Economic costs of motor vehicle crashes involving teenaged drivers in Kentucky, 1994

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Abstract

Objectives—To analyze data from motor vehicle crashes (MVCs) involving teenaged drivers in Kentucky for 1994, and derive cost estimates of these crashes.

Methods—Crash data were obtained from the *Kentucky Traffic Accident Facts 1994 Report* and the Kentucky Accident Reporting System. The National Highway Traffic Safety Administration's *Crash-Cost* program was used to generate cost estimates for Kentucky data.

Results—Teenaged drivers had significantly higher MVC fatal and non-fatal injury rates than did adult drivers. The death rates were 43.6 and 19.0 per 100 000 for teens and adult drivers, respectively. Odds ratios (ORs) were calculated to estimate the relative risk for (1) involvement in an MVC, (2) fatal or incapacitating injury, and (3) fatal injury for teenaged compared with adult drivers. The crude ORs were statistically significant at each age.

Cost estimates were calculated on a per person/vehicle basis. A single fatal injury was \$642 700. A critical injury was \$563 000. In general, unit costs rose with increasing levels of injury severity. For the total number of fatal injuries, costs exceeded \$91 million. For non-fatal injuries and property damage only crashes, total costs were \$318 million. Overall, the total cost estimate for MVCs involving teenaged drivers was nearly \$410 million.

Conclusions—Strategies aimed to reduce the number of MVCs attributed to teenaged drivers should reduce both the number and costs of crash related deaths and injuries. Graduated driver licensing (GDL) systems are one plausible approach toward achieving this goal. By recently enacting a GDL system in Kentucky, it is anticipated that many lives and dollars will be saved.

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Keywords: death rates; injury severity; *CrashCost*; graduated driver licensing (GDL).

The disproportionate involvement of teenaged drivers (16–19 year olds) in motor vehicle crashes (MVCs) is a persistent and pervasive problem throughout the United States (US) and in other developed countries. The teen driving problem is profound in the Commonwealth of Kentucky, which ranks consistently among the top 10 states in teenage death rates from MVCs.¹ In 1994, Kentucky teens died in MVCs at a rate more than *twice* that of adult

drivers (44 v 19 per 100 000 licensed drivers). While teenaged drivers represented 5.6% of Kentucky's licensed driving population in 1994,³ they were overrepresented as drivers in MVCs: of all crash involved drivers (203 758), 14% were teens (29 236); of all drivers involved in fatal MVCs (516), 12% (62) were teens; of all drivers involved in non-fatal MVCs (32 851), 5345 (16%) were teens; finally, of all drivers involved in property damage only (PDO) crashes (170 391), 14% (23 829) were teens.⁴ Of the 142 persons killed in crashes involving a teenaged driver, 62 (44%) were the driver.⁴ These data clearly indicate that the number of teenaged drivers involved in MVCs far exceeds their overall representation in the licensed driving population.

Based on information from *Kentucky Uniform Police Traffic Accident Reports*, alcohol was not a major contributing factor to MVCs involving teenaged drivers. Only 17 (14%) of the 120 fatal crashes involving a teen driver were alcohol related. By contrast, 242 (41%) of 586 fatal crashes involving only adult drivers were alcohol related.⁴

Major reports have been published previously that estimate the costs of injury in general,⁵ and the costs associated with MVCs in particular.^{6–9} While several studies have examined teenaged driver involvement in MVCs, to our knowledge only one study has examined the economic costs associated with teen MVCs.¹⁰ This report examines data from MVCs involving young drivers in Kentucky for 1994, and presents the findings of a detailed cost analysis of these crashes.

Methods

KENTUCKY CRASH DATA

Data regarding the numbers of fatal, non-fatal and PDO MVCs were compiled by the Kentucky State Police from all *Kentucky Uniform Police Traffic Accident Reports* submitted in 1994, and subsequently published in the *Kentucky Traffic Accident Facts 1994 Report*. Additional crash data were obtained from the Kentucky Accident Reporting System (KARS).² Information on the number of licensed drivers in Kentucky was obtained from the Transportation Cabinet,³ and population data were obtained from the Bureau of the Census.¹¹ Together, these data were used to calculate the costs of MVCs involving at least one teenaged driver in Kentucky during 1994. The data also were used to compare teenaged and adult drivers with respect to the risk of involvement in MVCs, and potential differences in MVC related costs.

The Kentucky State Police categorize MVC related injuries based on the five point KAB-

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CO scale, where K = ‘killed’; A = ‘incapacitating injury’; B = ‘non-incapacitating injury’; C = ‘possible injury’; and O = ‘no injury’. Definitions of these categories can be found in the National Safety Council’s *Manual on Classification of Motor Vehicle Traffic Accidents*.¹²

Although law enforcement officials are not trained to make sophisticated ‘medical’ assessments of crash victims, at least one study has shown that police officers’ judgments of injury severity are sufficiently accurate. Hansen *et al* examined the relationship between law enforcement officials’ KABCO coding of injury severity at a crash scene and emergency department physicians’ judgments using the same KABCO criteria.¹³ For nearly 50% of the cases, there was complete agreement between the police officers’ and physicians’ scores. Agreement was highest for the most severe (K+A) and least severe (C) injury categories. There was less agreement between the officers and physicians in the ‘B’ and ‘O’ categories. Moreover, 88% of the cases were given a KABCO score within one category of the investigating officer’s judgment. These results support the use of police officer assessments of injury severity in studies of MVCs (Hansen *et al*¹³ but see Miller *et al*⁷).

COST ESTIMATION

An IBM compatible software program, *CrashCost*,¹⁴ and accompanying documentation¹⁵ were obtained from the National Highway Traffic Safety Administration (NHTSA; Office of Plans and Policy, Washington, DC) to derive cost estimates. The source of *CrashCost* data and the derivation of each cost component for fatal and non-fatal injuries have been described in detail previously.⁶ Briefly, *CrashCost* uses the ‘human capital’ method to estimate the economic costs of MVCs. This approach includes both direct and indirect costs to individuals and to society that result from decreases in the general health status of those killed or injured in MVCs. Direct costs include emergency services, initial medical costs, rehabilitation costs, long term care and treatment, insurance administration expenses, legal costs, and employer/workplace costs. Indirect costs are productivity losses in the workplace and home due to temporary and permanent disability. The *CrashCost* program uses a 4% discount rate to estimate productivity losses based on the present value of future earnings. Estimates also are derived for costs other than those directly attributable to injury, such as property damage and travel delay. Importantly, *CrashCost* focuses on the economic impact of MVCs; thus, cost estimates do not include values for pain and suffering, nor do they measure decreases in ‘quality of life’ among MVC victims and their families.

While the cost components for fatal and non-fatal injuries are similar (see table 3), the methods of measurement are different. For non-fatal injuries, costs are calculated for injuries classified by the abbreviated injury scale (AIS). The AIS represents a standardized, albeit imperfect, system for categorizing

injury type, and for quantifying severity based on immediate threat to life.¹⁶ Because MVC related injuries are usually multiple, cost estimates are based on the maximum injury severity (MAIS) level for an individual. This method assumes that the distribution of injury severity levels in any given state is similar to that for the nation as a whole. For jurisdictions that use the KABCO system, *CrashCost* translates KABCO frequencies into MAIS frequencies (for details, see Blincoe¹⁵).

CrashCost includes a number of mechanisms for determining incidence when specific state data may be missing, and for adjusting data for locality and time period. For example, KARS data provide information on the number of PDO crashes but not for the number of PDO vehicles. The number of PDO vehicles was estimated by multiplying the total number of police reported PDO crashes by 1.7.¹⁵ In addition, many MVCs are not reported to the police, or reports get lost in state records. Because unreported crashes constitute a large proportion of crash costs, the number of reported MVCs has been adjusted to account for the percentage of unreported crashes by applying the following national estimates: MAIS 1, 23.7%; MAIS 2, 16.5%; MAIS 3, 6.8%; MAIS 4, 0.7%; MAIS 5, 0; fatal, 0; PDO, 48%.¹⁵ To adjust for unreported crashes, the number of police reported injuries and PDO vehicles are divided by one minus the per cent unreported. Finally, because *CrashCost* estimates are national averages expressed in 1992 terms, a locality adjustment was made for Kentucky (based on average per capita income), and for 1994 data (based on the Consumer Price Index (CPI) All Items index). (By using the All Items index, costs will be slight underestimates given larger increases in medical care costs relative to overall costs. However, because medical expenses comprise only 10% of overall costs, the results are not impacted significantly.)

Results

FATALITY AND INJURY RATES

When compared with older drivers, teenagers had significantly higher MVC related fatality and injury rates in Kentucky for 1994 (table 1). The death rate for 16–19 year old drivers was 43.6 per 100 000 licensed teenaged drivers, and 19.0 per 100 000 for drivers 20 years of age and older. Injury rates were highest for 16 year olds, and decreased with increasing age (up to 19 years; data not shown). On average,

Table 1 Fatal and non-fatal injuries to drivers involved in MVCs in Kentucky, 1994

Injury level	Drivers aged 16–19		Drivers aged 20+	
	Frequency	Rate*	Frequency	Rate*
Fatal	62	43.6	454	19.0
Incapacitating	855	602	4884	204
Non-incapacitating	2021	1422	9214	385
Possible	2469	1737	13408	560
None	23829	16769	146562	6123

*Per 100 000 licensed drivers (Transportation Cabinet, Division of Driver Licensing). Data is from the Kentucky Accident Reporting System (KARS).

non-fatal injury rates for 16–19 year olds were at least *three* times greater than those for older drivers (table 1). Odds ratios (ORs) were calculated to estimate the risk for three outcomes: (1) involvement in an MVC, (2) fatal or incapacitating injury, and (3) fatal injury for teenaged compared with adult drivers (table 2). For all three outcomes, the crude ORs were statistically significant at each age from 16 to 19 years. The overall OR for involvement in an MVC was greater for teenaged drivers (aged 16–19) (OR = 3.29, confidence interval (CI) = 3.26 to 3.34), and the risk of involvement in a fatal or incapacitating injury MVC was nearly as high (OR = 2.91, CI = 2.72 to 3.11). The risk of a teen driver sustaining a fatal injury was more than twice that for adult drivers (OR = 2.30, CI = 1.77 to 2.99) (table 2).

UNIT COSTS

To estimate the costs of MVCs involving at least one teenaged driver, we derived an overall estimate of the costs of MVCs in Kentucky for 1994. These costs were calculated for injury and non-injury related expenses on a ‘unit’ (that is, per injured person or per damaged vehicle) basis, and are presented in table 3. *CrashCost* estimated the cost of a single MVC related fatality at \$642 683. The most costly fatal injury expense category was productivity (wage work and household work), accounting for 80% of the total costs. Market productivity is the present discounted (4%) value of lost wages and fringe benefits over the victim’s remaining life span. Household productivity is the present value of activities performed in the home, valued at the market price to hire

someone else to accomplish these tasks.⁹ Insurance administration and legal/court costs accounted for 17% of the costs per fatality. The estimated cost of a single critical injury (MAIS 5) was \$562 905. For critical injuries, medical expenses accounted for 45%, and productivity losses accounted for 33% of the total unit costs. Other expenses ranged from \$5700 (MAIS 1) to \$151 000 (MAIS 4). In general, estimated unit costs rose with increasing levels of injury severity. These unit cost estimates are not age specific (see below); they have been adjusted only for locality (that is, Kentucky), and for the year of interest (that is, 1994).

TOTAL COSTS

To calculate the overall costs of MVCs involving teenaged drivers, unit costs were multiplied by the number of fatal, non-fatal, and PDO MVCs in which at least one teenaged driver was involved. For example, a single fatal injury estimated to cost \$642 683, was multiplied by 142 (the number of persons killed in a crash involving a teenaged driver) to obtain a total cost estimate of \$91.2 million for all fatal injuries (table 4). Following this procedure for all injury levels and for PDO vehicles resulted in a total cost estimate of \$410 million. Because drivers ‘at fault’ cannot be conclusively identified from crash reports, this total includes estimates for multivehicle crashes where another (that is, adult) driver may have been at fault. Thus, total costs may be an *overestimation* of the teen driving problem in economic terms.

Table 2 Comparison of teenaged drivers with all other licensed drivers in three types of MVCs in Kentucky, 1994

Age	Involvement in MVC		K+A injuries		Fatal injuries	
	Crude OR*	95% CI	Crude OR	95% CI	Crude OR	95% CI
16	5.16	5.01 to 5.32	4.40	3.82 to 5.07	2.44	1.23 to 4.68
17	3.63	3.54 to 3.73	2.78	2.40 to 3.19	2.56	1.53 to 4.24
18	2.90	2.83 to 2.98	2.73	2.40 to 3.10	1.87	1.08 to 3.19
19	2.61	2.54 to 2.67	2.43	2.13 to 2.78	2.45	1.52 to 3.90
16–19	3.29	3.26 to 3.34	2.91	2.72 to 3.11	2.30	1.77 to 2.99

OR=odds ratio; CI=confidence interval; K (killed)+A (incapacitating injury).
*Referent group was drivers ≥20.

Table 4 Total costs (\$) of MVCs involving a teenaged driver in Kentucky, 1994

Category	Unit cost	Frequency*	Total cost
Injury level			
MAIS 1	5724 ×	18834 =	107 805 816
MAIS 2	25076 ×	2171 =	54 439 996
MAIS 3	78861 ×	698 =	55 044 978
MAIS 4	150599 ×	85 =	12 800 915
MAIS 5	562905 ×	45 =	25 330 725
Fatal	642683 ×	142 =	91 260 986
PDO vehicle	1369 ×	46031 =	63 016 439
Total			409 699 855

*Frequency=the sum of police reported crashes and an estimate for unreported crashes. *CrashCost* models injuries by translating KABCO frequencies into MAIS frequencies.

Table 3 Unit cost estimates (\$) of MVCs by expense type and injury severity in Kentucky, 1994

	PDO	Injury level					Fatal
		MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	
Injury expenses							
Medical	–	690	5558	18725	57459	251633	3733
Premature funeral	–	–	–	–	–	–	2767
Emergency services	22	124	275	413	940	957	861
Vocational rehabilitation	–	12	80	174	227	432	–
Market productivity	–	971	9127	29856	41960	149044	418236
Household productivity	33	298	2488	7854	11131	38015	92710
Insurance administration	117	390	1592	5206	10669	41056	44769
Workplace costs	28	142	1075	2396	2610	4623	6091
Legal/court	–	274	1981	9364	18622	70438	65700
Subtotal	200	2901	22177	73989	143618	556198	634866
Non-injury expenses							
Travel delay	98	158	158	158	158	158	353
Property damage	1072	2665	2741	4715	6823	6549	7464
Subtotal	1169	2823	2899	4872	6981	6707	7816
Overall total	1369	5724	25076	78861	150599	562905	642683

Unit costs are on a per person/per vehicle basis. Numbers may not add to totals due to rounding. Estimates were derived by using NHTSA’s *CrashCost* software and were adjusted for locality (Kentucky) and current year (1994).

AGE SPECIFIC COSTS

In addition to determining the economic costs for all persons involved in MVCs where at least one teenager was a driver, we calculated estimates for the teenaged drivers themselves. It is not possible to calculate cost estimates for specific age groups with the *CrashCost* program; however, appropriate data for this analysis were provided by Dr Ted Miller and his associates at the Children’s Safety Network (CSN).¹⁷ These Kentucky specific data included the estimated cost per highway injury by age group and injury severity (KABCO) for the same cost categories included in the *CrashCost* program. By using these cost estimates (table 5) and the KABCO distribution of MVC related injuries to 16–19 year old drivers (table 6),² we derived the total estimated MVC related costs for involved teenaged drivers in Kentucky for 1994 (table 7). For the 62 teen drivers fatally injured in MVCs, cost estimates were more than \$53 million. Across all categories, total estimates were close to \$136 million. The average cost per injury category was \$4755. For comparison, the CSN cost estimates (table 5) for all ages were multiplied by the KABCO distribution of injuries for the

20+ drivers (table 6) to derive the total MVC related costs for all adult drivers in Kentucky for 1994 (table 8). Clearly, higher frequencies result in higher total cost estimates. However, for all adult drivers the average cost per injury category was \$4647, slightly lower than that calculated for teens alone.

Discussion

In the US, MVCs are the leading cause of death and disability for teenagers of driving age.¹⁸ Moreover, teenaged drivers account for a disproportionate number of MVCs when compared with older drivers.¹⁸ Generally, higher rates of MVC involvement are attributed to driving inexperience, poor decision making skills, and a propensity for risk taking behavior.¹⁹ Kentucky teens are no exception. In 1993 and 1994, Kentucky ranked first and ninth, respectively, in teen death rates from MVCs.¹ In the current study, NHTSA’s *CrashCost* program was used to derive cost estimates for MVCs involving teenaged drivers in Kentucky for 1994. Our findings show the economic toll of these crashes and further highlight the importance of taking steps to reduce the number and subsequent costs of these crashes.

Among teenaged drivers involved in MVCs in 1994, the death and injury rates were close to three times higher than were those among older drivers (table 1). Rates were highest among 16 year olds, and decreased with age up to 19 years (data not shown). Similarly, 16 year olds were at greater risk for involvement in MVCs, for sustaining fatal or incapacitating injuries, or being fatally injured in an MVC (table 2). ORs indicated that for each MVC outcome, risk decreased with increasing age. These data are consistent with the notion that 16 year olds represent the key at-risk population. Nationally, 35% of all 16 year old drivers were involved in an MVC in 1994. The percentages decreased to 31% among 17 year olds, 27% for 18 year olds, and 24% for 19 year olds. Among 20–24 year olds, the percentage was even lower at 18%.²⁰

That alcohol was not a major contributing factor in teenage MVCs in Kentucky may be surprising; however, national data showed that for 1993, only 5% of 16 year old drivers killed in MVCs had blood alcohol concentrations above the legal limit.¹⁹ Although this number increased to 28% among 17–19 year old drivers, among drivers 20 years of age and older, nearly half (48%) of the fatal MVCs involved alcohol.

Previous studies that have estimated the economic costs of MVCs used MVC related injury data from sources that derive estimates of fatal and non-fatal injuries on a national level.^{6,9} In the US, the total economic cost of MVCs and MVC related injuries was estimated at \$137.5 billion in 1990,⁶ and at \$150.5 billion in 1994.⁹ The *CrashCost* software allows for estimating the costs of MVCs in state or local jurisdictions by providing a means to adjust for the state specific economy and for current year of interest.

Table 5 Total estimated costs (\$) of MVC related injuries by age and injury severity

	Injury severity				
	O	C	B	A	K
15–19 years	501	5298	10303	43106	857159
All ages	635	6219	11435	42835	746264

In 1994 dollars and adjusted to Kentucky prices. Used for motor vehicle occupant, pedestrian, and bicycle injuries. Modified from Miller.¹⁷

Table 6 Frequency of MVCs by age of driver and injury severity

	Injury severity				
	O	C	B	A	K
16–19 years	23829	2469	2021	855	62
20+ years	146562	13408	9214	4884	454
All ages	170391	15877	11235	5739	516

Data is from the 1994 Kentucky Accident Reporting System (KARS).

Table 7 Total cost estimates (\$) for teenaged (16–19) drivers involved in MVCs

Injury severity	Frequency	Cost/injury	Total cost
K	62 ×	857159 =	53 143 858
A	855 ×	43106 =	36 855 630
B	2021 ×	10303 =	20 822 363
C	2469 ×	5298 =	13 080 762
O	23829 ×	501 =	11 938 329
Total	29236		135 850 942

Table 8 Total cost estimates (\$) for adult (20+) drivers involved in MVCs

Injury severity	Frequency	Cost/injury	Total cost
K	454 ×	746264 =	338 803 856
A	4884 ×	42835 =	209 206 140
B	9214 ×	11435 =	105 362 090
C	13408 ×	6219 =	83 384 352
O	146562 ×	635 =	93 066 870
Total	174522		829 823 308

The derivation of unit costs (table 3) serves the primary purpose of converting the *Crash-Cost* program's national data from 1992 price levels to Kentucky's price levels for 1994. On average, unit cost estimates for Kentucky in 1994 were 17% lower than those for the US in 1990⁶ after conversion to 1994 dollars. (The adjustment factor used was 1.13, which is the ratio of the 1994 CPI (148.2) to the 1990 CPI (130.7).)

For total cost estimates of MVCs involving teenaged drivers (table 4), the MAIS 1 injury category was estimated as the most costly, totaling nearly \$108 million and accounting for 26% of total costs. Fatal injury was the next most costly category, with estimates totaling more than \$91 million and accounting for 22% of the total. PDO vehicles had the highest incidence, but accounted for only 15% of the total estimated costs at \$63 million. By contrast, for the US in 1990, PDO crashes was the most costly category, totaling nearly \$36 billion and accounting for 26% of the total MVC costs.⁶ It is unlikely that this disparity is the result of differences in the crash reporting threshold, for Kentucky's threshold is not atypical (for example, \$500 damage). However, it is possible that a greater number of PDO crashes go unreported in Kentucky than do such crashes in other states. It is also possible that because Kentucky is largely a rural state, the ratio of severe injury to PDO MVCs is much larger than that for more urban areas. In general, faster traveling speeds are common on rural roads, and increased speed leads to more severe injury crashes.

While *CrashCost* proved adequate for estimating the economic costs of MVCs involving at least one teenaged driver, the program did not provide a means for estimating the economic costs of MVCs among different age groups. For example, do economic cost estimates differ across age groups, and what are the costs associated with fatal and non-fatal injuries to the teenagers themselves who are involved in MVCs? To answer these questions, we used age specific data for Kentucky provided to us by researchers at CSN.¹⁷

According to the CSN data (table 5), cost estimates for both the fatal (K; \$857 159) and incapacitating injury (A; \$43 106) categories were greater for 15–19 year olds than were the estimates for all ages (\$746 264 and \$42 835, respectively). By contrast, cost estimates for the non-incapacitating (B), possible (C), and no injury (O) categories were lower for 15–19 year olds than were the estimates for all ages (table 5¹⁷). Thus, age becomes an important factor when examining the costs of injury by level of severity.

Of the 142 persons killed in teen driver crashes in Kentucky during 1994, 62 (44%) were the teenaged driver.⁴ By multiplying the cost estimates for 15–19 year olds (table 5¹⁷) by the incidence of injuries sustained by 16–19 year old drivers (table 6²), we derived a total of \$136 million for MVC related expenses to teen drivers alone. While teenagers may not provide financial support for their families, fatal or permanently disabling injuries from MVCs

generate a tremendous economic loss by removing these youth from society as potential consumers and producers.

It is worth noting that the cost estimates derived by using *CrashCost* differ from those provided by CSN. For example, table 3 shows that the unit cost for a fatal injury was \$642 683. CSN's estimate (table 5) for a fatal injury was \$746 264 (for all ages). There are at least two possible explanations for the discrepancy between these estimates for the fatal, as well as other, injury categories. First, different discount rates were used; *CrashCost* used a 4% rate, and CSN used a 2.5% rate.¹⁷ The use of lower discount rates results in higher cost estimates. Second, *CrashCost* used the seven point MAIS injury classification system, whereas CSN used the five point KABCO system. Thus, the injury severity categories of the two systems are overlapping and not directly comparable.

The cost estimates presented in this study represent the economic costs of injury and non-injury related expenses as well as productivity losses resulting from MVCs. These cost estimates do not reflect the 'quality of life' losses associated with MVCs such as pain, suffering, and loss of life. Several studies have attempted to measure the dollar value of these intangible consequences (for example, Miller *et al.*^{8 10}). Thus, economic cost estimates of MVCs are relatively conservative estimates; 'comprehensive costs', which combines both economic costs and values for intangibles, can be an order of magnitude higher.

PAYMENT SOURCES

In general, the MVC related expenses are borne by the individual through expenses not covered by, or which exceed, insurance benefits, and by society through higher premiums and the reallocation of state and federal resources. According to NHTSA, the medical costs associated with MVC related injuries was estimated at nearly \$13.9 billion in 1990,⁶ and \$17.0 billion in 1994.⁹ Of this 1994 total, private insurance companies paid \$9.3 billion (55%); government sources subsidized approximately \$4.1 billion (24%); and 'other payers' (including 'self') were responsible for the remaining \$3.6 billion (21%).

Clearly, private insurers pay the majority of the medical costs associated with MVC related injuries. Importantly, the financial burden imposed upon the private sector by teenaged drivers involved in MVCs is even greater. According to the Highway Loss Data Institute, the injury claim frequency for cars insured to teenagers was more than double that for cars insured to adults.²¹ For collision claims, cars insured to teenagers had a 90% higher claim frequency.²¹

LIMITATIONS

The *CrashCost* software used to analyze the data for this report does have limitations. First, the software averages lost productivity costs across all age groups for each injury level.

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However, cost estimates have been shown to differ depending upon the age group(s) of interest.¹⁰ Second, the software uses proportions derived from national estimates for the distribution of injury severity, driver age, crash related costs, and crashes unreported to the police, then applies them to state data. The national estimates may not reflect the actual distributions of these factors in Kentucky. Finally, the impact of crashes involving teen-aged drivers cannot be fully realized by analyzing economic aspects alone. Other studies using different approaches go into greater detail and have put monetary values on intangibles. Such analysis is beyond the scope of this paper (but see Miller *et al*^{7 8 10}).

Implications for prevention

Strategies aimed at reducing the number of MVCs attributed to teenaged drivers should reduce substantially both the numbers of crash related deaths and injuries and the costs of these crashes. The use of graduated driver licensing (GDL) systems is one important approach for reducing the number and subsequent costs of MVC related deaths and injuries among teenagers, their passengers, and other drivers. The intent of GDL systems is to provide young, novice drivers an opportunity to gain practical driving experience in low risk settings without raising the age for licensure. By design, GDL systems target the driving behaviors (for example, risk taking, speeding, inattention) and crash characteristics (for example, single vehicle involvement, nighttime occurrences, multiple vehicle occupants) of teenagers that increase their risk for crash involvement. GDL systems also include strategies for enforcement of rules and procedures, and impose strict sanctions for violations.

In March 1996, the Kentucky General Assembly passed the *Graduated Drivers Licensing for Youth* bill (HB400), one of the most comprehensive GDL programs in the country. Under this new legislation young, novice drivers (at least 16 years old) begin with a learner's permit and a number of driving restrictions, including a six month waiting period before applying for a license, a period of supervised driving, a night-time (midnight to 6am) driving restriction, and a reduced point threshold for license suspension as a result of traffic citations. To obtain a provisional, 'minor's' license, the teenaged driver (16–18 years old) must pass a driving skills test and complete a state approved graduated licensing or driver education course. Full licensure can be obtained at age 18. Zero alcohol tolerance (0.02 blood alcohol concentration) is required of drivers at all stages of licensure until the driver is 21 years of age.

The primary elements of GDL programs are delayed licensure, night-time driving restrictions, and extended periods of supervised driving. If these elements prove effective in reducing the number of deaths and injuries from MVCs involving teenaged drivers, the

cost savings are likely to exceed operational costs of the program. Indeed, studies have demonstrated the effectiveness of these elements in reducing crashes among teenaged drivers. In Delaware and Connecticut, states which allow unrestricted licensing at age 16, crash rates among 16 year olds were significantly higher than were rates in Pennsylvania or New York, states that delay full licensure.²² Similarly, the effectiveness of night-time driving restrictions also has been shown in this²² and an earlier study.²³ In upstate New York (9pm to 6am curfew) and Pennsylvania (midnight to 6am curfew), both total crashes and crash rates were significantly lower than predicted during restricted driving periods by 65% and 54%, respectively.²² Preusser *et al* showed that curfew laws substantially reduced the number of crashes among 16 year old drivers that occurred during curfew hours.²³ In the four states (Louisiana, Maryland, New York, and Pennsylvania) that had curfew laws, the reductions in crashes ranged from 25% (Louisiana) to 69% (Pennsylvania). In evaluating the effectiveness of supervised driving, Ferguson *et al* showed that in upstate New York, where unsupervised driving by 16 year olds is generally not allowed, their crash rate was about one third (0.36) that for adults.²² The rate was even lower in New Jersey (0.13), where 16 year olds are only allowed to drive with supervision.

Are these individual elements equally effective when combined in a comprehensive GDL program? An evaluation of California's provisional licensing system showed a statistically significant reduction in the rate of MVCs among 15–17 year olds. The estimated reduction was 5.3% of their average rate before the program was implemented.²⁴ Maryland has also demonstrated small but significant reductions in the number of traffic related deaths and injuries to teenagers after implementation of a GDL system.²⁵ In New Zealand, a GDL system was started in 1987. During the subsequent five year period (1987–92) the number of serious MVC related injuries among 15–19 year olds declined 7–23%.²⁶

Conclusion

In this study, the cost estimates derived for MVCs involving teenaged drivers in Kentucky for 1994 clearly illustrate the enormous economic impact of these crashes on the state and its taxpayers. Attempts to reduce the number of Kentucky teenagers involved in MVCs would contribute substantially toward reducing the total numbers of traffic related deaths and injuries, and toward decreasing the costs of these crashes. By implementing a GDL program in Kentucky, a significant number of lives may be saved, injuries prevented, and economic costs substantially reduced.

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Does your child know how to use the emergency services?

A report in Newcastle's *Evening Chronicle* tells how a 5 year old saved his parents and 2 week old brother in a fire. The toddler woke at 5 am to find his home filled with smoke and dialled the emergency number, 999, himself before leading his family to safety.

Fatal 'surfing' on a fire engine

Andrew Chapman, writing in the *Daily Mail* (15 December 1996), tells the story of an 8 year old who was killed, trying to 'surf' on a moving fire engine in Burnley, Lancashire. He fell off the vehicle and was crushed under its wheels as it moved slowly. The death came a month after police and fire chiefs warned youngsters that the craze of jumping on appliances would end in tragedy. Several children, including some as young as 7, had recently been found clinging to the ladders on fire engines and a girl had been thrown off as the vehicle rounded a corner at speed. The police recognised that fire engines have a fascination for children but called on parents to warn their children of the perils.

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