distance are held constant. A recent study of extremely poor people in Los Angeles (*6*) discovered that 60 percent of the trips taken by the unemployed very poor were by nonmotorized modes, whereas 49.4 percent of the trips taken by the employed very poor were by these modes, with almost 7 percent of total trips taken by bicycle.

This conclusion, however—that the demographics of bicycle accident victims can be used as a marker reflecting the characteristics of bicycle users—is subject to strong mitigating factors. Some population groups may exhibit accidents rates disproportionate to both their representation in the general population and their participation in bicycling. For example, in his study of 919 bicycle–motor vehicle accidents in four American metropolitan areas, Cross (*3*) found that

> [W]hile the accident involvement of 12–15 year old bicyclists is more than twice as great as would be expected from the number of bicycle users in this age group . . . accident involvement of bicyclists between 30 and 59 years of age is less than one-fourth of that expected from the number of bicyclists in this age group.

Although Cross attributed this higher accident rate to specific types of operating characteristics, Kaplan, in his study of club bicyclists (*7*), discovered that both younger bicyclists and women had a higher accident rate, which he attributed to the tendency of both groups to have less bicycling experience. Overall, Kaplan found that the rate of accidents per bicyclist was 50 percent less for those with 10 years or more of bicycling experience than it was for those with less than 1 year of experience.

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The second reason for evaluating the characteristics of bicycle accident victims is to determine if certain population attributes can be used as a marker for other risk-exposing characteristics. These attributes could include urban-form features (population density, street form, and characteristics associated with neighborhood age), which are prevalent in some districts while absent in others.

Obviously, there is some conflict between this objective and the first. A high correlation between some population characteristic and a high incidence of accidents could be explained either as a factor that results in an increased rate of bicycle usage within the group or as a factor that leads to an increase in risk exposure per mile or hour of bicycle use. For this reason, explanations of causality should be treated with caution, and, as is true for any population-group correlation study, the conclusions drawn should be used as a guide for further study and not as a conclusive result.

The third reason for undertaking such an investigation is to know more about the characteristics of bicycling accident victims in order to aid in structuring accident prevention measures. This was the primary purpose of the 1978 Cross study, which had a significant effect on bicycle education programs targeted at different age groups. If demographic or economic characteristics appear to influence patterns of bicycle accidents, then programs marketed specifically at these groups could be considered. Alternatively, knowing more about the composition of high-risk groups could do much toward isolating the specific operating characteristics of such users which lead to increased accidents, and working toward remedial measures aimed at these characteristics. Some examples of high-risk characteristics could include higher rates of nighttime riding (a feature of commuters and those who are bicycling-dependent) or riding in dense, inner-city areas.

ABOUT DADE COUNTY, FLORIDA

Dade County, which contains the Miami-Hialeah Metropolitan Statistical Area (MSA), is the most populous county in Florida, containing 1.94 million residents in 1990. It encompasses a land area of 5035 km^2 (1,944 mi^2) with a population density of 385 persons per square kilometer (996 persons per square mile) (*8*). However, much of the western portion of the county is uninhabitable wetlands, so actual population densities are much higher. The Miami-Hialeah Urbanized Area, measuring 914 km^2 (353 mi^2), is second only to Los Angeles in terms of population density, with 2096 persons per square kilometer (5,429 persons per square mile) (*9*).

The median age of county residents in 1990 was 34.2 years, a figure identical to that in 1970. Unlike most places in the United States, the average age of county residents has not increased, largely because of an influx of Hispanic immigrants over the last 30 years, which has displaced a disproportionately large contingent of older, retired non-Hispanic whites. Therefore, age and ethnicity are to some degree correlated within the county. In 1990, 49.2 percent of all residents were Hispanic. The Hispanic residents of Dade County have broad representation across all economic strata because of the influx of Cuban refugees fleeing Cuba's Marxist-Leninist government, the bulk of whom were from that country's business and professional classes before the revolution of 1958. Over 59 percent of the county's Hispanic residents are of Cuban descent.

The average per capita personal income for the county in 1990 was $17,823, 4 percent less than that for the state ($18,539) and about 5 percent under that for the United States ($18,696) (*8*). Households in the county with incomes under the poverty line accounted for 17.6 percent of all households. Mean household income in 1989 for all households was $37,903; the mean income for Hispanic households was $32,311 and the mean income for black households was $25,870 (*10*).

METHODOLOGY

All law enforcement officers in the state of Florida are required to record on a standardized form vehicle accidents resulting in injury or significant property damage. This form, the Florida Traffic Crash Report, is forwarded to the central safety office of the Florida Department of Transportation (FDOT), which uses it to record crash statistics for the state. Any accident reports involving bicycles or pedestrians are, in turn, forwarded to the FDOT Pedestrian/Bicycle Office, which makes them available to planning and law enforcement agencies in Florida's 68 counties on an annual basis.

For this project, reports involving bicycle–motor vehicle accidents during the two-year period from January 1, 1990, to December 31, 1991, were reviewed. Only those reports containing a residential address for the bicyclist within the county were retained. This resulted in a total of 1,777 incidents. From this review, five pieces of information were recorded:

1. The age of the bicyclist,
2. The age of the motor vehicle driver,
3. The race or ethnicity of the bicyclist,
4. The race or ethnicity of the motor vehicle driver, and
5. The address of the bicyclist's place of residence.

An initial objective of the study was to identify both motorists and bicyclists by race or ethnic origin. However, it quickly became apparent that the recording of persons of Hispanic ethnic background was inconsistently reported on many accident forms. Inquiries to persons knowledgeable about Miami's Hispanic community indicated that there is a tendency for persons of Cuban national origin to report themselves and other Cuban-origin individuals as non-Hispanic whites in situations where the term "Hispanic" is not clearly defined as an ethnic, and not racial, identifier, as is the case on the Florida accident form. Because persons of Cuban national origin compose 59 percent of Dade County's Hispanic population, this raised the possibility of significant statistical bias. A spot survey of 200 accident forms yielded a statistically significant difference in the proportion of persons with traditionally Hispanic surnames who were identified as Hispanics between reporting officers with Hispanic and non-Hispanic surnames. For this reason, the racial composition of motorists and bicyclists was categorized as simply black or nonblack in this study.

The data from these 1,777 accidents were then subjected to two reviews. The first was a general comparison of accident patterns between black and nonblack bicycling accident victims, between black and nonblack motorists, and between black bicyclists and black motorists. This comparison was done for 13 age categories and across-the-board for all victims in an attempt to see whether any significant statistical anomalies were apparent. This analysis is presented in the following section.

A second review was more statistically rigorous. The residential address of each bicycling accident victim was taken from the accident report. This address was plotted by census tract in one of the 256 census tracts in Dade County. The number of accident victims per census tract and the per capita rate of accidents in each census tract were then compared with 14 economic and demographic characteristics for each census tract using a stepwise linear regression technique. A reverse stepwise procedure was used, in which all independent variables were included in the first regression run, after which the independent variable with the worst fit (i.e., a student's-t value closest to zero) was dropped and the regression was rerun. This cycle was continued, with one independent variable dropped after each run, until all remaining independent variables were significant. All dropped variables were then reinserted to determine if they were now statistically significant. The significant independent variables and the residuals of the final regression run were then examined for multicollinearity and heteroscedasticity using graphical analysis techniques.

DEMOGRAPHICS OF ACCIDENT VICTIMS

General Analysis

Of the 1,777 accident reports reviewed in this study, the gender of the bicyclist was included on 1,695 and omitted on 82. Of these 1,695 accident victims, 80.1 percent were male and 19.9 percent were female.

The race of the bicyclist was included on 1,773 accident forms. Of these, 464 were reported as being black, which was 26.2 percent of the total. The race of the automobile drivers was available on 1,480 of the accident forms. Of these, 287 were reported as being black, which was 22.4 percent of the total. Blacks compose a total of 20.1 percent of Dade's population. The difference in data availability was primarily due to the incidence of hit-and-run automobile drivers, which composed 16.7 of all drivers involved in these accidents. Only one bicyclist was reported in this category.

As indicated in Table 1, the elevated accident rate for black bicyclists cannot be plausibly attributed to random chance. Applying the chi-square test, the difference between the expected (20.1) and observed (26.2) percentages of black bicyclist victims is significant at the 99.9 confidence level. On the other hand, the difference between the expected and observed proportion of motor vehicle drivers involved in accidents with bicyclists is not significant.

Figure 1 shows a breakdown of the rate of accidents for all Dade County bicyclists and for the county's black bicyclists by age. For each age bracket, the accident rate is per 1,000 members of the age bracket for the full 24-month period. The accident rate for black bicyclists is sharply higher for the 5–9 and 10–14 age categories, and slightly higher for the 55–59 and 60–60 age categories. Accident rates for the 15–19 and 20–25 age categories are significantly lower than was the case for all bicyclists.

The most likely explanation for the elevated rate of bicycling accidents among blacks in Dade County is a more intensive use of the bicycle by black children between the ages of 5 and 15. These bicyclists have a much higher accident rate than is the case for all bicyclists in this group. Blacks under the age of 15 comprise 47.7 percent of all accidents by black bicyclists.

One possible explanation for this elevated rate is that blacks reside in areas with characteristics that contribute to the generation of accidents. Some of these characteristics could include more miles of major arterials or other high-volume streets, a disproportionately high share of streets of older design or in poor repair, lack of sidewalks, or a generally higher level of traffic due to land use or transport network patterns. However, if this were the case, one would expect these factors to result in higher accident rates among black bicyclists of all ages and black motor vehicle drivers involved in bicycle–motor vehicle accidents. This is not the case, as the latter category is consistent with overall population representation and the former category is actually lower for several age classes. In summary, the analysis of this limited data results in findings that, although interesting, are hardly indicative of any overarching causal pattern.

Regression Analysis

As outlined earlier, the residential addresses of the 1,777 cycling accident victims were plotted by census tract into one of Dade's 256 tracts. The total number of accident victims per census tract and the accident rate per 1,000 residents of each census tract was then regressed against a series of independent variables for each tract. These variables included

1. TOTPOP, total population;
2. AREA, land area (excluding water surface) in acres;
3. HOUSEVAL, estimated median home value of owner-occupied housing;
4. RENT, median contract rent of tenant-occupied dwellings;
5. INCOME, mean family income;
6. DENSITY, population density (TOTPOP/AREA);
7. KIDS 18%, proportion of residents 18 years old or less;
8. BLACK%, proportion of black residents;
9. WHITE%, proportion of non-Hispanic white residents;
10. POOR%, proportion of residents meeting federal poverty status in 1989;
11. HISPANIC%, proportion of nonblack Hispanic residents;
12. AVTRVLTME, average reported travel time to work, in minutes;
13. NOCAR%, proportion of households reporting no automobile availability;
14. CARSPERH, average automobile availability per household;
15. DUMMY1, one for census tracts 1.07, 1.08, 38, 39.01,

TABLE 1 Involvement in Bicycle–Motor Vehicle Accidents by Blacks, Dade County, Florida, 1990–1991

	Representation in: County Population (percent)	Representation in: Bicycle/MV Accidents (percent)	Chi-Square Value	Confidence Level
Cyclists		26.2	32.76	99.9
Motorists		22.4	4.72	N.S.
Total	20.1			

N.S. - Not Significant

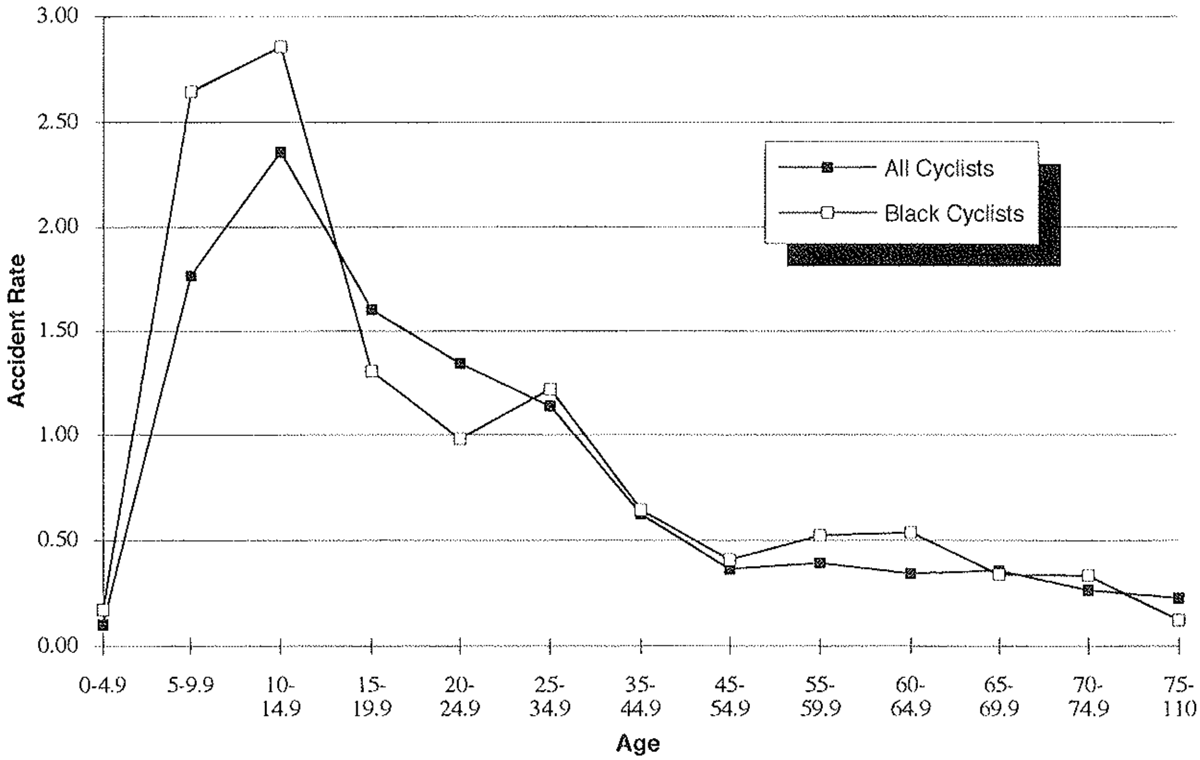

FIGURE 1 Bicycle Accidents per 1,000 Members of Age Cohort in Dade County, Florida, January 1, 1990 to December 31, 1991.

39.02, 39.04, 39.05, 39.06, 40, 41.01, 41.02, 42, 43, 44, 45, and zero otherwise;

16. DUMMY2, one for census tracts 42, 43, 44, 45, and zero otherwise; and

17. DUMMY5, one for census tract 48, and zero otherwise.

DUMMY1 and DUMMY2 were used to adjust for conditions in the city of Miami Beach, which is located on a barrier island in Biscayne Bay. The land use and transportation patterns for this barrier island are profoundly different from those on the mainland, especially for the very dense and highly mixed-use southern one-third of the city, known as South Beach. This area also experiences profound changes in both transportation and land use characteristics between the winter in-season time and the remainder of the year. DUMMY1 tags all Miami Beach census tracts, and DUMMY2 tags all census tracts in the South Beach district. DUMMY5 tags census tract 48, which is the Miami International Airport. This tract contains 105 residents, one of whom experienced a bicycle accident during the study period. This dummy variable was used to adjust for this anomalous situation in regressions examining accident rates per 1,000 residents.

Model 1: Aggregate Number of Accident Victims per Census Tract

The best-fitting model for explaining the aggregate number of accident victims per census tract is presented in Table 2.

The fit of the model was not improved by log-linear conversion of either or both independent or dependent variables. The final form of the model exhibits good—but not outstanding—predictive power, as the five independent variables explain a little over 56 percent of the variation in the number of accident victims. As expected, the most reliable single estimator of the total number of accident victims is the total population of the census tract. Larger census tracts have more victims. Two economic variables (the median rent

TABLE 2 Results of Model 1

Independent Variable	Coefficient	T-Statistic	Significance Level
Intercept	+2.3128107	3.0328	99.5
TOTPOP	+0.0000687	14.0091	99.9
RENT	-0.0023208	3.8291	99.9
POOR%	+7.0053297	4.1964	99.9
HISPANIC%	-2.9542956	3.9160	99.9
DUMMY2	+13.8111180	8.6156	99.9

Dependent Variable: Number of accident victims for the two-year study period.
Adjusted R Squared = .5652 F = 65.7476 Mean Squared Error= 12.3734

of tenant-occupied housing and the proportion of households living under the federal poverty line) are significant, and one demographic variable (the proportion of nonblack Hispanic residents) is also significant. The influence of HISPANIC% is weak, but consistent. The land use patterns prevalent in the southern one-third of the city of Miami Beach also exercise a strong influence, as is evident from the large coefficient and high Student's-T value of DUMMY2.

In summary, the results of Model 1 are not surprising. By far the most important variable explaining the number of bicycle accident victims in a census tract is the size of population of the census tract. In fact, that is why this model was run first: had this not been the result, the entire methodology of comparing accident rate with economic and demographic variables would have been suspect.

However, economics does play a contributory role, as both the median rental price and the proportion of poor households are inversely proportional to the number of victims in a statistically consistent manner. Somewhat surprisingly, demographic factors are not terribly important. The proportion of children, blacks, or whites does not appear to exert a consistent influence, and the presence of increasing numbers of Hispanic residents appears to be correlated with a slight reduction in the number of accident victims. In particular, the nonsignificance of KIDS 18% is unexpected, as previous analyses have indicated a strong influence of age factors on the number of bicycling accident victims. Overall, Model 1, although it sheds some light on the problem, is most valuable in indicating the need to evaluate victim incidence as a per capita rate if greater amounts of usable information are to be gathered.

Model 2: Per Capita Accident Rate

The best-fitting model explaining the per capita rate of bicycle accidents in each census tract is presented in Table 3.

As was the case for Model 1, this model's best fit occurred without a log-linear conversion of either dependent or independent variables. Overall, Model 2 exhibits a better fit than the first model, being capable of explaining about two-thirds of the total variation in accident rates between census tracts. Three of the four statistically significant nondummy independent variables in Model 1 were also significant in Model 2—RENT, POOR%, and HISPANIC%. The sign (positive or negative) and level of impact of these three variables were surprisingly consistent between the two models.

The influence of HISPANIC% was reliable, weak, and negative: census tracts with higher percentages of nonblack Hispanic residents had fewer accident victims and a lower accident rate. However, the impact was so low as to be almost negligible: an increase in the proportion of Hispanics from 20 to 40 percent would only result in an increase in the accident rate of .086—which is a very small increase, considering that accident rates frequently varied between .5 and 2.5.

RENT was reliable, negative, and of moderate impact. Neighborhoods with a higher average rent had fewer victims. An increase in the median rental rate of a census tract of $500 per month results in a decrease in the accident rate of .17.

POOR% was highly reliable in both models, positive, and very strong. A 20 percentage point increase in the proportion of poor households in a census tract results in an increase in the accident rate of over .66—a significant increase in a county in which household poverty rates regularly vary between 10 and 40 percent. Although closely related to poverty, INCOME was only moderately reliable, primarily because its coefficient was so small (a $10,000 difference in household annual income results in a change in the accident rate of .04). Although INCOME is of minor impact, it is illustrative in that it is consistently negative, a finding that supports the significance of RENT. Both findings suggest that reduced socioeconomic status within neighborhoods may point to increased accident rates.

In addition to these three variables, three additional independent variables (and two dummy variables) were significant. Surprisingly, both DENSITY and KIDS 18% were significant, but contrary to popular belief, both were negative. Census tracts with a higher proportion of children have lower accident rates. This is probably the result of a highly inverse correlation between both population density and the proportion of children, and economic status. Those census tracts with a high proportion of children tend to be located in suburban neighborhoods with low population densities and an above-average level of affluence. Both DENSITY and KIDS 18% data were reliable, but weak. However, the fact that both variables are not strongly positive is itself a significant finding. Many municipal and regional bicycle plans prepared in the past have relied exclusively on the proportion of children or population density to predict both bicycle use and bicycle accidents. The evidence uncovered in this study indicates that this may not be a prudent policy.

In addition, neither the data of NOCAR% nor CARSPERH were significant. This was less surprising, in that transit dependency in the county includes many non-automobiles-using households composed of elderly people with a wide range of incomes. These households generally have very low bicycle use rates, as the infirmities that have required elderly people to discontinue automobile use also affect their ability to bicycle. It is possible that one of these variables may prove to be significant in communities where a lack of

TABLE 3 Results of Model 2

Independent Variable	Coefficient	T-Statistic	Significance Level
Intercept	+1.1947987	4.8207	99.9
RENT	-0.0003293	3.3417	99.9
INCOME	-0.0000039	1.7868	90.0
DENSITY	-0.0224237	4.4479	99.9
KIDS18%	-1.9199688	2.8458	99.5
POOR%	+3.3059495	9.3431	99.9
HISPANIC%	-0.4293626	2.9932	99.5
DUMMY2	+1.3857402	5.2120	99.9
DUMMY5	+7.8607701	14.0786	99.9

Dependent Variable: Accident victims per 1000 residents per census tract.
Adjusted R Squared = .6468 F = 57.9983 Mean Squared Error= .29485

automobile access is more closely associated with financial condition and less correlated with age.

CONCLUSION AND RECOMMENDATIONS

Many factors contribute to the generation of bicycle–motor vehicle accidents. This study has examined only a few of these factors. In particular, this study did not examine the role that specific roadway or accident site characteristics play in the generation of such accidents. It is known from both anecdotal evidence and empirical studies that site-specific characteristics play an important role in the generation of accidents. This study did not seek to examine accident locations. Instead, it sought to examine the characteristics of the neighborhoods where bicycling accident victims lived. Several conclusions can be drawn from this examination.

1. Economic status appears to be a significant determinant of at-risk populations for bicycle–motor vehicle accidents. In both Models 1 and 2, economic factors played a significant role in predicting accidents between neighborhoods. In Model 2, economic factors (particularly the percentage of poor households within a neighborhood) played a preeminent role in the prediction of areas with high per capita accident rates. These factors appear to be more important than even the proportion of children or density of the neighborhood. This is not to say that age is not important: the most important at-risk group for bicycle accidents is the 5- to 20-year-old age group. However, it must be recognized that other economic and demographic factors contribute toward the creation of at-risk groups. It is likely that these risk factors may be mutually reinforcing: the very high accident rates for black children between the ages of 5 and 15 should be of particular concern.

2. Although the specific causal mechanism for this effect cannot be determined, variation in bicycle use rates appears to be the most plausible explanation. In the introduction to this paper, it was noted that the economic or demographic characteristics of a neighborhood may affect bicycle accidents in two ways: (1) by increasing bicycle use—primarily through a decreased access to automobile transportation—while keeping accident rates per mile or per hour of use constant, or (2) by increasing the risk of accident per mile or per hour while keeping the exposure level constant. Such an increase could result either from cultural factors (safe or unsafe operating practices) or from factors affecting the riding environment (use in safe or unsafe street environments).

On the basis of the data examined in this study, it is not possible to make a final determination as to which of these two is most significant. Circumstantial evidence, in the form of a comparison of accident rates by age between all bicyclists and black bicyclists suggests that the first explanation is more likely. If black children have such high accident rates as a result of bicycling in neighborhoods with some adverse characteristic (or because they ride more recklessly), why do young adult black bicyclists have an accident rate significantly below that of the population as a whole? A much more plausible explanation is that reduced access to automobile transportation by parents results in higher use rates for black children, and a higher rate of unemployment results in lowered rates of bicycle use by young black adults. The unemployed, of course, make fewer trips than those with regular jobs, whereas the use of young adults in service industries tends to force them to make either the trip to or the trip from work during hours of darkness.

In summary, it appears that in the same way that patterns of economic need heavily influence the use of transit by women, such factors often result in bicycle dependency by males, particularly males under the age of 35. This dependency appears to be increased in lower-density suburban areas, possibly as a result of the lower transit service available in these areas. Poor females use transit regardless of this level of deprivation; males will turn to the bicycle as an alternative. It is important that future studies on the subject address this particular question.

3. Bicycle plans should incorporate economic factors into estimates of bicycle demand. Traditionally, bicycle plans, where they have attempted to estimate ridership demand, have usually relied on the location of schools, universities, and major recreational areas. The data from this study suggest that areas of lower-than-average economic status should be included. This would be especially true in areas of relatively low population density because of lowered transit availability and unwalkable distances between homes, jobs, and retail locations. Suburban poverty may prove to be the single most important factor affecting the demand for bicycle use in large urban areas. This does not suggest that the more traditional demand factors should be ignored but that additional factors should be incorporated if meaningful patterns are to be discerned.

4. Efforts to improve bicycle safety may require reexamination. Bicycle planning as a whole has tended to concentrate on the needs of middle and upper-income neighborhoods. To some degree, this is the case because these neighborhoods are the most recently developed and (being built to newer right-of-way and construction standards) are the easiest to equip with bicycle facilities and other amenities. Because children tend to live in suburban areas, the needs of children and recreational bicyclists can be met simultaneously.

The evidence presented in this study suggests that bicycle planners should give greater attention to neighborhoods of lower-than-average affluence, particularly where extreme poverty exists and where transit availability is inferior. It appears likely that rather than being the transportation method of choice, the bicycle is often the mode of last resort.

Efforts to implement bicycle plans have usually called for a balanced "4-E" approach: engineering, enforcement, education, and encouragement. This strategy may need to be reassessed. If bicycle use is heavily dependent upon economic circumstances, then the importance of encouraging bicycle use becomes obviated. Bicycle use is a function of need, not desire. Likewise, the expenditure of resources on educational and enforcement efforts may need to be reassessed. If utilitarian bicycling is an involuntary activity motivated by the lack of a preferable alternative, then such elaborate outreach programs may have little effect. The audience may simply not be interested in what these programs have to say. This suggests that the role of specialized bicycle facilities may need to be strongly advanced to combat bicycle accident rates among this involuntary and dependent user population.

This study has clearly established that bicycle users are not a homogeneous group. It should be equally obvious that uniform bicycle planning measures are no longer satisfactory. In particular, bicycle planners should realize that many of their constituents may participate in bicycling out of need rather than desire and should structure their traditional 4-E programs accordingly.

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