Potential lives saved by in-vehicle alcohol detection systems

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ABSTRACT

Objectives: The objective of this study was to estimate the number of crash deaths specifically attributable to alcohol-impaired driving, with a focus on various strategies for introducing vehicle-based solutions. If alcohol detection systems are standard in all new vehicles, how many lives could be saved in the near term, and how long will it take to essentially eliminate alcohol-impaired driving? Alternatively, if such systems are offered as an option, how many lives could be saved?

Methods: Fatal crashes in the United States during 2015–2018 were classified by the highest driver blood alcohol concentration (BAC) and the corresponding age category of that driver. Based on the estimates of relative risk (RR) for a given driver group, eliminating alcohol in the driver's blood should lower risk by the attributable proportion, 1 – 1 / RR. Multiplying this quantity by the number of deaths for the driver group yielded the estimated number of lives potentially saved if the BACs were reduced to zero.

Results: Systems that restrict drivers with any BAC could prevent nearly 12,000 deaths per year, while systems that restrict BAC to less than 0.08 g/dL could prevent more than 9,000 deaths. Within 3 years of a mandate for vehicle-based alcohol detection systems, it is expected that the annual lives saved would be between 1,000 and 1,300. Within 6 years, it would be between 2,000 and 2,600 lives saved per year, and within 12 years it would be between 4,600 and 5,900 lives saved per year. A system required only for those convicted of alcohol-impaired driving could save between 800 and 1,000 lives per year. A system available only to fleets of vehicles could save between 300 and 500 lives per year.

Conclusions: Vehicle-based interventions will not immediately solve the problem of alcohol-impaired driving, but they are an important component of the overall strategy. Even if required as standard equipment in all new vehicles, it will take 12 years before there are enough to reach more than half of their potential. If vehicle-based interventions are instead voluntary or introduced as options, then progress toward a solution will be much slower.

Keywords: impaired driving; safety; blood alcohol concentration; attributable risk

INTRODUCTION

According to the World Health Organization, there are approximately 5 million injury deaths worldwide each year, with nearly 1 million attributable to alcohol consumption. More than 300,000 of these alcohol-attributable deaths occur on roadways (World Health Organization 2018). Despite the efforts of legislative bodies, government agencies, police, and nongovernmental organizations across the world, driving while under the influence of alcohol remains a major problem.

In the United States in 2018, 29% of roadway deaths occurred in crashes involving at least one driver impaired by alcohol (National Center for Statistics and Analysis 2019). In the same year, there were 1 million arrests for driving under the influence of alcohol (Federal Bureau of Investigation 2020). These statistics have barely changed during at least the past 10 years.

Interventions that have proven effective against impaired driving include stricter laws and sanctions, enhanced police enforcement, post-conviction monitoring and treatment, and alcohol ignition interlocks (Goodwin et al. 2015). All of these, however, have not been enough to eliminate impaired driving and the resulting crashes. For example, alcohol ignition interlocks, which require a nearly alcohol-free breath sample from a driver before the vehicle can be started, are usually required only for drivers recently convicted of driving under the influence. Research has shown that fewer than one in 50 drivers impaired by alcohol are caught and arrested, so interventions targeting convicted drivers will address only part of the problem (Hedlund and McCartt 2002).

Although alcohol-impaired drivers are much more likely to crash compared with sober drivers, some of their crashes may have occurred even if they had not been drinking. Lund et al. (2007, 2012) estimated the number of U.S. crash deaths specifically attributable to alcohol-impaired driving for the years 2005 and 2010. They concluded that alcohol-impaired drivers were responsible for 8,916 crash deaths in 2005 and 7,082 in 2010—about 21% of all crash deaths. Many fewer deaths were attributable to drivers with prior alcohol convictions (777 in 2005 and 552 in 2010), so interventions limited to convicted drivers will address fewer than 2% of all crash deaths, even if fully implemented.

Alcohol ignition interlocks are effective while installed, but they provide only temporary relief when used to sanction convicted drivers. A permanent and universal solution would be to have all vehicles produced with the technology needed to prevent impaired driving. Such vehicle-based systems have been developed and marketed, but whether they are equipped and activated on a vehicle is usually left to the discretion of the vehicle owner (Pollard et al. 2007). For example, the Volvo Alcoguard is offered as optional equipment, and it includes a bypass function for the driver (Volvo 2007). The Driver Alcohol Detection System for Safety (DADSS) project, a public-private partnership formed in 2008, seeks to develop a "seamless, accurate and reliable" system that will detect when a driver is alcohol-impaired and prevent the vehicle from moving (DADSS 2020). The plan is for automakers to eventually offer the system as an option in new vehicles.

The objective of the current study was to update the attributable risk calculations of Lund et al. (2007, 2012), but with a focus on various strategies for introducing vehicle-based solutions to the problem of alcohol-impaired driving. If alcohol detection systems are standard equipment in all new vehicles, how many lives could be

saved in the near term, and how long will it take to essentially eliminate alcohol-impaired driving? Alternatively, if such systems are offered as an option, how many lives could be saved?

METHOD

The relative risk (RR) of driver involvement in fatal crashes as a function of driver blood alcohol concentration (BAC) has been estimated several times using exposure data from U.S. national roadside surveys (Romano et al. 2018; Voas et al. 2012; Zador 1991; Zador et al. 2000). In the latest iteration, Romano et al. (2018) used data from the 2013–2014 Fatality Analysis Reporting System (FARS) and the 2013–2014 National Roadside Survey. They estimated the risk of driver death at a given BAC relative to a similar driver with no blood alcohol as:

$$RR = \exp(45.4*BAC) \text{ for drivers ages 16–21 years,} \quad (1)$$
$$RR = \exp(33.6*BAC) \text{ for drivers ages 22–34 years,} \quad (2)$$
$$RR = \exp(30.7*BAC) \text{ for drivers ages 35 years and over.} \quad (3)$$

Using these equations, a driver who is 16–21 years old with a BAC of 0.09 g/dL is 60 times as likely to die in a crash as a 16 to 21-year-old sober driver. Drivers ages 22–34 years and 35 years and over with BACs of 0.09 g/dL are 21 times and 16 times as likely to die in crashes compared with sober drivers in their respective age groups.

These relative risks are higher than those reported in earlier studies. For example, the coefficient for drivers ages 35 years and over was 21.4 in Voas et al. (2012) and 20.1 in Zador et al. (2000). Romano et al. (2018) concluded that the differences were due to a reduction in crash risk for sober drivers that was not shared by alcohol-impaired drivers. They speculated that this reduction in risk may have been due to the increased availability of safety-related advanced driver assistance systems in the vehicle fleet.

Using FARS data from 2015–2018, fatal crashes were classified by the highest driver BAC and the corresponding age category of that driver. BACs were based on alcohol test results, if available, or imputed BAC values (Subramanian 2002). Relative risks were computed using Equations (1)–(3), with BAC values 0.035, 0.065, 0.090, 0.125, and 0.220 g/dL representing the five BAC categories 0.02–0.049, 0.05–0.079, 0.08–0.099, 0.10–0.149, and 0.15+ g/dL. Based on the estimates of relative risk for a given driver group (highest driver BAC category and age category), eliminating alcohol in the driver's blood should lower risk by the attributable proportion, $1 - 1 / RR$ (Centers for Disease Control and Prevention 2012). Multiplying this quantity by the number of deaths for the driver group yielded the estimated number of lives potentially saved if the BACs were reduced to zero.

Going through the same calculations using the 95% confidence limits of the relative risks produced 95% confidence limits for the number of lives potentially saved. Risks relative to a given BAC other than zero were computed using the same coefficients as Equations (1)–(3) but multiplying these by the differences in the BACs. This is equivalent to computing the ratio of the relative risks for each BAC.

Calculations were repeated for drivers of vehicles less than 3 years old, drivers of vehicles less than 6 years old, drivers of vehicles less than 9 years old, and drivers of vehicles less than 12 years old. These were used to estimate the near-term and long-term effects of alcohol detection systems introduced through new vehicle designs. Calculations also were repeated for drivers of fleet vehicles and drivers with prior alcohol-impaired driving

convictions. These were used to estimate the effects of alcohol detection systems if installed only on a specific group of vehicles.

RESULTS

During 2015–2018, there were 147,324 deaths in crashes on U.S. roadways. In each of the four years, 29% of deaths occurred in crashes involving at least one driver impaired by alcohol (Table 1).

Table 1. Deaths in crashes on U.S. roadways, 2015–2018

Year	Deaths	Deaths involving an alcohol-impaired driver*	% involving an alcohol-impaired driver
2015	35,485	10,280	29.0
2016	37,806	10,967	29.0
2017	37,473	10,908	29.1
2018	36,560	10,511	28.8
	147,324	42,666	29.0

*Deaths in crashes involving at least one driver with a BAC of 0.08 g/dL or higher (National Center for Statistics and Analysis 2019).

The deaths in Table 1 were classified by the age group of the driver in the crash with the highest BAC. These counts and the relative risks of Equations (1)–(3) were used to estimate the potential lives saved if the highest driver BAC had been zero (for this analysis, any BAC below 0.02 is treated as zero). For example, a young (age 16–21) driver with a BAC between 0.02 and 0.049 g/dL has a risk 4.9 times as high as that of a young driver with zero BAC. Lowering that driver's BAC to zero should lower the risk by approximately (1 – 1 / 4.9) = 0.796, or 79.6%. During 2015–2018, 351 deaths occurred in crashes involving young drivers with 0.02–0.049 g/dL BACs and no drivers with higher BACs. So, if these drivers had zero BAC, approximately (351) (0.796) = 279 deaths could have been prevented.

Similarly, eliminating the blood alcohol of drivers ages 22–34 years and 35 years and over with BACs 0.02–0.049 g/dL could have prevented another 722 and 1,068 deaths, respectively. If all drivers with BACs of 0.02–0.049 g/dL had instead a zero BAC, about 2,069 deaths could have been prevented (Table 2). If all drivers of all BACs instead had zero BACs, approximately 47,721 of the 147,324 crash deaths during 2015–2018 could have been prevented. If all drivers had BACs below 0.08 g/dL (the legal limit in all states at the time), approximately 37,636 crash deaths could have been prevented—25.5% of all crash deaths and an average of 9,409 per year.

Table 2. Potential lives saved if all drivers were restricted to various BAC levels

Highest driver BAC in crash (g/dL)	2015–18 deaths	Potential lives saved if BACs were reduced to	
		Zero	Below 0.08 g/dL
0.02–0.049	3,016	2,069	0
0.05–0.079	3,797	3,357	0
0.08–0.099	3,316	3,146	947
0.10–0.149	10,534	10,358	8,182
0.15+	28,814	28,791	28,507
0.02+	49,477	47,721	37,636
(95% confidence limits)		(47,198; 48,089)	(36,778; 38,284)

Vehicles less than 3 years old accounted for 14% of the vehicles involved in U.S. fatal crashes during 2015–2018. Using similar calculations described earlier in *Results*, if only drivers of vehicles less than 3 years old were restricted to zero BAC, approximately 5,334 deaths could have been prevented during 2015–2018 (Table 3). If they were restricted to below 0.08 g/dL BAC, approximately 4,161 deaths could have been prevented.

Table 3. Potential lives saved if drivers of vehicles less than 3 years old were restricted to various BAC levels

Highest driver BAC in crash (g/dL)	2015–18 deaths	Potential lives saved if BACs were reduced to	
		Zero	Below 0.08 g/dL
0.02–0.049	357	245	0
0.05–0.079	446	392	0
0.08–0.099	374	354	105
0.10–0.149	1,220	1,199	944
0.15+	3,146	3,144	3,112
0.02+	5,543	5,334	4,161
(95% confidence limits)		(5,274; 5,375)	(4,065; 4,235)

In the same way, approximately 10,450 deaths could have been prevented during 2015–2018 if drivers of vehicles less than 6 years old were restricted to zero BAC, and approximately 8,150 deaths could have been prevented if they were restricted to below 0.08 g/dL BAC (see Appendix, Table A). Approximately 15,526 deaths could have been prevented during 2015–2018 if drivers of vehicles less than 9 years old were restricted to zero BAC, and approximately 12,148 deaths could have been prevented if they were restricted to below 0.08 g/dL BAC (see Appendix, Table B). Approximately 23,427 deaths could have been prevented during 2015–2018 if drivers of vehicles less than 12 years old were restricted to zero BAC, and approximately 18,385 deaths could have been prevented if they were restricted to below 0.08 g/dL BAC (see Appendix, Table C).

FARS records for each driver indicate the number of alcohol-impaired driving convictions within the 5 years prior to the crash. During 2015–2018, only 3% of drivers involved in fatal crashes had prior alcohol-impaired driving convictions, but 49% of the fatal crash-involved drivers with prior records had BACs of 0.08 g/dL or higher. If all drivers with prior alcohol-impaired driving convictions within the past 5 years were restricted to zero BAC, approximately 3,946 deaths could have been prevented during 2015–2018 (see Appendix, Table D). If they were restricted to below 0.08 g/dL BAC, approximately 3,348 deaths could have been prevented.

FARS records also indicate the type of ownership of each vehicle involved in a fatal crash: private vehicle, business/company/government vehicle, or rental vehicle. If fleet drivers are defined as those driving business/company/government/, and rental vehicles, then 11% of drivers involved in fatal crashes during 2015–2018 were fleet drivers, but only 6% of these fleet drivers had BACs of 0.08 g/dL or higher. If all fleet drivers were restricted to zero BAC, approximately 1,861 deaths could have been prevented during 2015–2018 (see Appendix, Table E). If they were restricted to below 0.08 g/dL BAC, approximately 1,390 deaths could have been prevented.

Effective December 30, 2018, the state of Utah lowered its per se BAC limit for drivers to 0.05 g/dL, so there is renewed interest in the U.S. in further lowering the legal BAC limit. If other states follow the lead of Utah, then it would make sense to set the vehicle-based BAC cutoff at 0.05 g/dL. Table 4 summarizes the results already

presented, but in terms of lives saved per year, and includes the results when restricting drivers to below 0.05 g/dL BAC. Restricting all drivers to zero BAC could have prevented on average 11,930 deaths per year during 2015–2018: 32.4% of the average annual crash deaths. Restricting drivers to BACs below 0.05 g/dL could have prevented on average 10,574 deaths per year (28.7%). Restricting drivers to BACs below 0.08 g/dL could have prevented on average 9,409 deaths per year (25.5%).

Table 4. Potential lives saved per year if drivers were restricted to various BAC levels

	Potential lives saved if BACs were reduced to		
Driver type	Zero	Below 0.05 g/dL	Below 0.08 g/dL
All drivers	11,930	10,574	9,409
Drivers of vehicles < 12 years old	5,857	5,178	4,596
Drivers of vehicles < 9 years old	3,882	3,426	3,037
Drivers of vehicles < 6 years old	2,612	2,301	2,038
Drivers of vehicles < 3 years old	1,334	1,174	1,040
Drivers with prior alcohol convictions	986	907	837
Fleet drivers	465	399	348

Finally, Romano et al. (2018) observed an increase in the relative risks obtained when using 2013–2014 data versus 2007 data. The data for the current study are even more recent, so it makes sense to check the sensitivity of the analyses to changes in the relative risks. Table 5 summarizes the results obtained using the relative risk curves of Voas et al. (2012) rather than those of Romano et al. (2018). As the relative risks are lower, the estimates of lives saved are lower than those in Table 4. However, the differences are not substantial. If all drivers had BACs below 0.08 g/dL, approximately 8,793 crash deaths could have been prevented each year—23.9% of all crash deaths.

Table 5. Potential lives saved per year if drivers were restricted to various BAC levels (using relative risks from Voas et al., 2012)

	Potential lives saved if BACs were reduced to		
Driver type	Zero	Below 0.05 g/dL	Below 0.08 g/dL
All drivers	11,526	10,009	8,793
Drivers of vehicles < 12 years old	5,654	4,898	4,292
Drivers of vehicles < 9 years old	3,746	3,240	2,835
Drivers of vehicles < 6 years old	2,520	2,175	1,902
Drivers of vehicles < 3 years old	1,286	1,109	970
Drivers with prior alcohol convictions	961	869	790
Fleet drivers	446	376	324

DISCUSSION

Eliminating alcohol-impaired driving in the United States could save more than 9,000 lives each year. This can be accomplished by equipping all vehicles with devices that precisely detect alcohol in drivers, and that prevent vehicle movement if the alcohol exceeds a given limit. And lowering the limit beyond the typical 0.08 g/dL BAC could save even more lives—potentially more than 11,000 per year.

There is public support for such vehicle-based alcohol detection systems, but they must be both seamless and reliable if they are to be accepted in privately owned vehicles. Systems that annoy drivers or mistakenly prevent sober drivers from traveling will not succeed. A 2009 survey asked adults across the U.S. if they would support a system in all vehicles that could "measure quickly, accurately, and unobtrusively the amount of alcohol in drivers." Twenty-eight percent of respondents said it was a good idea, and another 36% said it was a very good idea. Support was highest among women (McCartt et al. 2010).

Even if all new vehicles come equipped with such alcohol detection systems, it will take time to reach their full potential, as new vehicles account for just a portion of fatal crashes each year. Within 3 years of a mandate for vehicle-based alcohol detection systems, it is expected that annual lives saved would be around 1,000. Within 6 years of a mandate, annual lives saved would be around 2,000, and within 12 years it would be around 4,600. So, it would be approximately 12 years before reaching even halfway to the full potential of 9,400 lives saved per year.

An alcohol detection system available only in certain vehicles would have a smaller effect. For example, a system required only for those convicted of alcohol-impaired driving could save between 800 and 1,000 lives per year. A system available only to fleets of vehicles could save even fewer—between 300 and 500 lives per year. Drivers of vehicles owned by someone else are much less likely to be impaired by alcohol.

Finally, the impact of technology offered to vehicle purchasers as an added option will depend upon the popularity of the option. Rearview cameras have been a popular option and were on approximately 35% of all registered vehicles in 2018. Curve-adaptive headlights, however, were on only 3% of registered vehicles in 2018 (Highway Loss Data Institute 2019). Most individual vehicle purchasers are unlikely to choose an alcohol detection system as an option in their vehicle, especially if it involves significant cost. In the survey by McCartt et al. (2010), only 42% of respondents said they would be willing to pay to have such systems in their vehicles, even if the additional cost was less than $500.

There are several limitations to this analysis. First, the analysis looked at the effects of reducing alcohol for the driver with the highest BAC. Some crashes may still occur if they involve more than one driver impaired by alcohol. Secondly, it depends upon the accuracy of the relative risk curves described by Equations (1)–(3). These curves are based on a methodology that has been employed in at least four studies spanning more than 25 years, and, although the individual estimates have changed over time, the patterns are similar. Fatal crash risk increases as BAC increases, and alcohol affects crash risk more for young drivers than for older drivers. A third limitation is that the analysis assumes vehicle-based alcohol detection systems will work flawlessly. It is more likely that these systems will sometimes fail. It is also likely that drivers will discover methods for circumventing the systems. In that sense, the potential lives saved may well be lower than estimates presented here.

In conclusion, vehicle-based systems that block alcohol-impaired driving show great promise, potentially preventing more than 25% of the deaths occurring in U.S. roadway crashes. However, limited availability and use of these systems could drastically reduce their potential. Until the time when every vehicle on the road has a foolproof alcohol detection system, it is important to continue expanding deployment of the other countermeasures that have proven effective against alcohol-impaired driving.

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APPENDIX

Table A. Potential lives saved if drivers of vehicles less than 6 years old were restricted to various BAC levels

Highest driver BAC in crash (g/dL)	2015–18 deaths	Potential lives saved if BACs were reduced to	
		Zero	Below 0.08 g/dL
0.02–0.049	693	474	0
0.05–0.079	870	768	0
0.08–0.099	758	717	214
0.10–0.149	2,365	2,325	1,832
0.15+	6,171	6,166	6,104
0.02+	10,857	10,450	8,150
(95% confidence limits)		(10,328; 10,533)	(7,960; 8,293)

Table B. Potential lives saved if drivers of vehicles less than 9 years old were restricted to various BAC levels

Highest driver BAC in crash (g/dL)	2015–18 deaths	Potential lives saved if BACs were reduced to	
		Zero	Below 0.08 g/dL
0.02-0.049	1,010	690	0
0.05-0.079	1,277	1,127	0
0.08-0.099	1,115	1,056	316
0.10-0.149	3,506	3,447	2,717
0.15+	9,214	9,206	9,115
0.02+	16,122	15,526	12,148
(95% confidence limits)		(15,349; 15,650)	(11,865; 12,363)

Table C. Potential lives saved if drivers of vehicles less than 12 years old were restricted to various BAC levels

Highest driver BAC in crash (g/dL)	2015–18 deaths	Potential lives saved if BACs were reduced to	
		Zero	Below 0.08 g/dL
0.02-0.049	1,492	1,021	0
0.05-0.079	1,926	1,701	0
0.08-0.099	1,638	1,553	467
0.10-0.149	5,298	5,210	4,113
0.15+	13,953	13,942	13,805
0.02+	24,307	23,427	18,385
(95% confidence limits)		(23,168; 23,612)	(17,958; 18,706)

Table D. Potential lives saved if drivers with prior alcohol convictions were restricted to various BAC levels

Highest driver BAC in crash (g/dL)	2015–18 deaths	Potential lives saved if BACs were reduced to	
		Zero	Below 0.08 g/dL
0.02-0.049	170	115	0
0.05-0.079	206	181	0
0.08-0.099	188	178	53
0.10-0.149	711	699	550
0.15+	2,775	2,773	2,745
0.02+	4,050	3,946	3,348
(95% confidence limits)		(3,911; 3,968)	(3,282; 3,394)

Table E. Potential lives saved if drivers of fleet vehicles were restricted to various BAC levels

Highest fleet driver BAC in crash (g/dL)	2015–18 deaths	Potential lives saved if BACs were reduced to	
		Zero	Below 0.08 g/dL
0.02-0.049	164	109	0
0.05-0.079	182	159	0
0.08-0.099	155	146	42
0.10-0.149	405	398	310
0.15+	1,050	1,049	1,038
0.02+	1,956	1,861	1,390
(95% confidence limits)		(1,838; 1,878)	(1,360; 1,416)