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Author

Keeler, Theodore E.

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UNIVERSITY OF CALIFORNIA AT BERKELEY

Department of Economics

Berkeley, California 94720

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**Government Policy, Individual Actions, and Safety:
Some Evidence for Motor Vehicles**

Theodore E. Keeler

University of California, Berkeley

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Key words: transportation safety, highway safety, economics of health.

Abstract

This paper develops a statistical model analyzing the effects of regulatory and individual behavior on motor vehicle safety, using county-based cross-sectional data for the year 1970. The results indicate that in the more rural half of the counties, none of the regulatory variables (including the rural speed limit) have a meaningful effect on fatalities. In the higher-density half of the counties, the speed limit has a positive and significant effect. Some other regulatory and social variables also have a strong effect in the high-density sample, including education (increased levels of which reduce fatalities) and income per capita (higher levels of which also reduce fatalities significantly).

JEL Classification: 615, 913, 916

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Theodore E. Keeler
Economics Department
University of California at Berkeley

Government Policy, Individual Actions, and Safety: Some Evidence
for Motor Vehicles

Theodore E. Keeler

April 17, 1990

Matters of life and death go beyond economics, yet they are nevertheless highly relevant to important issues in economics. The study of the social and economic determinants of highway fatalities is thus of interest not only for its own sake, but also because of its relationship to important questions of economics and policy. First, such study contributes to our understanding of the effects of government regulatory policies on mortality. This issue is of interest both in its own right and because it serves as the foundation for benefit-cost analysis of such policies. Second, a study such as this is directly relevant to some important economic theories of individual behavior concerning the relationships between income and safety and between education and safety.

Regarding regulatory policies, the efficacy of government regulations in protecting health and safety has been questioned in many areas. For example, Peltzman (1975, 1987) has questioned whether regulations requiring prescription drugs or safety devices for autos have been effective.¹ In the area of traffic and highway regulations, there is much controversy as to the effectiveness of regulations and government policies on safety levels of the

¹Others have questioned the effectiveness of regulations more broadly, in other sectors of the U. S. economy. Work along these lines goes back to Stigler and Friedland (1962).

traveling public (among the most controversial are highway speed limits and regulations of auto safety attributes, vehicle inspection programs, and regulations relating to alcohol consumption).

As relates to more basic economic issues, a literature has developed in health economics asserting that individual, as well as regulatory variables, should have a strong effect on health and safety in many aspects of human life. One particular literature, with important contributions by Grossman (1972, 1975) argues that education levels should be closely (and very likely positively) related to levels of health and safety. Furthermore, Fuchs (1974), Grossman (1972), and Peltzman (1975) have asserted that there is likely a relationship between income on the one hand and health and safety on the other, though the direction of the relationship is ambiguous.

It is the aim of this paper to shed new light on these broad issues, all relating to the important area of highway safety. This has been an area of extensive study in the economics literature, and there is a continuing debate as to the determinants of highway fatalities and the appropriate policies to improve highway safety. In the United States, some studies have emphasized design of vehicles and roads (with emphasis on policies setting standards and regulations).² Others emphasize the importance of low speed limits, most especially the 55-mile-per-hour speed limit implemented in 1974 and partially removed in the late 1980's.³ Yet others emphasize the importance of controls

² For a summary of these regulations and a survey of this literature, see Crandall, et. al., 1986. Because the present study is a cross section one, and because vehicle safety regulations have changed primarily over time, the present study does not consider the effects of such regulations on highway safety.

³ The speed limit as a means for saving lives is controversial. See, for example, Lave (1985, 1989), McCarthy (1988), Fowles and Loeb (1989), Levy and Asch (1989) and Snyder (1989).

(including taxes) on alcohol consumption, and stronger legal actions against drunk driving.⁴ Finally, others have noted that vehicle inspection programs, more stringent driver training and licensing, and availability of emergency care facilities can also make a difference.⁵ It should be clear that the causes of highway fatalities stem from a complex combination of public policies and private actions, which makes measurement of the effects of these policies difficult. These problems of measurement, in turn, make any benefit-cost analysis of regulatory policies difficult. Yet a clearer understanding of these complex relationships is necessary to better allocate scarce resources in this area.

There are at least two crucial areas in which previous studies of these issues might profitably be extended. First, few models have been specified to include all the relevant variables into a single model (and there has been very little study of the relationship between education and highway safety, despite its clear importance at the theoretical level). It is, however, only by estimating such an integrated single model containing all relevant (and measurable) variables that it is possible to have hope of disentangling the effects of such variables. Second, as Lave (1989) has noted, typical studies of these issues have been done at the statewide, cross-sectional (or panel) level, severely limiting the number of observations available.

This paper achieves progress in solving both problems. First, I specify a fuller model than have previous studies, including demographic and social variables, as well as traditional transportation-related ones. Second, the

⁴For a summary of the evidence on alcohol policies, alcohol consumption, and motor vehicle fatalities, see Grossman (1989). For a complete and reasonably recent bibliography of work in this area, see Nelson (1988).

⁵See, for example, Busbaum and Colton (1966) Fuchs and Leveson (1967) and Fowles and Loeb (1989).

present study employs a county-level data base, affording over 3,000 observations, on a cross-section basis, far more than previous state-level analyses have done. This study is based on the year 1970, because there was a wide variation in speed limits then, making feasible analysis of the effects of that important variable (and technology and tastes were likely close enough to present ones to make the results of this study relevant to the present, as well).

The first section of this paper presents a discussion of the conceptual issues of specification of a functional relationship between motor vehicle accidents and relevant socio-economic variables. The second discusses the data, the sources, and the appropriate estimation procedure. The third section presents the results, and the fourth their implications, both for general knowledge of the causes of deaths on highways, and from the viewpoint of improving public policy.

I. SPECIFICATION

It is first worth considering what form is theoretically appropriate for the estimating equation. As was previously stated, the process generating motor vehicle accidents is a complicated one, depending on personal, technological, and legal variables, and the equation estimated is an approximation for such a process. There are, however, some important and basic aspects of this process which do suggest a form for the equation specified.

Form of equation. The probability that a particular member of a population will be killed in an auto accident during a given period is (fortunately) low; there is a finite count of fatalities in a given

population. In such general situations of regression with a small-count variable as dependent variable, Cook and Tauchen (1984), Hall, Hausman, and Griliches (1984), Rose (1988), and Kanafani and Keeler (1989) have argued that a Poisson process best describes the dependent variable, and that a general regression of the following form is a realistic approximation:

$$(1) \quad Y_i = \text{EXP}(a_0 + \sum_j a_j X_{ij} + e_i)$$

In this equation, the Y_i are observations on the dependent variable, X_{ij} is the i 'th observation on the j 'th independent variable intended to explain auto fatalities, and the e_i represent an econometric error term. Indeed, Cook and Tauchen (1984) have argued that this form is specifically appropriate for estimation of equations relating to auto fatalities, and have derived properties of the error term ~~in~~ for a cross-section of observations estimated in an equation of this form (more about this below). This is algebraically equivalent to

$$(2) \quad \text{LOG}(Y_j) = a_0 + \sum_j a_j X_{ij} + e_i$$

making the equation suitable for linear estimation. Estimation will be discussed below, but first, it is appropriate to consider the appropriate variables to include in (2).

The dependent variable. Motor vehicle fatalities would itself seem an appropriate variable. However, it would also seem most sensible to

standardize the dependent variable for the potential number of fatalities across counties. There are several ways of doing this, but the two most often used in previous studies are population (a measure of total potential drivers, passengers, and pedestrians who could die from accidents) and vehicle-miles (a measure of the amount of traffic). Both need to be taken account of. For our equation, we shall divide by population, but also use a variable measuring vehicle-miles per capita traveled as an independent variable, to be discussed below.

Personal and economic variables. Previous analysts in the economics of health and safety have noted that income can have a positive or negative effect on safety (Fuchs, 1974, Peltzman, 1975). Higher income implies, on the one hand, that the consumer can afford to invest in things which improve safety (such as safer cars, and may also have access to superior health care in the event of injury from an accident).

On the other hand, in the area of driving, higher income can also mean more risky behavior: faster cars, and possibly (as pointed out by Peltzman, 1975) taking more chances in driving. In any event, income would appear to be an important variable for inclusion.

Another demand variable which is important is something to measure the amount of driving done. Typically, the variable used is vehicle-miles traveled. This variable is not available at the county level, but another variable, closely-related to vehicle use, is available: retail sales of highway vehicle fuel. As will be seen, this would seem to be a very accurate proxy for vehicle-miles traveled.

Another personal variable which economists have found to be important in explaining behavior with respect to health and safety is education. The work of Grossman (1972, 1975) has shown theoretically that education is likely to

have a positive effects on health-promoting behavior, and there is evidence in many areas that this is in fact true. (See, for example, Farrell and Fuchs, 1982). Indeed, Fuchs (1982) has found that people with higher levels of education are more likely to use seat belts, and Fuchs and Leveson (1967) have found some direct evidence of a relationship here, also.

From this previous work, it is clear that education levels are an important potential variable for explaining motor-vehicle accidents, and but no previous study of the determinants of motor vehicle safety has included education variables (with the exception of the work of Fuchs and Leveson, 1967, which was based on a small data set and did not consider a number of other important variables). The present study includes two education variables: the per cent of the population over 25 with high school and college educations, respectively.

Another personal, demographic variable which is relevant to motor vehicle accidents is the per cent of the population made up of young people, who have a higher accident rate than other age groups in the population. Specifically, young men have accident rates higher than other parts of the population.⁶ So I also include a variable indicating the percent of the population made up of males aged 15-24.

Regulatory and legal variables. Numerous policy variables affect auto accidents, and we consider them now.

Perhaps the most controversial of these variables is the speed limit on expressways and on rural non-limited-access roads. A number of students of this issue believe strongly that a lower speed limit reduces accidents and reduces fatalities (see, for example, Fowles and Loeb, 1989, Levy and Asch,

⁶ See, for example, Cook and Tauchen, 1984.

1989, and Snyder, 1989). Another group, most especially Lave (1985, 1989) and McCarthy (1988) believes that within the range of speed limits currently available or under consideration (55-65 miles per hour) there is little or no relationship. They believe that it is the variance of speed on the road, rather than the speed itself, that affects accidents and fatalities.

Most previous studies have used the observed speed on rural roads as an exogenous variable here, and possibly the variance in speed, as well. But observed speed is not an exogenous variable from the viewpoint of public policy. And indeed, because enforcement can never be perfect, the actual speed cannot be a truly exogenous variable from the viewpoint of public policy. As a result, the present study analyzes the effects not of speed itself, but of publicly-imposed speed limits. Our focus will be on maximum speed possible on expressways and rural roads, since that is the object of the most controversy (use of a population density variable will control for situations in which urbanized counties have little opportunity to use the maximum speed, as will stratification of the sample into high-density and low-density components).

There are other important regulatory variables affecting motor-vehicle safety. The existence of a state vehicle inspection program has been found by previous studies to have an effect, as has more frequent license renewal testing.

Yet another set of regulatory variables relates to alcohol. States control availability and price of alcohol, through taxes, licensing restrictions, price regulations, hours of sale, minimum drinking ages, and, in some cases, prohibition on the sale and consumption of alcoholic beverages.

Minimum drinking age is controlled at the state level, and data on it is readily available, so it is included in the equations as a variable, county by

county (0 if the drinking age was 21 and 1 if it was lower).

Another appropriate variable would be the real price of alcoholic beverages, especially those known to be associated with motor accidents, namely beer. Real beer price data, however, are not available cross-sectionally at the county level, nor are data on alcohol consumption. Per capita consumption data are available, however, at the state level, and it is appropriate (at least to control for the effects of alcohol consumption in measuring the effects of other variables) to include average per capita alcohol consumption as a variable for each county. Initial work with the data indicated that total alcohol consumption is a better explanatory variable than is beer consumption, and that is the variable used.

Technological and other variables. Quick availability of emergency medical care is likely to have a strong impact on ability to save lives in the event of auto accidents, and as a result, the distance of the nearest hospital is likely to be important. So I include a variable for hospitals in the equation. A priori, it would seem that the proximity of one hospital in a given area would have a strong effect, but that the incremental effect of many hospitals in an area would be weaker, and evidence confirmed this to be the case. As a result, I have included a simple zero-one variable, equal to zero if there are no hospitals in the county, and one otherwise.

Population density is likely to affect fatality rates, because high densities imply a type of driving (frequent stops) which should, all other things equal, reduce the likelihood of fatal accidents. Therefore, in addition to stratifying by this, I include it as a variable.

II. Estimation and Data

This section considers appropriate techniques for estimation of (2), as well as summarizing the available sources for the data.

Estimation. Cook and Tauchen have argued that with the above specification, and with a Poisson distribution of the error term (approximated by the lognormal distribution), the error term across counties (or similar populations) can be expected to be heteroscedastic. Specifically, they note that the variance of the error term in (2) has the following relationship to the size of the county (or other population) observed:

$$(3) \quad \sigma^2 = b_0 + \log\left(1 + \frac{b_1}{POP}\right)$$

where POP is the population of the relevant state (in Cook and Tauchen's case) or county.

Given this, the appropriate econometric procedure is two-step, generalized least squares. First, estimate (2) using ordinary least squares. Second, estimate (3) using nonlinear least squares, using the squared residuals from the first-round equation as estimates of σ^2 . Third, use weighted least squares to re-estimate (2), using as weights reciprocal of the square root of the predicted value of σ^2 from (3). That is the estimation procedure used here (results for both ordinary least squares and generalized least squares are reported).

Data. All the data for this study have been collected at the county level for the U. S. A., excluding Alaska (because the roads there are so dramatically different from elsewhere). This affords a total of 3,107

observations for the United States.⁷ Sources for all the data used are reported in Table 1.

As previously stated, the year 1970 was selected, because at that time, there was wide variation in speed limits across states, and thus data for that year afford rich opportunities for testing the effects of speed limits on fatalities. Also, at that time, there was significant variation across states in minimum drinking age,⁸ and there is reason to believe that that, too, has some effect on fatalities.

In addition, the data were stratified into two sets, on the basis of population density. This was, first, strongly justified on a statistical basis: it was possible to reject the hypothesis that the two data sets had the same regression coefficients at the .001 level.⁹ But the reasons for this should also be evident on an a priori basis: many believe, for example, that a high speed limit may be safe in low-density areas, but not in heavily-populated ones. Indeed, it makes sense that all variables should be given the opportunity to have different effects in high- and low-density counties, and, since stratification into two groups still affords over 1,500 observations per group, very little is sacrificed in terms of a large statistical sample by doing this, either.¹⁰

⁷ The boroughs of New York City have been excluded, also, because separate fatality data are not available for them.

⁸ It was not, however, until well into the 1970's that minimum drinking age under 21 reached its widest range among states. This fact is discussed further below.

⁹ The relevant test statistic (comparing sums of squared residuals for pooled and unpooled ordinary least squares equations) is $F(14,3079) = 16.2$.

¹⁰ Another approach, which would arguably allow for both pooling of data and for differences where coefficients do differ, would be to pool both data sets, but to allow for different intercept variables between the samples, as well as different slopes for those variables for which slopes appear to

Table 1 shows the mean values and standard deviations of the sample for each of the variables in the equations. To get a sense of the densities involved, it is worth noting that the mean population density in the "low-density" sample is 14.8 people per square mile. A county such as this one is a rural one, but one with well-developed small cities and towns and agriculture. Examples of these counties may be found in most parts of the U. S., including agricultural parts of the Northeast (Potter County, Pennsylvania), the South (Van Buren County Tennessee), the Midwest (Chariton County Missouri), and more settled (but still rural) areas of the West (Mendocino County, California).

The mean population density of the high-density sample is 360.6. This is the sort of density found in counties with larger cities and some rural land, as well. Examples would be Kalamazoo County, Michigan and El Paso County, Texas.

These examples are given to be suggestive of the sorts of mean densities for which the results are most relevant, though density is itself a variable in the equations, as well.

III. Results

differ. The difficulty with this approach is that it is rather arbitrary as to which slopes should be allowed to differ. In any event, the results shown in Tables 2 and 3 are quite robust to use of this procedure. Specifically, when the two samples were pooled, with different constants and different slope coefficients for income, high school education, and speed limits, the qualitative results were identical to those shown in Tables 2 and 3, with the sole exception that the alcohol-related variables, alcohol consumed and minimum drinking age, became more statistically significant. The alcohol variable became significant at the 15 per cent level. While this is not highly significant, it nevertheless suggests what other studies have shown: with a data sample geared to studying the effects of alcohol on traffic fatalities, the results would show a meaningful effect.

The results of the equations are shown in Table 2 (for the low-density sample) and Table 3 (for the high-density sample).

They are revealing in several ways.

First, it is worth noting the difference in results between the two samples. The low-density sample has far fewer coefficients with meaningful results than the high-density sample. The variables which perform well and as expected include retail motor vehicle fuel sales (a proxy for vehicle-miles) and population density (which indicates that as densities rise, the probability of driving situations generating fatal accidents declines).

The alcohol-related variables are of the expected signs, in that higher levels of alcohol consumption increase accidents, as does a lower minimum drinking age (with the exception of the low-density GLS equation). However, the alcohol-related variables are not so significant as they might be, in either sample. There are at least two reasons why this is likely to be so. Regarding minimum drinking age, there was relatively little variation in that variable in 1970; variation increased in the 1970's. Regarding alcohol sales, it is likely that alcoholic beverages are often not consumed in the same county as they are purchased in. Still, there is evidence that with a larger sample, the alcohol variables would be considerably more significant.¹¹

With regard to the low-density counties, the results imply that if vehicles do not get too much in each others' way, there are relatively few variables which affect fatality rates (college education is near significant; more about that below).

Of the speed limit variable, in particular, it is evident that it is of the unexpected sign and not statistically significant. The result would seem

¹¹See footnote 10, above.

quite inconsistent with the claim that high speed limits cause fatalities in low-density areas.

With regard to the high-density sample, many variables which had no effect in the lower-density case become important. It would seem that the congestion inherent in higher densities makes these variables more influential.

Educational variables (both high school and college) are very important (as the college variable is in the case of the rural counties). The evidence shows strongly that increased education makes an important difference as relates to fatalities, right up through the college level. The most basic reasons for this should be clear: a higher level of education means the driver is more likely to read signs well, as are pedestrians who are included in the fatalities. Similarly, there is evidence that a higher level of education corresponds to a greater propensity to wear seat belts, and that was true in 1970 as it is now (see Fuchs, 1982). And it is likely, as well, that education helps one make less obvious judgments about driving, such as the decision as to when one has consumed too much alcohol to drive. Education also likely helps drivers make the most meaningful sense of traffic signs and even maps, which could help safety in an indirect way.

The relationship between income and fatalities follows a pattern similar to that for education. That is, as income rises, fatalities decline strongly. The implication here is that it is safety, rather than risky driving, that appeals to people as their income rises. This is plausible, in that over the past 25 years, newer cars have been consistently equipped with better safety features (many of which have been demonstrated to have at least some effect on safety; see Crandall, et. al., 1986), and those with higher incomes are more likely to own newer cars. Similarly, higher incomes are likely to be

correlated with larger cars, and larger cars have also been demonstrated to entail higher occupant safety.

In the high-density sample, the speed limit does indeed have a significant effect on safety levels. It is clear from this that if population density is high enough, lower speed limits do save lives.

Of the other variables, it is clear that the length of the license renewal period is somewhat important: it is significant at the 10 per cent level in the generalized least squares equation, and the sign indicates that a longer period between renewals increases fatalities.

On the other hand, the existence of a vehicle inspection program has consistently no effect on safety. As Fuchs (1967) pointed out some time ago, the effects of vehicle inspection programs appear to be relatively low once the effects of other socioeconomic variables have been accounted for.

The alcohol variables are of the expected sign, though they are not significant. As has already been indicated, though, their effects would likely be stronger with a better-suited data set.¹²

To get some perspective on these results, Table 4 shows some simple simulations of the effects of various changes in independent variables for the high-density sample, based on the generalized least squares results. In the table, effects are shown (in terms of per cent reduction in the annual fatality rate) from changes in each of the four variables shown to have a strong effect in the high-density sample (population density and vehicle-miles are not considered, because they seem much less closely related to public policy or even individual decisions). All changes (in both independent

¹²Cook and Tauchen (1984) and Saffer and Grossman (1987) are among the researchers who have found the effects of alcohol variables to be important. For an indication as to why our analysis may understate the significance of these variables, see footnote 10, above.

variables and fatalities) are based on the mean values of variables for the high-density sample as a starting point.

It must be emphasized that the changes shown are not intended to indicate realistic policy options, but rather simply to illustrate in an intuitive way the relative importance of each of the variables in influencing fatality rates. The results are of interest and worth discussion.

The first alternative considered is increasing the per cent of the population with a college degree by 10 or 20 per cent. As Table 4 shows, the resulting reduction in fatalities is small (1-2 per cent), but this result is to some degree misleading. That is because the increases start from a small base: in 1970 (as shown in Table 1) only slightly over 8 per cent of the population in the high-density sample had a college degree, a 10 or 20 per cent increase in that percentage is not large in absolute terms.

The second alternative analyzed is to increase the per cent of the population completing high school from a base of 45 per cent. The results indicate that this would have a more substantial effect on fatalities, reducing them by roughly 3-6 per cent. It is clear from this that there is a substantial relationship between safety and education, and (given the results for college, as well as high school education) it would appear to stem from more than merely the effects of driver training taught in school.

The third alternative considered is to increase annual per capita income by 10-20 per cent from mean levels. This, as shown, would have reduced fatalities by 2-5 per cent. While this effect is not an extremely large one, it is nevertheless clear that higher levels of income afford safer (probably newer) cars, and better access to health care, as well.

The final alternative considered is the reduction of the average maximum speed limit on expressways and uncrowded rural roads from a mean of 67 miles

per hour by 10 per cent or 20 per cent (a 20 per cent reduction from that mean would put the average speed limit at just under 55; in 1970, some states had maxima over 70, while some had maxima as low as 60 on limited-access highways; in many cases these higher speed limits also applied to expressways in metropolitan and suburban areas, so they are relevant to the high-density sample). The results show a substantial saving in fatalities of 5-10 per cent for an average high-density county. Once higher densities are reached, it would seem clear that there would be savings in lives to be had from speed limits under 65 or 70, though that still does not imply that such a speed limit would pass a benefit-cost test.

While all these variables are clearly important, it is nevertheless striking how powerful the income and education variables are in these equations, as well as population density. While it is clear that social policies can have some effects on highway fatalities (especially in higher-density areas), much of the variation is explained by variables controlled largely by individuals, rather than by the collective decisions.

IV. Conclusions and Implications for Further Research

Perhaps the most striking conclusion of this empirical exercise is that it appears to be individual and demographic factors which have the strongest effects on highway safety, rather than the regulatory variables which are most commonly cited as important. This is especially true in more rural counties, where regulatory variables appear to have practically no impact.

Even in more populated counties (with the exception of the speed limit, mentioned below), the regulatory variables play a relatively small role in explaining fatalities. Thus, the things which most strongly affect highway

fatalities are the levels of education people choose to attain (public policy has some power here, of course), the levels of income they earn, the amount they choose to drive their cars, and how high-density a living situation they choose.

Of the regulatory variables, the only ones which have a significant effect are the speed limit and the license renewal period, and they have such a meaningful effect only in counties of above-median density in the United States. This of course does not imply that these variables have no effect on fatalities, or that such regulations should be eliminated. Rather, it means that within the realistic variation in them found among states in the U. S., there is little evidence that they are effective (bigger variations in them could obviously have an effect).

The obvious question arises as to why the regulatory variables have seemed so unimportant. One strong possibility is that the data, even at the aggregate county level, are too imprecise to isolate the effects of these variables. Clearly, the variables relating to alcohol could be improved, because consumption of alcoholic beverages within a county and sales can be different quantities. Also, alcohol variables (both the tax and more obviously minimum drinking age) have been shown to have effects mainly on youth fatalities. We do not have data on youth fatalities at the county level, but that would obviously be useful (again, note that the variable for per cent males 15-24 did not have a significant effect in these equations either). Unquestionably, the results in these areas could be clarified with better data.

Yet, even given that the data are not so good as they could be, it is striking that the demographic, income, and education variables do so well in explaining fatalities. This would seem to suggest that they are very powerful

explanators of highway safety.

The likelihood of these relationships is well understood among health economists (Grossman, 1972, 1975; Leveson and Fuchs, 1967), but it has been ignored by most of those studying highway safety. Leveson and Fuchs warned in 1967 that failure to include demographic variables in highway fatality equations will likely overestimate the effects of regulatory variables. In the present case, the evidence would seem to support this view rather strongly.

There are further broad conclusions stemming from these results, relating to several other literatures.

First, the weakness of the regulatory variables and the strength of the individual decision variables in explaining phenomena here is consistent with results of Stigler and Friedland (1962) and Peltzman (1987) in very different contexts. The results here are similar to theirs in that they show little effect for well-intentioned regulatory policies in this area (with the exception of speed limits in high-density areas; in each area, only further research can show whether this holds up with other, better data sets, however).

Second, regarding the literature on the relationship between schooling and health found in health economics, the present study provides strong evidence supporting the existence of that relationship. As Fuchs (1982) has said, however, there is still some question as to whether education is exogenous in this case, or whether, instead, both education and high levels of safety or health are manifestations of the same desire to take care of oneself.

Third, these results shed some light on a related issue in health economics: whether higher levels of income are likely to entail more or less

healthy modes of living. Fuchs (1974) has suggested that for many activities (such as eating rich food), higher incomes in a highly-developed country may lead, all other things equal, to lower levels of health or safety. Peltzman (1975) has noted that this relationship could go either way in the case of driving (a trade-off between more expensive, possibly safer cars, and the pleasure of harder driving with faster cars as income rises). In the area of auto safety, these results give cause for optimism about the effects of higher incomes: they unambiguously increase safety, presumably through safer (newer and bigger) cars, but also, perhaps, through better emergency medical care.

Finally, this paper has some important implications for public policy (assuming, I believe reasonably, that 1970 conditions are not totally irrelevant to the present).

First, regarding the controversy surrounding the 55-mile-per-hour speed limit, the present paper suggests that current policy is about right: allow higher expressway speed limits (such as 65 miles per hour or even 70) on expressways in uncrowded rural areas, but keep it at lower levels (such as 55 miles per hour) in more crowded urban and suburban areas. But even this policy errs too much in favor of a lower speed limit: if, indeed, lower speeds do save lives in congested areas, it is still quite possible that the benefits of the lower speeds in added safety and saved fuel fail to equal the costs.¹³

Second, while it would probably be inappropriate to substantially relax regulations affecting drivers and driving (and alcohol consumption), those public policies likely to pay off the most in the long run for auto fatalities

¹³The benefits and costs of a 55-mile-per-hour speed limit are controversial matters, however. See, for example, Forester, McNown, and Singell (1984), Jondrow, Bowes, and Levy (1984), Kamarud (1988), and Mannering and Winston (1987).

are policies which will also be greatly beneficial in other areas of life: promote education--especially universal completion of high school. And pursue those economic policies which achieve general economic growth and improvement in incomes.

The results of this study imply that policies which aim at the improvement of the general well-being of the population (income and education) will have powerful positive side effects in an unexpected place: saving lives on highways.

Table 1. Variables and Descriptive Statistics

Variable	Definition	Low Density Sample Mean (S. D.)	High Density Sample Mean (S. D.)
FATPOP	Fatalities per 1,000 population ^d	0.5434188 (1.5153191)	0.3497889 (0.2943130)
ALCOHOL	Total alcohol consumption per Capita ^b	1.4382682 (0.3474617)	1.4459686 (0.3543224)
COLLEGE	Per cent over 25 with College degree ^c	6.3941442 (2.9676488)	8.2104765 (4.5304808)
DUMZER	Dummy variable for 0 fatalities ^d	0.0797941 (0.2710614)	0.0032196 (0.0566681)
GASPOP	Retail service station sales ^d	0.2310081 (0.5080633)	0.1747839 (0.0714171)
HOSPITAL	One if there is a hospital in county, zero otherwise ^e	0.7020592 (0.4575006)	0.8795879 (0.3255477)
INCOME	Per capita income ^c	2251.5097000 (484.5761300)	2581.3561 (578.04763)
INSP	Dummy = 1 if county is in state with vehicle inspection program ^f	0.8384813 (0.3681271)	0.8029620 (0.3978894)
LICREN	Time between license renewals ^g	3.1994852 (0.9669888)	3.1146169 (0.9631076)
MINAGE	Minimum drinking age ^h	20.4157010 (1.1030184)	20.424984 (1.1658562)
PCHIGH	Percent over 25 with high school diploma ^c	45.7489700 (76.5084400)	45.928139 (12.513322)
MALEYOUTH	1 if per cent males 16-24 is over mean for 3107 counties; 0 otherwise ^c	0.2187902 (0.4135591)	0.4056665 (0.4911787)
POPDEN	Population per square mile ^c	14.7528470 (9.6384071)	360.56917 (1819.8761)
SPDLIM	Highest speed limit--rural roads ⁱ	71.0585590 (3.8470158)	67.990985 (5.078753)

Data Sources

^aFatality data are from U. S. Department of Health and Human Services, Public Health Service, Vital Statistics of the United States, 1970, Vol. II, Part B: Mortality, pp. 7-693. For population data, c. f. c, below.

^bU. S. Brewers' Association, The Brewing Industry in the United States, Brewers' Almanac, 1973.

^cU. S. Bureau of the Census, 1970 Census of Population.

^dThese figures are for 1972, and are from U. S. Bureau of the Census, 1972 Census of Business.

^e"Hospitals," Journal of the American Hospital Association 44 (August 1, 1970), pp. 16-238.

^fCallahan (1970).

^gU. S. Bureau of Public Roads, Highway Statistics, 1970, p. 40.

^hCook and Tauchen (1984), pp. 187-188.

ⁱRand McNally Road Atlas, 1970.

Table 2. Regression Results: Low-density Sample

Variable	OLS Coefficient (T-statistic)	GLS Coefficient (T-statistic)
CONSTANT	-7.1572419 (-22.6331110)	-7.1318779 (-22.3347110)
ALCOHOL	0.0188667 (0.3870229)	0.0167802 (0.3350304)
COLLEGE	-0.0093741 (-1.4414030)	-0.0099292 (-1.5206900)
DUMZER	7.6033363 (126.8750400)	7.6282641 (125.4996300)
GASPOP	0.3090992 (10.0670050)	0.3756987 (8.6406813)
HOSPITAL	-0.0560008 (-1.5784110)	-0.0414374 (-1.1711810)
INCOME	-0.0000249 (-0.6097302)	-0.0000446 (-1.0801818)
INSP	-0.0139751 (-0.3366679)	-0.0126541 (-0.3057058)
LICREN	0.0163081 (1.0123894)	0.0171613 (1.0708294)
MALEYOUTH	0.0242469 (0.5986814)	-0.0433233 (-1.2649371)
MINAGE	-0.0379666 (-1.1027116)	0.0245302 (0.6091095)
PCHIGH	0.0000794 (0.3940665)	0.0000902 (0.4520788)
POPDEN	-0.0141711 (-8.0058058)	-0.0134802 (-7.6489218)
SPDLIM	-0.0047094 (-1.1240042)	-0.0049599 (-1.1792181)
Adjusted R Squared	0.9248640	0.9273890

Table 3. Regression Results- High-density sample

Variable	OLS Coefficient (T-statistic)	GLS Coefficient (T-statistic)
CONSTANT	-8.1815991 (-36.8762390)	-8.1970884 (-37.9119580)
ALCOHOL	0.0122238 (0.2968937)	0.0070495 (0.1751419)
COLLEGE	-0.0114256 (-2.8793799)	-0.0115324 (-3.0106177)
DUMZER	8.0344937 (39.3055460)	8.0534218 (39.3357270)
GASPOP	0.6732105 (3.9902865)	0.7065804 (4.3293379)
HOSPITAL	-0.0262931 (-0.7152097)	-0.0210101 (-0.5643039)
INCOME	-0.0000836 (-2.2414951)	-0.0000875 (-2.4305747)
INSP	0.0215120 (0.7408253)	0.0171899 (0.6066399)
LICREN	0.0187490 (1.5120914)	0.0219868 (1.7922323)
MALEYOUTH	-0.0003658 (-0.0136937)	0.0037978 (0.1450044)
MINAGE	-0.0201220 (-0.7687184)	-0.0168356 (-0.6577363)
PCHIGH	-0.0065513 (-3.7252015)	-0.0062256 (-3.6104614)
POPDEN	-0.0000525 (-7.8504233)	-0.0000516 (-8.3348760)
SPDLIM	0.0080450 (3.0536922)	0.0079514 (3.1169302)
Adjusted R Squared	0.5518260	0.8083530

Table 4. Hypothetical effects of changes in various independent variables for the Sample of Higher-density Counties

Variable Changed	Effects of change (per cent savings in fatalities)	
	10 per cent	20 per cent
Per cent change in variable		
Increase in per cent with college education	0.94	1.88
Increase in income	2.23	4.42
Increase in per cent with high school education	2.82	5.56
Decrease in speed limit	5.26	10.25

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