Trends in Socioeconomic Inequalities in Motor Vehicle Accident Deaths in the United States, 1995-2010

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Abbreviations: CI: Confidence interval; CPS: Current Population Survey; ICD: International Classification of Diseases; MVA: Motor vehicle accident; NHTS: National Household Transport Survey; NPTS: Nationwide Personal Transportation Survey; NVSS: National Vital Statistics System; PMT: Person-miles traveled; RII: Relative Index of Inequality; SEP: Socioeconomic Position; SII: Slope Index of Inequality; US: United States; VMT: Vehicle-miles traveled

Running head: Inequalities in motor vehicle accident mortality

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Data Sharing Statement: All of the publicly available data and statistical code for reproducing the results in this study are available with unrestricted open access from the corresponding author's Dataverse: http://dvn.iq.harvard.edu/dvn/dv/samharper

Abstract

Motor vehicle accident mortality has been declining overall, but little is known about trends by socioeconomic position. We examined trends in education-related inequalities in motor vehicle accident death rates from 1995-2010. We used deaths from the US National Center for Health Statistics and population estimates from the Current Population Survey, and we calculated vehicle- and person-miles traveled using the National Household Travel Survey. We used negative binomial regression to estimate crude and age-gender-race-adjusted mortality rates among adults ages 25 and over. We found larger mortality decreases among the more highly educated, and some evidence of mortality increases among the lowest educated. Adjusted death rates were 15.3 per 100,000 higher at the bottom versus the top of the education distribution in 1995, increasing to 17.9 (95% confidence interval [CI] 14.8,21.0) by 2010. In relative terms adjusted death rates were 2.4 (95%CI 1.7,3.0) times higher at the bottom versus the top of the education distribution in 1995, increasing to 4.3 times higher (95% CI 3.4,5.3) by 2010. Inequality increases were larger in terms of vehicle miles traveled. Although overall motor vehicle accident death rates declined during this period, socioeconomic differences in motor vehicle accident mortality have persisted or worsened over time.

Introduction

Deaths from motor vehicle accident-associated (MVA) injuries are among the leading causes of death in the United States, and are the leading cause for those ages 10-24.[1] In 2010, MVA injuries led to 35,332 deaths, with the highest death rates in those aged 15-24 and over the age of 75.[1] From 1958 to 2008, the US road traffic fatality rate per population declined by 40% and the fatality rate per distance driven declined by 76%, with the greatest declines being observed in the youngest and oldest ages.[2] These declines can be attributed to improvements in vehicle engineering, road design, emergency room care, and road safety legislation.[3] Legislation against alcohol-involved driving, such as 0.08g/dL blood alcohol concentration laws, sobriety checkpoints, and minimum legal drinking age laws, have reduced fatal and nonfatal crash injuries since they first were enacted in the 1970s.[4] Mandatory seat belt laws, particularly when robustly enforced, increase seat belt use and have reduced mortality since their introduction in 1984.[5,6] Alcohol impaired driving fatalities and safety restraint use have also improved.[7,8]

Although overall MVA mortality has declined substantially, persistent social inequalities remain. Rates among men are 2.5 times that of women, and rates in American Indians/Alaskan Natives are 2 to 5 times that of other race-ethnic groups.[9] Inequalities by socioeconomic position have been less well documented.[10,11] Some studies have found socioeconomic gradients at the neighborhood or state level, with MVA injuries and fatalities being more common in poorer regions as defined by income, poverty, and low education.[12-15] There have also been a few studies of socioeconomic inequalities in MVA-related mortality at the individual level. Lower educational status,[10,14,16] blue collar[14] or lower status occupations,[17] and lower incomes[14] have been associated with increased risk of traffic accident related mortality. Educational inequalities have also been observed when

examining risk status by annual vehicle trips.[10] Outside of the US, MVA-related injuries and deaths among adults in developed countries indicate evidence of similar socioeconomic gradients.[18-23]

The prior work on socioeconomic inequalities has limitations. No prior studies of individual socioeconomic position and MVA mortality have examined changes over time, which makes it difficult to know whether the national improvements have been shared equally. Moreover, no studies have assessed inequality trends using "exposure based" denominators that account for socioeconomic differences in the use of different modes of transport. Lower socioeconomic position is associated[24] with some modes of travel e.g., motorcycle, bicycle, walking that have higher mortality risks but also some with lower mortality risks e.g., bus travel.[25] We addresses this gap by examining crude and demographic-adjusted trends in MVA-associated mortality in the US in the years 1995 to 2010 by level of educational attainment. We estimate mortality rates both by population and by travel exposure and examine inequalities over time in absolute and relative terms.[26,27]

Methods

Data

Counts for MVA-related fatalities were obtained through the National Vital Statistics System NVSS from 1995 to 2010.[28] We included deaths of motor vehicle occupants, pedal cyclists, pedestrians, and other persons involving collisions between motor vehicles and fixed or moving objects, or motor vehicle non-collision accidents (e.g., fires, breakages, falls) occurring on public roadways or elsewhere. We used the ninth and tenth revisions of the International Classification of Diseases to classify the underlying cause of death from

MVAs for the periods 1995-1998, and 1999-2010, respectively (specific codes are listed in the footnote to Table 1). We aggregated deaths into strata based on age (25-34, 35-44, 45-54, 55-64, ≥65), gender, race (black, white, other or multiracial), educational attainment (less than high school, high school graduate or GED, some college or associate's degree, college graduate or higher), and year of death of the decedent. Age was restricted to those 25 and older to increase the likelihood that educational attainment would accurately reflect years of completed education.

We used two types of denominators for rate calculations: persons and miles traveled. The Current Population Survey (CPS) contains population counts by age, gender, race, and education, from which we estimated annual populations by averaging the monthly demographic totals over each year.[29] We also updated the sample with amended CPS extracts for years 2000-2002 which used corrected Census 2000 weights.[30] Consistent with previous studies,[31] we restricted our analysis to 45 states plus the District of Columbia, which are areas with at least 80% completeness of education reporting on death certificates in all years in 1995-2010 (see map in Web Figure 1). We estimated average miles traveled for demographic groups using data from the Nationwide Personal Transportation Survey (NPTS) in 1995 and the National Household Travel Survey (NHTS) in 2001 and 2009.[32-34] The NHTS/NPTS is a national telephone survey collecting data on trips made in a 24-hour period, which quantifies travel behavior and identifies traveler characteristics.[35] Because the NHTS/NPTS censored the identities of states with populations of less than 2 million persons in 1995 and 2001, we restricted the analyses using exposure-based denominators to 30 uncensored states shown in Web Figure 1 that also had ≥80% complete information on deaths by education.

We derived annual demographic totals of vehicle miles traveled (VMT) and a measure of person miles traveled (PMT) to estimate death rates as a function of travel exposure. VMT quantifies travel distance in privately owned vehicles and only records mileage of individuals who report driving vehicles. PMT quantifies travel distances for all forms of vehicular and non-vehicular transport for all occupants,[35] which is arguably more relevant for individuals of lower socioeconomic position, who are generally less likely to own cars. We modified the PMT measure by restricting it to forms of transport relevant to MVA fatalities, including privately owned vehicles, buses, streetcars, taxis, and vehicles for the disabled, in addition to non-motorized road transport such as cycling or walking.

The NHTS and NPTS were designed to be nationally representative of the civilian non-institutionalized population, but we found that respondents with low educational attainment were systematically underrepresented in 2009. For example, those aged 25+ with less than a high school education composed 13.2% of the US population but 9.4% of weighted NHTS. To account for possible under-coverage by education, we adjusted[10] the NHTS/NPTS person-weights by gender, race, age, and education category using the CPS as reference and regenerated adjusted travel day-weights used to estimate the VMT and PMT denominators. We used linear interpolation to generate annual estimates of VMT and modified PMT by demographic category from the benchmark years of 1995, 2001 and 2009, with extrapolation to 2010.

Statistical Analysis

To examine trends in MVA mortality rates per population and per miles of travel we fit a series of negative binomial regression models (Poisson models were overdispersed) with robust variance estimation and either persons or miles traveled as the offset.[36] Models

included fixed effects for each education group, each year, and product terms between the fixed effects for education and year. We used the *margins* command in Stata software version 12, (Statacorp, College Station, TX) to estimate marginal predicted incidence rates and standard errors using the delta method. We estimated overall and education-specific rates of MVA mortality, and calculated both crude rates and rates adjusted for age, gender, and race. To examine how inequalities in MVA deaths by educational attainment changed over time, we estimated mortality rate changes by education group between 1995 and 2010, and differences between education categories in each year. To see whether education-specific mortality trends were consistent across all races and sexes, we included a 3-way product term between education, year and race or sex and tested whether racial or gender differences in the education-specific rate trends were jointly equal to zero.

In additional to estimating differences in mortality for each education group, we also calculated the Slope and Relative Index of Inequality (SII[37] and RII,[26] respectively) in each year. The SII and RII take account of all education groups and account for changes over time in the distribution of education, which is particularly relevant as between 1995 and 2010 there was a shift towards higher education (the proportion of those 25 and older with a college degree or more increased from 23% in 1995 to 30% in 2010). For these measures we ranked the population by categories of education from highest to lowest in each year and calculated for each group the midpoint of its position in the cumulative distribution of the population (ridit score). We then used negative binomial models to regress deaths on the ridit score and covariates, and obtained marginal predictions of death rates. The SII represents the estimated absolute difference in mortality going from the top to the bottom of the cumulative education distribution educational category i.e., from 0 to 1.[37] We

calculated the Relative Index of Inequality as the ratio of predicted mortality rates at the bottom versus the top of the education distribution.[38,39]

Sensitivity Analyses

There are differences in coding of educational attainment by states over time, as some states revised the coding of education on death certificates after 1989. To test whether this had any impact on the trends we restricted our analysis to a sample of 16 states using the original 1989 form of education coding consistently throughout the sample period. We also assessed the robustness of our restriction to 80% completeness of education reporting by examining mortality rates in all states irrespective of missing educational information. Additionally, given some evidence of misclassification of education on death certificates (largely biased toward higher years/degree status), we implemented correction ratios based on a prior linkage study.[40] We multiplied observed death counts by the published correction ratio in each education group, separately for men and women, to obtain misclassification-corrected numbers of deaths. With respect to exposure-based denominators, we also performed sensitivity analysis to estimate the potential impact of misclassification of VMT/PMT. More highly educated individuals were more likely to have used travel diaries, which capture 0.5 more daily trips on average that recall alone.[41] We revised the age-gender-race-education-specific VMT/PMT for individuals who reported not using a travel diary by adding VMT/PMT implied by an additional 0.5 trip multiplied by their average travel distance used for this form of travel. We also re-estimated our analyses without adjusting the travel surveys for underrepresentation by education.

Results

Between 1995 and 2010 overall MVA mortality rates fell by 15-25% depending on whether they are measured as a function of population, VMT, or PMT (Table 1). Crude mortality rates were higher in men, blacks, and individuals 65 years of age or older. Crude mortality rates were highest in those with less than a high school education and decreased with ascending categories of educational attainment.

Education-specific trends in rates adjusted for age, gender, and race showed gradual declines in mortality in all groups when measured by population (Figure 1), but we found larger declines in mortality rates between 1995 and 2010 among college graduates (-6.4 deaths per 100,000 population, 95% confidence interval [CI] -8.9, -4.0) and high school graduates (-6.5 deaths per 100,000 population, 95% CI -8.6, -4.3, Table 2). While the mortality gap between high school graduates and college graduates was relatively constant over time, the gap between college graduates and those with some college increased by 3.8 deaths per 100,000 (95% CI 1.0, 6.7), from 0.30 in 1995 to 4.11 in 2010. Notably, all groups experienced a sharp decline in death rates around 2008, around the time of the large economic recession.

The two summary measures of inequality were also consistent with a pattern of increasing inequality. In 1995 the SII suggests that moving from the top to the bottom of the education distribution increased estimated mortality rates by 15.3 deaths per 100,000 (95% CI 10.7, 19.9). In relative terms this is more than a doubling of rates (RII = 2.4, 95% CI 1.8, 3.0). Between 1995 and 2010 both relative and absolute inequalities increased, but only the change in the RII was statistically distinguishable from zero.

Table 3 shows estimates for 30 states that permitted calculation of both population-based and exposure-based denominators. The population-based estimates and trends for this

subset of states were nearly identical to those for the 45 states plus DC. Figure 2 shows trends in deaths rates per 100 million VMT (trends per 100 million PMT were similar), and demonstrates a widening gap between those with less than a high school degree and all other groups. In fact, adjusted rates among those with less than a high school education actually increased by 2.75 (95% CI 0.29, 5.21) deaths per 100 million VMT, and 0.95 (95%CI -0.09, 1.99) deaths per 100 million PMT (Table 3). For exposure-based denominators, death rates for groups with at least a high school education generally decreased by a similar magnitude. We found no evidence that the relationship between education and mortality over time was modified on the additive scale by either race or gender (all $p>0.97$).

Summary measures of inequalities in exposure-based rates increased whether measured on the absolute or relative scale, though the increases were much larger on the relative scale (Table 3). The SII increased by 3 deaths per 100 million VMT (95% CI 0.3, 5.7) or 1.2 deaths per 100 million PMT (95% CI 0.0, 2.4) between 1995 and 2010. The ratio of death rates per 100 million VMT at the bottom versus the top of the education distribution increased from 5.6 to 21.4, an increase of 15.8 (95% CI 6.2, 25.3). Inequalities were generally smaller when estimated using deaths per 100 million PMT.

Sensitivity analyses restricting to the set of 16 US states using the original 1989 educational attainment coding on the death certificate suggested slightly larger inequalities (Web Table 1), but trends were quantitatively similar to the main results. National trends using all states irrespective of completeness of education reporting on death certificates were nearly identical to the estimates on our restricted sample of 30 states in Table 3 (Web Table 2). Adjustment for misclassification of education reporting on death certificates[40] (Web Table 3) estimated on the entire sample led to slightly larger education gradients in death rates, but changes over time were similar to our main results in Table 3, as were

adjustments for potential misreporting of VMT/PMT (Web Table 4). Finally, Web Table 5 shows larger increases in inequalities over time without our adjustments to increase the representativeness of travel weights.

Discussion

In this study we document strong socioeconomic patterning of MVA mortality and present some evidence that educational inequalities have increased between 1995 and 2010. Higher educated groups generally showed stronger declines in death rates over time, leading to increases in summary measures of inequality. The increases in inequality were particularly evident when using travel exposure-based denominators to calculate death rates, and were driven largely by increases in mortality rates among those with less than a high school education. The increase in exposure-based death rates we observe among those with less than a high school degree is especially striking given that overall MVA mortality rates are generally declining, though this finding must be viewed in light of several study limitations described below.

Consistent with prior evidence on recessions and traffic accident deaths,[42,43] we found that death rates decreased after the Great Recession in 2007 (Figures 1 and 2), with some indication that the absolute decrease was larger among the less educated. This may have kept educational inequalities from increasing more than they would have in the absence of the recession. Cotti and Tefft[44] provide evidence that most of the decrease comes from reductions in alcohol-related fatal crashes and fewer crashes per mile traveled, which also suggests that less educated groups may have derived some relative benefits of the recession in terms of fatal crashes avoided.

In comparing population-based versus exposure-based denominators, we found that relative educational inequalities in death rates were roughly twice as large after taking travel exposure into account. Since the late 1990s deaths per miles traveled have increased among those with the lowest education, widening inequalities to a larger extent than on a per-population basis. This suggests that characteristics of low SEP travelers, their vehicles, and the accidents they are involved in are important components of rising inequality. We additionally found that measured inequalities were larger when measured using PMT, likely by accounting for transport by bus, taxi, or walking, forms of transport that are more common among lower SEP individuals,[24] but are generally associated with lower exposure-based risk.

The excess risk among those with low education is likely due to several factors, including behavioral, contextual, and vehicle-related factors. Lower SEP has been associated with ownership of vehicles with lower crash-test ratings and absence of advanced vehicle safety features.[45] Taking account of miles-traveled may also relate to features such as rurality, which has been associated with greater overall risk of mortality[46] and mortality in the less educated.[10] Changing area characteristics may also have relevance, as rural and higher-poverty areas have seen declines in the presence of hospital trauma centers over time,[47] which may have increased MVA mortality in low SEP groups given limited access to trauma specialists.[48]

Despite the success of drunk-driving laws,[4] lower education has also been associated with higher blood alcohol concentration among crash victims in the US,[10] although studies relying on self-reports of drunk driving do not show socioeconomic gradients.[49,50] Less ambiguous is seat belt use,[5] where several studies show lower adherence in less educated individuals.[10,49,51-54] However, as seat belt use has increased faster among the less

educated,[55] educational inequalities in seat belt use have been declining, most likely due to greater responsiveness to mandatory seat belt laws.[56] Trends in seat belt use are thus somewhat inconsistent with our evidence that educational inequalities in death rates have increased, which suggests that mechanisms other than seat belt use may play an important role in explaining differences in MVA risk. Farmer and Lund[57] found that improvements to vehicle safety have played an important role in reducing MVA death rates, particularly since the mid-1990s. To the extent that rate of diffusion of safer vehicles lags among lower SEP groups because of higher costs or other mechanisms,[58] this may also serve as a contributing cause to increasing inequalities in MVAs.

There are some limitations to our analyses. First, we interpolated miles traveled between 2001 and 2009 based on surveys that allowed estimation by socioeconomic group. There is evidence that the Great Recession reduced vehicle miles traveled,[44] so we may have underestimated miles traveled in the years prior to the recession. To the extent that less educated groups reduced their miles traveled more than higher educated groups, this could have led to some overestimation of the education-related gradient in death rates between 2001 and 2009. Second, we used education as a measure of socioeconomic position but alternative indicators (such as income) could show different trends were they available on death certificates. One recent linkage study showed that both higher income and higher education demonstrated inverse associations with motor vehicle accident death using data from the US National Health Interview Survey, but data on MVA trends by income are scarce.[59] More importantly, educational attainment in the NVSS was based on years of education completed from 1989-2002 but on a revised item identifying degree conferred from 2003 onward, which was gradually adopted by states 31 states and DC in 2010. The 2003 revision identifies 2% more individuals with less than high school, 13% fewer

individuals with high school/GED, and 8% more individuals with some college.[1,60] Our sensitivity analyses on a subset of states predominately using the original education coding (Web Table 1) largely validated the robustness of our findings, although it showed weaker evidence of increases in mortality in the lowest educational group by PMT over time.

Third, creating sub-national samples of the NHTS/NPTS or the CPS could have led to measurement error in exposure-based denominators, since these surveys are primarily designed to be nationally representative. Our adjustments to travel survey weights to account for underrepresentation of low-educated groups may be conservative, as estimates without any adjustments showed larger increases in socioeconomic gradients. Fourth, the NHTS/NPTS is based on self-report and may lead to travel estimates measured with error, particularly measures recalling miles of travel. In all survey cycles, respondents were sent a travel diary to aid recall,[32-34] which were used by 75-80% of those reporting travel. Our sensitivity analyses adjusting for education-specific differences in the use of diaries were consistent with unadjusted results.

Our findings suggest that additional work should investigate underlying risk factors of MVA death at the individual or community level, with particular focus on how the distributions of these risk factors by education have changed over time. One potential strategy for evaluating risk factors by education would be data linkage between the Fatal Accident Reporting System and death certificate data, which as been previously explored cross-sectionally[10] but not longitudinally. Examining the sensitivity or relative benefit of different socioeconomic groups to road safety legislation would also seem worthwhile. Although we found declines overall in overall MVA mortality, it is apparent that these declines have not impacted all education groups equally and MVAs continue to contribute to the excess mortality among socioeconomically disadvantaged populations.

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Table 1: Crude death counts and rates for motor vehicle accident associated deaths by population, vehicle miles traveled VMT, and person miles traveled PMT among US adults aged 25+ by demographics, 1995-2010

		1995					2010				
		Population-based denominators[b]		Exposure-based denominators[c]			Population-based denominators[b]		Exposure-based denominators[c]		
		Deaths[a]	Rate per 100,000 population	Deaths[a]	Rate per 100 million VMT	Rate per 100 million PMT	Deaths[a]	Rate per 100,000 population	Deaths[a]	Rate per 100 million VMT	Rate per 100 million PMT
Gender	Male	17491	23.57	16107	1.69	1.43	16772	18.61	15381	1.54	1.29
	Female	8801	10.75	8167	1.46	0.90	7125	7.33	6492	1.01	0.66
Race	White	22204	16.71	20455	1.53	1.15	20076	13.10	18309	1.33	1.01
	Black	3124	18.59	3031	2.37	1.65	2894	13.90	2820	1.68	1.26
	Other	964	14.99	788	1.60	1.22	927	7.00	744	0.78	0.55
Education	< High School	7197	25.71	6722	3.81	2.58	4921	20.57	4590	4.14	2.70
	High School	11424	21.62	10551	2.15	1.57	10565	18.25	9650	2.10	1.53
	Some College	4252	10.94	3879	0.93	0.71	5025	10.26	4551	0.97	0.76
	College Graduate	3419	9.40	3122	0.72	0.56	3386	6.00	3082	0.51	0.40
Age	25 to 34	7206	18.79	6665	1.58	1.19	5211	13.60	4775	1.47	1.10
	35 to 44	5854	14.78	5374	1.19	0.94	4249	11.34	3890	0.99	0.76
	45 to 54	3815	13.11	3518	1.10	0.84	4792	11.58	4394	1.03	0.81
	55 to 64	2696	13.87	2487	1.41	1.01	3885	11.55	3558	1.17	0.89
	65+	6721	22.70	6230	4.19	2.66	5760	15.79	5256	2.72	1.85
Total		26292	16.84	24274	1.60	1.19	23897	12.76	21873	1.33	1.01

[a] ICD-10 codes: V02–V04, V09.0, V09.2, V12–V14, V19.0– V19.2, V19.4–V19.6, V20–V79, V80.3–V80.5, V81.0–V81.1, V82.0–V82.1, V83–V86, V87.0–V87.8, V88.0–V88.8, V89.0, V89.2.

[b] Based on aggregate of 45 states plus DC see Web Figure 1 for map of states.

[c] Based on aggregate of 30 states see Web Figure 1 for map of states.

Table 2: Age-gender-race adjusted motor vehicle accident death rates per 100,000 population by categories of educational attainment among adults aged 25 and over, 45 US States and District of Columbia

	1995			2010			Change from 1995 to 2010			
Education	Rate[a]	RD[b]	95% CI	Rate	RD	95% CI	Rate	95% CI	RD	95% CI
Less than High School	22.09	9.74	6.18, 13.30	18.43	12.49	10.17, 14.81	-3.66	-7.12, -0.21	2.75	-1.48, 6.98
High School Graduate/GED	22.15	9.80	6.96, 12.64	15.68	9.74	8.12, 11.36	-6.47	-8.64, -4.31	-0.06	-3.32, 3.19
Some College/Associate's Degree	12.64	0.30	-2.34, 2.94	10.05	4.11	3.00, 5.22	-2.59	-4.10, -1.08	3.82	0.95, 6.68
College Graduate	12.35	--		5.94	--		-6.41	-8.86, -3.96	--	
Slope Index of Inequality SII		15.30	10.67, 19.92		17.87	14.80, 20.95			2.58	-2.94, 8.09
Relative Index of Inequality RII		2.36	1.77, 2.96		4.33	3.39, 5.27			1.97	0.85, 3.08

Abbreviations: RD, Rate difference

Table 3: Age-gender-race adjusted motor vehicle accident death rates per population and travel exposure by categories of educational attainment among adults aged 25 and over, 30 US states[a]

	1995			2010			Change from 1995 to 2010			
Denominator and Education	Rate	RD	95% CI	Rate	RD	95% CI	Rate	95% CI	RD	95% CI
Per 100,000 Population										
Less than High School	21.85	9.51	5.78, 13.24	18.06	12.22	9.90, 14.53	-3.79	-7.32, -0.26	2.71	-1.67, 7.08
High School Graduate/GED	22.05	9.72	6.63, 12.80	15.42	9.58	7.94, 11.21	-6.64	-8.99, -4.28	-0.14	-3.62, 3.34
Some College/Associate's Degree	12.02	-0.32	-3.00, 2.37	9.74	3.90	2.83, 4.96	-2.28	-3.60, -0.97	4.22	1.33, 7.11
College Graduate	12.34	--		5.84	--		-6.50	-9.08, -3.91	--	
Slope Index of Inequality SII		15.21	10.37, 20.05		17.56	14.51, 20.61			2.35	-3.33, 8.04
Relative Index of Inequality RII		2.38	1.74, 3.02		4.35	3.41, 5.29			1.97	0.84, 3.11
Per 100 Million Vehicle Miles Traveled										
Less than High School	4.75	3.42	2.62, 4.21	7.50	6.86	4.50, 9.22	2.75	0.29, 5.21	3.44	0.95, 5.93
High School Graduate/GED	3.30	1.96	1.40, 2.53	2.36	1.72	1.34, 2.10	-0.93	-1.53, -0.34	-0.24	-0.92, 0.44
Some College/Associate's Degree	1.49	0.15	-0.25, 0.56	1.11	0.47	0.29, 0.65	-0.38	-0.67, -0.09	0.31	-0.13, 0.76
College Graduate	1.33	--		0.64	--		-0.69	-1.03, -0.35	--	
Slope Index of Inequality SII		4.92	3.80, 6.05		7.93	5.49, 10.37			3.01	0.33, 5.68
Relative Index of Inequality RII		5.61	3.76, 7.46		21.37	12.05, 30.69			15.76	6.24, 25.28
Per 100 Million Person Miles Traveled										
Less than High School	2.69	1.77	1.35, 2.19	3.64	3.20	2.22, 4.17	0.95	-0.09, 1.99	1.43	0.36, 2.49
High School Graduate/GED	2.17	1.25	0.88, 1.62	1.51	1.07	0.84, 1.29	-0.66	-1.04, -0.28	-0.18	-0.62, 0.25
Some College/Associate's Degree	0.96	0.04	-0.20, 0.28	0.80	0.36	0.25, 0.46	-0.16	-0.31, -0.01	0.32	0.05, 0.58
College Graduate	0.92	--		0.45	--		-0.48	-0.69, -0.26	--	
Slope Index of Inequality SII		2.66	2.06, 3.27		3.86	2.85, 4.87			1.19	0.02, 2.37
Relative Index of Inequality RII		4.53	3.17, 5.89		13.61	8.68, 18.53			9.08	3.95, 14.21

Abbreviations: RD, rate difference.

[a] Marginal predicted rates after negative binomial regression see Methods for details. See Web Figure 1 for map of states.

Figure 1. Age-gender-race adjusted trends in motor vehicle accident deaths per 100,000 population by categ
education among those aged 25 and over, 45 US states and District of Columbia.

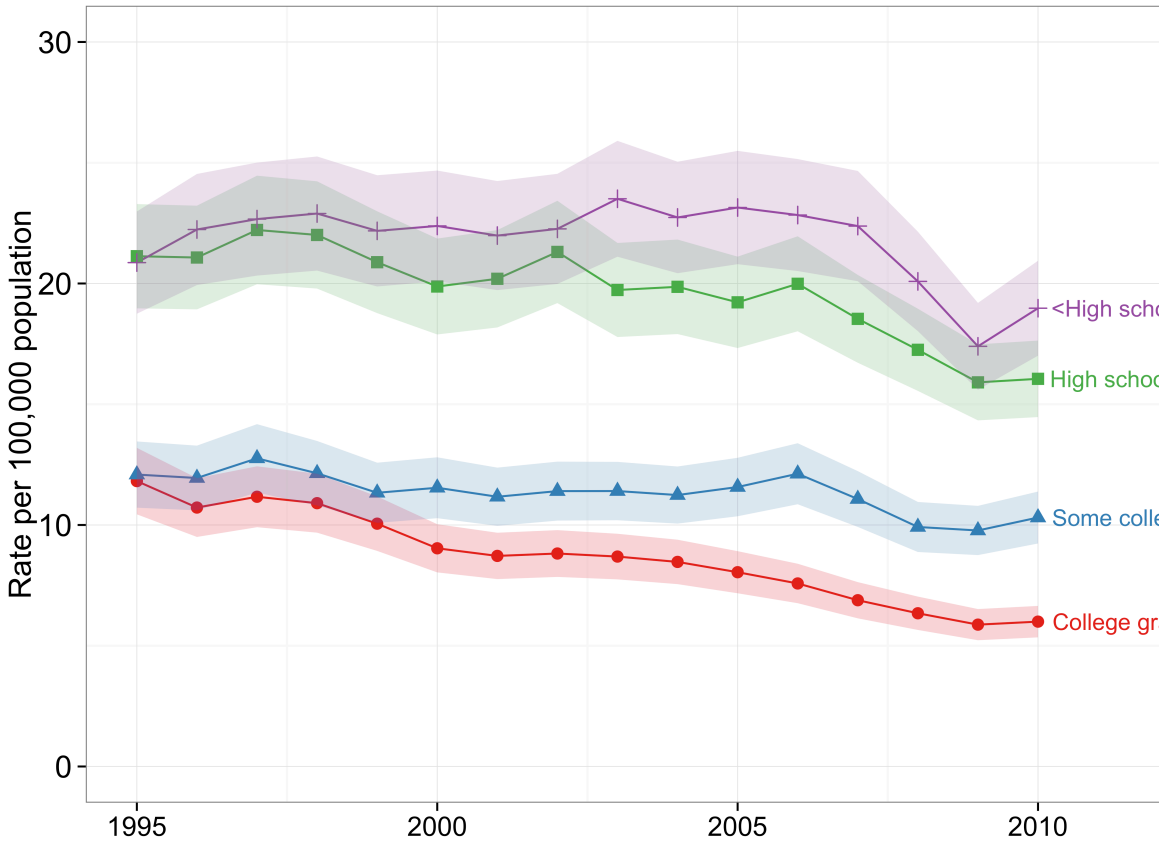
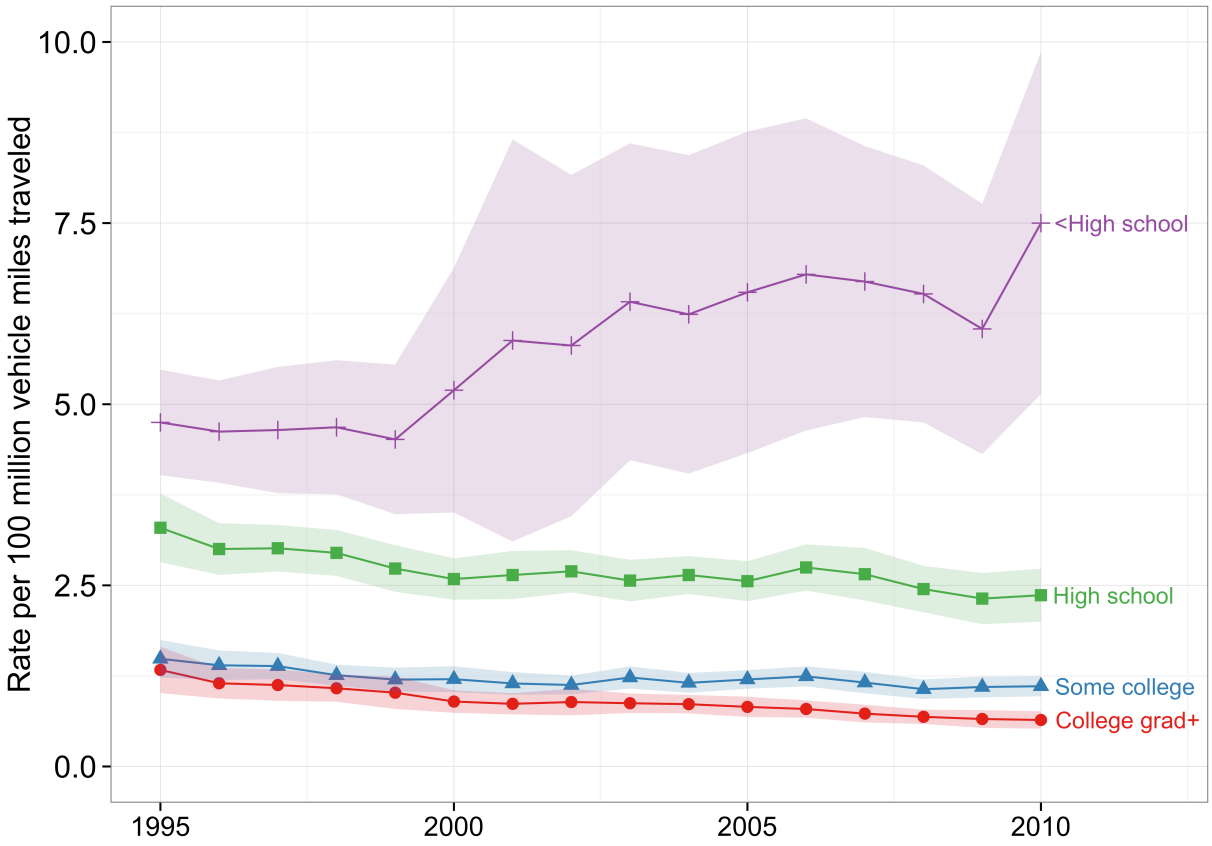
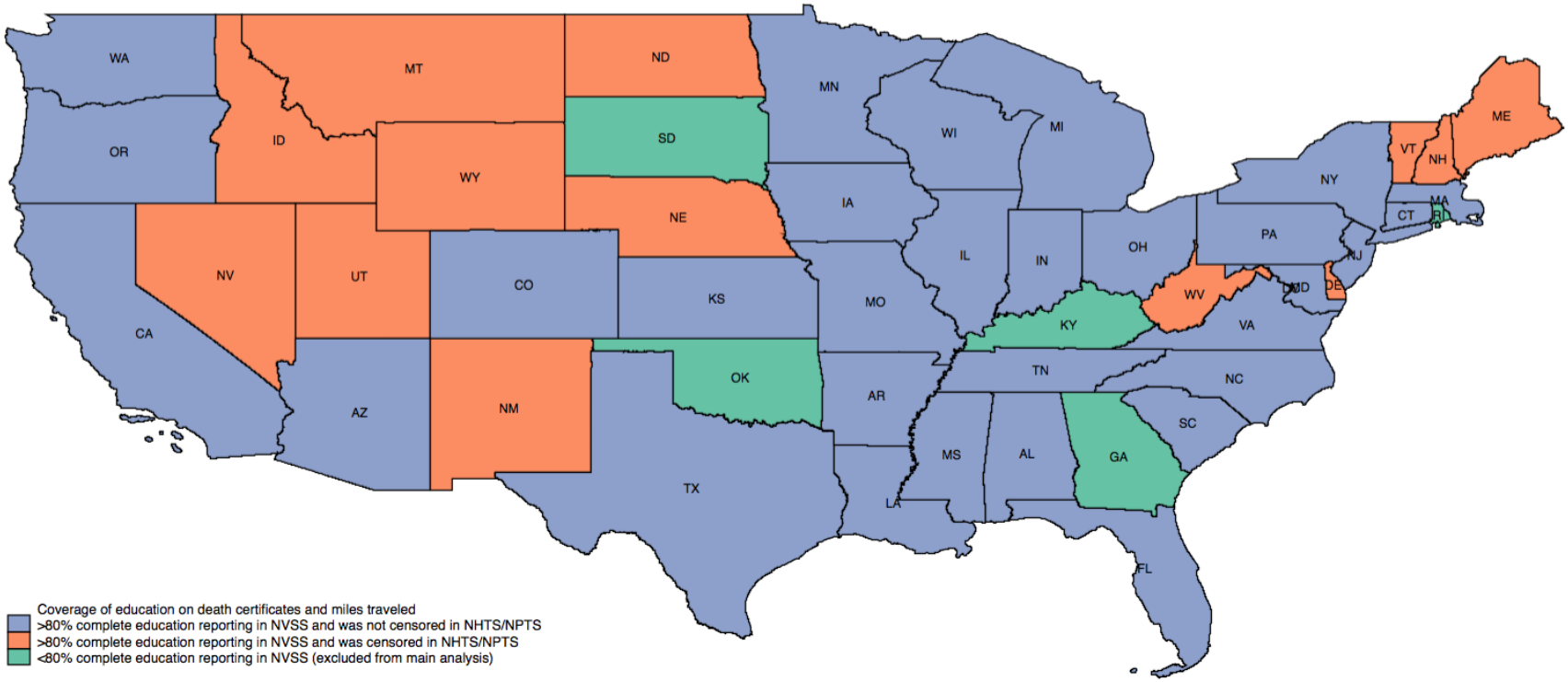


Figure 2. Age-gender-race adjusted trends in motor vehicle accident deaths per 100 million vehicle miles traveled by category of education among those aged 25 and over, 30 US states.



Web Figure 1: US states used in population-based and exposure-based analyses.



Note: Alaska (AK) and Hawaii (HI) are not shown but have >80% complete education reporting and censored miles.

Web Table 1: Age-gender-race adjusted motor vehicle accident death rates per population and travel exposure by categories of educational attainment among adults aged 25 and over, US states predominately using original (1989) educational attainment coding, 1995-2010.[a]

	1995			2010			Change from 1995 to 2010			
Denominator and Education	Rate[a]	RD[b]	95% CI	Rate	RD	95% CI	Rate	95% CI	RD	95% CI
Per 100,000 Population[b]										
Less than High School	26.52	14.78	(10.17, 19.39)	22.78	16.21	(13.31, 19.10)	-3.74	(-8.25, 0.78)	1.42	(-3.98, 6.83)
High School Graduate/GED	21.56	9.83	(6.05, 13.60)	17.16	10.58	(8.48, 12.69)	-4.40	(-7.52, -1.29)	0.76	(-3.54, 5.05)
Some College/Associate's Degree	11.94	0.20	(-2.86, 3.27)	10.17	3.59	(2.19, 4.99)	-1.77	(-3.33, -0.21)	3.39	(0.03, 6.75)
College Graduate	11.73	--		6.57	--		-5.16	(-8.14, -2.18)	--	
Slope Index of Inequality		21.58	(15.48, 27.67)		21.88	(18.13, 25.63)			0.30	(-6.77, 7.37)
Relative Index of Inequality		3.18	(2.21, 4.14)		4.99	(3.79, 6.18)			1.81	(0.28, 3.35)

	1995			2009[d]			Change from 1995 to 2009[d]			
	Rate[a]	RD[b]	95% CI	Rate	RD	95% CI	Rate	95% CI	RD	95% CI
Per 100 Million Person-Miles of Travel[c]										
Less than High School	3.42	2.50	(1.62, 3.39)	3.38	2.83	(1.88, 3.79)	-0.04	(-1.31, 1.23)	0.33	(-0.97, 1.62)
High School Graduate/GED	2.04	1.12	(0.66, 1.59)	1.63	1.09	(0.81, 1.36)	-0.40	(-0.88, 0.07)	-0.04	(-0.58, 0.50)
Some College/Associate's Degree	0.95	0.04	(-0.24, 0.32)	0.79	0.24	(0.10, 0.39)	-0.17	(-0.36, 0.03)	0.20	(-0.11, 0.52)
College Graduate	0.91	--		0.54	--		-0.37	(-0.62, -0.12)	--	
Slope Index of Inequality		3.44	(2.34, 4.55)		3.41	(2.43, 4.40)			-0.03	(-1.49, 1.43)
Relative Index of Inequality		5.99	(3.56, 8.41)		10.23	(6.13, 14.34)			4.25	(-0.53, 9.03)

Abbreviations: RD, rate difference; GED: general education development

[a] Marginal predicted rates after negative binomial regression.

[b] US population of 16 states: AL, AK, CO, HI, IA, LA, MD, MA, MN, MS, NC, PA, TN, VA, WV, WI

[c] US population of 13 states: AL, CO, IA, LA, MD, MA, MN, MS, NC, PA, TN, VA, WI; CPS-reweighted NHTS/NPTS estimates. There was insufficient data to estimate VMT in this restricted sample of states.

[d] To avoid extrapolation of negative values of PMT in some strata in 2010 we restricted the time period to 1995-2009.

Web Table 2: Age-gender-race adjusted motor vehicle accident death rates per population and travel exposure by categories of educational attainment among adults aged 25 and over, all US states and District of Columbia irrespective of completeness of educational attainment on death records, 1995-2010.[a]

	1995			2010			Change from 1995 and 2010			
Denominator and Education	Rate	RD	95% CI	Rate	RD	95% CI	Rate	95% CI	RD	95% CI
Per 100,000 Population										
Less than High School	20.86	9.05	(5.67, 12.42)	18.98	12.98	(10.55, 15.41)	-1.89	(-5.31, 1.53)	3.93	(-0.21, 8.07)
High School Graduate/GED	21.13	9.31	(6.65, 11.98)	16.05	10.05	(8.45, 11.66)	-5.08	(-7.13, -3.03)	0.74	(-2.36, 3.84)
Some College/Associate's Degree	12.09	0.27	(-2.22, 2.76)	10.31	4.31	(3.22, 5.40)	-1.78	(-3.19, -0.37)	4.04	(1.32, 6.76)
College Graduate	11.82			6.00	--		-5.82	(-8.15, -3.49)	--	
Slope Index of Inequality		14.29	(9.92, 18.66)		18.54	(15.36, 21.72)			4.25	(-1.12, 9.63)
Relative Index of Inequality		2.33	(1.74, 2.91)		4.41	(3.45, 5.37)			2.08	(0.96, 3.21)
Per 100 Million Vehicle-Miles of Travel										
Less than High School	4.46	3.24	(2.62, 3.86)	7.53	6.89	(4.33, 9.45)	3.07	(0.46, 5.69)	3.65	(1.01, 6.28)
High School Graduate/GED	3.03	1.81	(1.36, 2.26)	2.52	1.88	(1.46, 2.29)	-0.51	(-1.06, 0.04)	0.07	(-0.55, 0.68)
Some College/Associate's Degree	1.41	0.19	(-0.14, 0.53)	1.18	0.54	(0.36, 0.73)	-0.22	(-0.49, 0.05)	0.35	(-0.03, 0.73)
College Graduate	1.22	--		0.64	--		-0.57	(-0.85, -0.30)	--	
Slope Index of Inequality		4.63	(3.73, 5.52)		8.16	(5.53, 10.78)			3.53	(0.76, 6.29)
Relative Index of Inequality		5.73	(4.11, 7.35)		21.32	(11.73, 30.91)			15.59	(5.85, 25.34)
Per 100 Million Person-Miles of Travel										
Less than High School	2.45	1.58	(1.26, 1.91)	3.38	2.92	(2.11, 3.73)	0.93	(0.07, 1.78)	1.33	(0.46, 2.21)
High School Graduate/GED	2.02	1.16	(0.83, 1.48)	1.61	1.15	(0.92, 1.39)	-0.41	(-0.76, -0.06)	-0.00	(-0.40, 0.39)
Some College/Associate's Degree	0.94	0.07	(-0.14, 0.28)	0.86	0.40	(0.29, 0.51)	-0.08	(-0.23, 0.07)	0.33	(0.09, 0.57)
College Graduate	0.87	--		0.46	--		-0.41	(-0.6, -0.22)	--	
Slope Index of Inequality		2.39	(1.90, 2.88)		3.68	(2.81, 4.55)			1.29	(0.29, 2.28)
Relative Index of Inequality		4.31	(3.16, 5.46)		12.14	(8.11, 16.16)			7.83	(3.63, 12.03)

Abbreviations: RD, rate difference; GED: general education development

[a] Marginal predicted rates after negative binomial regression.

Web Table 3: Age-gender-race adjusted motor vehicle accident death rates per population and travel exposure by categories of educational attainment among adults aged 25 and over, US states and District of Columbia with mortality counts adjusted for classification of educational attainment and death certificate measurement error, 1995-2010.[a]

	1995			2010			Change from 1995 and 2010			
Denominator and Education	Rate	RD	95% CI	Rate	RD	95% CI	Rate	95% CI	RD	95% CI
Per 100,000 Population[b]										
Less than High School	26.43	15.44	(11.69, 19.19)	22.05	16.70	(14.14, 19.27)	-4.38	(-8.33, -0.42)	1.26	(-3.24, 5.77)
High School Graduate/GED	18.02	7.03	(4.60, 9.47)	12.86	7.51	(6.17, 8.86)	-5.16	(-6.90, -3.41)	0.48	(-2.29, 3.25)
Some College/Associate's Degree	14.31	3.33	(0.80, 5.85)	11.35	6.00	(4.90, 7.09)	-2.97	(-4.68, -1.25)	2.67	(-0.08, 5.43)
College Graduate	10.99	--		5.35	--		-5.64	(-7.81, -3.47)	--	
Slope Index of Inequality		19.08	(14.40, 23.77)		20.20	(17.01, 23.39)			1.11	(-4.49, 6.72)
Relative Index of Inequality		2.90	(2.19, 3.60)		5.09	(4.00, 6.18)			2.19	(0.89, 3.49)
Per 100 Million Vehicle-Miles of Travel[c]										
Less than High School	5.73	4.54	(3.61, 5.47)	9.04	8.46	(5.69, 11.24)	3.30	(0.40, 6.20)	3.92	(1.00, 6.84)
High School Graduate/GED	2.67	1.48	(1.01, 1.95)	1.93	1.35	(1.04, 1.66)	-0.74	(-1.22, -0.26)	-0.13	(-0.69, 0.44)
Some College/Associate's Degree	1.69	0.50	(0.09, 0.90)	1.25	0.67	(0.49, 0.86)	-0.44	(-0.78, -0.10)	0.18	(-0.27, 0.62)
College Graduate	1.19	--		0.58	--		-0.61	(-0.91, -0.31)	--	
Slope Index of Inequality		5.72	(4.46, 6.98)		9.22	(6.25, 12.19)			3.50	(0.30, 6.70)
Relative Index of Inequality		6.94	(4.66, 9.22)		27.55	(15.17, 39.92)			20.60	(8.00, 33.21)
Per 100 Million Person-Miles of Travel[c]										
Less than High School	3.24	2.41	(1.95, 2.88)	4.40	4.00	(2.82, 5.18)	1.17	(-0.09, 2.42)	1.59	(0.32, 2.86)
High School Graduate/GED	1.75	0.93	(0.62, 1.24)	1.24	0.83	(0.65, 1.02)	-0.52	(-0.82, -0.21)	-0.10	(-0.45, 0.26)
Some College/Associate's Degree	1.09	0.27	(0.03, 0.50)	0.91	0.50	(0.40, 0.61)	-0.19	(-0.37, -0.01)	0.23	(-0.03, 0.49)
College Graduate	0.82	--		0.40	--		-0.42	(-0.61, -0.23)	--	
Slope Index of Inequality		3.10	(2.45, 3.75)		4.46	(3.20, 5.71)			1.36	(-0.05, 2.76)
Relative Index of Inequality		5.57	(3.94, 7.20)		17.21	(10.61, 23.81)			11.64	(4.81, 18.47)

Abbreviations: RD, rate difference; GED, general education development

[a] Marginal predicted rates after negative binomial regression. Death counts adjusted using gender-specific correction ratios published in Rostron BL, Boies JL, Arias E. Education reporting and classification on death certificates in the United States. Hyattsville, MD: U.S. Dept. of Health and Human Services, Centers for Disease Control and Prevention; 2010.

[b] US population of 45 states plus the District of Columbia. See Web Figure 1 for map of states.

[c] US population of 30 states. See Web Figure 1 for map of states.

Web Table 4: Age-gender-race adjusted motor vehicle accident death rates per travel exposure by categories of educational attainment among adults aged 25 and over, 30 US states, adjusting for potential differential measurement error among respondents not using travel diary

	1995			2010			Change from 1995 to 2010			
Denominator and Education	Rate	RD	95% CI	Rate	RD	95% CI	Rate	95% CI	RD	95% CI
Per 100 Million Vehicle-Miles of Travel										
Less than High School	4.53	3.23	(2.47, 3.99)	7.01	6.39	(4.19, 8.58)	2.48	(0.19, 4.77)	3.15	(0.83, 5.47)
High School Graduate/GED	3.16	1.86	(1.31, 2.42)	2.26	1.64	(1.27, 2.00)	-0.90	(-1.48, -0.32)	-0.23	(-0.89, 0.44)
Some College/Associate's Degree	1.43	0.13	(-0.25, 0.52)	1.07	0.45	(0.28, 0.62)	-0.36	(-0.63, -0.09)	0.31	(-0.11, 0.74)
College Graduate	1.30	--		0.62	--		-0.67	(-1.01, -0.34)	--	
Slope Index of Inequality		4.65	(3.58, 5.73)		7.40	(5.14, 9.67)			2.75	(0.25, 5.25)
Relative Index of Inequality		5.49	(3.68, 7.30)		20.47	(11.60, 29.33)			14.98	(5.91, 24.05)
Per 100 Million Person-Miles of Travel										
Less than High School	2.57	1.67	(1.27, 2.07)	3.40	2.97	(2.05, 3.88)	0.83	(-0.14, 1.81)	1.30	(0.30, 2.30)
High School Graduate/GED	2.08	1.18	(0.82, 1.55)	1.42	0.99	(0.78, 1.20)	-0.66	(-1.03, -0.29)	-0.19	(-0.62, 0.23)
Some College/Associate's Degree	0.92	0.03	(-0.21, 0.27)	0.77	0.34	(0.24, 0.44)	-0.15	(-0.30, -0.00)	0.31	(0.06, 0.57)
College Graduate	0.90	--		0.43	--		-0.46	(-0.68, -0.25)	--	
Slope Index of Inequality		2.51	(1.93, 3.10)		3.57	(2.63, 4.51)			1.06	(-0.05, 2.17)
Relative Index of Inequality		4.43	(3.09, 5.78)		12.99	(8.27, 17.70)			8.55	(3.63, 13.48)

Abbreviations: RD, rate difference; GED, general education development

[a] Marginal predicted rates after negative binomial regression . See Web Figure 1 for map of states

Web Table 5: Age-gender-race adjusted motor vehicle accident death rates per population and travel exposure by categories of educational attainment among adults aged 25 and over, 30 US states with no adjustment of travel weights[a]

	1995			2010			Change from 1995 to 2010			
Denominator and Education	Rate	RD	95% CI	Rate	RD	95% CI	Rate	95% CI	RD	95% CI
Per 100 Million Vehicle-Miles of Travel										
Less than High School	6.15	5.20	(3.99, 6.41)	11.88	11.30	(6.72, 15.88)	5.73	(1.01, 10.45)	6.10	(1.38, 10.82)
High School Graduate/GED	2.62	1.67	(1.18, 2.16)	2.59	2.01	(1.46, 2.56)	-0.03	(-0.70, 0.65)	0.34	(-0.39, 1.08)
Some College/Associate's Degree	1.13	0.18	(-0.11, 0.48)	1.06	0.48	(0.23, 0.72)	-0.07	(-0.33, 0.18)	0.30	(-0.09, 0.68)
College Graduate	0.95	--		0.58	--		-0.37	(-0.66, -0.08)	--	
Slope Index of Inequality		6.88	(5.23, 8.53)		12.92	(7.99, 17.86)			6.04	(0.88, 11.21)
Relative Index of Inequality		11.28	(7.14, 15.43)		43.47	(17.77, 69.17)			32.19	(6.12, 58.26)
Per 100 Million Person-Miles of Travel										
Less than High School	3.52	2.86	(2.19, 3.52)	6.13	5.74	(3.27, 8.20)	2.61	(0.06, 5.15)	2.88	(0.33, 5.43)
High School Graduate/GED	1.73	1.06	(0.77, 1.36)	1.66	1.27	(0.93, 1.61)	-0.06	(-0.48, 0.35)	0.21	(-0.24, 0.66)
Some College/Associate's Degree	0.75	0.08	(-0.10, 0.26)	0.76	0.36	(0.22, 0.51)	0.01	(-0.13, 0.16)	0.28	(0.05, 0.51)
College Graduate	0.67	--		0.40	--		-0.27	(-0.45, -0.09)	--	
Slope Index of Inequality		3.82	(2.93, 4.71)		6.70	(4.09, 9.31)			2.88	(0.14, 5.62)
Relative Index of Inequality		8.99	(5.93, 12.05)		30.30	(13.31, 47.28)			21.30	(3.99, 38.62)

Abbreviations: RD, rate difference; GED, general education development

[a] Marginal predicted rates after negative binomial regression. See Web Figure 1 for map of states