Death and Injury from Motor Vehicle Crashes
A Tale of Two Countries

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Objective: To determine why road deaths dropped by 33.9% in the United Kingdom, compared to 6.5% in the United States, between 1990 and 1999.

Methods: Deaths per billion vehicle kilometers traveled (D/BVKM), and case fatality rates (CFR) in the United States and the United Kingdom were tracked. Time trends in CFR can be used to track the direct effects of speed of impact. CFR is a crash-phase outcome that is independent of exposure, and varies approximately to the fourth power of the speed of crash impact. Joinpoint regression analysis was used to analyze changes in time trends of CFR.

Results: In the 1990s, the decrease in deaths in the United Kingdom was attributable mostly to the 29.6% drop in the CFR. In the United States, the CFR dropped by only 6.6%. The United Kingdom introduced speed cameras and an array of speed-calming measures. By contrast, in the United States, use of speed cameras was extremely rare, and speed limits and speeds increased in 32 of the 50 states, mostly in 1995 and 1996, after which CFR actually rose (p <.0001). Intercountry differences in time trends in seat belt use, trauma care, vehicle kilometers traveled, congestion, and driving under the influence of alcohol (DUI), along with massive increase in use of higher-risk sports utility vehicles in the United States, did not account for the contrasting trends in deaths through the 1990s. But increases in DUI in the United States after 1997 may have contributed to increases in speed-related crashes.

Conclusions: The reductions in CFR, probably from small drops in speed of impact account for the disproportionately greater drop in death tolls in the United Kingdom compared to the United States. The temporal fit between drops in CFR and deaths following the introduction of speed cameras in the United Kingdom and increases in speed (speed creep), CFR, and deaths in the United States following raised speed limits suggests that diverging changes in speeds of impact accounted mainly for these changes. Use of D/BVKM to correct for exposure concealed the lack of progress after 1990 in the United States, since falling time trends in D/BVKM reflect increases in congestion. If the United States had implemented United Kingdom–type speed control policies and not raised speed limits, there would have been an estimated 6500 to 10,000 (~16% to 25%) fewer road deaths per year during the period following speed-limit increases (1996 to 1999), including many DUI-related deaths. Reductions of up to 50% are now achievable based on newer population-wide strategies for speed control.

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Introduction

During the 1990s, annual road death tolls fell by 34% in the United Kingdom,[1] compared to a 6.5% drop in the United States.[2] The hypothesis for this study was that contrasting strategies, policies, and programs for speed control in the United States and United Kingdom accounted for the different trends. The hypothesis is suggested by the empirical observations that crash, injury, and death tolls increase and decrease in proportion to the rise and fall in average speeds to the approximately first, second, and fourth power, respectively, in keeping with algebraic relationships deriving from Newtonian physics.[3] These relationships hold for occupants, both belted and unbelted,[4] and for pedestrians.[5] A 10% increase or decrease in crash speeds produces a respective rise or fall of approximately 45% in deaths per crash in drivers.[6]

This study exploited the use of the case fatality rate (CFR), the proportion of killed to all injured, a measure of the lethality of injury.[7] The CFR, because it is independent of changes in exposure (billion vehicle kilometers traveled [BVKM]), measures mainly the direct effects of the speed of impact, but will also reflect trends in crash phase (e.g., seat belts and airbags) and

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Table 1. VKM traveled, road deaths, and case fatality rate in United Kingdom and United States, 1990–1999

	VKM traveled (billions)		Deaths (n)		Deaths per billion VKM traveled		Case fatality rate (%)	
Year	**U.S.**	**UK**	**U.S.**	**UK**	**U.S.**	**UK**	**U.S.**	**UK**
1990	3452	411	44,599	5177	12.9	12.6	1.36	1.52
1991	3497	412	41,508	4568	11.9	11.1	1.32	1.47
1992	3618	412	39,250	4229	10.8	10.3	1.26	1.36
1993	3697	412	40,150	3814	10.9	9.3	1.26	1.25
1994	3796	423	40,716	3650	10.7	8.6	1.23	1.16
1995	3901	431	41,817	3621	10.7	8.4	1.19	1.17
1996[a]	3999	443	42,065	3598	10.5	8.1	1.19	1.12
1997	4124	453	42,013	3599	10.2	7.9	1.24	1.10
1998	4237	459	41,501	3421	9.8	7.5	1.28	1.05
1999	4333	467	41,717	3423	9.6	7.3	1.27	1.07

[a]Speed limits were raised in 32 U.S. states.
Sources: Department of Environment, Transport, and the Regions, available at www.detr.gov.uk, and U.S. Department of Transportation, National Highway Traffic Safety Administration, Traffic Safety Facts, available at www.nhtsa.dot.gov/.
VKM, vehicle kilometers.

post–crash-phase countermeasures.[8] Trends in CFR serve as a reasonably accurate surrogate indicator of systemwide trends in speeds of impact in keeping with the foregoing Newtonian relationships.[9]

Methods

We performed a longitudinal comparison of trends for road deaths, persons injured, vehicle kilometers traveled (1 km=0.6214 mile), deaths per billion vehicle kilometers traveled (D/BVKM), and CFR in the United States and the United Kingdom for 1990 to 1999. Data on deaths, injuries, and D/BVKM were obtained for the United States and the United Kingdom between 1990 and 1999 from official databases.[1,2] The CFR was calculated as the risk of death among all individuals injured in road crashes (presented as deaths per 100 injured) (Table 1) (Figure 1).

Trends of speeds on low- and high-speed roads were analyzed in relationship to two interventions: the introduction of speed cameras and other measures to reduce speed in the United Kingdom starting in 1990, and the raise in speed limits in 1995 and 1996 in 32 of 50 states in the United States.

The strengths of a longitudinal comparison of trends in one country relative to another are those of time series models: differences between the United Kingdom and United States in the reporting and classification of deaths and injuries by road category and other parameters cancel out when definitions, cut-off points, and biases within each country remain approximately the same throughout the period of observation. Joinpoint regression analysis was used to analyze changes in time trends of CFR.[10] This method tests the null hypothesis (using a maximum of two changes in slope with an overall significance level of 0.05) that no significant changes in the slope of CFR occur during the observation period (1990 to 1999). Trends were tracked and compared for deaths and CFR for the United Kingdom and the United States for road-user subgroups—passenger cars, light trucks (including sport utility vehicles [SUVs]), heavy trucks, motorcycles, buses, pedestrians, and pedal cyclists (Tables 2 and 3).

To test the effect of the uniquely large increase in SUV travel in the United States, expected death tolls were estimated for the beginning and end of the decade in the United States if all fatal occupants of the SUVs (light trucks in Table 3) with their higher CFRs, had been riding in passenger cars, with their lower CFRs. The number observed killed in SUVs was multiplied by the ratio of expected/observed CFRs; the expected CFR is that seen in passenger cars during the same year. Trends in deaths and CFR were compared for types of roads and road speed in both countries (Table 4), and systemwide speeds, trends in number of drivers, vehicles, exposure (BVKM) congestion, truck kilometrage (BVKM), driving under the influence of alcohol (DUI) fatalities, arrests and breath tests, seat belt use enforcement, trauma care, and congestion (Table 5).

Fisher's transformation was used to calculate p values and confidence intervals for correlation coefficients for relationships between road fatalities and kilometers (Table 5).[11] Data on speed came from sources cited in Table 5, as well as the Department for Transport (2001 to 2003)[12] for the United Kingdom, and Farmer et al.[13] and Parker for the United States.[14] (See Appendix.)

To determine the degree to which changes in case fatality, which is uniquely sensitive to speed of impact, account for changes in death tolls ($K_{(ATTRIB)}$) in both the United Kingdom and the United States, we used the following equation[1,9]:

$$K_{(ATTRIB)} = K_B\left(\mathrm{CFR}_A \,/\, \mathrm{CFR}_B\right) - K_B$$

where K_B represents persons killed per year at baseline (before), and CFR_B and CFR_A are the proportion of those

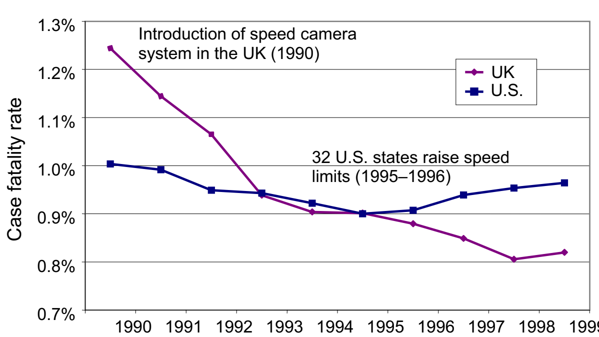

Figure 1. Case fatality rate in passenger car crashes in the United States and United Kingdom, 1990–1999.

Table 2. United Kingdom: road fatalities and CFR[a] by road user type, 1990–1999

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Change between 1990 and 1999
Passenger cars											
Killed	2371	2053	1978	1760	1764	1749	1806	1795	1696	1687	−28.8%
CFR	1.24%	1.14%	1.07%	0.94%	0.90%	0.90%	0.88%	0.85%	0.81%	0.82%	−34.1%
LGV drivers and passengers											
Killed	129	119	117	91	64	69	61	64	67	65	−49.6%
CFR	1.33%	1.37%	1.44%	1.23%	0.85%	0.96%	0.85%	0.86%	0.87%	0.91%	−31.2%
HGV drivers and passengers											
Killed	67	65	70	59	41	57	63	45	60	52	−22.4%
CFR	1.74%	1.80%	2.10%	1.77%	1.22%	1.71%	1.94%	1.36%	1.74%	1.49%	−14.4%
Motorcycle											
Killed	659	548	469	427	444	445	440	509	498	547	−17.0%
CFR	1.69%	1.78%	1.74%	1.70%	1.82%	1.89%	1.90%	2.08%	2.02%	2.09%	23.7%
Pedestrian											
Killed	1676	1488	1343	1237	1113	1029	989	973	906	867	−48.3%
CFR	2.83%	2.81%	2.66%	2.63%	2.35%	2.25%	2.18%	2.18%	2.07%	2.08%	−26.6%
Pedal cyclist											
Killed	256	242	204	185	171	212	202	183	158	171	−33.2%
CFR	0.98%	0.99%	0.84%	0.79%	0.71%	0.87%	0.84%	0.76%	0.71%	0.77%	−21.4%
Buses											
Killed	19	25	19	35	21	35	11	14	18	11	−42.1%
CFR	0.19%	0.28%	0.21%	0.38%	0.21%	0.38%	0.12%	0.15%	0.18%	0.11%	−43.8%
All road users[b]											
Killed	5177	4568	4229	3814	3650	3621	3598	3599	3421	3423	−33.9%
CFR	1.52%	1.47%	1.36%	1.25%	1.16%	1.17%	1.12%	1.10%	1.05%	1.07%	−29.6%

[a]Killed divided by all injury severities.
[b]Includes other motor or non–motor vehicle users, and unknown road user type and casualty age (UK numbers).
Source: Department of Environment, Transport, and the Regions, available at www.detr.gov.uk.
CFR, case fatality rate; LGV, light goods vehicle; HGV, heavy goods vehicle.

Table 3. United States: Road fatalities and CFR[a] by road user type,[b] 1990–1999

	1990	1991	1992	1993	1994	1995	1996[c]	1997	1998	1999	Change between 1990 and 1999
Passenger cars											
Killed	24,092	22,385	21,387	21,566	21,997	22,423	22,505	22,199	21,194	20,818	−13.6%
CFR	1.00%	0.99%	0.95%	0.94%	0.92%	0.90%	0.91%	0.94%	0.95%	0.96%	−3.9%
Light trucks											
Killed	8,601	8,391	8,098	8,511	8,904	9,568	9,932	10,249	10,705	11,243	30.7%
CFR	1.67%	1.47%	1.46%	1.40%	1.39%	1.31%	1.29%	1.34%	1.38%	1.31%	−21.8%
Large trucks											
Killed	705	661	585	605	670	648	621	723	742	758	7.5%
CFR	1.65%	2.31%	1.69%	1.86%	2.18%	2.11%	1.85%	2.28%	2.49%	2.25%	36.0%
Motorcycle											
Killed	3,244	2,806	2,395	2,449	2,320	2,227	2,161	2,116	2,294	2,472	−23.8%
CFR	3.72%	3.39%	3.55%	3.99%	3.91%	3.76%	3.78%	3.84%	4.47%	4.71%	26.7%
Pedestrian											
Killed	6,482	5,801	5,549	5,649	5,489	5,584	5,449	5,321	5,228	4,906	−24.3%
CFR	5.81%	6.18%	5.87%	5.67%	5.63%	6.10%	6.23%	6.46%	7.04%	5.46%	−6.1%
Pedal cyclist											
Killed	859	843	723	816	802	833	765	814	760	750	−12.7%
CFR	1.13%	1.24%	1.13%	1.19%	1.28%	1.23%	1.30%	1.38%	1.41%	1.45%	28.0%
Buses											
Killed	32	31	28	18	18	33	21	18	38	58	81.3%
CFR	0.10%	0.15%	0.14%	0.11%	0.11%	0.17%	0.10%	0.11%	0.24%	0.26%	171.4%
Total[b]											
Killed	44,599	41,508	39,250	40,150	40,716	41,817	42,065	42,013	41,501	41,717	−6.7%
CFR	1.36%	1.32%	1.26%	1.26%	1.23%	1.19%	1.19%	1.24%	1.28%	1.27%	−6.8%

[a]Killed divided by all injury severities.
[b]Includes unknown road user type.
[c]Speed limits raised in 32 states.
Source: U.S. Department of Transportation. National Highway Traffic Safety Administration, Traffic Safety Facts, available at www.nhtsa.dot.gov/.
CFR, case fatality rate.

killed among all those injured before (1990) and after (1999).

To estimate the expected reduction in annual death tolls in the United States in 1999 from the CFR observed in the United Kingdom in 1999, the following equation[2] was applied:

$$K_{\text{reduction}} = K_{(\text{USA1999})} - \left(\text{CFR}_{(\text{UK1999}} / \text{CFR}_{(\text{USA1999})}\right) \times K_{\text{USA1999}}$$

where

$K_{\text{reduction}}$ = deaths prevented in 1999 from reduction in CFR to that of United Kingdom in 1999
$K_{(\text{USA1999})}$ = road deaths in United States, 1999
$\text{CFR}_{(\text{UK1999})}$ = CFR in United Kingdom, 1999
$\text{CFR}_{(\text{USA1999})}$ = CFR in United States, 1999

A variation of the above equations was applied to test an alternative scenario: the effect of the proportionate change in CFR in the United Kingdom through the 1990–1999 decade on the 1999 death toll in the United States. Data were analyzed in 2001 to 2004.

Results

From 1990 to 1999, road deaths dropped 33.9% in the United Kingdom (from 5177 to 3423), and 6.4% in the United States (from 44,599 to 41,717) (Table 1), although the toll was uniquely low in 1992 (39,250). The D/BVKM dropped 42.1% in the United Kingdom, compared to a 25.6% drop in the United States. The CFR fell progressively by 29.6% (1.52% to 1.07%) in the United Kingdom, compared to a concave-shaped U trend in CFR in the United States, ending with a fall of only 6.6% (1.36% to 1.27%). In the United Kingdom, the 29.6% drop in CFR and the 33.9% drop in deaths indicate that approximately 87.3% of reduction in deaths was attributable to reduction in the CFR (29.6/33.2=87.3%). Similar trends hold for most subgroups.

In both countries, joinpoint regression analysis showed that there was no statistical evidence for more than one variation in the trend of CFR over the decade in either country. CFR rose significantly ($p=0.001$, global F test) in the United States, reversing direction after 1995, but continued to decline in the United Kingdom, and less so after 1994 ($p<0.004$). In the United States, there was slope reversal from −0.03 to +0.02 after 1995 ($p=0.003$), compared to −0.07 to −0.02 in the United Kingdom ($p<0.007$).

In the United Kingdom, reductions in deaths and CFR occurred in all road user subgroups, except for motorcyclists (Table 2).

In the United States, deaths dropped among car passengers (the largest single category; $n>20{,}000$), motorcyclists, pedestrians, and pedal cyclists, but rose in occupants of light and heavy trucks. There were smaller reductions in the CFR in the United States compared to the United Kingdom among occupants of passenger cars, light trucks, and pedestrians during the 1990s, and, unlike the United Kingdom, very large increases in the CFR among occupants of large trucks, pedal cyclists, and motorcyclists. For deaths and CFR in passenger cars (the largest single category; $n>20{,}000$) specifically, there were respective drops of 28.6% and 33.9% in the United Kingdom, as compared to substantially smaller corresponding drops of 13.6% and 4.0% in the United States (Table 2).

In the United States, the fall in CFR from 1.00% to 0.90% in passenger occupants from 1990 to 1995 was abruptly reversed in 1996. This reversal coincided with speed limit increases, rising to 0.96% in 1999 in 32 states within a year of November 1995 (Table 3) (Figure 1).[13,14] But the 13.6% drop in car passengers killed exceeded the 4% drop in CFR; 964 (29.4%) of the 3274 fewer deaths were attributable to reduced CFR. Had the drop in CFR been that reported in the United Kingdom, there would have been 8167 fewer deaths.

Light Trucks and SUVs

For the United Kingdom, the proportional contribution of deaths from light-goods vehicles ([LGVs] <3.5 tons gross weight) was <3% throughout the decade, and trivially influenced overall trends (Table 2).

By contrast, in the United States, there was a large rise in deaths in light trucks (30.7%), a category that includes SUVs, resulting in a 29.7% increase in BVKM offset by a fall in the CFR of 21.6% from 1.67% to 1.31%. The increase in deaths in SUV occupants offset falling death tolls among passenger car occupants (Table 3). Had every U.S. traveler killed in an SUV been in a passenger car throughout the decade, there would have been 3451 fewer deaths (−7.7%) in 1990, and 3004 fewer deaths (−7.2%) in 1999 nationwide. But the drop in CFR in light trucks, that is, mostly SUVs, starting in the early 1990s was aborted around 1995–1996, when speed limits were raised (Table 3).

In the United Kingdom, in the 1995–1999 period, reduced death tolls (−6.6%, −6.1%) and CFR (−8.6%, −8.3%) occurred on roads with speed limits ≤40 mph and >40 mph. Concurrently, in the United States, deaths fell 4.0% on lower-speed roadways (≤55 mph limit), but rose 1.4% on roadways with speed limits of >55 mph. But CFR rose by 5.0% on the former and 0.4% on the latter (Tables 4 and 5).

Pedestrians

In the United Kingdom, 1232 (73%) of the observed number of deaths (N=1676) were specifically attributable to a 27% reduction in CFR (Table 2). In fact, there were 867 fewer pedestrian deaths, a reduction of 49%, or 55% (27%/49%) of the total reduction.

By contrast, in the United States, there were 390 fewer pedestrian deaths attributable to a much smaller

Table 4. United Kingdom and United States: road casualties and CFR[a] by road speed, 1990–1999

Speed limit of roadway	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Change between 1995 and 1999	Change between 1993 and 2000
UK roadway speed limits												
Built-up roads (≤40 mph)[b]												
Killed	ND	ND	ND	1,720	1,611	1,497	1,534	1,470	1,392	1,398	−6.6%	−18.7%
Injured	ND	ND	ND	209,390	216,767	213,654	219,347	222,910	221,633	218,361	2.2%	4.3%
CFR	ND	ND	ND	0.81%	0.74%	0.70%	0.69%	0.66%	0.62%	0.64%	−8.6%	−21.9%
Non–built-up roads (>40 mph)[b]												
Killed	ND	ND	ND	1,892	1,874	1,941	1,899	1,938	1,855	1,823	−6.1%	−3.6%
Injured	ND	ND	ND	82,020	83,336	81,726	85,194	87,365	86,203	83,864	2.6%	2.2%
CFR	ND	ND	ND	2.25%	2.20%	2.32%	2.18%	2.17%	2.11%	2.13%	−8.3%	−5.6%
UK total (all speed limits)[c]												
Killed	ND	ND	ND	3,814	3,650	3,621	3,598	3,599	3,421	3,423	−5.5%	−10.3%
Injured	ND	ND	ND	302,321	311,709	307,066	316,980	324,204	321,791	316,887	3.2%	4.8%
CFR	ND	ND	ND	1.25%	1.16%	1.17%	1.12%	1.10%	1.05%	1.07%	−8.3%	−14.2%
U.S. roadway speed limits[d]												
<55 mph												
Killed	ND	ND	ND	ND	18,171	18,798	18,616	18,323	18,005	18,039	−4.0%	ND
Injured	ND	ND	ND	ND	ND	2,712,000	2,692,200	2,597,000	2,421,000	2,478,000	−8.6%	ND
CFR	ND	ND	ND	ND	ND	0.69%	0.69%	0.70%	0.74%	0.72%	5.0%	ND
≥55 mph												
Killed	ND	ND	ND	ND	21,897	22,317	22,715	22,521	22,554	22,621	1.4%	ND
Injured	ND	ND	ND	ND	ND	752,000	789,800	803,000	771,000	759,000	0.9%	ND
CFR	ND	ND	ND	ND	ND	2.88%	2.80%	2.73%	2.84%	2.89%	0.4%	ND
U.S. total (all speed limits)[c]												
Killed	ND	ND	ND	ND	40,716	41,817	42,065	42,013	41,501	41,717	−0.2%	ND
Injured	ND	ND	ND	ND	3,265,000	3,464,000	3,482,000	3,399,000	3,192,000	3,235,894	−6.6%	ND
CFR	ND	ND	ND	ND	1.23%	1.19%	1.19%	1.22%	1.28%	1.27%	6.4%	ND

[a]Data before 1993 for the UK and before 1995 for the United States were not available; casualty data were unavailable for U.S. roadways with ≤40 mph for years 1995 and 1996.
[b]Builtup roads in the UK have a speed limit ≤40 mph; non–built up roads have speed limits >40 mph.
[c]Includes unknown road user type.
[d]Speed limit raised in United States in 32 states.
Sources: Department of Environment, Transport, and the Regions, available at www.detr.gov.uk, and U.S. Department of Transportation, National Highway Traffic Safety Administration, Traffic Safety Facts, available at www.nhtsa.dot.gov/. Data were not available for UK roads before 1993 and for U.S. roads before 1995.
CFR, case fatality rate; ND, no data.

Table 5. United Kingdom and United States: trends in road crash determinants, exposure and countermeasures, 1990–1999

	United Kingdom	**United States**
Trends in exposure and congestion		
Nationwide traffic (kilometrage; bvkm)	Up 14.0%	Up 26.0%
Correlation between road fatalities and kilometrage[a]	r=−0.76 (p<0.01)	r=−0.77 (p<0.01)
Licensed drivers	Data unavailable	Up 12%
Licensed vehicles	Up 15.0%	Up 15.4%
Vehicles per kilometer of road	Up 11.0%	Up 14.0%
Mean systemwide speed		
Urban	32–36 mph Systemwide 15–19 mph in London	Data unavailable
Interurban	70 mph (cars) 54 mph (lorries)	Up 0.2–3.0 mph (all vehicles)
Drinking and driving		
Legal limit for drivers (blood)	80 mg/100 ml	80 to 100 mg/100 ml
Alcohol-related fatalities	Down 29.0% (1990–1997)	Down 28.5% (1990–1998)
DUI arrests	Down 15.0% (1990–1998)	Down 12.5% (1993–1998)
Drivers testing positive on breath test (35 micrograms/100 ml of breath)	Down 4.0% (1990–1998)	Data unavailable
General enforcement	Up 9.6% (1990–1998)	Data unavailable
Changes in ratio of truck kilometrage to all vehicle kilometrage (1990–1999)	No change (6.0%)	Up 10% (7.1% to 7.8%)
Trends in trauma care	Little measurable improvement	Major reported benefits
Trends in quality of reporting	No reported differences between UK and U.S.	No reported differences between UK and U.S.

[a]Fisher's transformation to calculate correlation coefficient: r=−0.77; p<0.01, CI 95%=−0.557, −0.888, 1970–1998. In the United States for 1990–1999, r=−0.03; p>0.05. In the United Kingdom, the r=−0.76; p<0.01, 95% CI=−0.29−−0.93, 1989–1998. VKM data not available prior to 1989 for the United Kingdom.

[b]In the United States, 49 states currently have laws mandating seat belt use, and all 50 states had mandatory child restraint laws by 1985.

Sources: Department of Environment, Transport, and the Regions, available at www.detr.gov.uk, and U.S. Department of Transportation, National Highway Traffic Safety Administration, Traffic Safety Facts, available at www.nhtsa.dot.gov and www- fars.nhtsa.dot.gov. U.S. travel speed data from Parker[14] and Farmer et al.[13] Trauma care data from Lecky et al.[19], Nicholl and Turner[20], and Nathens et al.[22]. Kilometrage data (see Table 1). Licensed drivers, U.S. from 167 million to 187.2 million; registered vehicles, UK from 24.7 million to 28.4 million, U.S. from 184.3 million to 212.7 million; alcohol-related fatalities, UK from 760 to 540, U.S. from 22,084 to 15,786; arrests for drink driving, UK from 232,000 to 190,000. In 1998, 1.4 million Americans were arrested for driving under the influence (DUI) (representing one in every 132 licensed drivers), and in 1993, 1.6 million Americans (representing 1 in every 108 licensed drivers) (data were unavailable for 1990 and 1999) tested positive on breathalyzer, UK 16% of those tested to 12% of those tested; traffic offenses issued (not including parking), UK from 2,670,000 to 2,927,000. CI, confidence interval; DUI, driving under influence; VKM, vehicle kilometers.

reduction in CFR—7%, or 29% (7%/24%) of the full reduction.

Motorcyclists

In the 1990–1999 period, in the United States and the United Kingdom, deaths among motorcycle riders fell 24% and 17%, respectively, despite increases of 27% and 24% in CFR in the two countries, respectively (Tables 2 and 3). In the United States, nearly the entire increase in CFR occurred in 1998–1999, but in the United Kingdom, where helmet laws are mandatory, there was a gradual increase in CFR throughout the 1990s, but an abrupt increase in deaths from 1997 forward.

Determinants of Case Fatality Rates

In the United Kingdom, speeds fell after the introduction of speed cameras.[12] In the United States, speeds rose 0.2 to 3.0 mph in 65-mph zones following speed limit increases (Table 5).[13–16] In the United Kingdom (where average motorway speeds are 70 mph), speed at the camera sites dropped on average by 5.6 mph. Drivers exceeding speed limits at pilot camera sites fell from 55% to 16%, and drivers exceeding limits by >15 mph fell from 5% to 1%.

During the 1990s, seat belt use, estimated to reduce case fatality by up to 65%,[17] rose from approximately 80% to 90% in the United Kingdom, as compared to a steeper increase from 49% to 71% in the United States.[18] Differences were small for time trends in deaths attributed to DUI (−29.0% from 1990 to 1997, and −28.5% from 1990 to 1998); arrests for drunk driving (15% from 1990 to 1998, and 12.5% from 1993 to 1998); licensed vehicles (+15% and +15.4% from 1990 to 1999); and vehicles per kilometer of road length (+11% and +14% from 1990 to 1999). BVKM, which inversely correlates with fatalities (United Kingdom, r=−0.77, 1989–1998; United States, r=−0.76, 1970–1998), increased almost twofold more in the United States compared to the United Kingdom. Congestion (vehicles/kilometer of road length), which reduces speeds, and therefore should be protective by reducing CFR, increased 3% more in the United States compared to the United Kingdom.

In the United Kingdom, CFR fell despite no major reported benefit from improvements in regional trauma care,[19,20] which, if they occurred, reportedly reduced by some 8% the overall CFR of hospitalized children with an injury surveillance scale of >16, since many die before reaching the hospital.[21] In the United States, CFR increased nationwide after 1996, despite an 8% to 10% reduction in vehicle crash mortality in 22 states with regional trauma care systems, and improved triage protocols, prehospital treatment and transfer, hospital admissions, and coordination among hospitals.[22]

Validity of Risk Estimates

In 1999, had the CFR in the United States been that of the United Kingdom for the same year, there would have been 35,147 deaths, or 6569.6 fewer than the 41,717 reported (a 15.7% reduction). The National Highway Traffic Safety Administration[14] estimated that speed accounts for 21% of U.S. road deaths, which means 8760.6 deaths of the full 1999 toll. This latter estimate implies that a drop in the CFR observed in the United Kingdom in 1999 would have prevented approximately 75% (6569/8760) of the full toll of deaths attributed to speeding in the United States. But, if our baseline had been the 1990 toll of 44,599 deaths, there would have been 9452 fewer deaths in 1999, or a 22.7% reduction compared to the 1999 toll. If the proportional reduction in CFR in the United States had been the same as that in the United Kingdom ($1 - [1.07/1.52]$) (Table 1), then there would have been 31,395 deaths, that is, 10,022 fewer deaths, representing a 24.6% reduction.

Discussion

Our findings indicate that the sustained drop in road deaths in absolute numbers in the United Kingdom in the 1990s was attributable mostly to the drop in CFR, an outcome that exponentially amplifies trends in the speed of impact in both directions.[3] After the United States raised speed limits in 1995–1996, the initial drop during the early 1990s in deaths and CFR reversed itself after 1995, despite large increases in seat belt use, improvements in trauma care, and reductions in DUIs. The temporal fit between drops in CFR and deaths in the United Kingdom following the introduction of speed cameras, and the rises in CFR and deaths in the United States following raised speed limits and speed creep[23]—the gradual upward trend in speeds—suggests that changes in the speed of impact accounted for these changes.

In the United States after 1995, CFR rose in all categories, notably passenger cars (the largest category), but D/BVKM continued to fall much more—a finding seen in Israel following the increase in speed limits.[9] The fact that the rise occurred within all categories of crashes, including SUVs, suggests that the speed of impact, not the changing of the case mix of crashes, accounted for the rise in deaths in the United States after 1996. The overall trends in passenger cars specifically in the United States suggest that their occupants were protected by trends that in the aggregate prevented deaths despite a trivial fall in reported CFR, and perhaps from switchover to SUVs. But the increased use through the decade of SUVs (still a more dangerous vehicle in which to crash) paradoxically does not explain the failure of the United States to substantially reduce its total death toll by 1999 relative to 1990, since the ascending death tolls from much more VKM in SUVs were offset by a large decline in CFR in their occupants.[24] Even so, the CFR remained higher than in private cars, and especially in smaller SUVs involved in rollovers.

Our findings suggest that the sustained drop in death tolls and CFR in the United Kingdom compared to the reversal of the drop in the United States during the 1990s resulted mainly from contrasting policies toward speed management. In the United Kingdom, there was a national speed control policy, including national and regional speed camera networks.[25] In 1990, the United Kingdom set a national target to reduce road deaths by 33% by year 2000 compared to annual tolls in the 1981–1985 period. Beginning in 1991, it introduced speed cameras, restricted zones with special speed limits, special speed limits for trucks, and, in urban areas, road bumps, roundabouts, chicanes, gateways, and other environmental measures. The fact that deaths and CFR began falling right away suggested the immediate impact of these measures, or possibly an anticipatory effect, or both. By 1996, 102 roadside cameras served >700 sites.[26] A recent systematic review of 14 before-and-after observational studies, mainly from the United Kingdom, reported that deaths and injuries at speed camera sites fell from 17% to 71%, respectively.[27] In addition, speed calming via roundabouts produced a 37% reduction (pooled estimate) in deaths and an 11% reduction in injuries plus deaths.[28] Since 2000, new speed camera sites targeted at high-risk roads in certain regions in the United Kingdom are saving an additional 100 lives per year, and appear to be achieving further local reductions of up to 40%.[29,30]

By contrast, in the United States, only 16 cities have implemented sporadic use of speed cameras, there have been no national or state policies to introduce speed camera networks and none are on interstates.[31]

Since 1995–1996, 32 of 50 states raised speed limits to ≥65 mph on interstates, and of these 23 raised their limits to 70 or 75 mph. There was a 4% rise in travel speeds and a 17% rise in deaths in the 1995–1999 period on these roads.[12,13,15] Our findings provide support for the statement that gradual increased speeds—speed creep, speed spillover, and speed adaptation from highways to other roads[32]—accounted for the upward turn in CFR (Table 1) from 1995 onward in the United States. The evidence for spillover is that the proportional rise in CFR on roads with speed limits ≤55 mph was greater than on high speed roads.

We suggest that the higher speeds of impact led to higher CFRs and resulted in dissipation of benefits from proven countermeasures and increased congestion.[33] Since 1925, longitudinal data have shown a 92% drop in D/BVKM from 18 per 100 million in 1925 to 1.5 per 100 million in 1999, despite ten-fold increases in VKM, six-fold increases in the number of drivers, and eleven-fold growth in motor vehicle numbers.[34,35] Cross-sectional data show that D/BVKM in states in the Northeast Corridor, which has the most congested roads, are one third to one fourth of those of the states with the highest D/BVKM rates.[23,35]

Limitations and Exceptions

The first limitation of this study is that the data on injuries may not have been totally comparable, given the fact that there are some differences in methods and reporting criteria in both countries. The second limitation is that the ecologic design may have overlooked factors other than speed creep that account for the trend differences. However, the fact that each population served as its own control should overcome the first limitation, given the algebraic logic of the comparisons of trends between countries, even where there are differences in reporting criteria. We suggest that the longitudinal component of the study enabled us to address the second limitation, because we could identify plausible temporal associations between increases in speed limits and CFR deaths in the United States on the one hand, as against introduction of speed camera networks and falls in CFR and deaths in the United Kingdom on the other. It is implausible that artifacts or biases in sampling or reporting within both these countries could have accounted for the close temporal associations.

Because the fall in CFR in the United Kingdom after 1990 and the rise in CFR in the United States occurred after 1995–1996 within most crash subtypes, changes in case mix of crashes, including SUVs, do not account for the overall differences in trends between the United Kingdom and the United States. But overall increases in CFR from more speeding after 1997 could have been partly attributable to recent increases in DUI, including binge drinking,[37] because DUI drivers involved in crashes are more likely to be speeding than nondrinking drivers[38,39] and CFR increases with higher blood alcohol content in drivers.[40]

The drops in pedestrian deaths in both countries appear to result mostly from reductions in exposure of pedestrians to street traffic, notably from less walking, especially in the United States. In the United States, repeal of motorcycle helmet laws in 1997 plausibly explains the jump in CFR thereafter.[41] In the United Kingdom, the sudden upsurge in deaths in the 1997–1999 period may be largely attributable to the rising popularity of scooters and motorcycles and more power.[1] The available findings do not provide support for better trauma care as the reason for the United Kingdom's better results.

What This Study Adds . . .

This study found that a drop in the road death toll of 33.9% in the United Kingdom in the 1990s, as compared with a fall of only 6.6% in the United States was specifically attributable to a fall in the case fatality rate.

The UK success followed strategies to reduce speed, whereas the U.S. failure came from raised speed limits and speed creep.

Increased use of SUVs did not account for the difference in time trends.

Conclusion

We suggest that the sustained reductions in road deaths and case fatality in the 1990s in the United Kingdom were attributable largely to policies to reduce speed. In the United States, small increases in travel speeds accounted for its failure to achieve similarly large reductions in deaths, which still exceeded 42,000 per year.[42] Because large changes in CFR result from small changes in speed, small nationwide increases in travel speeds appeared to have canceled out safety benefits from concurrent increases in seat belt use, earlier reductions in DUI, improvements in trauma care, or more crash-phase countermeasures during the 1990s. We hypothesize that detection and deterrence of increased speeds would substantially reduce the toll from DUI (some 17,000 deaths per year), much of which occur because of higher speeds.

We suggest that if the United States implemented the far from perfect speed control policies of the United Kingdom during the 1990s,[43] and had not raised speed limits, there would have been between some 6500 to 10,000 (16% to 25%) fewer deaths per year, tolls three to five times that from the Twin Towers terror attack, a one-time event. Findings from Victoria, Australia[44] suggest that reductions of up to 50% in death tolls relative to 1990 baselines could come from strategies for deploying speed camera networks that aim to shift speed distributions to the left for the entire population, and not just target high-risk spots or high-risk groups.[45]

This study states the case for implementing recommendations[33,46] for immediate large prospective trials of speed camera networks and speed-calming measures in the United States. [36]

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Appendix

In the United States, the General Estimates System (GES) of the National Automotive Sampling System (NASS) collects data on a representative, random proportion probability sample of approximately of 0.4% of all minor, serious, and fatal crashes involving passenger cars, pickup trucks, vans, large trucks, motorcycles, and pedestrians, and select cases from police crash reports (also known as PARS: Police Accident Reports) at police agencies within randomly selected areas of the country (www-nrd.nhtsa.dot.gov/departments/nrd-30/ncsa/NASS.html. UK data on injuries are collected from 58 local processing authorities and reported centrally using standardized forms (www.dft.gov.uk/stellent/groups/dft_transtats/documents/page/dft-transstats_506091.pdf).