

California's Graduated Driver License Law: Effects on Older Teenagers

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Abstract

Many traffic safety researchers believe Graduated Driver Licensing (GDL) laws save lives by imposing restrictions, stronger licensing requirements, and delayed licensure status on drivers under age 18. To determine the effects of California's GDL law on traffic fatalities among older (age 18-19) and younger (age 16-17) teens by age, sex, accident characteristics, and license status, mortality data from California's Center for Health Statistics, driver and accident data from the Fatality Analysis Reporting System, and population data from the California Department of Finance were analyzed for the 1995-2004 period. Compared to California who began driving before the GDL law took effect and to corresponding trends among Californians ages 20 through 44, 16- and 17-year-olds subject the GDL law experienced net decreases of 13% in motor vehicle fatality rates and 14% in driver involvements in fatal accidents. However, 18- and 19-year-olds subjected to GDL programs experienced net increases of 11% in traffic fatalities and 10% in involvements of drivers in fatal accidents, more than offsetting the declines among younger teenagers. These results support reassessment of the effects of the GDL law, including its specific requirements, on older teenagers.

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Introduction

High rates of motor vehicle crashes and fatalities involving teenage drivers have been attributed to inexperience with driving and risk-taking due to immature age (Chen et al., 2000; Ulmer, Williams, & Preusser, 1997). To allow new drivers under age 18 to obtain experience while minimizing risks, states have replaced simple, single-stage drivers' licensing procedures that required brief training and testing with graduated drivers' licensing (GDL) laws, which provide lengthy, multistaged, supervised training and probationary periods. California's Graduated Driver Licensing (GDL) law, effective July 1, 1998, is considered among the most restrictive of any state's (Masten & Hagge, 2003; Smith, Pierce, Ray & Murrin, 2001). As summarized in [Appendix A](#), the law requires new teenage drivers to successfully complete a year-long, three-stage process to obtain a full privilege license (California Department of Motor Vehicles, 2006).

Preliminary studies report that GDL laws reduce traffic crashes and fatalities among 16-year-olds

and, in some cases, 17-year-olds (Chen, Baker & Li, 2006; Foss, Feaganes & Rodgman, 2001; Morrissey, Grabowski, Dee & Campbell, 2006; Shope, Molnar, Elliott & Waller, 2001). Several studies, none citing data more recent than 2001, find that California's GDL law reduced fatalities and certain types of fatal crashes among 16-year-olds (Cooper, Gillen & Atkins, 2004; Leaf, 2002; Rice, Peek-Asa & Kraus, 2004; Williams, Nelson & Automobile Club of Southern California, 2000, 2001), though one initial study warns that GDL laws may have unexpected consequences for older teenagers (Masten & Hagge, 2003). Unfortunately, few longer-term analyses exist (Dee, Grabowski, Morrissey, 2005; Hedlund Shults & Compton, 2003; Simpson, 2003). This study examines the effects of California's GDL law on fatalities involving teenagers and drivers ages 16-19 licensed before and after the GDL law took effect. If high rates of crashes among 16-17 year-old drivers are due mainly to immaturity and risk-taking inherent in young age, as most researchers argue, GDL laws would be expected to save teenage lives by

delaying the age at which full licensing privileges are allowed (see [Appendix A](#)).

Data and Analysis

Data for this study include mortality vital statistics, driver and passenger involvements in fatal crashes, and population counts. California's Center for Health Statistics (1995-2004), using death certificates filed by medical examiners, reports mortality statistics for state residents, including those caused by motor vehicle accidents, including the age, sex, dates of birth and death, and county of residence for each decedent. The U.S. Highway Traffic Safety Administration's Fatality Analysis Reporting System (FARS Web-Based Encyclopedia, 2006), using law enforcement reports, provides details on fatal accidents involving motor vehicles traveling on public roadways. These include the date, time, number of vehicle occupants, and location of each crash, and the age, sex, injury severity, license status, intoxication, citation for driving improperly, and zip code of residence for each driver and passenger involved. The California Department of Finance's Demographic Research Unit (2006) provides estimates and projections of the state's population, including by age, sex, and year. Driver's licenses by age and year for 1995-2004 are provided by the Research & Development Branch, California Department of Motor Vehicles (2006).

The outcome of interest is motor vehicle fatality rates involving California residents during the specified study period (1995-2004). Motor vehicle fatality victims listed by the CHS as having resided in California's 58 counties, and drivers and passengers involved in fatal accidents listed by FARS as residing in zip codes 90000 through 96162, are California residents. Drivers are cited here as licensed California drivers if they are coded by FARS as holding a valid California driver's license. CHS vital statistics, FARS fatal crash involvement, and Department of Finance population data are

used to calculate and compare California teenagers' motor vehicle fatality rates per 100,000 population for ages 16 through 19, categorized by whether or not they were subject to the requirements of California's GDL law.

Mortality Statistics

Motor vehicle deaths and fatal traffic crash involvements for these teenaged groups are examined in two ways. The "birth cohort" analysis examines the 2,021 California residents ages 16 through 19 who were born from January 1, 1980, through December 31, 1984, who died in motor vehicle accidents during the 1996-2004 period. This cohort is divided into symmetrical subcohorts: (a) Prelaw (born January 1, 1980-June 30, 1982) who turned age 16 in the 30-month period before the GDL law took effect, and (b) Postlaw (born July 1, 1982-December 31, 1984) who turned 16 in the first 30 months after the law took effect and were subjected to its licensing requirements.

The preliminary comparison of the motor vehicle fatality rates of the postlaw versus prelaw subcohorts by sex is presented in [Appendix B](#) and [Appendix C](#). A change of less than one indicates a decline in postlaw fatality rates compared to prelaw rates.

The comparisons in [Appendix B](#) and [Appendix C](#) are described as preliminary because they do not control for larger, population-level trends caused by changes in seat belt, drunken driving, and other traffic safety laws, economic cycles, weather, and other factors that affect traffic death rates for all age groups. To control for these larger factors, motor vehicle fatality and driver involvement rates for each teenage group in the prelaw and postlaw cohorts are expressed as Incident rate ratios (IRRs) to the corresponding traffic death and driver involvement rates for California residents 20 through 44 (see Foss, Feaganes & Rodgman, 2001; Shope, Molnar, Elliott & Waller, 2001).

Table 1
Incident rate ratios (IRRs), prelaw and postlaw teen motor vehicle death rates vs. age 20-44 by sex, and change in (Adjusted) IRRs from prelaw to postlaw period

Age	Prelaw	Postlaw	Adj. IRR	95% CI
Both Sexes				
16	1.16	0.89	0.76	(0.68-0.85)
17	1.45	1.38	0.95	(0.86-1.04)
18	1.78	2.09	1.17	(1.08-1.26)
19	1.88	1.96	1.05	(0.97-1.13)
16-17	1.31	1.14	0.87	(0.81-0.94)
18-19	1.83	2.02	1.11	(1.05-1.17)
16-19	1.57	1.62	1.03	(0.99-1.08)
Male				
16	0.97	0.77	0.80	(0.69-0.91)
17	1.22	1.21	0.99	(0.87-1.10)
18	1.51	2.03	1.34	(1.22-1.47)
19	1.81	1.87	1.03	(0.94-1.13)
16-17	1.10	1.00	0.91	(0.83-0.99)
18-19	1.66	1.95	1.17	(1.09-1.25)
16-19	1.38	1.51	1.09	(1.04-1.15)
Female				
16	1.69	1.22	0.72	(0.56-0.88)
17	2.08	1.89	0.91	(0.72-1.10)
18	2.56	2.25	0.88	(0.71-1.04)
19	1.99	2.20	1.10	(0.87-1.33)
16-17	1.88	1.56	0.83	(0.70-0.96)
18-19	2.27	2.22	0.98	(0.84-1.12)
16-19	2.07	1.92	0.93	(0.83-1.03)

Sources: Motor vehicle deaths, Center for Health Statistics (1995-2004), California Department of Health Services.

Populations: Demographic Research Unit, California Department of Finance (2006).

The necessity of using IRRs expressing teenaged fatality rates as ratios to those of older residents, as opposed to just using simple rates, is evident in [Appendix B](#): there has been a general increase in traffic fatality rates among all age groups over the 1995-2004 period that, if not factored out, would make it appear that the GDL program is associated with a major increase in teenage deaths. To accomplish this, a comparison set of traffic death rates among 20-44-year-olds is calculated for each teen age being examined to control for these larger factors. Note that for each 30-month subcohort, deaths among 16 year-olds will occur at the beginning of each subcohort's death period (from January 1, 1996,

through June 30, 1999, for the prelaw subcohort, and from July 1, 1998, through January 31, 2002, for the postlaw subcohort), while those of 19-year-olds will occur at the end (from January 1, 1999, through June 30, 2002, for the prelaw subcohort, and from July 1, 2001, through December 31, 2004, for the postlaw subcohort), with those of 17- and 18-year-olds occupying time periods in between. Thus, the time periods of traffic deaths and populations for 20-44-year-olds used to calculate IRRs must match those of the teen age to which they are compared. The motor vehicle death counts and populations for each teen age and for the 20-44-year-olds used

as the comparison group for each teen age are shown in [Appendix B](#).

In Tables 1, [Appendix D](#), and [Appendix E](#), an IRR of less than one indicates the teen age has a lower risk of fatality than corresponding 20-44-year-olds. The IRRs for postlaw versus prelaw subcohorts are compared by Adjusted IRRs, which express the difference in IRRs in the postlaw versus the prelaw period. An Adjusted IRR of less than one means that a teenage traffic fatality rate relative to the corresponding rate among 20-44 year-olds is lower in the postlaw period than in the prelaw period, indicating the GDL law is associated with a decline in teenage fatalities or fatal driver involvements. An Adjusted IRR is statistically significant if its Confidence Interval (CI, also shown) does not contain 1.00.

Driver involvement statistics

The second analysis uses FARS data to compare the IRRs of postlaw versus prelaw cohorts of the 4,806 California residents ages 16-19 involved as drivers in fatal motor vehicle crashes during 1995-2004. Because FARS does not provide birth dates of traffic crash victims that would allow true cohorts to be delineated as for mortality vital statistics, the prelaw cohort in this analysis consists of drivers involved in fatal accidents from 1995 through the year before the date their age first was subjected to GDL requirements, and the postlaw cohort consists of drivers in fatal crashes in the years after the date their age first was subjected to the GDL law through 2004. Crashes occurring in the 12 months before, and the 12 months after, the date on which each age is first subjected to the GDL law are not included for that age, since this "transition period" includes both prelaw and postlaw drivers and evidences temporary fluctuations in the licensing of new drivers (Foss, Feaganes & Rodgman, 2001; Shope, Molnar, Elliott & Waller, 2001). The GDL law's restrictions and requirements first applied to 16 year-olds on July 1, 1998; the first 16 year-old drivers licensed under its regulations would have been on the road beginning on January 1, 1999 (along with older 16-year-olds licensed before the law took effect); and all 16 year-olds driving after July 31, 1999, would have been subjected

to the GDL law. Further, there is evidence of a surge in licensing of 16 year-olds prior to the GDL law taking effect. Thus, the prelaw period for 16 year-olds is January 1, 1995, through June 30, 1997, the transition period is July 1, 1997, through June 30, 1999, and the postlaw period is July 1, 1999, through December 31, 2004. Table 2 shows, for each teen age and its corresponding 20-44-year-old comparison population, the prelaw, transition, and postlaw time periods and the fatality and population counts for the prelaw and postlaw periods. After excluding the transition years, 3,772 fatal crashes involving 16-19 year-old drivers remain for analysis.

Because California's GDL law allows teenagers to avoid its requirements if they wait until age 18 to obtain their driver's licenses, and because some 18- and 19-year-olds in fatal accidents could have moved to California from other states without GDL laws, it could be argued that 18-19-year-old California residents' traffic fatality and driver involvement experiences cannot be evaluated in the same way as 16-17-year-old residents, who almost certainly would have been subjected to the law. For several reasons, this study treats ages 18-19 the same as 16-17. First, any postlaw change in traffic deaths involving teenagers who waited until age 18 to obtain licenses to avoid the GDL program would be a result of the GDL law, rendering their traffic fatality experience a valid subject for evaluation in the same sense as for any postlaw change in traffic deaths involving 16-year-olds who deferred driving until age 18. California Department of Motor Vehicle (2006) figures indicate that the proportion of 16 year-olds licensed to drive fell from 22.0% before the law to 18.2% after, and for 17 year-olds, from 39.6% to 37.1%; while the proportion of 18 year-olds with driver's licenses rose from 54.0% before the law to 55.6% after; for age 19, from 64.2% before to 66.3% after; and for age 20-44, from 86.7% before to 86.9% after. Because one purpose of the GDL law is to deter younger teens from driving until they reach older ages, changes in the postlaw involvement in fatal crashes of teenagers driving without valid licenses also would be a potential effect of the GDL law meriting evaluation. Finally, it would be farfetched to suggest that 18- and 19-year-

olds immigrating to California from other states in the postlaw period, becoming California residents, and involving themselves in fatal crashes to a vastly greater extent than corresponding 18-19-year-old immigrants during the prelaw period (and of postlaw California 18-19-year-olds emigrating to become residents of other states) would have a significant impact on

overall fatality trends in a state with nearly one million 18-19-year-old residents. Appendix D and Appendix E show the fatal crash experiences of California teenage residents (using the numbers of teens and 20-44-year-olds with valid licenses as rate denominators) who are licensed California drivers separately alongside corresponding rates for all drivers.

Table 2
Drivers involved in fatal motor vehicle crashes by age, prelaw and postlaw periods, populations, and crash rates per 100,000 population, with comparative figures for age 20-44 (N=3,772)

Age	Prelaw				Transition Period	Postlaw			
	Period	Crashes	Pop. (X 1000)	Rate		Period	Crashes	Pop. (X 1000)	Rate
16	1/95 - 6/97	160	1,142	14.0	7/97-6/99	7/99 - 12/04	314	2,807	11.2
17	1/95 - 6/98	346	1,594	21.7	7/98-6/00	7/00 - 12/04	476	2,292	20.8
18	1/95 - 6/99	637	2,054	31.0	7/99-6/01	7/01 - 12/04	643	1,808	35.6
19	1/95 - 6/00	747	2,522	29.6	7/00-6/02	7/02 - 12/04	449	1,324	33.9
16-17		506	2,735	18.5			790	5,099	15.5
18-19		1,384	4,576	30.2			1,092	3,133	34.9
Age 20-44, drivers involved in fatal crashes during time periods corresponding to teen ages for comparison									
vs 16	1/95 - 6/97	7,249	32,034	22.6	7/97-6/99	7/99 - 12/04	15,666	73,300	21.4
vs 17	1/95 - 6/98	9,733	44,966	21.6	7/98-6/00	7/00 - 12/04	13,070	60,193	21.7
vs 18	1/95 - 6/99	12,187	57,989	21.0	7/99-6/01	7/01 - 12/04	10,255	46,977	21.8
vs 19	1/95 - 6/00	14,783	71,096	20.8	7/00-6/02	7/02 - 12/04	7,409	33,641	22.0
16-17		16,982	77,000	22.1			28,736	133,492	21.5
18-19		26,970	129,085	20.9			17,664	80,617	21.9

Rates of fatal crash involvements are calculated for each age and compared for each cohort (Table 2). As for the birth cohort, the teenaged driver cohorts' postlaw versus prelaw IRRs, expressed as ratios to corresponding fatal crash involvement rates of California residents ages 20-44, are compared to produce Adjusted IRRs. These Adjusted IRRs form the basis for evaluating the changes in fatal accident involvements among teenaged drivers associated with the GDL law.

Appendix D shows the IRRs and Adjusted IRRs by gender and driver's license status for California teenaged residents involved as drivers in fatal crashes. Appendix E examines the effects on teenage fatal crash experience of three specific restrictions imposed by GDL laws — prohibitions on driving by novice drivers under age 18 (unless supervised by adults over age 25)

alone, late at night (midnight to 5 a.m.), or with teenaged passengers. Also presented are fatal crash IRRs for teenaged drivers listed as driving improperly (which means those who tested positively for drug or alcohol intoxication, were mentioned on police reports for improper driving, or were formally cited for driving improperly) compared to rates of drivers ages 20-44 similarly noted for driving improperly during the same periods. Improper driving notations and citations often involve subjective judgment by officers and should be regarded as such.

The driver cohort analysis includes all deaths for each age in each year, 1995 through 2004, prior to and following the date of initial exposure to the law. The birth cohort analysis includes all deaths for each age level in adjacent, symmetrical populations differing only in their

exposure versus non-exposure to the GDL requirements. The mortality and driver involvement cohorts examined in this study reflect the maximum, equivalent periods of prelaw and postlaw accident exposure that can be examined using the most recent data (2004).

Results

Tables 1, [Appendix D](#), and [Appendix E](#) show the key results. After the GDL law was adopted, younger teenagers and female teenagers showed declines in motor vehicle deaths and fatal accident involvements while older teens and males showed increases. Because older teens and males suffer fatal traffic mishaps at considerably higher rates than younger teens and females, the overall result is that California's GDL law is associated with a small, nonsignificant increase in teenaged traffic deaths.

Traffic fatality outcomes

Relative to the traffic fatality Incident Rate Ratio (IRR) of 16-year-olds in the prelaw birth cohort to corresponding rates among 20-44-year-olds, the IRR among the postlaw birth cohort of 16-year-old Californians subjected to the GDL law was 24% lower (Adjusted IRR, 0.76; 95% CI, 0.68-0.85) (Table 1). However, the corresponding IRR for postlaw 18-year-olds was 17% higher than prelaw 18-year-olds (Adjusted IRR, 1.17; 95% CI, 1.08-1.26). Postlaw 17-year-olds experienced nonsignificantly lower, and 19-year-olds nonsignificantly higher fatality IRRs. Because 18- and 19-year-olds have higher traffic death rates than 16- and 17-year-olds, the overall result is that California teens ages 16-19 subjected to the GDL law suffered traffic death IRRs 3% higher than those not subjected to the law, a higher death rate which approaches statistical significance (Adjusted IRR, 1.03; 95% CI, 0.99-1.08).

The change in teenage motor vehicle death rates after the GDL law took effect varied considerably by gender as well as by age. Under the GDL program, traffic death rates did not change significantly among teenaged girls but rose among boys (Adjusted IRR, 1.09; 95% CI 1.04-1.15). Among both males and females, a shift in fatalities from younger to older ages is

evident. The changes are significant for 16-year-old females (down 28%), and males (down 20%), and for males ages 18 (up 34%).

Driver involvement outcomes

Analysis of fatal crash involvements reveals offsetting changes for postlaw teenaged drivers similar to those found for fatalities ([Appendix D](#)). There is a significant, 16%, IRR decline for 16-year-olds (Adjusted IRR, 0.84; 95% CI, 0.77-0.92), no consistent change for age 17, and significantly increased IRRs of 10% for 18-year-olds (Adjusted IRR, 1.10; 95% CI, 1.04-1.16) and 8% for 19-year-olds (Adjusted IRR, 1.08; 95% CI, 1.02-1.14). Because the prelaw time period is dominated by 16-17-year-olds, and the postlaw period by 18-19-year-olds, it is problematic to calculate a single IRR statistic for 16-19-year-olds as a whole. However, it is evident that the increase in fatal crash involvements by 18-19-year-old drivers after the GDL law took effect numerically equals, and probably exceeds, the decline among 16-17-year-olds.

Sixteen-year-old drivers show significant declines in crash involvements for both sexes. Nineteen-year-old drivers suffered significant increases for both males and females, as did 18-year-old males. For both sexes, the decline among 16-year-olds was sufficient to produce significantly lower postlaw IRRs among 16-17-year-olds (down 14%), while the increase among 18-year-olds and males produced a significant rise for 18-19-year-olds (up 10%).

The GDL law was also followed by significant increases in involvements in fatal crashes by unlicensed teenaged drivers. Before the GDL law took effect, 19.4% of drivers under age 18 and 22.5% ages 18-19 involved in fatal crashes were unlicensed; after the law, 28.9%, and 25.8%, respectively. Among drivers 20-44, the proportion of fatal crashes involving unlicensed drivers remained stable at around 24% during the period. However, licensed teenaged drivers did not consistently fare better than unlicensed ones after the GDL law. Postlaw 16-17 year-olds show a significant decrease in fatal crash involvement rates by licensed drivers and a significant increase in such accidents among

unlicensed drivers. Teenagers ages 18-19 show significant postlaw increases in both licensed and unlicensed-driver crash IRRs.

Appendix E evaluates three common restrictions associated with GDL laws by license status. The pattern is unexpected. Fatal crashes involving single drivers (that is, ones unsupervised by adults) were higher among California-licensed teenaged drivers of all ages after the GDL took effect (significantly so for 18-year-olds and for unlicensed older teens), but not for unlicensed 16-17-year-olds. Late-night fatal crash IRRs rose sharply among 16-17-year-olds legally licensed under GDL laws, though not among 16-17-year-olds driving without licenses or among 18-19-year-olds. Crashes involving teenaged drivers with teenaged passengers declined significantly for 16-17-year-olds after the GDL program took effect; no change occurred among older teens, and there was no difference in trend between licensed and unlicensed drivers. Finally, postlaw crash IRRs involving improper driving were significantly lower among younger teens, both licensed and unlicensed, but were significantly higher among 18-19-year-olds, including those with valid California licenses.

Fatality changes associated with California's GDL law

Applying the significant IRRs and confidence intervals for traffic fatality trends, California's GDL law is associated with an annual average of 20 fewer traffic deaths (95% CI, 9-29) and 23 fewer driver fatal crash involvements (95% CI, 16-31) among 16-17-year-olds, offset by 24 more traffic deaths (95% CI, 11-38) and 28 more driver involvements in fatal crashes (95% CI, 17-39) among 18-19-year-olds. These fatality numbers are not additive due to the different time periods involved in their generation. The most reasonable conclusion from these data is that California's GDL program is associated with no effect on teenage traffic fatality or fatal crash risks.

Limitations

California's youth population, though large, is composed of many diverse elements. Larger numbers and more specific study of the detailed demographics and individual case histories of

16-19-year-old drivers involved in fatal crashes are needed to pinpoint which aspects of GDL laws may produce greater risks to which populations of teenagers, particularly older ones. Further, the ratio variables used as the main statistic in this study, while efficient and used by many authors, present some methodological problems (error terms in both the numerator and denominator) that make their comparison somewhat more problematic than for simple rates. Basic means-test and regression analyses produced results similar to this analysis.

Discussion

The results of this study are based on more than 3,700 fatal crash involvements and 2,000 traffic fatalities among California teenagers over the most recent period available as of this writing (1995-2004). Regardless of type of measure (fatalities or driver involvements), time period (initial years or longer-term), or index (single-driver, late-night, improper-driving involvements, etc.) employed, the results are consistent: California's Graduated Driver Licensing (GDL) law is associated with shifts in traffic death risks, but not with improved traffic safety, among teenagers. If anything, there may be a slight net increase in teenage fatalities following the GDL law.

Effects by age

This "seesaw" effect consists primarily of a shift of 25-30% toward more fatal crash involvements and traffic deaths among older (age 18-19) teenagers relative to younger (age 16-17) ones, and, secondarily, from a 15-20% increase in traffic deaths among male versus female teens. While fatal crashes involving unlicensed teenage drivers increased by 34% relative to those involving licensed teenage drivers after the GDL law took effect, the impact of this trend on overall teenage fatality and fatal crash involvements is inconsistent. In several categories, teenaged drivers licensed under the GDL program experienced increases in traffic death and fatal crash risks comparable to or worse than those of teenagers driving without valid licenses.

The sizeable, consistent increase in fatalities and fatal accident involvements among 18-year-olds

(and, in several comparisons, 19-year-olds) who were subjected to GDL requirements as younger teens is the chief, unintended consequence associated with California's GDL law. This seesaw effect, in which laws delaying hazardous adult behaviors are found to reduce risks for younger teenagers at the expense of raising them for older teenagers and young adults, has also been found following implementation of state laws raised the drinking age to 21 (Asch & Levy, 1987; Dee & Evans, 2001).

These findings suggest two alternative hypotheses. First, driving at age 18-19 entails lower risks per mile driven than driving at age 16-17 not because of the greater maturity of older ages, but mainly because of the experience gained driving at younger ages. The increases in traffic fatality outcomes among older teenaged drivers subject to the GDL law's supervisions and restrictions, especially those attributed to improper driving and driving alone, suggest older postlaw teens may lack the realistic experience with riskier situations that was once gained at ages 15, 16, or 17. In fact, age 16 may be a safer age than age 18 (or older) to initiate full-privilege driving, perhaps because of greater family controls and more rapid learning curves at younger ages. This point is suggested by the fact that the prelaw-to-postlaw shift from younger to older drivers in fatal driver involvements (25%-30%) was greater than the shift in younger to older driver's licensing numbers (20%) alone would have predicted. Under this interpretation, prohibiting persons under age 18, or 21, from driving holds the potential of larger increases in risks to young adults licensed without previous teenage driving experience. This hypothesis is supported by the unusually large increase in fatal accident involvements among 18-year-olds (and, to a lesser extent, 19-year-olds) first allowed full driving privileges under GDL laws.

Effects by gender

The increases in fatalities involving males and male drivers (but not females) at age 18, and of greater fatality increases among female 19 year-olds than males, indicate a differing response to the GDL law by gender. Whether this is due to varying responses of parents, authorities, or girls

themselves to curtail younger females' driving privileges more than young males' under increased legal restriction is not clear.

Effects by accident type

The alternative hypothesis that young-driver inexperience, rather than young age per se, is paramount is both supported and complicated by the unexpected findings regarding the specific restrictions imposed by California's GDL program. Increased fatal accident IRRs among postlaw 16-17 year-old drivers involving single-driver and late-night driving are not easily explained, given specific GDL restrictions aimed at preventing these very outcomes. It may be that the GDL law's restrictions on first-year drivers' (usually 16-year-olds') driving at night prevents them from gaining experience necessary to drive safely during late-night hours and encourages more hazardous, clandestine driving. The only significant decrease in fatal crashes relating to a GDL mandate — the reduction involving 16-17-year-old drivers transporting teenaged passengers — may be a questionable benefit. Banning younger teens from transporting peers means these same teenagers must either drive alone or be transported by older drivers (generating more crashes involving 20-44-year-olds with teen passengers). The near-significant postlaw increase in lone-driver fatal crashes among 16-17-year-olds (Adjusted IRR, 1.09; 95% CI, 0.98-1.21) is a plausible outcome of preventing younger teenagers from transporting each other, resulting in more teenagers driving alone rather than carpooling.

Effects by license status

The increase in fatal accidents involving unlicensed teenaged drivers of all ages suggests a main effect of California's GDL law has been to deter some of the postlaw population from obtaining driver's licenses at all. The increase in accidents by unlicensed teenage drivers after the law took effect does not reflect a larger trend, since the proportion of accidents involving unlicensed drivers 20-44 did not increase. However, 18-19-year-old drivers lawfully licensed under the GDL program also show increased fatal crash risks (Adjusted IRR, 1.07; 95% CI, 1.03-1.12).

Conclusion

The second alternative hypothesis is that GDL programs are an inefficient means of reducing young-driver risks because they target all teenagers rather than the specific high-risk fraction responsible for most serious accidents, and because their major element of teenage driver training (supervision by parents or other nearby adults) may add to rather than reduce risks in that problematic fraction. Despite recent suggestions in the press of extreme teenage risks, traffic fatalities caused by teenaged drivers are rare events, averaging approximately one fatality per four million trips (Chen et al, 2000) by 16-17 year-old drivers, or per 15 million miles driven by teens (calculated from Table A-17, U.S. Department of Transportation, 2001). Given that the best predictor of a teenagers'

driving record is their parents' driving record (Bianchi & Summala, 2004; Taubman-Ben-Ari, Mikulincer & Gillath, 2005), GDL laws deputizing any parent or nearby adult over age 25 with a license as a driving instructor for novice teenagers may work to perpetuate intergenerational bad driving habits.

The results of this study add to previously expressed concerns that GDL laws, especially restrictive ones, have negative effects on older teenaged drivers, particularly males. This potential merits reassessment of the advisability and structure of policies designed to delay adult privileges and greater caution in recommending such policies until longer-term effects on both younger and older teenagers and young adults can be quantified.

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Appendix A Minimum Requirements for Teenage Driver's Licensure State of California

Minimum requirements for teenage drivers' licensure before and after implementation of California's Graduated Driver Licensing (GDL) law

Before GDL:

California's previous provisional licensing program, implemented October 1, 1983, included the following components for licensing of applicants under age 18:

- 1-month instruction permit period allowing driving only when supervised by parent/guardian, spouse, or licensed adult 25 years of age or older.
- Teen driver successfully completes driver education and driver training course.
- Parent certification that teen successfully completed exercises in parent/teen guide and is skilled enough to pass DMV driving test.
- Control program monitoring violations in first year after licensing.

Under GDL (California Vehicle Code Section 12814), beginning July 1, 1998:

Stage 1: Supervised learner's permit process (minimum 6 months):

- Parent/guardian certifies that teen driver completed 50 hours of behind-the-wheel practice (10 hours of which must be at night) supervised by a parent/guardian, spouse, adult age 25 older, or certified driving instructor.
- Teen driver successfully completes driver education and driver training course.
- Teen driver, except in specified circumstances, may not drive between midnight and 5 a.m., or transport passengers under age 20, unless supervised as defined above.

Stage 2: Provisional licensing stage (12 months, or until 18th birthday)

- Provisional license granted if student driver is over 16 but less than 18 and passes advanced driver training and behind-the-wheel test.
- Unless accompanied by licensed driver age 25 or older, student may not transport passengers under age 20 between midnight and 5 a.m.
- Amendments, effective January 1, 2006, extend the prohibition on new, unsupervised drivers under age 18 driving from 11 p.m. (rather than midnight) to 5 a.m., and transporting passengers younger than 20 to one year (rather than 6 months).

Stage 3: Student granted full-privilege license after first two steps successfully completed if there are no outstanding DMV or court-ordered restrictions, suspensions, or probations.

Appendix B

Motor vehicle deaths, population (in thousands), and death rates per 100,000 population in the 30-month period before and after the teen cohort was first subjected to Graduated Driver Licensing (GDL) law (1995-2004)

Age	Prelaw				Postlaw			Post- vs. Prelaw
	Deaths	Population (x 1000)	Rate*		Deaths	Population (x 1000)	Rate	Rate Comparison
16	173	1,195	14.5		132	1,233	10.7	0.74
17	215	1,212	17.7		216	1,249	17.3	0.98
18	263	1,230	21.4		363	1,280	28.4	1.33
19	290	1,257	23.1		369	1,324	27.9	1.21
16-17	388	2,407	16.1		348	2,481	14.0	0.86
18-19	553	2,487	22.2		732	2,604	28.1	1.26
16-19	941	4,894	19.2		1,080	5,085	21.2	1.10
Age 20-44 motor vehicle deaths, population, and death rates per 100,000 population during the same time periods as for each teen age above, used as comparison group								
vs 16	4,023	32,272	12.5		3,984	32,980	12.1	0.97
vs 17	3,975	32,498	12.2		4,160	33,246	12.5	1.02
vs 18	3,929	32,723	12.0		4,549	33,470	13.6	1.13
vs 19	4,058	32,991	12.3		4,779	33,652	14.2	1.15
16-17	7,998	64,771	12.3		8,143	66,226	12.3	1.00
18-19	7,987	64,714	12.2		9,327	67,121	13.9	1.14
16-19	15,985	130,485	12.3		17,470	133,348	13.1	1.07

*Death rate per 100,000 population by age, 30-month prelaw and postlaw period.

Sources: Motor vehicle deaths, Center for Health Statistics (1995-2004), California Department of Health Services.

Populations: Demographic Research Unit, California Department of Finance (1995-2004).

Appendix C

Motor vehicle deaths, population (in thousands), and death rates per 100,000 population by sex in 30-month period before and after each age subjected to GDL law (N=2,021)

Age	Prelaw			Postlaw			Post- vs. Prelaw
	Deaths	Population (X 1000)	Rate	Deaths	Population (X 1000)	Rate	Rate Comparisons
Male							
16	108	624	17.3	87	636	13.7	0.79
17	138	633	21.8	142	645	22.0	1.01
18	171	643	26.6	266	662	40.2	1.51
19	214	660	32.4	267	691	38.7	1.19
16-17	246	1,257	19.6	229	1,281	17.9	0.91
18-19	385	1,304	29.5	533	1,353	39.4	1.33
16-19	631	2,561	24.6	762	2,634	28.9	1.17
20-44*	2,976	16,705	17.8	3,274	17,130	19.1	1.07
Female							
16	65	572	11.4	45	597	7.5	0.66
17	77	579	13.3	74	603	12.3	0.92
18	92	587	15.7	97	618	15.7	1.00
19	76	597	12.7	102	633	16.1	1.27
16-17	142	1,150	12.3	119	1,200	9.9	0.80
18-19	168	1,183	14.2	199	1,251	15.9	1.12
16-19	310	2,334	13.3	318	2,451	13.0	0.98
20-44*	1,020	15,916	6.4	1,094	16,207	6.7	1.05

*Figures for age 20-44 shown are average for the periods corresponding to each teen age level during 30-month period before and after GDL applied to each age.

Sources: Motor vehicle deaths, Center for Health Statistics (1995-2004), California Department of Health Services.

Populations: Demographic Research Unit, California Department of Finance (1995-2004).

Appendix D

Incident rate ratios (IRR), teenage drivers involved in fatal crashes vs. ages 20-44 before and after each teen age was subjected to GDL law, by age, sex, license status, and change in IRR (adjusted) from prelaw to postlaw period (N=3,772)

Age	Prelaw		Postlaw		Change in incident rate ratio (Adj. IRR)	
	n	IRR	n	IRR	Adj. IRR	95% CI
All teenage drivers (n=3,772)						
16	160	0.62	314	0.52	0.84	(0.77-0.92)
17	346	1.00	476	0.96	0.95	(0.89-1.02)
18	637	1.48	643	1.63	1.10	(1.04-1.16)
19	747	1.42	449	1.54	1.08	(1.02-1.14)
16-17	506	0.84	790	0.72	0.86	(0.81-0.90)
18-19	1,384	1.45	1,092	1.59	1.10	(1.06-1.14)
Male drivers (n=2,271)						
16	108	0.54	208	0.46	0.85	(0.75-0.94)
17	239	0.90	332	0.88	0.98	(0.90-1.06)
18	465	1.40	493	1.66	1.19	(1.11-1.26)
19	555	1.38	321	1.44	1.05	(0.98-1.12)
16-17	347	0.75	540	0.65	0.87	(0.82-0.93)
18-19	1,020	1.39	814	1.57	1.13	(1.08-1.18)
Female drivers (n=1,051)						
16	52	0.84	106	0.72	0.85	(0.72-0.98)
17	107	1.30	144	1.18	0.91	(0.80-1.02)
18	172	1.66	150	1.53	0.92	(0.82-1.02)
19	192	1.52	128	1.79	1.18	(1.05-1.31)
16-17	159	1.10	250	0.93	0.84	(0.76-0.92)
18-19	364	1.58	278	1.64	1.03	(0.95-1.11)
Licensed drivers (n=2,852)						
16	126	2.53	218	2.28	0.90	(0.80-0.99)
17	282	2.35	344	2.14	0.91	(0.84-0.98)
18	497	2.42	508	2.69	1.11	(1.04-1.18)
19	575	1.93	302	1.83	0.95	(0.88-1.01)
16-17	408	2.39	562	2.19	0.92	(0.86-0.98)
18-19	1,072	2.13	810	2.29	1.07	(1.03-1.12)
Unlicensed drivers (n=920)						
16	34	0.09	96	0.11	1.14	(0.95-1.34)
17	64	0.17	132	0.23	1.32	(1.14-1.51)
18	140	0.40	135	0.40	1.01	(0.89-1.13)
19	172	0.52	147	0.77	1.46	(1.30-1.62)
16-17	98	0.13	228	0.15	1.15	(1.03-1.28)
18-19	312	0.46	282	0.53	1.16	(1.07-1.25)

Appendix E

Incident Rate Ratios for teenaged drivers vs. age 20-44, by age, driver's license status, selected classes of fatal motor vehicle crashes, and changes (Adjusted IRR) from before to after GDL laws (N=3,772)

Age	All drivers (licensed and unlicensed)					Licensed California drivers		
	N	Prelaw IRR	Postlaw IRR	Adj. IRR	95% CI	N	Adj. IRR	95% CI
Crashes involving improper (including intoxicated) driving (n=2,917)								
16	388	0.79	0.67	0.84	(0.76-0.93)	269	0.90	(0.79-1.01)
17	639	1.24	1.16	0.93	(0.86-1.00)	468	0.88	(0.80-0.96)
18	1,000	1.84	1.97	1.07	(1.01-1.14)	752	1.10	(1.02-1.18)
19	890	1.66	1.79	1.08	(1.01-1.15)	646	1.00	(0.93-1.08)
16-17	1,027	1.05	0.89	0.85	(0.80-0.90)	737	0.90	(0.84-0.97)
18-19	1,890	1.74	1.89	1.09	(1.04-1.14)	1,398	1.10	(1.04-1.16)
Single-driver fatal crashes (n=1,499)								
16	165	0.32	0.33	1.05	(0.89-1.21)	126	1.14	(0.94-1.34)
17	296	0.57	0.62	1.08	(0.96-1.20)	244	1.07	(0.93-1.20)
18	522	0.93	1.23	1.32	(1.21-1.44)	431	1.28	(1.16-1.40)
19	516	1.01	1.20	1.19	(1.09-1.29)	399	1.01	(0.91-1.11)
16-17	461	0.46	0.46	1.00	(0.90-1.09)	370	1.09	(0.98-1.21)
18-19	1,038	0.97	1.22	1.25	(1.18-1.33)	830	1.18	(1.10-1.26)
Late-night fatal crashes (midnight-4:59 a.m.) (n=648)								
16	51	0.38	0.33	0.88	(0.63-1.12)	26	1.59	(0.98-2.21)
17	123	0.82	0.88	1.07	(0.88-1.26)	83	1.22	(0.96-1.48)
18	216	1.67	1.42	0.85	(0.74-0.96)	159	0.92	(0.78-1.07)
19	258	1.84	1.92	1.04	(0.92-1.17)	180	0.92	(0.79-1.06)
16-17	174	0.63	0.58	0.92	(0.79-1.06)	109	1.26	(1.03-1.50)
18-19	474	1.76	1.63	0.93	(0.84-1.01)	339	0.93	(0.83-1.03)
Crashes with teenaged passenger (n=1,696)								
16	256	4.07	2.97	0.73	(0.64-0.82)	187	0.73	(0.63-0.84)
17	427	6.12	5.24	0.86	(0.77-0.94)	331	0.80	(0.71-0.89)
18	588	8.17	7.49	0.92	(0.84-0.99)	471	0.94	(0.85-1.02)
19	425	5.50	6.14	1.12	(1.01-1.22)	324	0.99	(0.88-1.10)
16-17	683	5.24	4.00	0.76	(0.71-0.82)	518	0.79	(0.72-0.85)
18-19	1,013	6.70	6.91	1.03	(0.97-1.10)	795	1.02	(0.95-1.10)