



PB98-128424

# TEEN AND SENIOR DRIVERS

December 1997

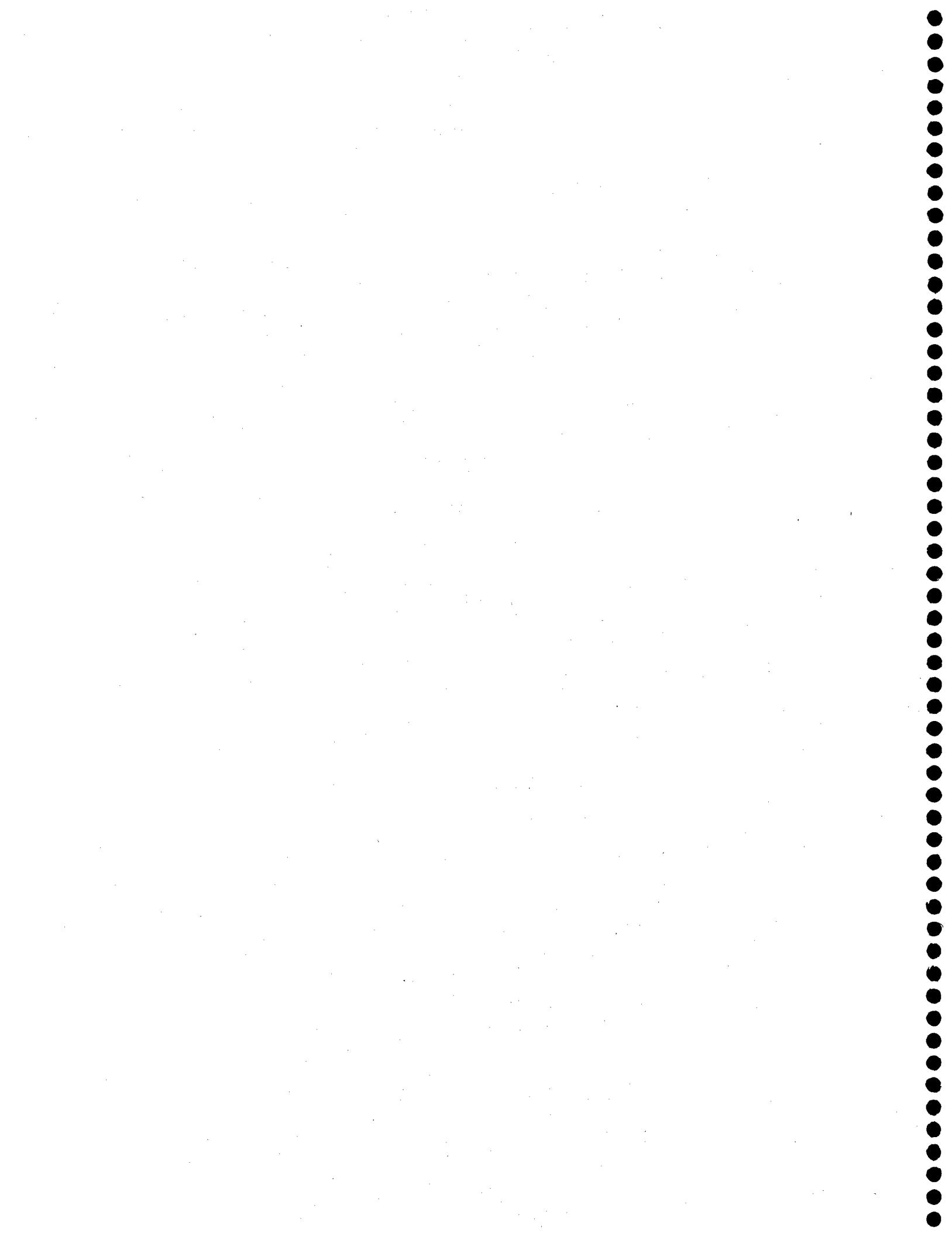
Prepared by  
**California Department of Motor Vehicles**  
and  
**Beverly Foundation**

**PETE WILSON**  
Governor

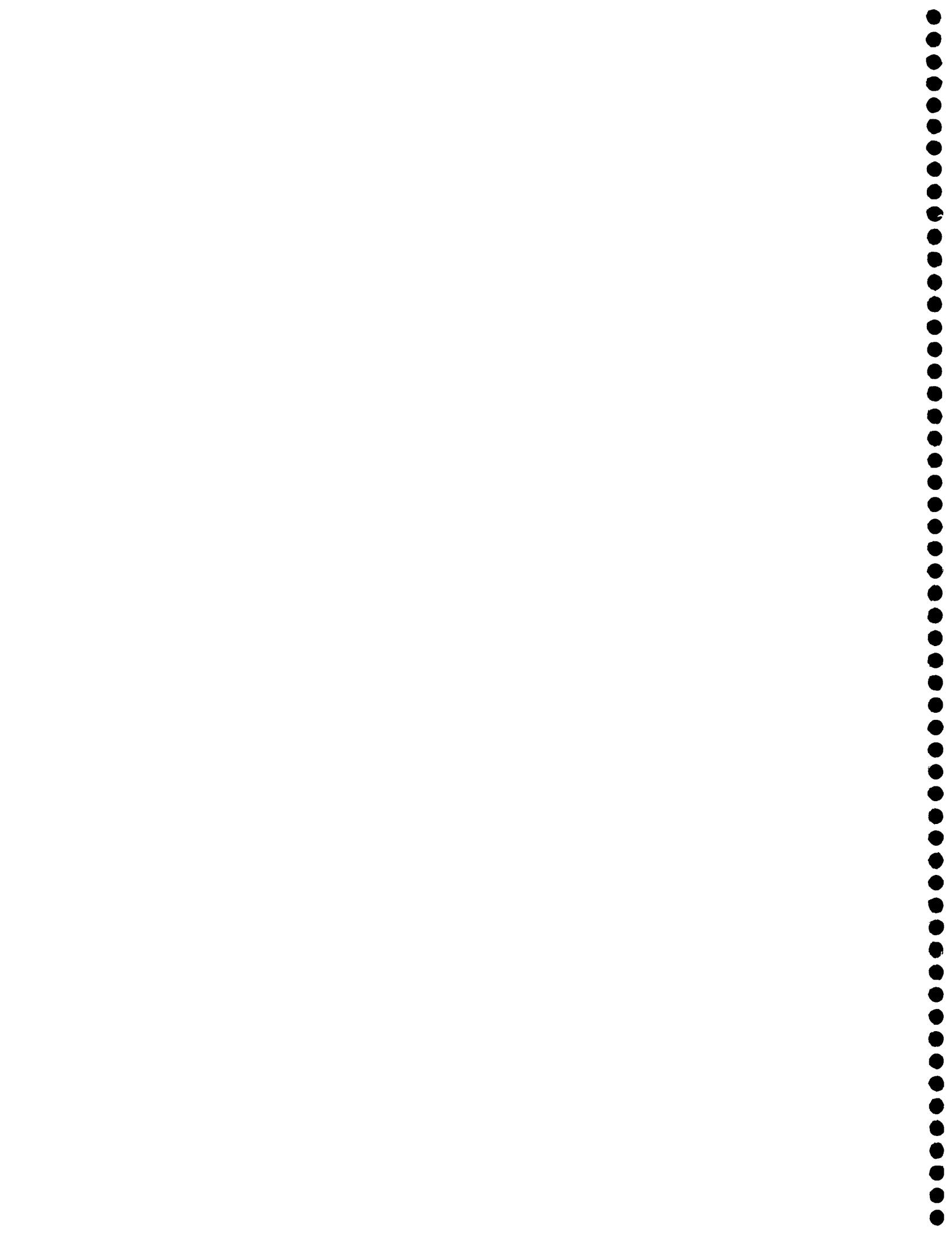
**DEAN DUNPHY, Secretary**  
Business, Transportation and Housing Agency

**SALLY REED**  
Director

REPRODUCED BY: **NTIS**  
U.S. Department of Commerce  
National Technical Information Service  
Springfield, Virginia 22161



REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188
<p>Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.</p>			
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED	
4. TITLE AND SUBTITLE		5. FUNDING NUMBERS	
Teen and Senior Drivers			
6. AUTHOR(S)			
Rhonda Aizenberg and Debbie M. McKenzie			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)		8. PERFORMING ORGANIZATION REPORT NUMBER	
CA Department of Motor Vehicles Research & Development Section P.O. Box 932382, F-126 Sacramento, CA 94232-3820		Beverly Foundation AND 44 South Mentor Ave. Pasadena, CA 91106-2902 CAL-DMV-RSS-97-168	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES			
12a. DISTRIBUTION/AVAILABILITY STATEMENT		12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words)			
<p>This report updates information on teen and senior drivers published in earlier California Department of Motor Vehicles' reports, <i>Teen Driver Facts</i> (Huston, 1986), <i>Senior Driver Facts</i> (Huston &amp; Janke, 1986), and <i>Teen and Senior Drivers</i> (Romanowicz &amp; Gebers, 1990; Gebers, Romanowicz, &amp; McKenzie, 1993). The information is meant to assist highway safety administrators in making program and policy decisions affecting teen and senior drivers, and may also be of use to the insurance industry, traffic safety researchers, and the general public.</p> <p>The report also summarizes research on risk-taking and alcohol consumption among teen drivers and on the increase in impairment of driving-related abilities among senior drivers. Countermeasures for teen and senior drivers are also discussed.</p>			
14. SUBJECT TERMS			15. NUMBER OF PAGES 94
young drivers, aged drivers, driver attitudes, risk-taking, visual acuity, hazard perception			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT  Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE  Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT  Unclassified	20. LIMITATION OF ABSTRACT



## Preface

This revision of the California Department of Motor Vehicles (DMV) publication, *Teen and Senior Drivers*, contains driver and collision statistics through 1995. The report format has been substantially altered over the previous issues, and the content has been expanded.

The report highlights key crash characteristics of teen and senior drivers. These highlights are based on extensive tables containing voluminous data on drivers of all ages, and readers are encouraged to use the report as a resource both for questions concerning teens and seniors and for questions concerning drivers generally.

To make reading and reference easier, certain technical terms and statistical measures are defined at the beginning of Section 1 and then briefly explained again when they are used later in the report.

Although there exist a number of national periodic reports on the relationship between age, gender and collision risk, these reports rely on the accuracy of state-provided data concerning the number of licensed drivers by age. Unlike California, some states do not have accurate figures on the number of licensed drivers by age group. As a result, national collision rates per licensed driver will be distorted. This may be one of the reasons why California data have consistently shown evidence of an upswing in collision rates per licensed driver at age 70, whereas national statistics do not show an upswing until age 85 or older (see Figure 5 in National Highway Traffic Safety Administration, 1993).

Statements made in earlier publications of *Teen and Senior Drivers* incorrectly indicate that instruction permits were included in the driver license counts. Because of this misunderstanding, an age group of "16 and under" was created for the collision risk measures in prior reports. Including collisions for drivers under 16, but not including licensed drivers under 16, caused the risk measures for the "16 and under" and the "19 and under" age groups to be somewhat inflated. The current report has corrected this error.

This report represents a collaborative effort by Dr. Rhonda Aizenberg, Beverly Foundation, and Debbie McKenzie, California DMV Research and Development Branch. Michael Gebers, Robert Hagge and Patricia Romanowicz of my staff provided technical assistance. Ms. Romanowicz conducted the literature review and wrote the major portion of Section 2 of the report.

John Luke, Beverly Foundation, also warrants special acknowledgment for his valuable assistance in preparing tables and figures in Section 1 and for providing editorial support. Special thanks to Bev Christ, California Highway Patrol, for providing the collision data from the Statewide Integrated Traffic Records System and for her technical assistance.

R.C. Peck, Chief  
Research and Development Branch  
California Department of Motor Vehicles



# Teen and Senior Drivers

## Contents

<u>Section</u>	<u>Page</u>
Introduction .....	1
Overview	
Significance	
Section 1. California Teen and Senior Drivers .....	3
Overview	
Data Sources	
Definitions	
Exposure Rates	
Population Trends and Driver Licensure Rates .....	8
Population Trends	
Percentage of Residents Licensed	
Profile of the Licensed Population	
Age/Sex Trends in the Licensed Population	
Drivers in Casualty Collisions .....	16
Drivers Involved and At Fault	
Sex Differences	
Age Differences	
Trends	
Casualty Collision Exposure Rates .....	22
Per Driver Rate and Relative Involvement Index .....	22
General Patterns	
Sex Differences	
Age Differences	
Mileage-Adjusted Rate .....	23
Number of Miles Driven	
Mileage-Adjusted Rate	
Sex Differences	
Age Differences	

## Contents (cont'd)

<u>Section</u>	<u>Page</u>
Alcohol and Driving .....	35
Had-Been-Drinking (HBD) Casualty Collisions .....	35
Percentage of Casualty Collisions Involving Alcohol	
Per Driver Rates of HBD Collisions	
Sex Differences	
Age Differences	
Arrests for Driving Under the Influence (DUI) or for Hit-and-Run ....	37
General Patterns	
Age Differences	
Primary Collision Factor .....	45
General Patterns	
Sex Differences	
Age Differences	
Driver Movement Preceding Collision .....	50
General Patterns	
Age Differences	
Type of Collision .....	56
General Patterns	
Age Differences	
Time of Collision .....	61
General Patterns	
Age Differences	
Section 2. Research and Countermeasures .....	71
Young Drivers .....	71
Collision Involvement Factors .....	71
Risk Taking and Risk Perception	
Driving Inexperience	
Alcohol	
Collision Countermeasures .....	74
Driver Education and Training	
Provisional Licensing	
BAC Limits	
Driving Curfews	

## Contents (cont'd)

<u>Section</u>	<u>Page</u>
Conclusion .....	77
Senior Drivers .....	77
<b>Collision Involvement Factors</b> .....	77
Vision	
Cognition and Perception	
Reaction Time	
Medical Impairments	
<b>Collision Countermeasures</b> .....	80
Driver Improvement	
Driver Testing	
Mail Renewals	
Graded Licensing	
Driving Record	
Self-Reports	
Medical Review	
Vehicle/Highway Factors	
Conclusion .....	84
Bibliography .....	85
Appendix A. Statistical Curve Smoothing Technique .....	93

## List of Tables

<u>Number</u>		<u>Page</u>
1	Percentage of Estimated Population by Age, California 1985-2025 .....	11
2	Licensed Drivers, Population, and Percentage of Population Licensed to Drive by Age and Sex, California 1995 .....	12
3	Percentage of Total Licensed Drivers by Age and Sex, California 1995 ....	14
4	Percentage of Male and Female Licensed Drivers by Age, California 1981, 1985 and 1995 .....	15
5	Percentage of Drivers Involved or At Fault in Fatal/Injury and Fatal Collisions by Age and Sex, California 1995 .....	18
6	Teens and Seniors as a Percentage of Total and At-Fault Drivers in Fatal/Injury Collisions, California 1981-1995 .....	20
7	Total and At-Fault Fatal/Injury and Fatal Collisions Per 1,000 Licensed Drivers by Age and Sex, California 1995 .....	26
8	Relative Involvement in Fatal/Injury and Fatal Collisions by Age and Sex, California 1995 .....	27
9	Relative Involvement in At-Fault Fatal/Injury and Fatal Collisions by Age and Sex, California 1995 .....	28
10	Estimated Average Annual Miles Driven by Age and Sex, California 1990	31
11	Total and At-Fault Fatal/Injury and Fatal Collisions Per 1 Million Miles Driven by Age and Sex, California 1995 .....	32
12	Had-Been-Drinking (HBD) Drivers in Fatal/Injury and Fatal Collisions, Percentage of Collision-Involved Drivers Identified as HBD, and HBD Drivers in Collisions Per 10,000 Licensed Drivers by Age and Sex, California 1995 .....	38
13	Had-Been-Drinking (HBD) Drivers At Fault in Fatal/Injury and Fatal Collisions, Percentage of At-Fault Drivers Identified as HBD, and HBD At-Fault Drivers Per 10,000 Licensed Drivers by Age and Sex, California 1995 .....	39
14	Relative Involvement in Had-Been-Drinking (HBD) Fatal/Injury and Fatal Collisions by Age and Sex, California 1995 .....	40
15	Relative Involvement in Had-Been-Drinking (HBD) At-Fault Fatal/Injury and Fatal Collisions by Age and Sex, California 1995 .....	41
16	Relative Involvement in Arrests for Driving Under the Influence of Alcohol/Drugs (DUI) or for Hit-and-Run by Age, California 1995 .....	44

## List of Tables (cont'd)

<u>Number</u>		<u>Page</u>
17	Percentage of Fatal/Injury Collisions by Primary Collision Factor and Age and Sex of Driver At Fault, California 1995.....	47
18	Percentage of Fatal Collisions by Primary Collision Factor and Age and Sex of Driver At Fault, California 1995 .....	48
19	Percentage of Drivers in Fatal/Injury and Fatal Collisions by Driver Movement Preceding Collision and Age, California 1995 .....	52
20	Percentage of Drivers At Fault in Fatal/Injury and Fatal Collisions by Driver Movement Preceding Collision and Age, California 1995 .....	53
21	Percentage of Drivers in Fatal/Injury and Fatal Collisions by Type of Collision and Age, California 1995 .....	57
22	Percentage of Drivers At Fault in Fatal/Injury and Fatal Collisions by Type of Collision and Age, California 1995 .....	58
23	Percentage of Drivers in Fatal/Injury Collisions by Time of Day and Age, California 1995 .....	62
24	Percentage of Drivers in Fatal Collisions by Time of Day and Age, California 1995 .....	63
25	Percentage of Drivers At Fault in Fatal/Injury Collisions by Time of Day and Age, California 1995 .....	64
26	Percentage of Drivers At Fault in Fatal Collisions by Time of Day and Age, California 1995 .....	65

## List of Figures

<u>Number</u>		<u>Page</u>
1	Percentage of Estimated Population by Age, California 1985-2025 .....	11
2	Percentage of Population Licensed to Drive by Age and Sex, California 1995 .....	13
3	Percentage of Total Licensed Drivers by Age, California 1995 .....	14
4	Teens and Seniors as a Percentage of Total Licensed Drivers, California 1981-1995 .....	15
5	Percentage of Drivers in Fatal/Injury and Fatal Collisions by Age and Sex, California 1995 .....	19
6	Percentage of Drivers At Fault in Fatal/Injury and Fatal Collisions by Age and Sex, California 1995 .....	19
7	Teens and Seniors as a Percentage of Total Drivers in Fatal/Injury Collisions, California 1984-1995 .....	21
8	Teens and Seniors as a Percentage of Total Drivers At Fault in Fatal/Injury Collisions, California 1984-1995 .....	21
9	Fatal/Injury Collisions Per 1,000 Licensed Drivers and Relative Involvement Index by Age and Sex, California 1995 .....	29
10	Fatal Collisions Per 1,000 Licensed Drivers and Relative Involvement Index by Age and Sex, California 1995 .....	29
11	At-Fault Fatal/Injury Collisions Per 1,000 Licensed Drivers and Relative Involvement Index by Age and Sex, California 1995 .....	30
12	At-Fault Fatal Collisions Per 1,000 Licensed Drivers and Relative Involvement Index by Age and Sex, California 1995 .....	30
13	Estimated Average Annual Miles Driven by Age and Sex, California 1990	31
14	Fatal/Injury Collisions Per 1 Million Miles Driven by Age and Sex, California 1995 .....	33
15	Fatal Collisions Per 1 Million Miles Driven By Age and Sex, California 1995 .....	33
16	At-Fault Fatal/Injury Collisions Per 1 Million Miles Driven by Age and Sex, California 1995 .....	34
17	At-Fault Fatal Collisions Per 1 Million Miles Driven by Age and Sex, California 1995 .....	34

## List of Figures (cont'd)

<u>Number</u>		<u>Page</u>
18 Had-Been-Drinking (HBD) Fatal/Injury Collisions Per 10,000 Licensed Drivers and Relative Involvement Index by Age and Sex, California 1995 .....	42	
19 Had-Been-Drinking (HBD) Fatal Collisions Per 10,000 Licensed Drivers and Relative Involvement Index by Age and Sex, California 1995 .....	42	
20 Had-Been-Drinking (HBD) At-Fault Fatal/Injury Collisions Per 10,000 Licensed Drivers and Relative Involvement Index by Age and Sex, California 1995 .....	43	
21 Had-Been-Drinking (HBD) At-Fault Fatal Collisions Per 10,000 Licensed Drivers and Relative Involvement Index by Age and Sex, California 1995 .....	43	
22 Relative Involvement in Arrests for Driving Under the Influence of Alcohol/Drugs (DUI) or for Hit-and-Run by Age, California 1995 .....	44	
23 Primary Collision Factor for Drivers At Fault in Fatal/Injury Collisions by Age, California 1995 .....	49	
24 Primary Collision Factor for Drivers At Fault in Fatal Collisions by Age, California 1995 .....	49	
25 Percentage of Teen and Senior Drivers in Fatal/Injury Collisions by Driver Movement Preceding Collision, California 1995 .....	54	
26 Percentage of Teen and Senior Drivers in Fatal Collisions by Driver Movement Preceding Collision, California 1995 .....	54	
27 Percentage of Teen and Senior Drivers At Fault in Fatal/Injury Collisions by Driver Movement Preceding Collision, California 1995 .....	55	
28 Percentage of Teen and Senior Drivers At Fault in Fatal Collisions by Driver Movement Preceding Collision, California 1995 .....	55	
29 Percentage of Teen and Senior Drivers in Fatal/Injury Collisions by Type of Collision, California 1995 .....	59	
30 Percentage of Teen and Senior Drivers in Fatal Collisions by Type of Collision, California 1995 .....	59	
31 Percentage of Teen and Senior Drivers At Fault in Fatal/Injury Collisions by Type of Collision, California 1995 .....	60	
32 Percentage of Teen and Senior Drivers At Fault in Fatal Collisions by Type of Collision, California 1995 .....	60	
33 Percentage of Teen and Senior Drivers in Fatal/Injury Collisions by Time of Day of Collision, California 1995 .....	66	

**List of Figures (cont'd)**

<u>Number</u>		<u>Page</u>
34	Percentage of Teen and Senior Drivers in Fatal Collisions by Time of Day of Collision, California 1995 .....	67
35	Percentage of Teen and Senior Drivers At Fault in Fatal/Injury Collisions by Time of Day of Collision, California 1995 .....	68
36	Percentage of Teen and Senior Drivers At Fault in Fatal Collisions by Time of Day of Collision, California 1995 .....	69
37	Relative Risk of a Fatal Crash as a Function of BAC and Age .....	74
38	Actual and Modeled Average Annual Miles Driven by Age, California 1990	94

# INTRODUCTION

---

## Overview

This report updates information on teen and senior drivers presented in earlier publications by the California Department of Motor Vehicles (*Teen Driver Facts*, Huston, 1986; *Senior Driver Facts*, Huston and Janke, 1986; and *Teen and Senior Drivers*, Romanowicz and Gebers, 1990, and Gebers, Romanowicz and McKenzie, 1993).

The report contains two sections. *Section 1* presents a series of tables and figures that focus on age/sex differences in driver licensing, driver involvement and fault in casualty collisions, and arrests for offenses relating to driving under the influence. A summary is presented of key highlights. *Section 2* reviews the research literature on the antecedents of collisions for teen and senior drivers and on countermeasures that have been used to improve their driving practices.

## Significance

The automobile is the primary means of transportation in the United States. Fully 87% of trips are taken in a privately owned vehicle. Among adults aged 65 or older, 90% of trips involve the use of an automobile (Federal Highway Administration, 1993).

While motor vehicles offer a convenient and accessible means of mobility, motor vehicle collisions are a leading cause of death. Even in the older ages, they are the primary cause of accidental death up to age 78 and are second only to falls for persons aged 79 or older (National Safety Council, 1996).

Much attention has been given to the driving performance of teens, who are disproportionately involved in motor vehicle collisions. It is generally acknowledged that inexperience, immature judgment and a proclivity toward risk-taking place teens at a disadvantage behind the wheel.

During the past decade, highway traffic safety administrators, policymakers and researchers have begun to focus increasingly on the driving safety of older adults. Much of this concern has been triggered by demographic trends—specifically, the aging of the population and the implications it has for the number of older drivers on our roads.

Studies indicate that while collision risk increases among older drivers, advanced age by itself does not heighten a person's risk of collision involvement. In fact, the sheer value of on-the-road

experience gives many older drivers a distinct safety advantage. However, if a person lives long enough, age-related changes in health and functional ability can be expected to alter the performance of critical skills needed for driving.

This report presents detailed information on teen and senior driver involvement and fault in casualty collisions, and on differences and similarities between crash characteristics for teens and seniors. The information is intended to assist highway traffic safety administrators in making program and policy decisions and may also be of use to the insurance industry, traffic safety researchers and the general public.

# SECTION 1

## CALIFORNIA TEEN AND SENIOR DRIVERS

---

### Overview

Section 1 focuses on traffic casualty collisions in California and on how involvement and fault in these collisions vary for drivers depending upon age and sex. The emphasis is on teen and senior drivers and on identifying differences and similarities in their collision patterns and characteristics.

Because demographic factors affect the composition of licensed drivers, recent trends in California's resident population are addressed first. Age/sex differences are then examined in licensure rates and in the distribution of the licensed population.

An analysis follows of total and age/sex-specific collision frequencies, rates, causes and attributes. To assess age/sex differences in crash severity, data are presented separately for drivers in fatal collisions and in total casualty (fatal/injury) collisions. At-fault drivers are examined separately from all collision-involved drivers to determine how culpability varies for drivers by age and sex.

Subsections are as follows:

- Population trends and driver licensure rates
- Drivers in casualty collisions
- Casualty collision exposure rates—per driver rate, relative involvement index, and mileage-adjusted rate
- Alcohol and driving—had-been-drinking casualty collisions and arrests for driving under the influence or for hit-and-run
- Primary collision factor
- Driver movement preceding collision
- Type of collision
- Time of collision

### Data Sources

Data have been drawn from various sources:

*California Department of Motor Vehicles* – source for data on California licensed drivers and estimated annual miles driven.

Data on licensed drivers are included for the period 1981-1995 and are derived from a 10% sample of motor vehicle records for persons aged 16 or older holding a California driver license. (As reported in the Preface, prior reports incorrectly stated that the

license volumes contained drivers with instruction permits. This current report has corrected the error.)

Estimated miles driven refer to 1990 and were derived from a smoothing technique applied by Gebers, Romanowicz and McKenzie (1993) to California data collected in the Nationwide Personal Transportation Survey conducted by the Federal Highway Administration. Appendix A includes a discussion of the smoothing technique.

*California Highway Patrol (CHP)* – source for data on driver involvement and driver fault in fatal and injury collisions.

Data are examined for 1981-1995 and refer to casualty collisions on California state highways and all other public roads. (CHP records exclude collisions on private property.)

Since this report focuses on the relationship between driver age and collisions, data are restricted to cases in which age of driver is reported. (Data on driver age is missing for less than 8% of drivers involved or at fault in casualty collisions.)

*California Department of Justice* – arrests for driving under the influence and for hit-and-run in 1995.

*California Department of Finance* – California's estimated population for 1981-2025.

## Definitions

Below is a list of definitions for key terms used in Section 1. The definitions are based on those used by the agency compiling the data.

### ***At-Fault Driver***

The driver involved in a collision considered by the law enforcement officer to be most at fault.

### ***Driving Under the Influence (DUI)***

In California, it is illegal to drive with a blood alcohol level of .08% or greater or to be under the influence of other drugs when operating a motor vehicle.

### ***Fatal Collision***

A motor vehicle collision resulting in the death of one or more persons within 30 days of the event.

**Fatal/Injury Collisions or Casualty Collisions**  
Fatal and injury collisions combined.

***Had-Been-Drinking Driver***

A driver determined by the investigating officer to have been drinking alcohol irrespective of level of impairment.

***Injury Collision***

A motor vehicle traffic collision resulting in injury to one or more persons. An injury includes severe wound, other visible injuries or complaint of pain (in which the injury may not be evident).

***Pedestrian***

Any person not in or upon a vehicle, bicycle or animal. Includes persons on skateboards (nonmotorized), roller skates, skis, sleds and wheelchairs.

***Primary Collision Factor***

The one element or driving action that, in the investigating officer's opinion, best describes the primary or main cause of the collision.

***Type of Collision***

The first event in the collision and the type of crash in general. Head-on, sideswipe, rear-end and broadside are used only if two or more motor vehicles are involved.

**Exposure Rates**

Several rates and measures are used in this report to relate collision involvement, collision fault, and arrests to exposure to the event. These include:

***Mileage-Adjusted Collision Rate*** – relates collision involvement and fault to the number of miles driven. The rate is calculated by dividing the number of drivers in a group involved (or at fault) in fatal/injury (or fatal) collisions by the number of licensed drivers in that group, divided by the average number of miles driven by drivers in that group, multiplied by 1 million.

As noted by Janke (1991), this traditional mileage-adjusted rate has limitations as a measure of driving safety performance. Low-mileage drivers tend to accumulate their miles under different environmental conditions than high-mileage drivers. These differences affect collision risk but are not taken into account in calculating mileage-adjusted rates.

People driving high mileages tend to accumulate most of their miles on freeways or on other divided multilane highways with limited access. People driving low mileages, on the other hand, typically log most of their miles on congested city streets with two-way traffic and no restriction of access.

Females are more likely than males, and teens and, especially, seniors are more likely than middle-aged adults, to be low mileage drivers and to accumulate their miles on city streets. Since the driving task is more challenging and exposure to collisions is greater on these roads, the collision rate per mile driven is less favorable on city streets than on freeways. Data from the California Business, Transportation and Housing Agency (1985) indicate that there are 2.75 times as many collisions per mile driven on nonfreeways as on freeways.

*Per Licensed Driver Collision Rate* – relates collision involvement and fault to the number of licensed drivers exposed to the event. The rate is calculated by dividing the number of drivers in a group involved (or at fault) in fatal/injury (or fatal) collisions by the number of licensed drivers in that group, then multiplying by 1,000.

Some caution should be exercised in interpreting the per licensed driver collision rate since it is unknown to what extent out-of-state and unlicensed drivers are represented in the crash data. These drivers likely account for a relatively small component of drivers in collisions in California. But the distortion caused by this source of error could inflate the per licensed driver collision rate for groups disproportionately represented by out-of-state or unlicensed drivers. Conversely, the rate could be underestimated if many members of a group are licensed but do not drive; this is especially likely in the case of older adults and is more characteristic of females than males. Further, the per licensed driver rates do not take into account age and gender variations in actual driving exposure (i.e., miles driven).

*Per Licensed Driver Had-Been-Drinking (HBD) Collision Rate* – this measure is similar to the per licensed driver collision rate described above, but relates specifically to involvement and fault in HBD collisions. The rate is calculated by dividing the number of drivers in a group involved (or at fault) in HBD fatal/injury (or fatal) collisions by the number of licensed drivers in the group, then multiplying by 10,000.

HBD collisions include collisions where even small amounts of alcohol are believed to have been consumed. To the extent that collisions for the different age/sex groups are disproportionately caused by out-of-state or unlicensed drivers, comparisons between groups are distorted. Overall, though, this source of error is believed to be minor.

***Relative Involvement Index*** – measures the risk of being involved (or at fault) in an event, taking into account the number of licensed drivers exposed to the risk. The index is calculated by dividing the proportion a given group represents of all drivers involved (or at fault) in a given event (e.g., fatal/injury collisions) by the proportion that group represents of all licensed drivers.

A relative involvement index of “1” indicates that the group is neither overinvolved nor underinvolved in the event (i.e., collisions or arrests); the group’s involvement is consistent with what is expected given its share of licensed drivers. If the index climbs above “1,” the group has a higher than expected rate of involvement in the event based on its representation in the licensed driver population. Conversely, if the index falls below “1,” the group has a lower than expected rate of involvement.

In addition to comparing a given group’s rate to that of *all* drivers, comparisons *between groups* are possible by dividing the indices for the respective groups. (This concept is explained more fully on page 22.)

Relative involvement indices are presented in Section 1 for casualty collisions as well as for arrests for traffic offenses related to driving under the influence. Like the per licensed driver rate, the relative involvement index for any given group will be inflated to the extent that out-of-state and unlicensed drivers are represented in the crash or arrest data for that group, and will be underestimated to the extent that members of the group are licensed but do not drive. Further, the index does not adjust for age and gender differences in actual driving exposure.

## Population Trends and Driver Licensure Rates

---

### Population Trends

During the forty-year period 1985 to 2025, California's population will grow increasingly older as the baby boom generation ages (Table 1, Figure 1). In 1985, adults aged 65 or older accounted for 10.3% of California's total population, representing an estimated 2.7 million residents. By 2025, the share of elderly is expected to climb to 16.6%, when 8.7 million Californians are expected to be aged 65 or older.

Especially significant will be the increase in the percent of adults of advanced old age—those 75 years or older. Projections indicate that from 1985 to 2025 the proportion of the population aged at least 75 will increase by two-thirds, from 4.3% to 7.1%.

During this same period, there will be an overall decline in the percentage of teens aged 16-19, dropping from 6.5% of California's total population in 1985 to 5.4% in 2025. By 2025, teens aged 16-19 will be outnumbered by adults aged 75 or older (2.85 million vs. 3.75 million).

### Percentage of Residents Licensed

The percentage of residents holding a California driver license increases with age until age 50, then decreases, dropping sharply among adults of advanced old age (Table 2, Figure 2).

In 1995, over 20 million people held a California driver license, representing more than four in five residents aged 16 or older.

A larger percentage of males (84.7%) than females (76.4%) were licensed to drive. The sex disparity in licensure rates persists in all age groups and widens significantly in the advanced old ages. By age 85, close to half (45.8%) of men were licensed as compared to one in five (19.6%) women.

Overall, 67.8%, or 2.4 million, adults aged 65 or older held a California driver license. Of teens aged 16-19, 45.8% were licensed, representing 775,500 drivers.

In California, drivers can qualify for an instruction permit at age 15, which allows them to gain supervised driving experience prior to licensure. Most applicants postpone applying for a permit until immediately before their 16th birthday.

Of those aged 16, more than one-fifth (22.7%) are licensed to drive. The percentage licensed almost doubles (41.1%) by age 17 and jumps to 64.2% by age 19.

### **Profile of the Licensed Population**

Closely mirroring the age distribution of the total resident population aged 16 and above, the licensed population is skewed towards the young-adult and middle ages. About half of all licensed drivers are under age 40, and one-quarter are aged 30-39 (Table 3, Figure 3).

Males represent slightly more than half (52.4%) of all California licensed drivers (Table 3). They outnumber female licensed drivers at all ages, with the exception of the 70-84 age groups.

### **Age/Sex Trends in the Licensed Population**

Demographic trends forecast significant changes in the age distribution of the licensed population. As the total population ages, older adults are expected to account for a rising share of licensed drivers.

This trend is already evident from 1981-1995, when adults aged 65 or older increased from 9.9% to 12.0% of all California licensed drivers (Table 4, Figure 4).

The shift in age structure occurred for both sexes but, at least in the past, has been somewhat more pronounced among female licensed drivers than among male licensed drivers (Table 4). In 1995, 12.6% of licensed females were aged 65 or older, up from 9.8% in 1981. In comparison, 11.4% of licensed males were aged 65 or older in 1995, as compared to 10.0% in 1981. The propensity for new cohorts of older adults, especially older females, to be licensed has been documented nationwide since the 1950s and is expected to continue, given improved morbidity rates at the older ages.

Significantly, California's older licensed population is growing at a faster pace than its older resident population. From 1981 to 1995, the number of licensed drivers aged 65 or older grew by 54.6%, while the number of residents in this age group increased by 41.8%. Among senior drivers, those aged 75 or older are increasing most rapidly and in 1995 represented 34.8% of all licensed older drivers, up from 26.9% in 1981. Overall, 4.2% of licensed drivers were aged at least 75 in 1995 (Table 4, Figure 4).

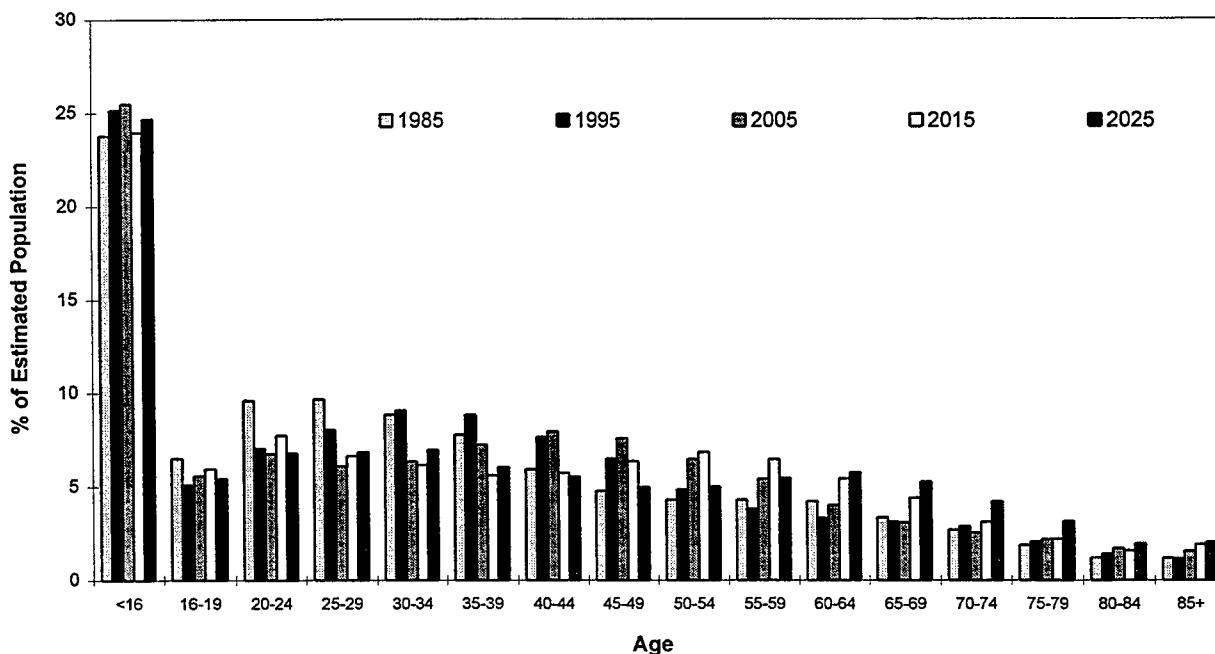
Teens, by contrast, account for a declining share and number of licensed drivers. In 1981, 6.3% of licensed drivers were aged 16-19, but by 1995 this figure had fallen to 3.9%. During this period, the

number of licensed teens dropped from 991,750 to 775,500, representing a 21.8% reduction. Demographic shifts as well as reductions in public funding for high school driver training, which prevented or delayed many teens from obtaining a driver license, largely account for these declines.

**Table 1. Percentage of Estimated Population by Age, California 1985-2025**

Age	% of Population				
	1985	1995	2005	2015	2025
<16	23.77	25.16	25.47	23.95	24.67
16-19	6.52	5.10	5.59	5.95	5.44
20-24	9.61	7.03	6.75	7.73	6.79
25-29	9.68	8.04	6.08	6.64	6.85
30-34	8.86	9.08	6.35	6.16	6.97
35-39	7.77	8.83	7.24	5.61	6.04
40-44	5.92	7.65	7.95	5.72	5.53
45-49	4.76	6.48	7.58	6.35	4.96
50-54	4.30	4.85	6.47	6.85	4.98
55-59	4.30	3.82	5.42	6.44	5.45
60-64	4.21	3.32	4.01	5.41	5.75
65-69	3.35	3.13	3.09	4.40	5.25
70-74	2.69	2.88	2.55	3.11	4.20
75-79	1.88	2.07	2.18	2.20	3.15
80-84	1.20	1.41	1.70	1.58	1.96
85+	1.18	1.15	1.57	1.90	2.03
Total (%)	100.00	100.00	100.00	100.00	100.00
n	26,402,649	33,188,930	39,424,114	45,574,195	52,518,236

Source: Data for 1985 from California Department of Finance, *Historical State Population Estimates, with Components of Change and Crude Rates, July 1, 1941 to 1996*, Sacramento, CA. Data for 1995-2025 from California Department of Finance, *Projected Total Population of California Counties: 1990-2040* (Report 93 P-3), Sacramento, CA.

**Figure 1. Percentage of Estimated Population by Age, California 1985-2025**

Source: Data for 1985 from California Department of Finance, *Historical State Population Estimates, with Components of Change and Crude Rates, July 1, 1941 to 1996*, Sacramento, CA. Data for 1995-2025 from California Department of Finance, *Projected Total Population of California Counties: 1990-2040* (Report 93 P-3), Sacramento, CA.

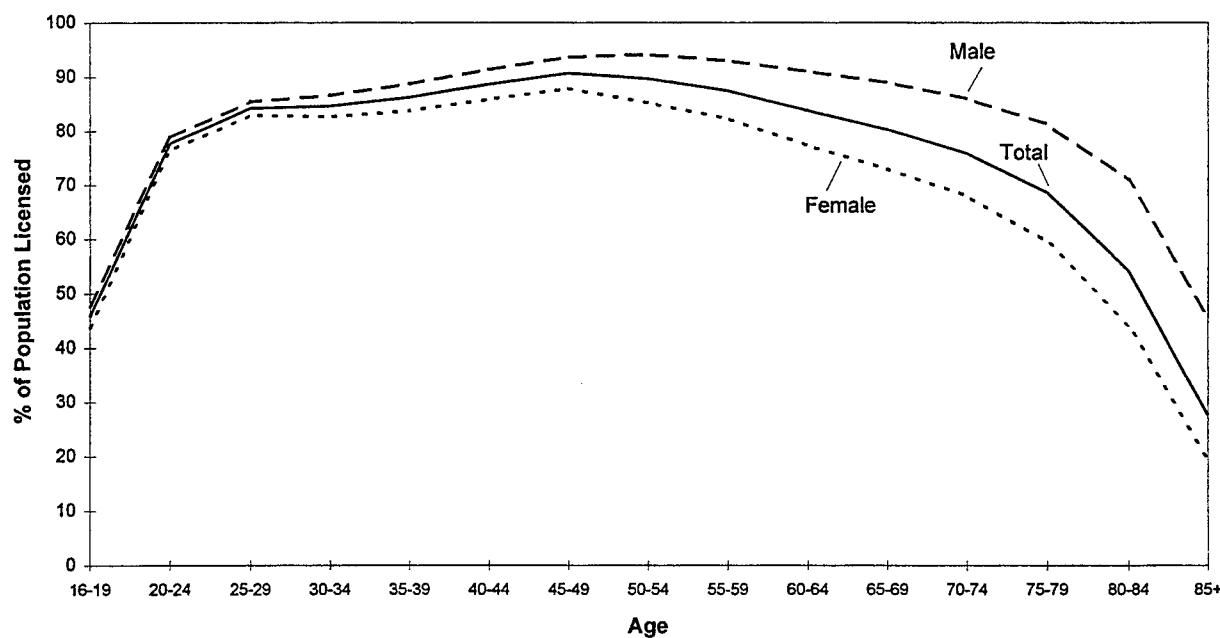
**Table 2. Licensed Drivers, Population, and Percentage of Population Licensed to Drive by Age and Sex, California 1995**

Age	Total			Male			Female		
	Licensed Drivers (Thousands)	Population (Thousands)	% Population Licensed	Licensed Drivers (Thousands)	Population (Thousands)	% Population Licensed	Licensed Drivers (Thousands)	Population (Thousands)	% Population Licensed
16	96	423	22.70	50	218	22.94	46	206	22.33
17	171	416	41.11	91	214	42.52	80	202	39.60
18	232	423	54.85	126	219	57.53	106	204	51.96
19	276	430	64.19	151	226	66.81	125	205	60.98
16-19	776	1,694	45.81	418	876	47.72	358	817	43.82
20-24	1,814	2,332	77.79	986	1,249	78.94	828	1,083	76.45
25-29	2,251	2,669	84.34	1,222	1,429	85.51	1,029	1,240	82.98
30-34	2,552	3,012	84.73	1,359	1,569	86.62	1,193	1,443	82.67
35-39	2,531	2,931	86.35	1,326	1,493	88.81	1,205	1,437	83.86
40-44	2,252	2,538	88.73	1,167	1,276	91.46	1,085	1,263	85.91
45-49	1,954	2,152	90.80	1,003	1,070	93.74	951	1,082	87.89
50-54	1,444	1,609	89.75	749	795	94.21	695	815	85.28
55-59	1,110	1,268	87.54	576	619	93.05	534	648	82.41
60-64	923	1,100	83.91	479	526	91.06	444	574	77.35
65-69	836	1,040	80.38	423	475	89.05	413	566	72.97
70-74	725	955	75.92	359	417	86.09	366	538	68.03
75-79	471	686	68.66	232	285	81.40	239	401	59.60
80-84	254	468	54.27	125	176	71.02	129	292	44.18
85+	106	383	27.68	54	118	45.76	52	265	19.62
<b>Total</b>	<b>20,000</b>	<b>24,837</b>	<b>80.53</b>	<b>10,479</b>	<b>12,373</b>	<b>84.69</b>	<b>9,521</b>	<b>12,464</b>	<b>76.39</b>

Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA.

Population data from California Department of Finance, *Projected Total Population of California Counties: 1990-2040* (Report 93 P-3), Sacramento, CA.

**Figure 2. Percentage of Population Licensed to Drive by Age and Sex, California 1995**



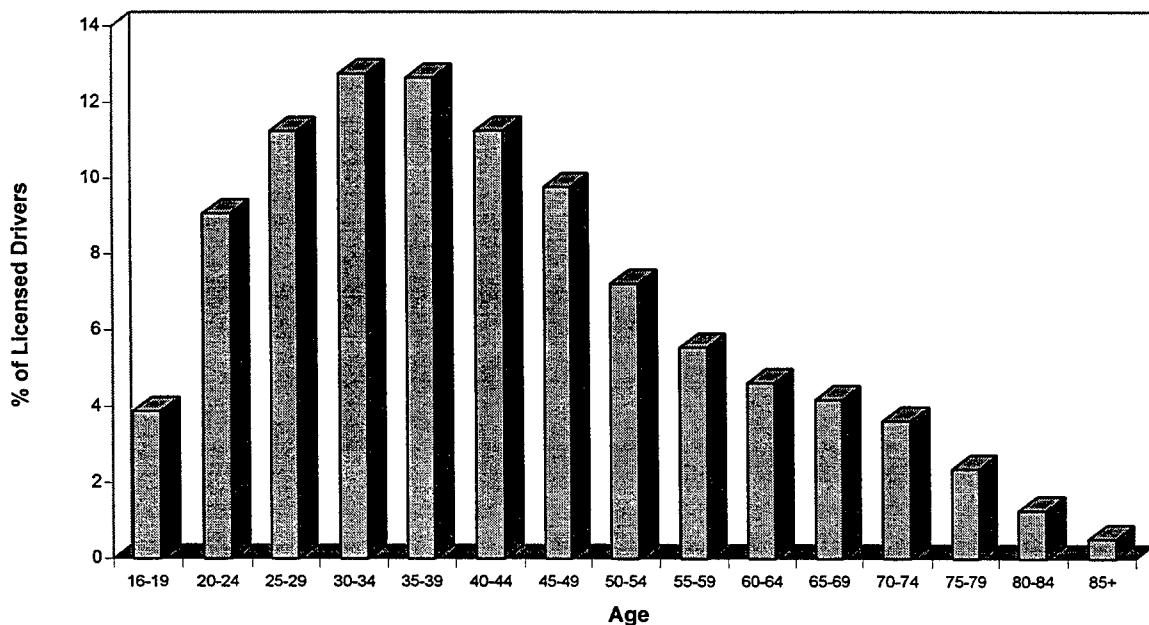
Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA. Population data from California Department of Finance, *1995 Projected Total Population of California Counties: 1990-2040* (Report 93 P-3), Sacramento, CA.

**Table 3. Percentage of Total Licensed Drivers by Age and Sex, California 1995**

Age	% of Total Licensed Drivers		
	Total	Male	Female
16-19	3.88	2.09	1.79
20-24	9.07	4.93	4.14
25-29	11.25	6.11	5.14
30-34	12.76	6.80	5.96
35-39	12.65	6.63	6.02
40-44	11.26	5.83	5.43
45-49	9.77	5.02	4.76
50-54	7.22	3.74	3.48
55-59	5.55	2.88	2.67
60-64	4.62	2.39	2.22
65-69	4.18	2.11	2.06
70-74	3.62	1.79	1.83
75-79	2.36	1.16	1.19
80-84	1.27	0.63	0.65
85+	0.53	0.27	0.26
<b>Total (%)</b>	<b>100.00</b>	<b>52.40</b>	<b>47.60</b>
<i>n</i>	20,000,200	10,479,600	9,520,600

Source: California Department of Motor Vehicles,  
*Age and Sex Report* (July 1, 1995), Sacramento, CA.

**Figure 3. Percentage of Total Licensed Drivers by Age, California 1995**

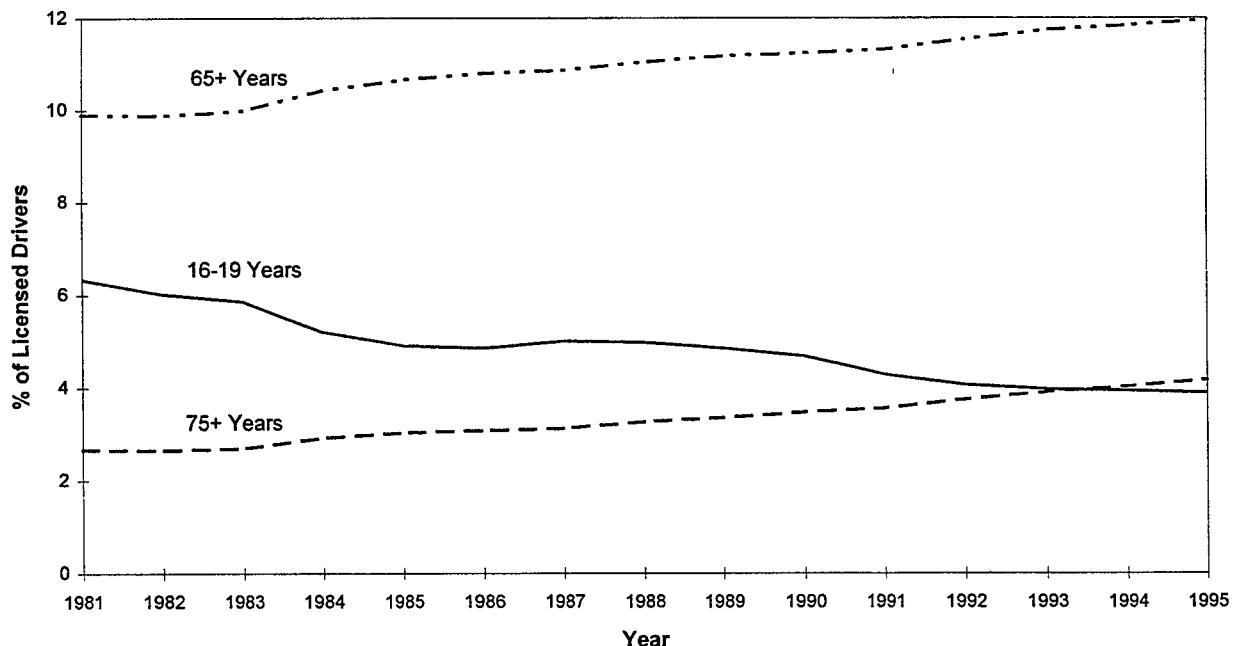


Source: California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA.

**Table 4. Percentage of Male and Female Licensed Drivers by Age, California 1981, 1985 and 1995**

Age	1981			1985			1995		
	% of Total	% of Male	% of Female	% of Total	% of Male	% of Female	% of Total	% of Male	% of Female
16-19	6.34	6.52	6.13	4.91	5.08	4.73	3.88	3.99	3.76
20-24	13.41	13.65	13.14	12.03	12.28	11.74	9.07	9.41	8.70
25-29	13.94	14.09	13.76	14.02	14.25	13.77	11.25	11.66	10.80
30-34	12.97	12.80	13.16	13.09	13.15	13.03	12.76	12.97	12.53
35-39	9.82	9.75	9.89	11.63	11.50	11.78	12.65	12.66	12.65
40-44	7.79	7.72	7.86	8.77	8.74	8.82	11.26	11.13	11.40
45-49	6.78	6.72	6.83	6.96	6.92	7.00	9.77	9.57	9.99
50-54	6.72	6.65	6.80	6.13	6.10	6.17	7.22	7.15	7.30
55-59	6.72	6.55	6.90	5.99	5.91	6.07	5.55	5.50	5.61
60-64	5.64	5.56	5.74	5.79	5.64	5.96	4.62	4.57	4.67
65-69	4.31	4.27	4.36	4.47	4.34	4.61	4.18	4.04	4.34
70-74	2.92	2.92	2.92	3.17	3.08	3.27	3.62	3.42	3.84
75-79	1.67	1.71	1.62	1.87	1.82	1.91	2.36	2.22	2.51
80-84	0.75	0.79	0.70	0.86	0.87	0.86	1.27	1.19	1.36
85+	0.24	0.29	0.19	0.30	0.33	0.27	0.53	0.52	0.55
Total (%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
n	15,649,990	8,302,850	7,347,140	17,021,790	8,967,110	8,054,580	20,000,200	10,479,600	9,520,600

Source: California Department of Motor Vehicles, *Age and Sex Report* (June 30, 1981; July 14, 1985; July 1, 1995), Sacramento, CA

**Figure 4. Teens and Seniors as a Percentage of Total Licensed Drivers, California 1981-1995**

Source: California Department of Motor Vehicles, *Age and Sex Report* (mid-year, 1981-1995), Sacramento, CA.

## Drivers in Casualty Collisions

---

### Drivers Involved and At Fault

In 1995, 343,614 California drivers were involved in fatal/injury collisions; of these, 5,228 (1.5%) were in fatal collisions (Table 5).

Of drivers in fatal/injury collisions, 152,743 (44.5%) were at fault; 2,686 drivers in fatal collisions (51.4%) were at fault.<sup>1</sup>

### Sex Differences

Overall, male drivers outnumber female drivers in casualty crashes (Table 5). They represent 208,559, or 60.7%, of drivers in fatal/injury collisions and 3,901, or 74.6%, of drivers in fatal collisions. Their representation among at-fault drivers is somewhat greater, indicating that when involved in collisions, males are more likely than females to be at fault. Of drivers at fault in total casualty crashes, 96,783, or 63.4%, are male. Some 2,041, or 76.0%, of drivers responsible for fatal collisions are male.

### Age Differences

For both males and females, the age distribution of drivers in casualty collisions is heavily skewed toward the young and middle years (Table 5). More collision-involved drivers fall in the 20-24 age group than in any other single five-year age group. Relatively few drivers in collisions fall within each of the five-year older age groups. This pattern persists regardless of crash severity (fatal or fatal/injury) or fault of driver (Figures 5 and 6).

As a group, seniors aged 65 or older comprise 7.1% (or 24,235) of drivers in fatal/injury collisions and 9.4% (or 493) of drivers in fatal collisions. Their shares of at-fault drivers are somewhat greater, comprising 8.4% (or 12,801) of at-fault drivers in fatal/injury crashes and 10.9% (or 292) of at-fault drivers in fatal crashes.

Teens aged 16-19 represent 10.2% (or 34,941) of all drivers in fatal/injury collisions and 8.9% (or 463) of drivers in fatal collisions. Similar to their senior counterparts, their shares of at-fault drivers are somewhat greater: 13.5% (or 20,567) and 10.8% (or 289) for fatal/injury collisions and fatal collisions, respectively.

---

<sup>1</sup> As noted on page 4, these figures refer to drivers in collisions for whom age is reported, and represent the vast majority of drivers involved or at fault in casualty collisions. Age is reported for 94.5% of drivers involved in casualty collisions and for 92.6% of those at fault.

**Trends**

Seniors are accounting for an increasing share of drivers in casualty collisions, largely due to their growing representation among licensed drivers. In 1995, 7.1% of drivers in fatal/injury collisions were aged 65 or older, as compared to 4.9% in 1981 (Table 6). Their share of at-fault drivers increased from 6.4% in 1984 (the earliest year for which data are available) to 8.4% in 1995 (Table 6, Figure 8).

Teens aged 16-19, on the other hand, represent a declining percentage of drivers in casualty collisions—10.1% in 1995 as compared to 14.6% in 1981. Similarly, their representation among drivers at fault in these collisions dropped to 13.5% in 1995 from 16.0% in 1984.

The growth evidenced since the 1980s in the percentages of seniors among drivers involved and at fault in casualty collisions (43.3% and 31.3%, respectively) exceeds the percentage declines documented for teenagers (30.8% and 15.6%, respectively). The trend toward an increasing proportion of casualty collisions involving older drivers is projected to continue over the next 25–30 years as a result of the increasing proportion of senior drivers.

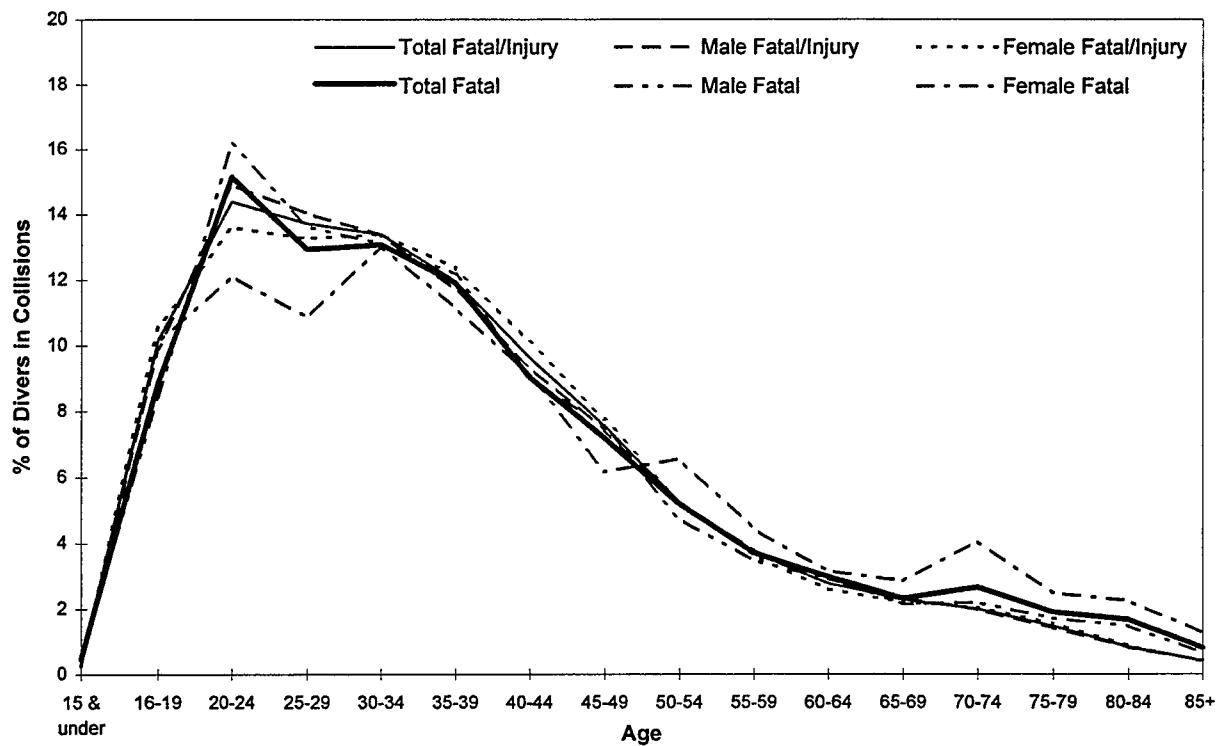
**Table 5. Percentage of Drivers Involved or At Fault in Fatal/Injury and Fatal Collisions by Age and Sex, California 1995**

Age	Drivers Involved in Collisions						Drivers At Fault in Collisions					
	Fatal/Injury			Fatal			Fatal/Injury			Fatal		
	% of Total	% of Male	% of Female	% of Total	% of Male	% of Female	% of Total	% of Male	% of Female	% of Total	% of Male	% of Female
15 & under	0.30	0.33	0.26	0.46	0.51	0.30	0.51	0.54	0.46	0.86	0.93	0.62
16	1.71	1.55	1.97	1.34	1.20	1.73	2.56	2.28	3.04	1.75	1.67	2.02
17	2.37	2.25	2.55	2.01	1.79	2.64	3.20	3.05	3.46	2.46	2.35	2.79
18	3.05	3.04	3.05	2.72	2.51	3.32	4.01	4.03	3.98	3.20	3.23	3.10
19	3.04	3.05	3.02	2.79	2.92	2.41	3.70	3.77	3.56	3.35	3.43	3.10
16-19	10.17	9.89	10.60	8.86	8.43	10.10	13.47	13.13	14.04	10.76	10.68	11.01
20-24	14.40	14.92	13.61	15.15	16.18	12.13	16.16	17.18	14.40	17.83	19.75	11.78
25-29	13.73	14.03	13.26	12.93	13.64	10.85	13.65	14.17	12.74	13.37	14.36	10.23
30-34	13.39	13.38	13.40	13.08	13.10	13.04	12.52	12.71	12.18	12.55	12.93	11.32
35-39	11.96	11.69	12.37	11.92	12.18	11.15	10.61	10.42	10.93	10.20	10.68	8.68
40-44	9.64	9.34	10.10	9.05	9.02	9.12	8.28	8.05	8.67	7.48	7.20	8.37
45-49	7.56	7.43	7.75	7.19	7.54	6.18	6.32	6.21	6.52	6.22	6.12	6.51
50-54	5.27	5.25	5.30	5.20	4.74	6.56	4.43	4.32	4.62	4.24	3.67	6.05
55-59	3.73	3.80	3.63	3.73	3.49	4.45	3.16	3.09	3.27	3.05	2.74	4.03
60-64	2.80	2.92	2.60	3.00	2.95	3.17	2.52	2.46	2.62	2.57	2.25	3.57
65-69	2.29	2.34	2.21	2.33	2.15	2.86	2.28	2.18	2.46	2.16	1.81	3.26
70-74	2.01	1.98	2.05	2.68	2.20	4.07	2.27	2.06	2.63	2.64	1.86	5.12
75-79	1.48	1.43	1.57	1.91	1.72	2.49	1.91	1.68	2.31	2.46	2.01	3.88
80-84	0.85	0.83	0.88	1.68	1.49	2.26	1.26	1.15	1.46	2.46	2.11	3.57
85+	0.42	0.43	0.40	0.82	0.67	1.28	0.65	0.64	0.67	1.15	0.88	2.02
Total (%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
n <sup>a</sup>	343,614	208,559	135,055	5,228	3,901	1,327	152,743	96,783	55,960	2,686	2,041	645

<sup>a</sup> Excludes drivers for whom age is not reported.

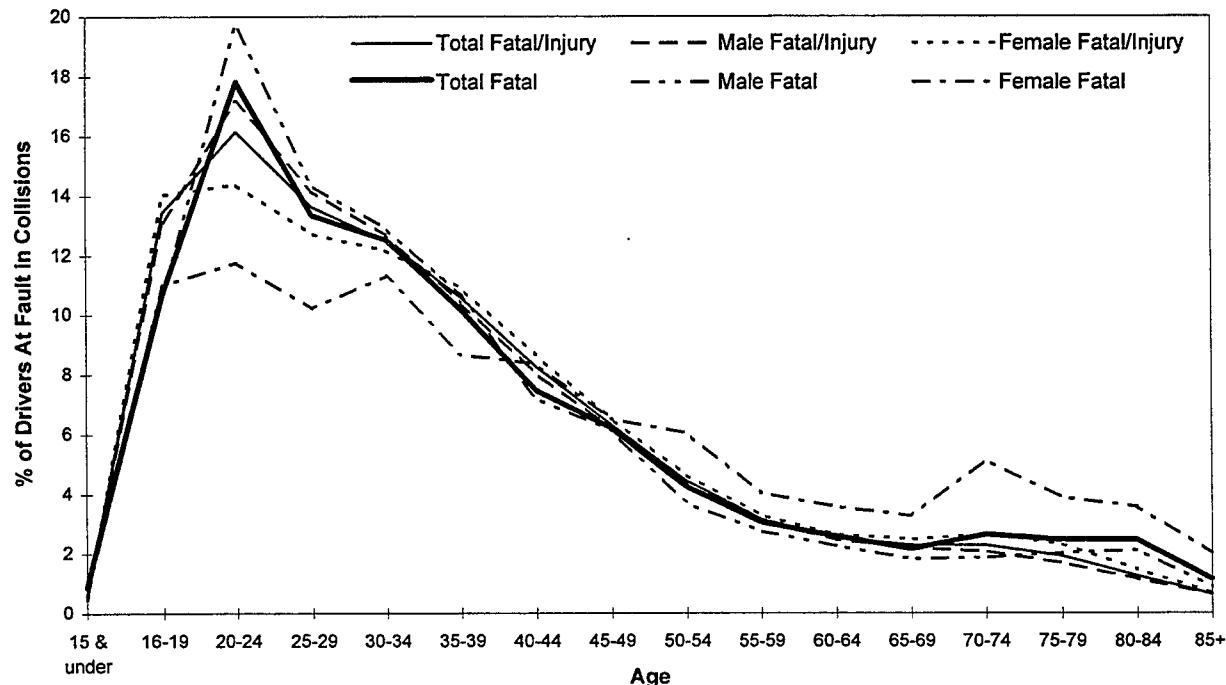
Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Figure 5. Percentage of Drivers in Fatal/Injury and Fatal Collisions by Age and Sex, California 1995**



Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Figure 6. Percentage of Drivers At Fault in Fatal/Injury and Fatal Collisions by Age and Sex, California 1995**



Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Table 6. Teens and Seniors as a Percentage of Total and At-Fault Drivers in Fatal/IInjury Collisions, California 1981-1995**

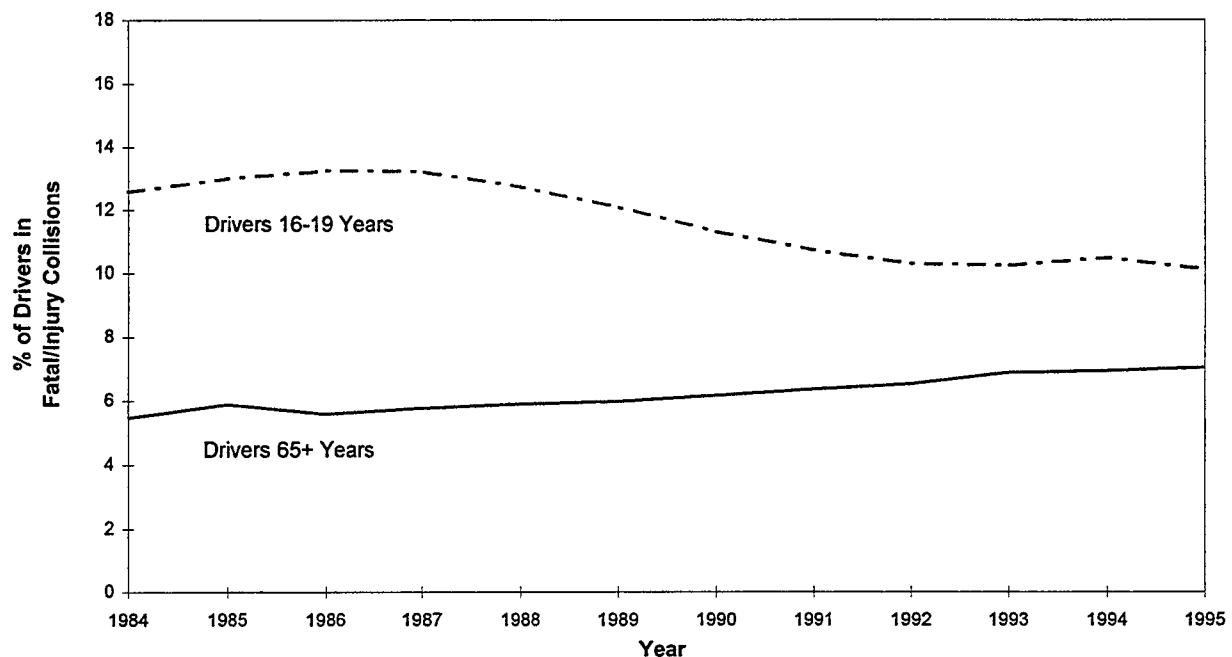
Year	Drivers in Fatal/IInjury Collisions			Drivers At Fault in Fatal/IInjury Collisions		
	Total Number <sup>a</sup>	% Aged 16-19	% Aged 65+	Total Number <sup>a</sup>	% Aged 16-19	% Aged 65+
1981	338,871	14.55	4.92	— <sup>b</sup>	—	—
1982	323,408	13.46	5.24	—	—	—
1983	343,843	12.88	5.40	—	—	—
1984	364,929	12.58	5.48	145,464	15.99	6.38
1985	361,611	13.00	5.90	142,967	16.65	7.07
1986	390,850	13.25	5.59	159,146	16.93	6.57
1987	405,780	13.22	5.77	176,452	16.61	6.76
1988	401,306	12.74	5.91	175,519	16.08	6.96
1989	404,819	12.10	5.99	181,634	15.18	7.03
1990	404,736	11.31	6.17	180,921	14.30	7.24
1991	383,286	10.73	6.37	171,141	13.76	7.58
1992	370,687	10.30	6.53	163,630	13.32	7.88
1993	350,258	10.25	6.89	154,814	13.39	8.19
1994	354,569	10.50	6.95	156,637	13.83	8.22
1995	343,614	10.14	7.05	152,743	13.47	8.38

<sup>a</sup> Excludes drivers for whom age is not reported.

<sup>b</sup> At-fault data are not available for 1981-1983.

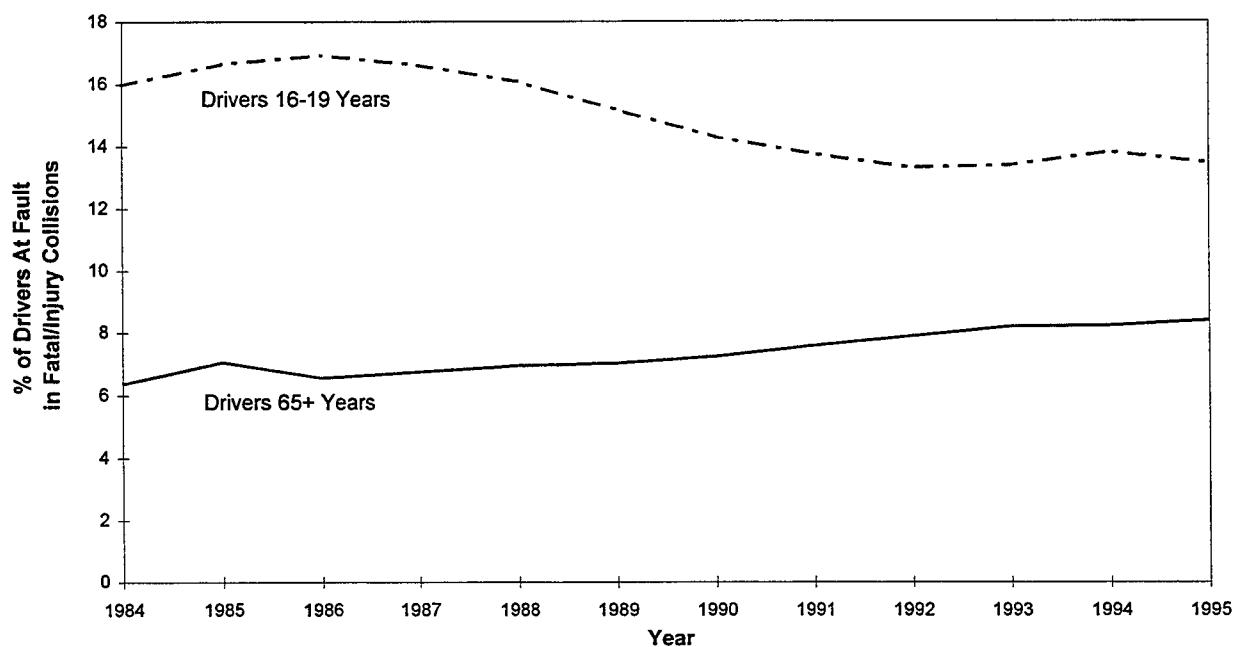
Source: California Highway Patrol, *Annual Report of Fatal and Injury Motor Vehicle Traffic Accidents* (1981-1995), Sacramento, CA.

**Figure 7. Teens and Seniors as a Percentage of Total Drivers in Fatal/Injury Collisions, California 1984-1995**



Source: California Highway Patrol, *Annual Report of Fatal and Injury Motor Vehicle Traffic Accidents* (1984-1995), Sacramento, CA.

**Figure 8. Teens and Seniors as a Percentage of Total Drivers At Fault in Fatal/Injury Collisions, California 1984-1995**



Source: California Highway Patrol, *Annual Report of Fatal and Injury Motor Vehicle Traffic Accidents* (1984-1995), Sacramento, CA.

## Casualty Collision Exposure Rates

---

---

### Per Driver Rate and Relative Involvement Index

#### General Patterns

Overall, 17.13 in 1,000 licensed drivers are involved in fatal/injury collisions, and 7.60 in 1,000 licensed drivers are at fault in these collisions. The rate of involvement in fatal collisions is 0.26 per 1,000 licensed drivers; 0.13 in 1,000 licensed drivers are at fault in fatal crashes (Table 7).

#### Sex Differences

Regardless of age, males consistently exhibit higher per driver rates and relative involvement indices in casualty collisions than females. (Figures 9 and 10 plot per driver rates and relative involvement indices together, on separate ordinates, for fatal/injury and fatal collisions, respectively. The corresponding data for at-fault fatal/injury and at-fault fatal collisions are plotted in Figures 11 and 12.)

The sex disparity is especially evident in fatal crashes. Overall, 0.37 in 1,000 licensed male drivers are involved in fatal collisions, compared to 0.14 in 1,000 licensed females (Table 7). Males have a relative involvement index of 1.42 for fatal collisions, while the corresponding index for females is 0.53 (Table 8).

That the relative involvement index for males exceeds "1" means they have a higher than average rate of involvement in fatal collisions based on their representation in the driving population. Specifically, a relative involvement index of 1.42 for fatal collisions means that males have, on average, a fatal collision rate 42% higher than all drivers (i.e.,  $1.42 - 1.00 = 0.42$ ). The index of 0.53 for fatal collisions for females, by contrast, indicates they average a rate 47% lower than all drivers based on their representation in the licensed driver population (i.e.,  $1.00 - 0.53 = 0.47$ ).

In addition to comparing collision rates for a given group with the rate for *all* drivers, relative involvement indices can be used to make comparisons between groups by dividing the indices for the respective groups. For example, males aged 20-24 have a relative involvement index of 3.07 for at-fault fatal collisions, while the corresponding index for females aged 20-24 is 0.69 (Table 9). To determine how much greater the rate is for males than females, 3.07 is divided by 0.69. The result is 4.45, which means that males aged 20-24 have, on average, a rate of fault in fatal collisions 4.45 times greater than females in this age group.

<b>Age Differences</b>	<p>For both males and females, per driver rates and indices of involvement and fault in fatal/injury collisions and in fatal collisions are highest in the younger ages and peak for teens (Tables 7-9, Figures 9-12).</p> <p>Teens aged 16-19 have an especially high risk of being at fault in casualty collisions. For every 1,000 teenagers licensed, 26.52 are at fault in fatal/injury collisions (Table 7). Their relative involvement index for at-fault fatal/injury collisions (3.49) indicates that, on average, teens have a rate of culpability 249% higher than all drivers (Table 9).</p> <p>After age 19, per driver rates and indices of involvement and fault in fatal/injury and fatal collisions drop dramatically for both males and females. They continue to decline as driver age increases, until about age 70, when there is an upturn. The rise at the advanced ages can be attributed in part to declines in driving skill, but also reflects the increased vulnerability of older frail drivers to injury and death in crashes that would not kill or seriously injure younger drivers. To the extent that the older age groups include members who are licensed but no longer drive, their per driver collision rates are underestimated.<sup>2</sup></p> <p>The upswing in risk at the older ages is especially notable for fatal collisions (Figure 10) and is steepest for at-fault fatal collisions, particularly for males (Figure 12). By age 85, men have, on average, a rate of fault in fatal collisions 149% higher than all drivers; the rate for women in this age group averages 87% higher than all drivers.</p>
<b>Number of Miles Driven</b>	<p><b>Mileage-Adjusted Rate</b></p> <p>Number of miles driven, an important indicator of a driver's exposure to the risk of a collision while on the road, varies significantly by age and sex. Overall, drivers in the intermediate ages accumulate more miles than either teen or, especially, senior drivers, and males average more miles than females.</p> <p>More specifically, the number of miles driven increases steadily until age 40, and then declines as age of driver increases (Table 10, Figure 13). By age 85, drivers average 2,797 miles annually, about one-fourth the miles driven by drivers of all ages (11,331 miles).</p>

<sup>2</sup> See page 6, Per Licensed Driver Collision Rate, for a fuller discussion of this point.

The decline in miles driven at the older ages reflects a number of factors, including the reduced presence of the elderly in the work force and the absence of work-related travel, as well as declining functional abilities and poor health.

At all ages, males drive significantly more miles than females. The disparity is most evident among drivers aged 55-69; males in these age groups average more than twice as many miles as their female age peers.

**Mileage-Adjusted Rate**

Overall, for every 1 million miles driven, 1.51 drivers aged 16 or older are involved in fatal/injury collisions and 0.02 are in fatal collisions; 0.67 drivers aged 16 or older are at fault in fatal/injury collisions and 0.01 are at fault in fatal collisions (Table 11).

**Sex Differences**

Per mile driven, females have higher rates of involvement and fault in total casualty collisions than males (Table 11). This disparity persists in almost all age groups (Figures 14 and 16). Overall, for every 1 million miles driven, 1.57 women aged 16 or older are in fatal/injury collisions and 0.65 are at fault. This compares to 1.27 and 0.59, respectively, for men (Table 11).

For fatal collisions, by contrast, mileage-adjusted rates of involvement and fault are identical for males and females of all ages combined (Table 11). However, up until the middle ages, and especially in the younger years, rates for males tend to exceed those for females (Figures 15 and 17).

**Age Differences**

Mileage-adjusted rates of involvement and fault in fatal/injury collisions and in fatal collisions follow a U-shaped curve from youth to old age. High in the teen years, each of these rates drops precipitously at age 20 and continues to decline until the late middle years, when there is an upturn. Rates then begin to rise, accelerating rapidly after age 79 (Figures 14-17).

As noted in connection with the previous discussion of per licensed driver collision rates and relative involvement indices, the steep upswing evidenced at the upper ages in casualty collisions per mile driven is confounded by the increased frailty and vulnerability to injury and death that occurs at the advanced ages, particularly after age 80.

While mileage-adjusted collision rates are greatest for elderly drivers, it is inaccurate to conclude, for example, that drivers aged 85 and older (who have a mileage-adjusted fatal/injury collision rate of 4.81) are more than five times as hazardous as drivers aged 45-49 (who have a rate of 0.88) (Table 11). Such a conclusion is based on the erroneous assumption that collisions occur in proportion to miles driven (Janke, 1991). As summarized by Gebers, Romanowicz and McKenzie (1993), teens and, especially, seniors drive fewer miles than middle-aged adults, and those driving low mileages tend to accumulate more of their miles on surface streets, where congestion, complicated road designs and multiple traffic signs and signals present significant hazards. By contrast, high-mileage drivers accumulate most of their miles on freeways or other divided multilane highways with limited access. Because the driving task is simpler and exposure to collisions is lower on these roads, the collision rate per mile driven is much lower.<sup>3</sup>

---

<sup>3</sup> See page 5, Mileage-Adjusted Collision Rate, for a fuller discussion of this point.

**Table 7. Total and At-Fault Fatal/Injury and Fatal Collisions Per 1,000 Licensed Drivers by Age and Sex, California 1995**

Age	Total Collisions						At-Fault Collisions					
	Fatal/Injury			Fatal			Fatal/Injury			Fatal		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
16	61.50	64.43	58.29	0.73	0.94	0.50	40.87	44.13	37.28	0.49	0.68	0.29
17	47.66	51.80	42.98	0.61	0.77	0.44	28.56	32.49	24.11	0.39	0.53	0.22
18	45.06	50.49	38.62	0.61	0.78	0.41	26.37	31.01	20.88	0.37	0.53	0.19
19	37.76	42.05	32.60	0.53	0.75	0.26	20.43	24.17	15.91	0.33	0.46	0.16
16-19	45.06	49.39	40.00	0.60	0.79	0.37	26.52	30.43	21.96	0.37	0.52	0.20
20-24	27.28	31.55	22.20	0.44	0.64	0.19	13.61	16.86	9.73	0.26	0.41	0.09
25-29	20.96	23.94	17.42	0.30	0.44	0.14	9.26	11.22	6.93	0.16	0.24	0.06
30-34	18.03	20.53	15.18	0.27	0.38	0.15	7.49	9.05	5.71	0.13	0.19	0.06
35-39	16.24	18.38	13.87	0.25	0.36	0.12	6.40	7.60	5.08	0.11	0.16	0.05
40-44	14.71	16.70	12.57	0.21	0.30	0.11	5.61	6.68	4.47	0.09	0.13	0.05
45-49	13.29	15.45	11.01	0.19	0.29	0.09	4.94	5.99	3.84	0.09	0.12	0.04
50-54	12.53	14.61	10.29	0.19	0.25	0.13	4.69	5.58	3.72	0.08	0.10	0.06
55-59	11.56	13.74	9.19	0.18	0.24	0.11	4.35	5.19	3.43	0.07	0.10	0.05
60-64	10.41	12.73	7.91	0.17	0.24	0.09	4.17	4.97	3.30	0.07	0.10	0.05
65-69	9.42	11.56	7.23	0.15	0.20	0.09	4.17	4.98	3.34	0.07	0.09	0.05
70-74	9.53	11.53	7.56	0.19	0.24	0.15	4.79	5.57	4.02	0.10	0.11	0.09
75-79	10.81	12.82	8.86	0.21	0.29	0.14	6.21	7.02	5.42	0.14	0.18	0.10
80-84	11.50	13.91	9.17	0.35	0.46	0.23	7.59	8.91	6.32	0.26	0.34	0.18
85+	13.46	16.46	10.33	0.40	0.48	0.33	9.31	11.33	7.22	0.29	0.33	0.25
<b>Total</b>	<b>17.13</b>	<b>19.84</b>	<b>14.15</b>	<b>0.26</b>	<b>0.37</b>	<b>0.14</b>	<b>7.60</b>	<b>9.19</b>	<b>5.85</b>	<b>0.13</b>	<b>0.19</b>	<b>0.07</b>
<i>n</i> <sup>a</sup>	342,585	207,880	134,705	5,204	3,881	1,323	151,961	96,259	55,702	2,663	2,022	641

<sup>a</sup> Excludes drivers in collisions who are under age 16 or for whom age is not reported.

Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA.

Collision data from California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Table 8. Relative Involvement in Fatal/Injury and Fatal Collisions by Age and Sex, California 1995**

Age	Group as % of Total Licensed Drivers			Fatal/Injury Collisions						Fatal Collisions					
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
16	0.48	0.25	0.23	1.72	0.94	0.78	3.59	3.76	3.40	1.35	0.90	0.44	2.81	3.61	1.94
17	0.85	0.45	0.40	2.38	1.37	1.01	2.78	3.02	2.51	2.02	1.35	0.67	2.36	2.96	1.68
18	1.16	0.63	0.53	3.06	1.85	1.20	2.63	2.95	2.25	2.73	1.88	0.85	2.35	3.00	1.58
19	1.38	0.76	0.63	3.05	1.85	1.19	2.20	2.45	1.90	2.81	2.19	0.61	2.03	2.90	0.98
16-19	3.88	2.09	1.79	10.20	6.02	4.18	2.63	2.88	2.34	8.90	6.32	2.57	2.29	3.03	1.44
20-24	9.07	4.93	4.14	14.45	9.08	5.37	1.59	1.84	1.30	15.22	12.13	3.09	1.68	2.46	0.75
25-29	11.25	6.11	5.14	13.77	8.54	5.23	1.22	1.40	1.02	12.99	10.22	2.77	1.15	1.67	0.54
30-34	12.76	6.80	5.96	13.43	8.15	5.28	1.05	1.20	0.89	13.14	9.82	3.32	1.03	1.44	0.56
35-39	12.65	6.63	6.02	11.99	7.12	4.88	0.95	1.07	0.81	11.97	9.13	2.84	0.95	1.38	0.47
40-44	11.26	5.83	5.43	9.67	5.69	3.98	0.86	0.97	0.73	9.09	6.76	2.33	0.81	1.16	0.43
45-49	9.77	5.02	4.76	7.58	4.52	3.06	0.78	0.90	0.64	7.23	5.65	1.58	0.74	1.13	0.33
50-54	7.22	3.74	3.48	5.28	3.19	2.09	0.73	0.85	0.60	5.23	3.55	1.67	0.72	0.95	0.48
55-59	5.55	2.88	2.67	3.75	2.31	1.43	0.67	0.80	0.54	3.75	2.61	1.13	0.68	0.91	0.42
60-64	4.62	2.39	2.22	2.81	1.78	1.03	0.61	0.74	0.46	3.02	2.21	0.81	0.65	0.92	0.36
65-69	4.18	2.11	2.06	2.30	1.43	0.87	0.55	0.67	0.42	2.34	1.61	0.73	0.56	0.76	0.35
70-74	3.62	1.79	1.83	2.02	1.21	0.81	0.56	0.67	0.44	2.69	1.65	1.04	0.74	0.92	0.57
75-79	2.36	1.16	1.19	1.49	0.87	0.62	0.63	0.75	0.52	1.92	1.29	0.63	0.82	1.11	0.53
80-84	1.27	0.63	0.65	0.85	0.51	0.35	0.67	0.81	0.54	1.69	1.11	0.58	1.33	1.78	0.89
85+	0.53	0.27	0.26	0.42	0.26	0.16	0.79	0.96	0.60	0.83	0.50	0.33	1.55	1.84	1.25
<b>Total</b>	<b>100.00</b>	<b>52.40</b>	<b>47.60</b>	<b>100.00</b>	<b>60.68</b>	<b>39.32</b>	<b>1.00</b>	<b>1.16</b>	<b>0.83</b>	<b>100.00</b>	<b>74.58</b>	<b>25.42</b>	<b>1.00</b>	<b>1.42</b>	<b>0.53</b>

<sup>a</sup> Excludes drivers in collisions who are under age 16 or for whom age is not reported.<sup>b</sup> Relative involvement index is the collision involvement for the age/sex group as a percent of collision involvement for all drivers (aged 16 or older), divided by the percent of total licensed drivers represented by that group.

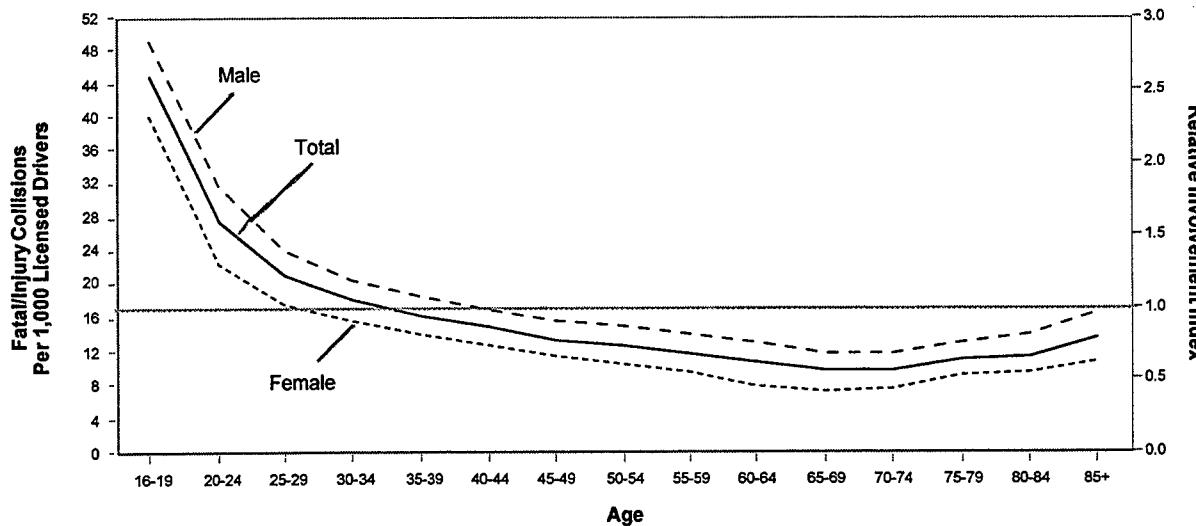
Source: License data from California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Table 9. Relative Involvement in At-Fault Fatal/Injury and Fatal Collisions by Age and Sex, California 1995**

Age	Group as % of Total Licensed Drivers			At-Fault Fatal/Injury Collisions						At-Fault Fatal Collisions					
				Group as % of Total At-Fault Drivers <sup>a</sup>			Relative Involvement Index <sup>b</sup>			Group as % of Total At-Fault Drivers <sup>a</sup>			Relative Involvement Index <sup>b</sup>		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
16	0.48	0.25	0.23	2.57	1.45	1.12	5.38	5.81	4.91	1.76	1.28	0.49	3.69	5.10	2.14
17	0.85	0.45	0.40	3.21	1.94	1.27	3.76	4.28	3.17	2.48	1.80	0.68	2.90	3.97	1.69
18	1.16	0.63	0.53	4.03	2.57	1.47	3.47	4.08	2.75	3.23	2.48	0.75	2.78	3.94	1.41
19	1.38	0.76	0.63	3.71	2.40	1.31	2.69	3.18	2.09	3.38	2.63	0.75	2.45	3.48	1.20
16-19	3.88	2.09	1.79	13.53	8.36	5.17	3.49	4.01	2.89	10.85	8.19	2.67	2.80	3.92	1.49
20-24	9.07	4.93	4.14	16.25	10.94	5.30	1.79	2.22	1.28	17.99	15.13	2.85	1.98	3.07	0.69
25-29	11.25	6.11	5.14	13.72	9.02	4.69	1.22	1.48	0.91	13.48	11.00	2.48	1.20	1.80	0.48
30-34	12.76	6.80	5.96	12.58	8.09	4.48	0.99	1.19	0.75	12.65	9.91	2.74	0.99	1.46	0.46
35-39	12.65	6.63	6.02	10.66	6.64	4.02	0.84	1.00	0.67	10.29	8.19	2.10	0.81	1.23	0.35
40-44	11.26	5.83	5.43	8.32	5.13	3.19	0.74	0.88	0.59	7.55	5.52	2.03	0.67	0.95	0.37
45-49	9.77	5.02	4.76	6.36	3.95	2.40	0.65	0.79	0.51	6.27	4.69	1.58	0.64	0.94	0.33
50-54	7.22	3.74	3.48	4.46	2.75	1.70	0.62	0.73	0.49	4.28	2.82	1.46	0.59	0.75	0.42
55-59	5.55	2.88	2.67	3.17	1.97	1.20	0.57	0.68	0.45	3.08	2.10	0.98	0.55	0.73	0.37
60-64	4.62	2.39	2.22	2.53	1.56	0.97	0.55	0.65	0.43	2.59	1.73	0.86	0.56	0.72	0.39
65-69	4.18	2.11	2.06	2.29	1.39	0.91	0.55	0.66	0.44	2.18	1.39	0.79	0.52	0.66	0.38
70-74	3.62	1.79	1.83	2.28	1.31	0.97	0.63	0.73	0.53	2.67	1.43	1.24	0.74	0.80	0.68
75-79	2.36	1.16	1.19	1.92	1.07	0.85	0.82	0.92	0.71	2.48	1.54	0.94	1.05	1.33	0.79
80-84	1.27	0.63	0.65	1.27	0.73	0.54	1.00	1.17	0.83	2.48	1.61	0.86	1.95	2.58	1.34
85+	0.53	0.27	0.26	0.65	0.40	0.25	1.23	1.49	0.95	1.16	0.68	0.49	2.19	2.49	1.87
<b>Total</b>	100.00	52.40	47.60	100.00	63.34	36.66	1.00	1.21	0.77	100.00	75.93	24.07	1.00	1.45	0.51

<sup>a</sup> Excludes drivers in collisions who are under age 16 or for whom age is not reported.<sup>b</sup> Relative involvement index is the at-fault collision involvement for the age/sex group as a percent of at-fault collision involvement for all drivers (aged 16 or older), divided by the percent of total licensed drivers represented by that group.Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA. Collision data from California Highway Patrol, *1995 Statewide Integrated Traffic Records System*, Sacramento, CA.

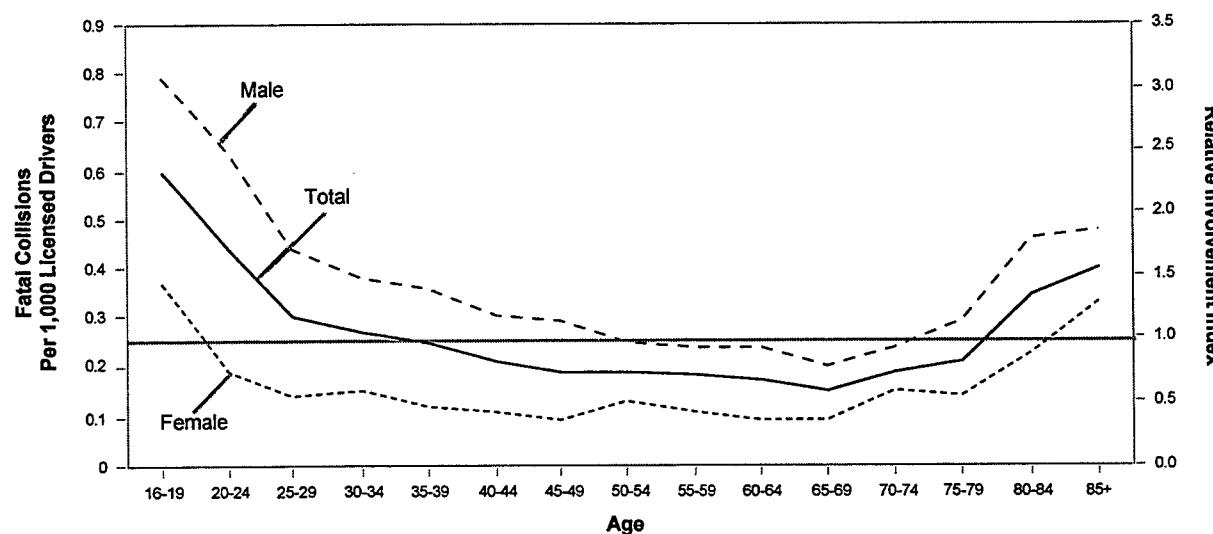
**Figure 9. Fatal/Injury Collisions Per 1,000 Licensed Drivers and Relative Involvement Index by Age and Sex, California 1995**



Note: Relative involvement index is the collision involvement for the age/sex group as a percent of collision involvement for all drivers, divided by the percent of total licensed drivers represented by that group.

Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA. Collision data from California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

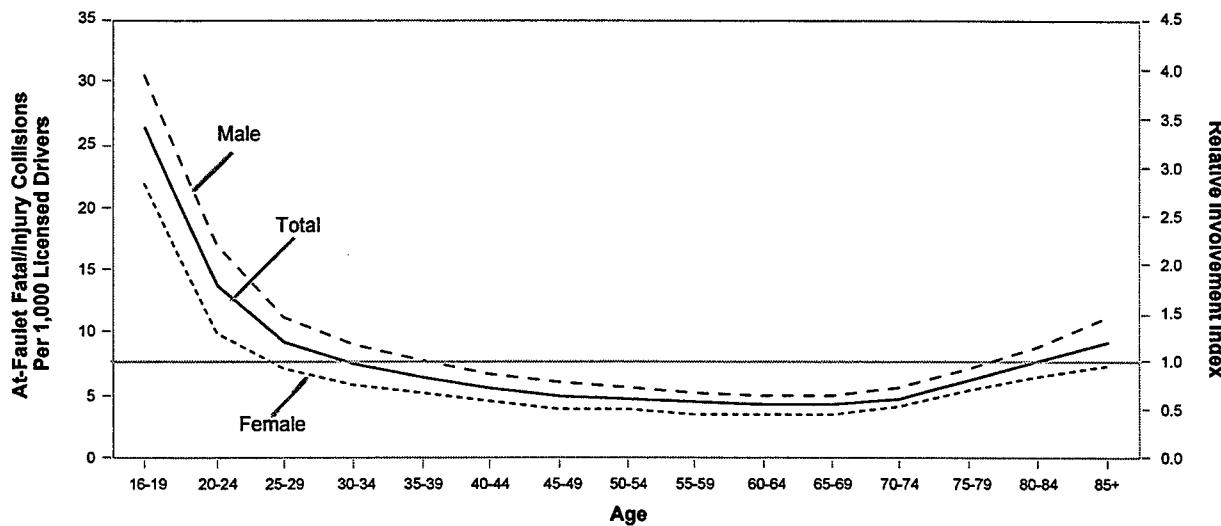
**Figure 10. Fatal Collisions Per 1,000 Licensed Drivers and Relative Involvement Index by Age and Sex, California 1995**



Note: Relative involvement index is the collision involvement for the age/sex group as a percent of collision involvement for all drivers, divided by the percent of total licensed drivers represented by that group.

Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA. Collision data from California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

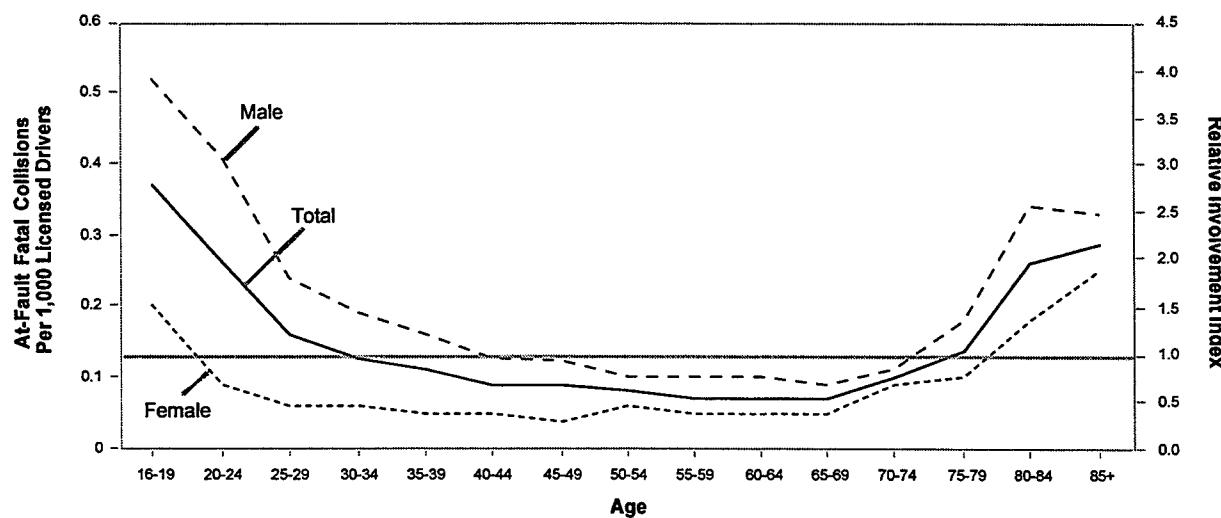
**Figure 11. At-Fault Fatal/Injury Collisions Per 1,000 Licensed Drivers and Relative Involvement Index by Age and Sex, California 1995**



Note: Relative involvement index is the at-fault collision involvement for the age/sex group as a percent of at-fault collision involvement for all drivers, divided by the percent of total licensed drivers represented by that group.

Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA. Collision data from California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Figure 12. At-Fault Fatal Collisions Per 1,000 Licensed Drivers and Relative Involvement Index by Age and Sex, California 1995**



Note: Relative involvement index is the at-fault collision involvement for the age/sex group as a percent of at-fault collision involvement for all drivers, divided by the percent of total licensed drivers represented by that group.

Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA. Collision data from California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

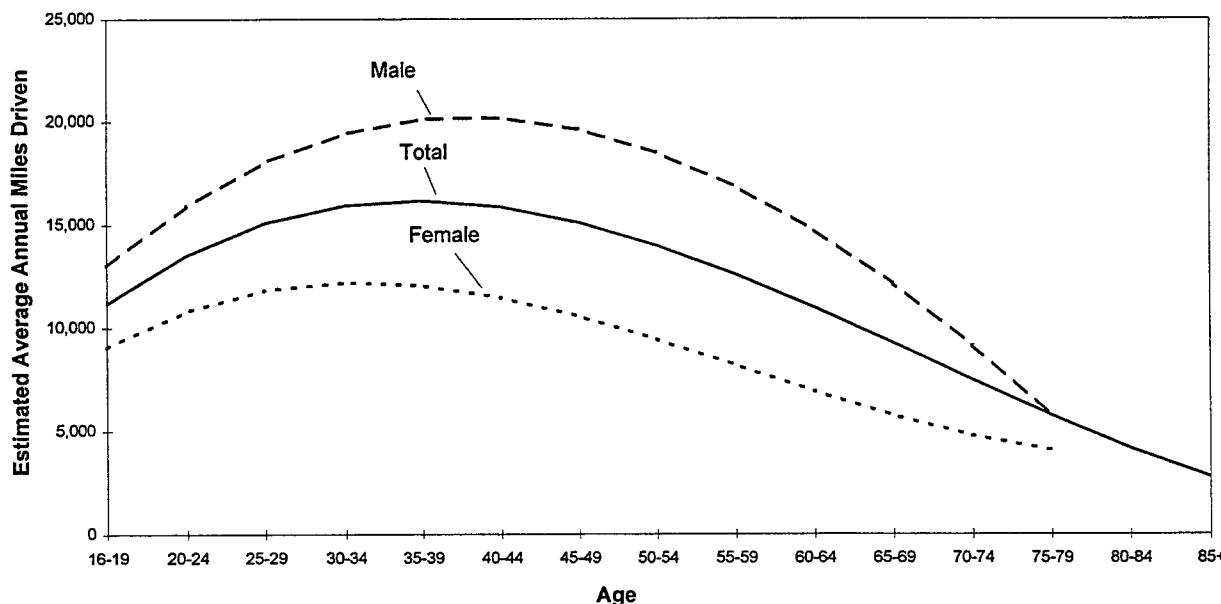
**Table 10. Estimated Average Annual Miles Driven by Age and Sex, California 1990**

Age	Average Annual Miles		
	Total	Male	Female
16-19	11,183	13,029	9,072
20-24	13,530	15,916	10,821
25-29	15,089	18,035	11,831
30-34	15,945	19,427	12,208
35-39	16,181	20,131	12,053
40-44	15,880	20,187	11,471
45-49	15,126	19,635	10,563
50-54	14,002	18,514	9,433
55-59	12,592	16,864	8,185
60-64	10,979	14,724	6,920
65-69	9,248	12,134	5,743
70-74	7,480	9,135	4,755
75-79 <sup>a</sup>	5,760	5,764	4,062
80-84	4,171	—	—
85+	2,797	—	—
<b>Total</b>	<b>11,331</b>	<b>15,653</b>	<b>9,009</b>

<sup>a</sup> For the separate male and female categories, the 75-79 age group represents drivers aged 75 or older.

Source: Mileage estimates derived from a smoothing technique applied by Gebers, Romanowicz and McKenzie (1993) to California data from the 1990 *Nationwide Personal Transportation Survey*, Federal Highway Administration, Washington, DC.

**Figure 13. Estimated Average Annual Miles Driven by Age and Sex, California 1990**



Note: For the separate male and female categories, the 75-79 age group represents drivers aged 75 or older.

Source: Mileage estimates derived from a smoothing technique applied by Gebers, Romanowicz and McKenzie (1993) to California data from the 1990 *Nationwide Personal Transportation Survey*, Federal Highway Administration, Washington, DC.

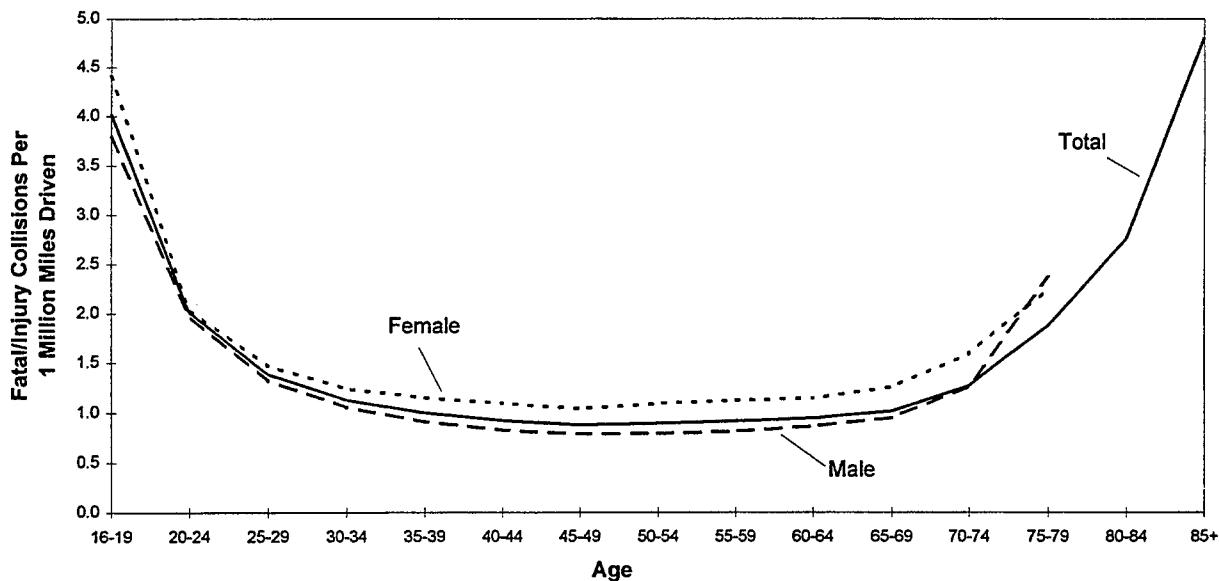
**Table 11. Total and At-Fault Fatal/Injury and Fatal Collisions Per 1 Million Miles Driven by Age and Sex, California 1995**

Age	Total Collisions						At-Fault Collisions					
	Fatal/Injury			Fatal			Fatal/Injury			Fatal		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
16-19	4.03	3.79	4.41	0.05	0.06	0.04	2.37	2.34	2.42	0.03	0.04	0.02
20-24	2.02	1.98	2.05	0.03	0.04	0.02	1.01	1.06	0.90	0.02	0.03	0.01
25-29	1.39	1.33	1.47	0.02	0.02	0.01	0.61	0.62	0.59	0.01	0.01	0.01
30-34	1.13	1.06	1.24	0.02	0.02	0.01	0.47	0.47	0.47	0.01	0.01	0.01
35-39	1.00	0.91	1.15	0.02	0.02	0.01	0.40	0.38	0.42	0.01	0.01	0.00
40-44	0.93	0.83	1.10	0.01	0.01	0.01	0.35	0.33	0.39	0.01	0.01	0.00
45-49	0.88	0.79	1.04	0.01	0.01	0.01	0.33	0.31	0.36	0.01	0.01	0.00
50-54	0.89	0.79	1.09	0.01	0.01	0.01	0.33	0.30	0.39	0.01	0.01	0.01
55-59	0.92	0.81	1.12	0.01	0.01	0.01	0.35	0.31	0.42	0.01	0.01	0.01
60-64	0.95	0.86	1.14	0.02	0.02	0.01	0.38	0.34	0.48	0.01	0.01	0.01
65-69	1.02	0.95	1.26	0.02	0.02	0.02	0.45	0.41	0.58	0.01	0.01	0.01
70-74	1.27	1.26	1.59	0.03	0.03	0.03	0.64	0.61	0.85	0.01	0.01	0.02
75-79 <sup>a</sup>	1.88	2.36	2.25	0.04	0.06	0.05	1.08	1.42	1.46	0.02	0.04	0.04
80-84	2.76	—	—	0.08	—	—	1.82	—	—	0.06	—	—
85+	4.81	—	—	0.14	—	—	3.33	—	—	0.10	—	—
<b>Total<sup>b</sup></b>	<b>1.51</b>	<b>1.27</b>	<b>1.57</b>	<b>0.02</b>	<b>0.02</b>	<b>0.02</b>	<b>0.67</b>	<b>0.59</b>	<b>0.65</b>	<b>0.01</b>	<b>0.01</b>	<b>0.01</b>

<sup>a</sup> For the separate male and female categories, the 75-79 age group represents drivers aged 75 or older.

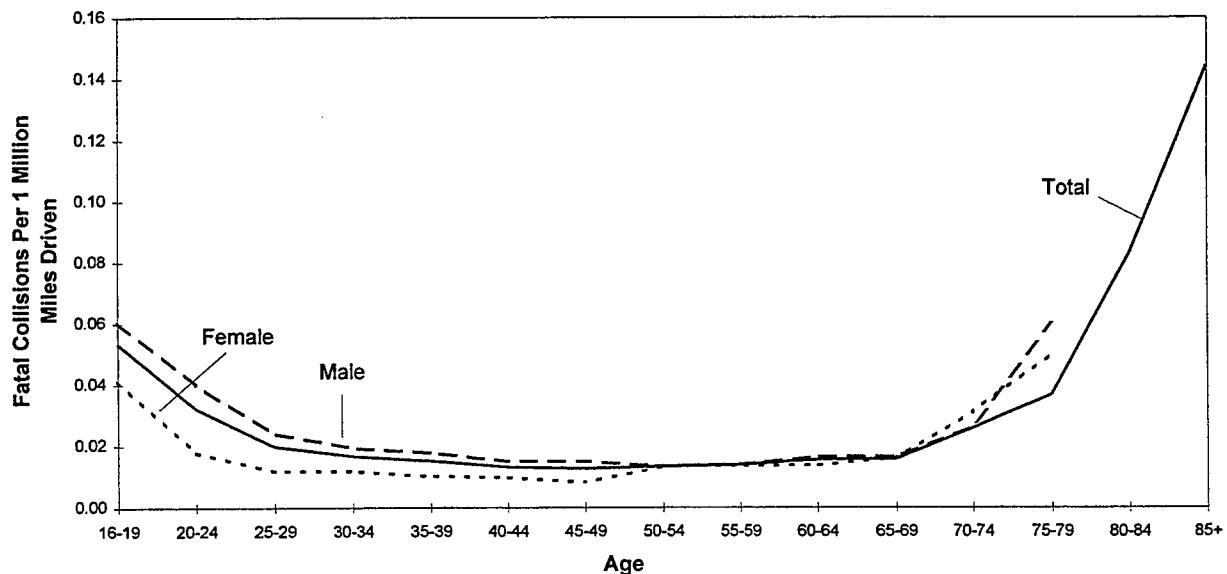
<sup>b</sup> Excludes drivers in collisions who are under age 16 or for whom age is not reported.

Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA. Collision data from California Highway Patrol, *1995 Statewide Integrated Traffic Records System*, Sacramento, CA. Mileage estimates derived from a smoothing technique applied by Gebers, Romanowicz and McKenzie (1993) to California data from the *1990 Nationwide Personal Transportation Survey*, Federal Highway Administration, Washington, DC.

**Figure 14. Fatal/Injury Collisions Per 1 Million Miles Driven by Age and Sex, California 1995**

Note: For the separate male and female categories, the 75-79 age group represents drivers aged 75 or older.

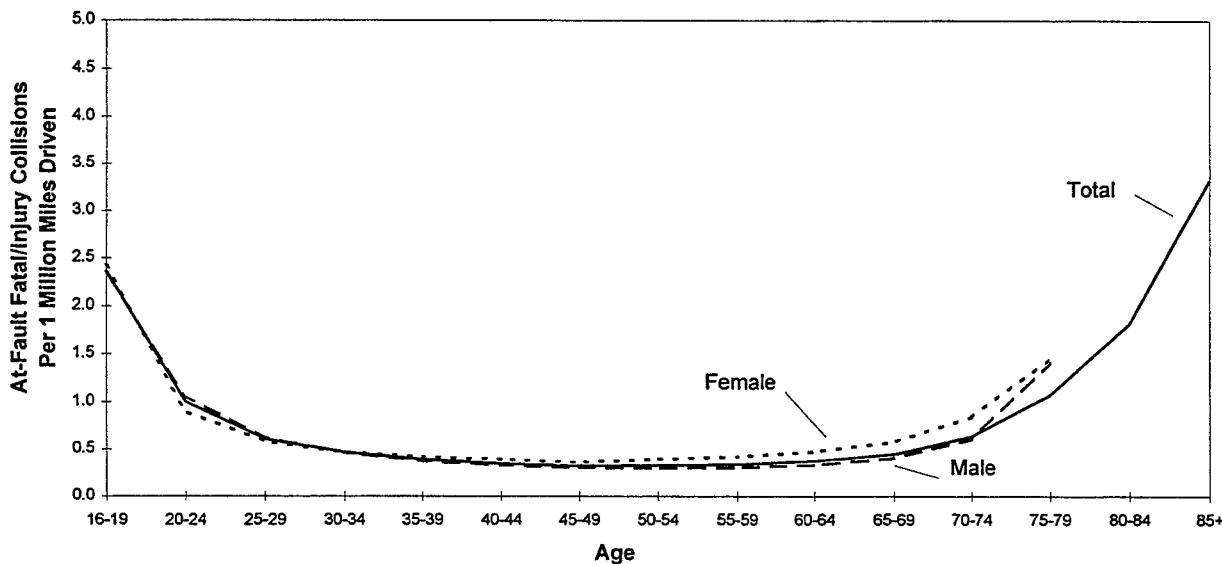
Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA. Collision data from California Highway Patrol, *1995 Statewide Integrated Traffic Records System*, Sacramento, CA. Mileage estimates derived from a smoothing technique applied by Gebers, Romanowicz and McKenzie (1993) to California data from the *1990 Nationwide Personal Transportation Survey*, Federal Highway Administration, Washington, DC.

**Figure 15. Fatal Collisions Per 1 Million Miles Driven by Age and Sex, California 1995**

Note: For the separate male and female categories, the 75-79 age group represents drivers aged 75 or older.

Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA. Collision data from California Highway Patrol, *1995 Statewide Integrated Traffic Records System*, Sacramento, CA. Mileage estimates derived from a smoothing technique applied by Gebers, Romanowicz and McKenzie (1993) to California data from the *1990 Nationwide Personal Transportation Survey*, Federal Highway Administration, Washington, DC.

**Figure 16. At-Fault Fatal/Injury Collisions Per 1 Million Miles Driven by Age and Sex, California 1995**

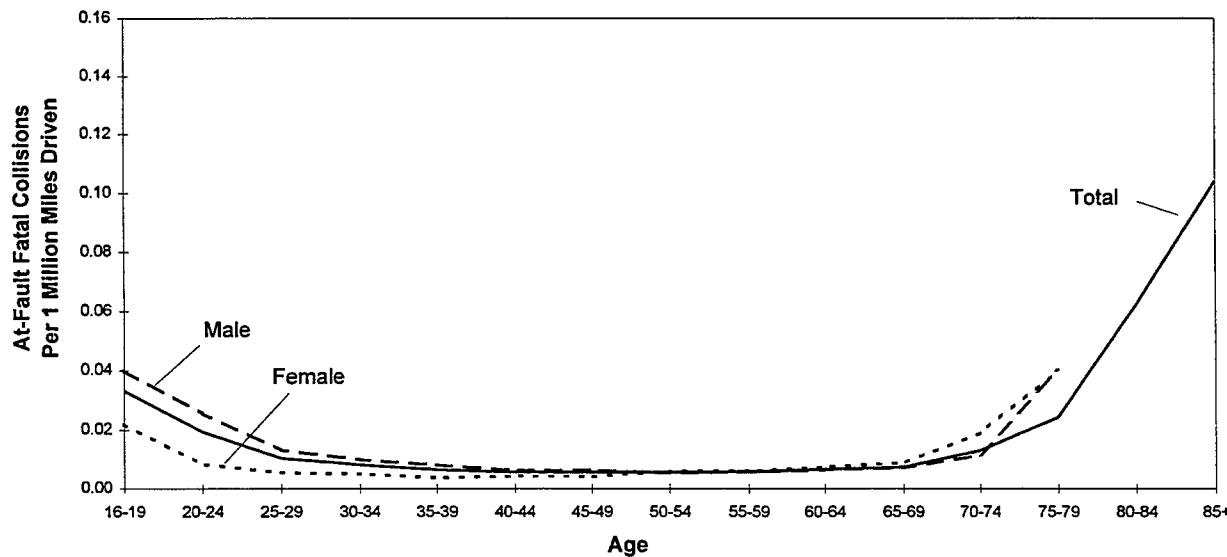


Note: For the separate male and female categories, the 75-79 age group represents drivers aged 75 or older.

Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA.

Collision data from California Highway Patrol, *1995 Statewide Integrated Traffic Records System*, Sacramento, CA. Mileage estimates derived from a smoothing technique applied by Gebers, Romanowicz and McKenzie (1993) to California data from the *1990 Nationwide Personal Transportation Survey*, Federal Highway Administration, Washington, DC.

**Figure 17. At-Fault Fatal Collisions Per 1 Million Miles Driven by Age and Sex, California 1995**



Note: For the separate male and female categories, the 75-79 age group represents drivers aged 75 or older.

Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA.

Collision data from California Highway Patrol, *1995 Statewide Integrated Traffic Records System*, Sacramento, CA. Mileage estimates derived from a smoothing technique applied by Gebers, Romanowicz and McKenzie (1993) to California data from the *1990 Nationwide Personal Transportation Survey*, Federal Highway Administration, Washington, DC.

## Alcohol and Driving

### Had-Been-Drinking (HBD) Casualty Collisions

#### Percentage of Casualty Collisions Involving Alcohol

Of drivers aged 16 or older in fatal/injury collisions, 22,063, or 6.4%, were considered by the investigating officer to have consumed some alcohol prior to their collision (Table 12). As expected, an even larger percentage of drivers at fault in casualty collisions were identified as had-been-drinking (HBD): of drivers aged 16 or older who are at fault, 12.8%, or 19,428, were identified as HBD (Table 13).

The role of alcohol is even more prevalent among drivers in fatal collisions: 1,010, or 19.4%, of drivers aged at least 16 who are in fatal collisions were identified as HBD (Table 12). Of drivers at fault in fatal collisions, the percentage jumps to 33.1%, or 880 drivers aged 16 or older (Table 13).

In interpreting these HBD collision rates, it is important to keep in mind that most casualty collisions do not result in chemical testing of drivers for the presence of alcohol. As a result, these data considerably underestimate the prevalence of alcohol in collisions, particularly for drivers with low blood alcohol levels.

#### Per Driver Rates of HBD Collisions

Of every 10,000 licensed drivers, 11.03 had been drinking in fatal/injury collisions, and 0.50 had been drinking in fatal collisions (Table 12). Close to 10 (9.71) in every 10,000 licensed drivers had been drinking and were at fault in fatal/injury collisions; 0.44 had been drinking and were at fault in fatal crashes (Table 13).

#### Sex Differences

Significantly larger shares of male drivers than female drivers involved or at fault in fatal/injury or fatal collisions were considered to have consumed alcohol. However, for both males and females, the percentages who had been drinking are substantially greater among drivers in fatal collisions than in total casualty collisions, and among those at fault than among all collision-involved drivers (Tables 12 and 13). In fatal/injury collisions, 8.7% of male drivers aged 16 or older were identified as HBD, compared to 2.9% of females; of drivers at fault in these collisions, the percentages climb to 16.6% for males and 6.1% for females. In fatal collisions, 22.2% of male drivers aged 16 or older were identified as HBD, compared to 11.3% of females; of those at fault, 37.4% of males had been drinking versus 19.3% of females.

Males demonstrate significantly higher per driver rates and indices of involvement and culpability in HBD collisions than females, regardless of age or crash severity. However, some caution should be used in evaluating the data on HBD drivers in fatal collisions for the youngest and oldest age groups, particularly for females, since these numbers fluctuate significantly from year to year. (Figures 18 and 19 plot, on separate ordinates, the per driver rate and relative involvement index in HBD fatal/injury collisions and HBD fatal collisions, respectively. The per driver rate and involvement index in HBD at-fault fatal/injury collisions and HBD at-fault fatal collisions are plotted in Figures 20 and 21, respectively.)

After adjusting for differences in their numbers within the licensed driver population, males are more than four times as likely as females to be involved or at fault in HBD fatal/injury collisions; the sex disparity is even stronger for HBD fatal collisions, where the risk of involvement and fault for males is more than five times greater than for females (see the sex-specific per driver rates and indices in Tables 12-15).

Overall, for every 10,000 male licensed drivers, 17.28 are involved, and 15.29 are at fault, in HBD fatal/injury collisions. The corresponding figures for females are 4.15 and 3.58, respectively. Rates of involvement and fault in HBD fatal collisions are, respectively, 0.82 and 0.72 per 10,000 male licensed drivers and 0.16 and 0.13 per 10,000 female licensed drivers (Tables 12 and 13).

#### **Age Differences**

While high among teens, per driver rates and indices of involvement and fault in HBD fatal/injury and HBD fatal collisions peak among drivers aged 20-24, then decline rapidly as driver age increases (Tables 12-15). In the case of total HBD casualty collisions, the decline is rapid and consistent until age 85, when there is an upturn. For HBD fatal collisions, some minor fluctuations in the rates and indices are evidenced in the middle and older ages. Nevertheless, by age 80, drivers have a negligible risk of involvement or fault in HBD fatal/injury or HBD fatal collisions (Figures 18-21).

Even though drinking is illegal under age 21, teens have high per driver rates and indices of involvement and culpability in HBD fatal and HBD fatal/injury collisions (Tables 12-15). Nonetheless, only a small percentage of teens involved in casualty collisions were identified as HBD (Tables 12 and 13). Even among teens at fault in fatal/injury crashes, only 6.1% were identified as HBD.

This compares to 12.8% identified as HBD among all drivers aged 16 or older at fault in these crashes (Table 13).

## **Arrests for Driving Under the Influence (DUI) or for Hit-and-Run**

### **General Patterns**

In 1995, 200,635 Californians aged 16 or older were arrested for driving under the influence of alcohol/drugs (DUI) (Table 16). Included among those arrested are drivers involved in collisions as well as those who may be collision-free.

Some 6,559 drivers aged 16 or older were arrested for hit-and-run. To some extent, hit-and-run offenses reflect DUI behavior, since they are often committed by drivers who had used alcohol or other drugs.

### **Age Differences**

Although possession of alcohol is not legal in California until age 21, teens aged 16-19 have a greater risk of involvement in DUI arrests than the general licensed driver population and have the highest risk of any age group of being arrested for hit-and-run (Table 16, Figure 22). Their relative involvement index for hit-and-run arrests is 4.73, indicating that, on average, their rate of arrests for hit-and-run is 373% higher than for all drivers.

Drivers aged 20-24 are second to teens in their risk of arrest for hit-and-run. They have the highest risk of any age group of arrests for DUI.

Beginning at age 25, the risk of arrest for DUI or hit-and-run declines, dropping precipitously in the older ages. Relatively few drivers arrested for these offenses are aged 60 or older. In fact, senior drivers have, on average, rates of arrests for DUI and hit-and-run about 80% lower than the rates for the general licensed driver population.

**Table 12. Had-Been-Drinking (HBD) Drivers in Fatal/Injury and Fatal Collisions, Percentage of Collision-Involved Drivers Identified as HBD, and HBD Drivers in Collisions Per 10,000 Licensed Drivers by Age and Sex, California 1995**

Age	Number of HBD Drivers in Collisions			% of Collision-involved Drivers Identified as HBD			HBD Drivers in Collisions Per 10,000 Licensed Drivers		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
<b>Fatal/Injury</b>									
16	116	89	27	1.97	2.76	1.02	12.12	17.76	5.92
17	245	201	44	3.01	4.27	1.28	14.33	22.14	5.49
18	466	389	77	4.45	6.13	1.87	20.05	30.95	7.21
19	521	445	76	4.99	7.00	1.86	18.86	29.45	6.07
16-19	1,348	1,124	224	3.86	5.45	1.57	17.38	26.91	6.26
20-24	4,280	3,693	587	8.65	11.87	3.19	23.59	37.44	7.09
25-29	3,935	3,292	643	8.34	11.25	3.59	17.48	26.93	6.25
30-34	3,571	2,870	701	7.76	10.28	3.87	13.99	21.11	5.88
35-39	2,951	2,301	650	7.18	9.44	3.89	11.66	17.35	5.40
40-44	2,142	1,697	445	6.47	8.71	3.26	9.51	14.54	4.10
45-49	1,445	1,187	258	5.56	7.66	2.46	7.39	11.83	2.71
50-54	873	713	160	4.82	6.52	2.24	6.04	9.52	2.30
55-59	581	463	118	4.53	5.84	2.40	5.23	8.03	2.21
60-64	382	319	63	3.97	5.24	1.79	4.14	6.67	1.42
65-69	235	193	42	2.98	3.95	1.41	2.81	4.56	1.02
70-74	179	151	28	2.59	3.65	1.01	2.47	4.21	0.77
75-79	89	69	20	1.75	2.32	0.94	1.89	2.97	0.84
80-84	30	24	6	1.02	1.38	0.51	1.18	1.92	0.46
85+	22	16	6	1.54	1.79	1.11	2.07	2.95	1.15
<b>Total<sup>a</sup></b>	<b>22,063</b>	<b>18,112</b>	<b>3,951</b>	<b>6.44</b>	<b>8.71</b>	<b>2.93</b>	<b>11.03</b>	<b>17.28</b>	<b>4.15</b>
<b>Fatal</b>									
16	8	7	1	11.43	14.89	4.35	0.84	1.40	0.22
17	9	6	3	8.57	8.57	8.57	0.53	0.66	0.37
18	27	20	7	19.01	20.41	15.91	1.16	1.59	0.66
19	31	27	4	21.23	23.68	12.50	1.12	1.79	0.32
16-19	75	60	15	16.20	18.24	11.19	0.97	1.44	0.42
20-24	220	202	18	27.78	32.01	11.18	1.21	2.05	0.22
25-29	158	140	18	23.37	26.32	12.50	0.70	1.15	0.18
30-34	168	135	33	24.56	26.42	19.08	0.66	0.99	0.28
35-39	128	109	19	20.55	22.95	12.84	0.51	0.82	0.16
40-44	71	60	11	15.01	17.05	9.09	0.32	0.51	0.10
45-49	73	68	5	19.41	23.13	6.10	0.37	0.68	0.05
50-54	39	29	10	14.34	15.68	11.49	0.27	0.39	0.14
55-59	28	22	6	14.36	16.18	10.17	0.25	0.38	0.11
60-64	17	13	4	10.83	11.30	9.52	0.18	0.27	0.09
65-69	10	6	4	8.20	7.14	10.53	0.12	0.14	0.10
70-74	11	8	3	7.86	9.30	5.56	0.15	0.22	0.08
75-79	9	6	3	9.00	8.96	9.09	0.19	0.26	0.13
80-84	3	2	1	3.41	3.45	3.33	0.12	0.16	0.08
85+	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
<b>Total<sup>a</sup></b>	<b>1,010</b>	<b>860</b>	<b>150</b>	<b>19.41</b>	<b>22.16</b>	<b>11.34</b>	<b>0.50</b>	<b>0.82</b>	<b>0.16</b>

<sup>a</sup> Excludes drivers in collisions who are under age 16 or for whom age is not reported.

Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA. Collision data from California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Table 13. Had-Been-Drinking (HBD) Drivers At Fault in Fatal/Injury and Fatal Collisions, Percentage of At-Fault Drivers Identified as HBD, and HBD At-Fault Drivers Per 10,000 Licensed Drivers by Age and Sex, California 1995**

Age	Number of HBD Drivers At Fault in Collisions			% of At-Fault Drivers Identified as HBD			HBD At-Fault Drivers Per 10,000 Licensed Drivers		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
<b>Fatal/Injury</b>									
16	108	84	24	2.76	3.80	1.41	11.29	16.77	5.26
17	228	189	39	4.67	6.41	2.02	13.33	20.81	4.86
18	428	359	69	6.98	9.21	3.09	18.42	28.56	6.46
19	482	418	64	8.54	11.45	3.21	17.44	27.66	5.11
16-19	1,246	1,050	196	6.06	8.26	2.49	16.07	25.14	5.48
20-24	3,877	3,370	507	15.70	20.27	6.29	21.37	34.17	6.12
25-29	3,485	2,931	554	16.72	21.37	7.77	15.48	23.98	5.39
30-34	3,138	2,521	617	16.42	20.49	9.05	12.30	18.55	5.17
35-39	2,563	2,002	561	15.82	19.85	9.17	10.13	15.09	4.66
40-44	1,845	1,460	385	14.59	18.74	7.93	8.19	12.51	3.55
45-49	1,248	1,021	227	12.92	16.99	6.22	6.39	10.18	2.39
50-54	725	603	122	10.71	14.42	4.71	5.02	8.05	1.75
55-59	500	396	104	10.36	13.23	5.68	4.50	6.87	1.95
60-64	315	264	51	8.19	11.10	3.47	3.41	5.52	1.15
65-69	208	172	36	5.97	8.17	2.61	2.49	4.07	0.87
70-74	156	133	23	4.50	6.66	1.56	2.15	3.71	0.63
75-79	77	61	16	2.63	3.74	1.24	1.63	2.63	0.67
80-84	26	22	4	1.35	1.97	0.49	1.02	1.76	0.31
85+	19	14	5	1.92	2.28	1.33	1.78	2.58	0.96
<b>Total<sup>a</sup></b>	<b>19,428</b>	<b>16,020</b>	<b>3,408</b>	<b>12.78</b>	<b>16.64</b>	<b>6.12</b>	<b>9.71</b>	<b>15.29</b>	<b>3.58</b>
<b>Fatal</b>									
16	7	6	1	14.89	17.65	7.69	0.73	1.20	0.22
17	8	5	3	12.12	10.42	16.67	0.47	0.55	0.37
18	22	18	4	25.58	27.27	20.00	0.95	1.43	0.37
19	28	24	4	31.11	34.29	20.00	1.01	1.59	0.32
16-19	65	53	12	22.49	24.31	16.90	0.84	1.27	0.34
20-24	197	183	14	41.13	45.41	18.42	1.09	1.86	0.17
25-29	136	120	16	37.88	40.96	24.24	0.60	0.98	0.16
30-34	150	124	26	44.51	46.97	35.62	0.59	0.91	0.22
35-39	109	93	16	39.78	42.66	28.57	0.43	0.70	0.13
40-44	62	52	10	30.85	35.37	18.52	0.28	0.45	0.09
45-49	61	56	5	36.53	44.80	11.90	0.31	0.56	0.05
50-54	36	27	9	31.58	36.00	23.08	0.25	0.36	0.13
55-59	25	19	6	30.49	33.93	23.08	0.23	0.33	0.11
60-64	14	11	3	20.29	23.91	13.04	0.15	0.23	0.07
65-69	8	5	3	13.79	13.51	14.29	0.10	0.12	0.07
70-74	9	6	3	12.68	15.79	9.09	0.12	0.17	0.08
75-79	6	5	1	9.09	12.20	4.00	0.13	0.22	0.04
80-84	2	2	0	3.03	4.65	0.00	0.08	0.16	0.00
85+	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
<b>Total<sup>a</sup></b>	<b>880</b>	<b>756</b>	<b>124</b>	<b>33.05</b>	<b>37.39</b>	<b>19.34</b>	<b>0.44</b>	<b>0.72</b>	<b>0.13</b>

<sup>a</sup>Excludes drivers in collisions who are under age 16 or for whom age is not reported.

Source: License data from California Department of Motor Vehicles, Age and Sex Report (July 1, 1995), Sacramento, CA. Collision data from California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Table 14. Relative Involvement in Had-Been-Drinking (HBD) Fatal/Injury and Fatal Collisions by Age and Sex, California 1995**

Age	Group as % of Total Licensed Drivers			HBD Fatal/Injury Collisions						HBD Fatal Collisions					
				Group as % of Total Involved Drivers <sup>a</sup>			Relative Involvement Index <sup>b</sup>			Group as % of Total Involved Drivers <sup>a</sup>			Relative Involvement Index <sup>b</sup>		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
16	0.48	0.25	0.23	0.53	0.40	0.12	1.10	1.61	0.54	0.79	0.69	0.10	1.66	2.77	0.43
17	0.85	0.45	0.40	1.11	0.91	0.20	1.30	2.01	0.50	0.89	0.59	0.30	1.04	1.31	0.74
18	1.16	0.63	0.53	2.11	1.76	0.35	1.82	2.81	0.65	2.67	1.98	0.69	2.30	3.15	1.30
19	1.38	0.76	0.63	2.36	2.02	0.34	1.71	2.67	0.55	3.07	2.67	0.40	2.22	3.54	0.63
16-19	3.88	2.09	1.79	6.11	5.09	1.02	1.58	2.44	0.57	7.43	5.94	1.49	1.92	2.84	0.83
20-24	9.07	4.93	4.14	19.40	16.74	2.66	2.14	3.39	0.64	21.78	20.00	1.78	2.40	4.06	0.43
25-29	11.25	6.11	5.14	17.84	14.92	2.91	1.58	2.44	0.57	15.64	13.86	1.78	1.39	2.27	0.35
30-34	12.76	6.80	5.96	16.19	13.01	3.18	1.27	1.91	0.53	16.63	13.37	3.27	1.30	1.97	0.55
35-39	12.65	6.63	6.02	13.38	10.43	2.95	1.06	1.57	0.49	12.67	10.79	1.88	1.00	1.63	0.31
40-44	11.26	5.83	5.43	9.71	7.69	2.02	0.86	1.32	0.37	7.03	5.94	1.09	0.62	1.02	0.20
45-49	9.77	5.02	4.76	6.55	5.38	1.17	0.67	1.07	0.25	7.23	6.73	0.50	0.74	1.34	0.10
50-54	7.22	3.74	3.48	3.96	3.23	0.73	0.55	0.86	0.21	3.86	2.87	0.99	0.53	0.77	0.28
55-59	5.55	2.88	2.67	2.63	2.10	0.53	0.47	0.73	0.20	2.77	2.18	0.59	0.50	0.76	0.22
60-64	4.62	2.39	2.22	1.73	1.45	0.29	0.38	0.60	0.13	1.68	1.29	0.40	0.36	0.54	0.18
65-69	4.18	2.11	2.06	1.07	0.87	0.19	0.25	0.41	0.09	0.99	0.59	0.40	0.24	0.28	0.19
70-74	3.62	1.79	1.83	0.81	0.68	0.13	0.22	0.38	0.07	1.09	0.79	0.30	0.30	0.44	0.16
75-79	2.36	1.16	1.19	0.40	0.31	0.09	0.17	0.27	0.08	0.89	0.59	0.30	0.38	0.51	0.25
80-84	1.27	0.63	0.65	0.14	0.11	0.03	0.11	0.17	0.04	0.30	0.20	0.10	0.23	0.32	0.15
85+	0.53	0.27	0.26	0.10	0.07	0.03	0.19	0.27	0.10	0.00	0.00	0.00	0.00	0.00	0.00
<b>Total</b>	100.00	52.40	47.60	100.00	82.09	17.91	1.00	1.57	0.38	100.00	85.15	14.85	1.00	1.63	0.31

<sup>a</sup>Excludes drivers in collisions who are under age 16 or for whom age is not reported.

<sup>b</sup>Relative involvement index is the HBD collision involvement for the age/sex group as a percent of HBD collision involvement for all drivers (aged 16 or older), divided by the percent of total licensed drivers represented by that group.

Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA.  
Collision data from California Highway Patrol, *1995 Statewide Integrated Traffic Records System*, Sacramento, CA.

**Table 15. Relative Involvement in Had-Been-Drinking (HBD) At-Fault Fatal/Injury and Fatal Collisions by Age and Sex, California 1995**

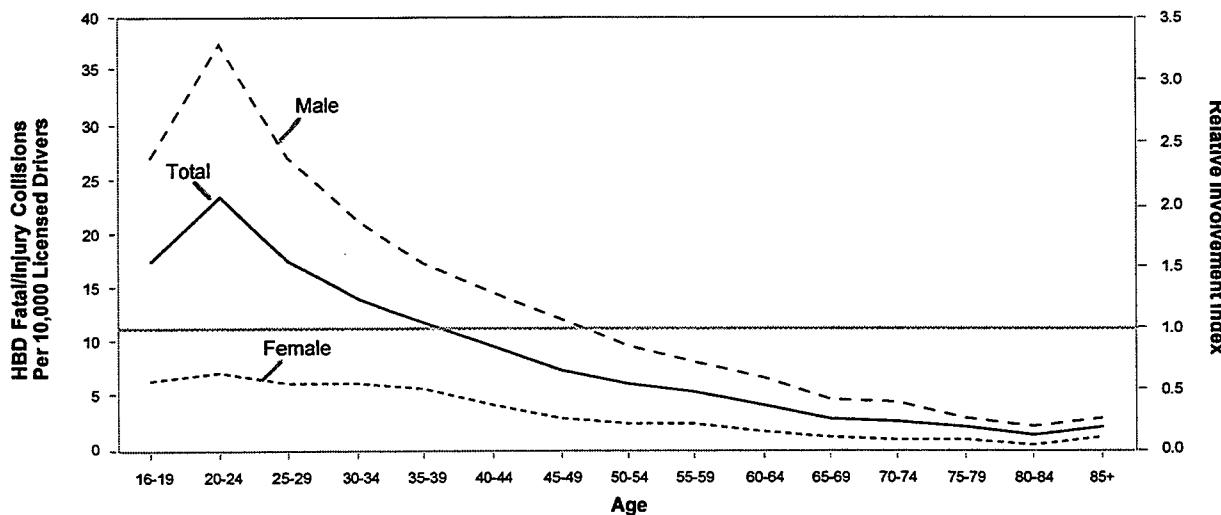
Age	Group as % of Total Licensed Drivers			HBD At-Fault Fatal/Injury Collisions						HBD At-Fault Fatal Collisions					
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
16	0.48	0.25	0.23	0.56	0.43	0.12	1.16	1.73	0.54	0.80	0.68	0.11	1.66	2.72	0.50
17	0.85	0.45	0.40	1.17	0.97	0.20	1.37	2.14	0.50	0.91	0.57	0.34	1.06	1.25	0.85
18	1.16	0.63	0.53	2.20	1.85	0.36	1.90	2.94	0.67	2.50	2.05	0.45	2.15	3.25	0.85
19	1.38	0.76	0.63	2.48	2.15	0.33	1.80	2.85	0.53	3.18	2.73	0.45	2.30	3.61	0.73
16-19	3.88	2.09	1.79	6.41	5.40	1.01	1.65	2.59	0.56	7.39	6.02	1.36	1.90	2.88	0.76
20-24	9.07	4.93	4.14	19.96	17.35	2.61	2.20	3.52	0.63	22.39	20.80	1.59	2.47	4.22	0.38
25-29	11.25	6.11	5.14	17.94	15.09	2.85	1.59	2.47	0.55	15.45	13.64	1.82	1.37	2.23	0.35
30-34	12.76	6.80	5.96	16.15	12.98	3.18	1.27	1.91	0.53	17.05	14.09	2.95	1.34	2.07	0.50
35-39	12.65	6.63	6.02	13.19	10.30	2.89	1.04	1.55	0.48	12.39	10.57	1.82	0.98	1.59	0.30
40-44	11.26	5.83	5.43	9.50	7.51	1.98	0.84	1.29	0.37	7.05	5.91	1.14	0.63	1.01	0.21
45-49	9.77	5.02	4.76	6.42	5.26	1.17	0.66	1.05	0.25	6.93	6.36	0.57	0.71	1.27	0.12
50-54	7.22	3.74	3.48	3.73	3.10	0.63	0.52	0.83	0.18	4.09	3.07	1.02	0.57	0.82	0.29
55-59	5.55	2.88	2.67	2.57	2.04	0.54	0.46	0.71	0.20	2.84	2.16	0.68	0.51	0.75	0.26
60-64	4.62	2.39	2.22	1.62	1.36	0.26	0.35	0.57	0.12	1.59	1.25	0.34	0.34	0.52	0.15
65-69	4.18	2.11	2.06	1.07	0.89	0.19	0.26	0.42	0.09	0.91	0.57	0.34	0.22	0.27	0.17
70-74	3.62	1.79	1.83	0.80	0.68	0.12	0.22	0.38	0.06	1.02	0.68	0.34	0.28	0.38	0.19
75-79	2.36	1.16	1.19	0.40	0.31	0.08	0.17	0.27	0.07	0.68	0.57	0.11	0.29	0.49	0.10
80-84	1.27	0.63	0.65	0.13	0.11	0.02	0.11	0.18	0.03	0.23	0.23	0.00	0.18	0.36	0.00
85+	0.53	0.27	0.26	0.10	0.07	0.03	0.18	0.27	0.10	0.00	0.00	0.00	0.00	0.00	0.00
<b>Total</b>	<b>100.00</b>	<b>52.40</b>	<b>47.60</b>	<b>100.00</b>	<b>82.46</b>	<b>17.54</b>	<b>1.00</b>	<b>1.57</b>	<b>0.37</b>	<b>100.00</b>	<b>85.91</b>	<b>14.09</b>	<b>1.00</b>	<b>1.64</b>	<b>0.30</b>

<sup>a</sup> Excludes drivers in collisions who are under age 16 or for whom age is not reported.

<sup>b</sup> Relative involvement index is the HBD at-fault collision involvement for the age/sex group as a percent of HBD at-fault collision involvement for all drivers (aged 16 or older), divided by the percent of total licensed drivers represented by that group.

Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA. Collision data from California Highway Patrol, *1995 Statewide Integrated Traffic Records System*, Sacramento, CA.

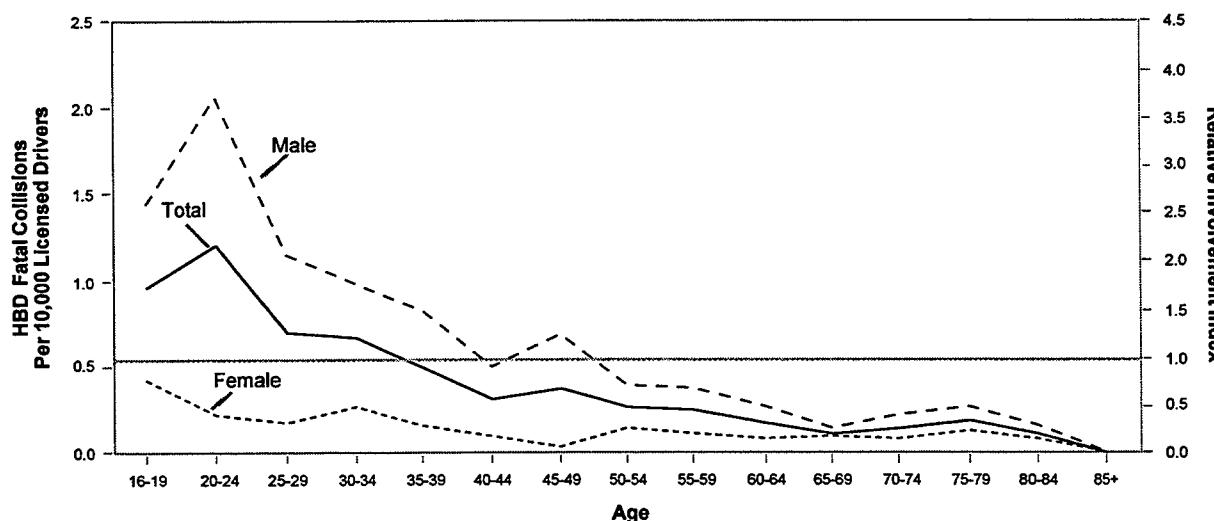
**Figure 18. Had-Been-Drinking (HBD) Fatal/Injury Collisions Per 10,000 Licensed Drivers and Relative Involvement Index by Age and Sex, California 1995**



Note: Relative involvement index is the HBD collision involvement for the age/sex group as a percent of HBD collision involvement for all drivers, divided by the percent of total licensed drivers represented by that group.

Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA. Collision data from California Highway Patrol, *1995 Statewide Integrated Traffic Records System*, Sacramento, CA.

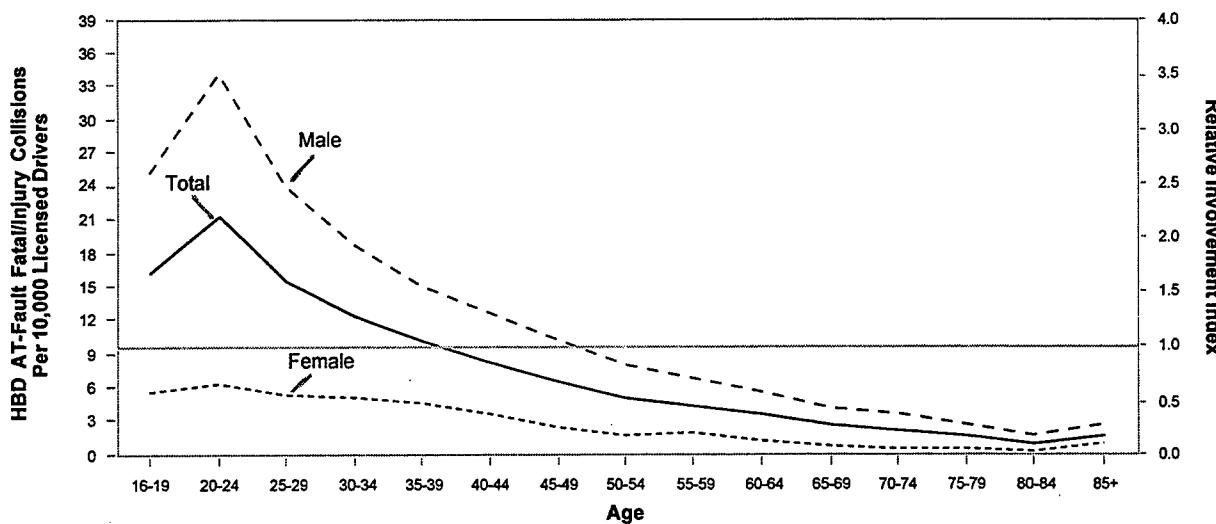
**Figure 19. Had-Been-Drinking (HBD) Fatal Collisions Per 10,000 Licensed Drivers and Relative Involvement Index by Age and Sex, California 1995**



Note: Relative involvement index is the HBD collision involvement for the age/sex group as a percent of HBD collision involvement for all drivers, divided by the percent of total licensed drivers represented by that group.

Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA. Collision data from California Highway Patrol, *1995 Statewide Integrated Traffic Records System*, Sacramento, CA.

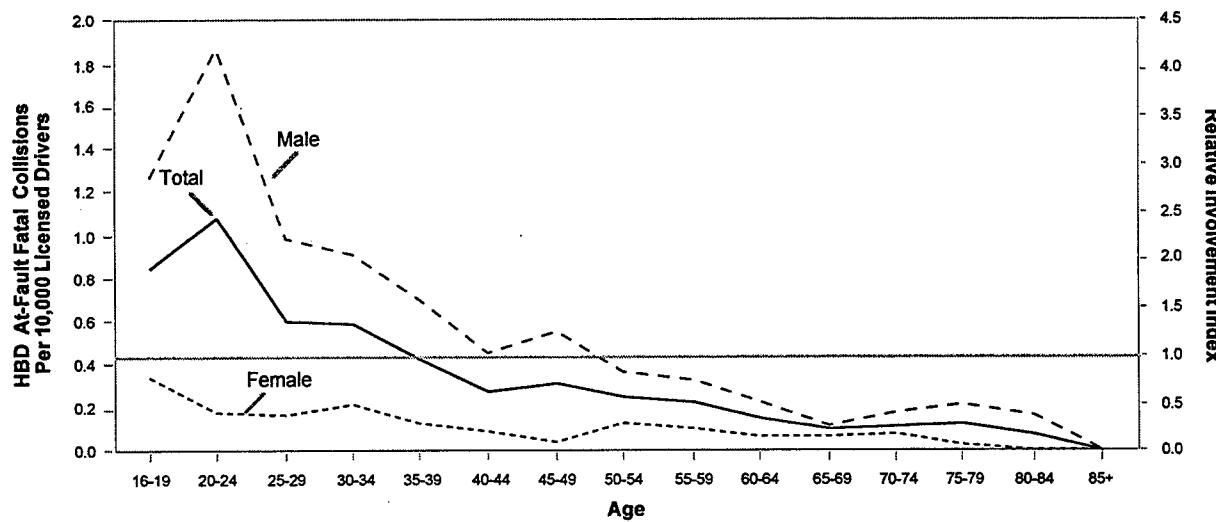
**Figure 20. Had-Been-Drinking (HBD) At-Fault Fatal/Injury Collisions Per 10,000 Licensed Drivers and Relative Involvement Index by Age and Sex, California 1995**



Note: Relative involvement index is the HBD at-fault collision involvement for the age/sex group as a percent of HBD at-fault collision involvement for all drivers, divided by the percent of total licensed drivers represented by that group.

Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA. Collision data from California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Figure 21. Had-Been-Drinking (HBD) At-Fault Fatal Collisions Per 10,000 Licensed Drivers and Relative Involvement Index by Age and Sex, California 1995**



Note: Relative involvement index is the HBD at-fault collision involvement for the age/sex group as a percent of HBD at-fault collision involvement for all drivers, divided by the percent of total licensed drivers represented by that group.

Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA. Collision data from California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

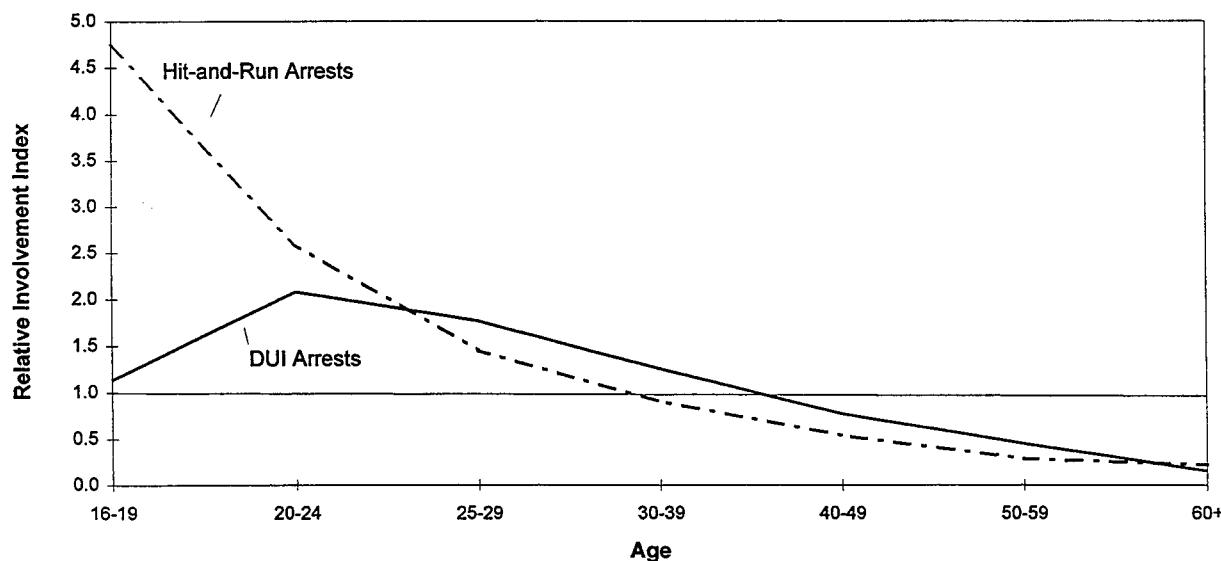
**Table 16. Relative Involvement in Arrests for Driving Under the Influence of Alcohol/Drugs (DUI) or for Hit-and-Run by Age, California 1995**

Age	% of Total Licensed Drivers	DUI Arrests			Hit-and-Run Arrests		
		Number	% of Total	Relative Involvement Index <sup>a</sup>	Number	% of Total	Relative Involvement Index <sup>a</sup>
16	0.48	457	0.23	0.47	236	3.60	7.50
17	0.86	1,083	0.54	0.63	283	4.31	5.02
18	1.16	3,087	1.54	1.33	335	5.11	4.40
19	1.38	4,235	2.11	1.53	351	5.35	3.88
16-19	3.88	8,862	4.42	1.14	1,205	18.37	4.73
20-24	9.07	37,960	18.92	2.09	1,542	23.51	2.59
25-29	11.25	39,974	19.92	1.77	1,073	16.36	1.45
30-39	25.41	64,276	32.04	1.26	1,515	23.10	0.91
40-49	21.03	32,752	16.32	0.78	746	11.37	0.54
50-59	12.77	11,610	5.79	0.45	241	3.67	0.29
60+	16.58	5,201	2.59	0.16	237	3.61	0.22
Total	100.00	200,635	100.00	1.00	6,559	100.00	1.00

<sup>a</sup> Relative involvement index is the arrest involvement for the age group as a percent of arrest involvement for all drivers (aged 16 or older), divided by the percent of total licensed drivers represented by that group.

Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA. Arrest data from California Department of Justice, *1995 Statewide Criminal Justice Profile*, Sacramento, CA.

**Figure 22. Relative Involvement in Arrests for Driving Under the Influence of Alcohol/Drugs (DUI) or for Hit-and-Run by Age, California 1995**



Note: Relative involvement index is the arrest involvement for the age group as a percent of arrest involvement for all drivers (aged 16 or older), divided by the percent of total licensed drivers represented by that group.

Source: License data from California Department of Motor Vehicles, *Age and Sex Report* (July 1, 1995), Sacramento, CA. Arrest data from California Department of Justice, *1995 Statewide Criminal Justice Profile*, Sacramento, CA.

## Primary Collision Factor

### General Patterns

Unsafe speed is the primary collision factor for drivers at fault in fatal/injury collisions, regardless of sex. Of all at-fault drivers aged 16 or older, 29.1% can attribute their crash to unsafe speed. Second most significant is violation of right-of-way, identified as the primary collision factor for 20.5% of drivers aged 16 or older who are at fault in casualty collisions (Table 17).

In contrast, alcohol/drug use is the primary cause of fatal collisions for at-fault male and female drivers. Overall, 34.7% of drivers aged 16 or older who are at fault in fatal crashes can attribute their collisions to alcohol/drugs (Table 18).

### Sex Differences

Alcohol/drug use and unsafe speed are proportionately more often implicated as the primary collision factor in fatal/injury and fatal collisions caused by male than by female drivers; by contrast, improper turns and, especially, violations of right-of-way tend to occur with relatively greater frequency among at-fault female than at-fault male drivers (Tables 17 and 18).

### Age Differences

Unsafe speed is the primary collision factor for drivers at fault in fatal/injury collisions until age 60, when it begins to be outranked by right-of-way violations (Table 17, Figure 23). It is an especially important cause of casualty collisions for teens: one-third (34.2%) of teens aged 16-19 who are at fault in fatal/injury crashes can attribute their collisions to unsafe speed.

For drivers at fault in fatal collisions, alcohol/drug use is the dominant cause until the later ages, when it is again outranked by right-of-way violations (Table 18, Figure 24). The significance of alcohol/drugs as a causal factor rises as age of driver increases until age 40, when it begins to decline, dropping rapidly after age 59.

These general patterns persist for both male and female drivers (Tables 17 and 18). That right-of-way violations increase as a causal factor in collisions for older drivers likely reflects age-related physical and cognitive changes—particularly inattention, difficulties judging space and distance, and slowed perception and response—and changes in driving exposure with advancing age. Specifically, a greater proportion of driving in the older ages occurs on city streets, where right-of-way violations are more likely to occur.

By contrast, collisions for teens typically reflect risk-taking behaviors, notably unsafe speed and alcohol/drug use.<sup>4</sup>

---

<sup>4</sup> These patterns are discussed in more detail in Section 2 of this report.

**Table 17. Percentage of Fatal/Injury Collisions by Primary Collision Factor and Age and Sex of Driver At Fault, California 1995**

Primary Collision Factor	% of Drivers At Fault in Fatal/Injury Collisions								
	Total <sup>a</sup>	16-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
<b>Total</b>									
Unsafe speed	29.11	34.18	30.52	29.38	28.25	27.05	23.62	19.51	17.85
Right-of-way	20.52	20.04	17.08	18.06	20.00	23.12	29.58	37.21	41.86
Alcohol/drugs	11.46	5.46	14.14	14.80	12.83	9.51	6.14	2.80	1.20
Signs/signals	9.72	9.09	9.49	8.92	9.20	10.60	12.74	13.20	13.00
Improper turn	9.38	12.47	9.53	8.45	8.38	8.97	8.79	8.68	8.65
Passing/lane change	4.20	3.40	4.35	4.40	4.58	4.68	4.30	3.22	2.26
Wrong side of road	3.26	4.56	3.13	3.05	3.00	2.89	2.76	3.33	3.25
Following too close	3.87	3.56	4.00	4.33	4.08	3.78	2.99	2.49	2.53
Other moving violations <sup>b</sup>	6.01	5.05	5.43	6.12	6.85	6.61	6.90	7.26	6.91
All other <sup>c</sup>	2.45	2.20	2.33	2.48	2.83	2.79	2.20	2.30	2.50
<b>Total (%)</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>
<b>n</b>	<b>151,961</b>	<b>20,567</b>	<b>45,530</b>	<b>35,318</b>	<b>22,305</b>	<b>11,594</b>	<b>7,330</b>	<b>6,393</b>	<b>2,924</b>
<b>Male</b>									
Unsafe speed	30.13	35.49	30.89	30.03	29.65	28.42	25.87	21.11	19.94
Right-of-way	17.16	16.90	14.11	14.76	16.25	19.67	26.49	35.12	38.84
Alcohol/drugs	14.90	7.50	18.20	18.48	16.56	12.43	8.41	4.19	1.56
Signs/signals	9.02	9.14	8.99	8.28	7.93	9.70	11.20	12.21	11.79
Improper turn	8.74	11.76	8.67	7.94	7.73	8.53	8.14	8.49	9.08
Passing/lane change	4.42	3.49	4.39	4.68	4.97	5.32	4.46	3.36	2.54
Wrong side of road	3.40	4.92	3.26	3.26	3.01	3.11	2.79	3.03	3.18
Following too close	3.85	3.45	3.77	4.27	4.33	3.75	3.19	2.89	2.77
Other moving violations <sup>b</sup>	5.86	5.05	5.31	5.86	6.62	6.19	7.18	7.28	7.40
All other <sup>c</sup>	2.52	2.31	2.41	2.45	2.93	2.89	2.27	2.32	2.89
<b>Total (%)</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>
<b>n</b>	<b>96,259</b>	<b>12,711</b>	<b>30,342</b>	<b>22,388</b>	<b>13,801</b>	<b>7,175</b>	<b>4,484</b>	<b>3,628</b>	<b>1,730</b>
<b>Female</b>									
Unsafe speed	27.35	32.05	29.80	28.28	25.98	24.82	20.06	17.40	14.82
Right-of-way	26.33	25.13	23.01	23.79	26.08	28.72	34.43	39.96	46.23
Alcohol/drugs	5.52	2.15	6.04	8.44	6.76	4.77	2.57	0.98	0.67
Signs/signals	10.94	9.00	10.48	10.02	11.27	12.06	15.18	14.50	14.74
Improper turn	10.47	13.61	11.24	9.33	9.43	9.69	9.80	8.93	8.04
Passing/lane change	3.82	3.26	4.27	3.93	3.95	3.64	4.04	3.04	1.84
Wrong side of road	3.01	3.96	2.86	2.69	2.98	2.53	2.71	3.73	3.35
Following too close	3.92	3.76	4.46	4.42	3.68	3.82	2.67	1.95	2.18
Other moving violations <sup>b</sup>	6.29	5.05	5.68	6.57	7.21	7.29	6.47	7.23	6.20
All other <sup>c</sup>	2.34	2.04	2.16	2.54	2.67	2.65	2.07	2.28	1.93
<b>Total (%)</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>
<b>n</b>	<b>55,702</b>	<b>7,856</b>	<b>15,188</b>	<b>12,930</b>	<b>8,504</b>	<b>4,419</b>	<b>2,846</b>	<b>2,765</b>	<b>1,194</b>

<sup>a</sup> Excludes drivers in collisions who are under age 16 or for whom age is not reported.<sup>b</sup> "Other moving violations" consist of infractions for impeding traffic, violating pedestrian right-of-way, starting/backing, improper driving and falling asleep.<sup>c</sup> "All other" consists of infractions for hazardous parking, unsafe equipment, other hazards and "not stated."

Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Table 18. Percentage of Fatal Collisions by Primary Collision Factor and Age and Sex of Driver At Fault, California 1995**

Primary Collision Factor	% of Drivers At Fault in Fatal Collisions								
	Total <sup>a</sup>	16-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
<b>Total</b>									
Unsafe speed	15.17	21.45	17.30	13.09	12.77	12.76	14.96	9.49	13.40
Right-of-way	7.29	5.54	4.06	4.09	5.71	9.18	11.81	24.09	32.99
Alcohol/drugs	34.70	23.53	40.69	45.66	37.77	31.12	16.54	9.49	2.06
Signs/signals	7.51	8.65	8.11	6.55	5.43	6.12	11.81	8.03	9.28
Improper turn	14.19	18.69	12.17	11.78	15.22	16.33	17.32	17.52	16.49
Passing/lane change	3.64	2.42	3.46	3.27	4.35	5.61	4.72	4.38	2.06
Wrong side of road	9.76	13.49	7.04	8.02	8.97	10.71	14.96	17.52	16.49
Other moving violations <sup>b</sup>	4.66	2.77	3.94	4.58	5.98	6.12	5.51	5.84	6.19
All other <sup>c</sup>	3.08	3.46	3.22	2.95	3.80	2.04	2.36	3.65	1.03
<b>Total (%)</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>
<i>n</i>	2,663	289	838	611	368	196	127	137	97
<b>Male</b>									
Unsafe speed	16.32	23.39	17.53	13.07	14.71	13.74	21.69	12.66	13.11
Right-of-way	5.00	4.13	3.16	3.53	2.57	4.58	3.61	22.78	31.15
Alcohol/drugs	38.87	25.23	43.97	48.34	43.75	35.11	18.07	12.66	3.28
Signs/signals	7.22	9.17	8.05	6.22	4.78	5.34	12.05	10.13	3.28
Improper turn	12.51	16.06	10.06	11.00	13.24	16.79	15.66	15.19	19.67
Passing/lane change	3.66	2.29	3.59	2.90	3.68	6.11	6.02	6.33	3.28
Wrong side of road	9.20	13.76	6.47	8.09	8.46	9.92	16.87	13.92	18.03
Other moving violations <sup>b</sup>	4.15	1.83	3.59	4.36	5.51	6.11	4.82	3.80	6.56
All other <sup>c</sup>	3.07	4.13	3.59	2.49	3.31	2.29	1.20	2.53	1.64
<b>Total (%)</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>
<i>n</i>	2,022	218	696	482	272	131	83	79	61
<b>Female</b>									
Unsafe speed	11.54	15.49	16.20	13.18	7.29	10.77	2.27	5.17	13.89
Right-of-way	14.51	9.86	8.45	6.20	14.58	18.46	27.27	25.86	36.11
Alcohol/drugs	21.53	18.31	24.65	35.66	20.83	23.08	13.64	5.17	0.00
Signs/signals	8.42	7.04	8.45	7.75	7.29	7.69	11.36	5.17	19.44
Improper turn	19.50	26.76	22.54	14.73	20.83	15.38	20.45	20.69	11.11
Passing/lane change	3.59	2.82	2.82	4.65	6.25	4.62	2.27	1.72	0.00
Wrong side of road	11.54	12.68	9.86	7.75	10.42	12.31	11.36	22.41	13.89
Other moving violations <sup>b</sup>	6.24	5.63	5.63	5.43	7.29	6.15	6.82	8.62	5.56
All other <sup>c</sup>	3.12	1.41	1.41	4.65	5.21	1.54	4.55	5.17	0.00
<b>Total (%)</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>
<i>n</i>	641	71	142	129	96	65	44	58	36

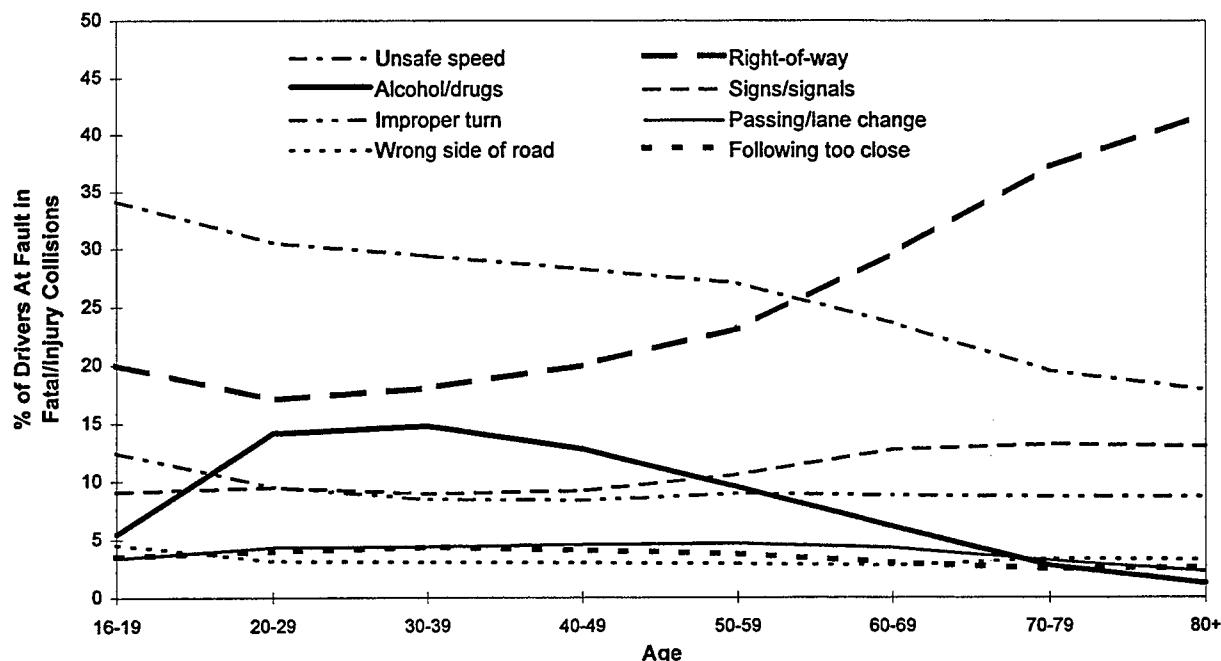
<sup>a</sup> Excludes drivers in collisions who are under age 16 or for whom age is not reported.

<sup>b</sup> "Other moving violations" consist of infractions for impeding traffic, following too close, violating pedestrian right-of-way, starting/backing, improper driving and falling asleep. Following too close is included here because it is rarely a primary collision factor in fatal collisions.

<sup>c</sup> "All other" consists of infractions for hazardous parking, unsafe equipment, other hazards and "not stated."

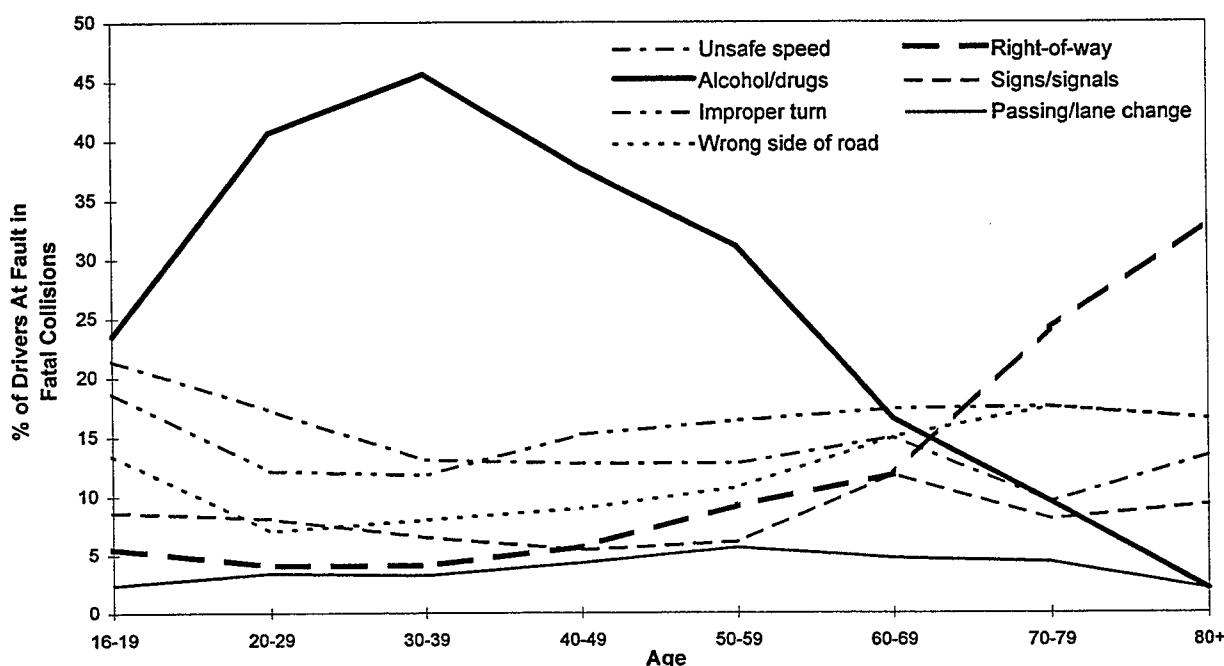
Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Figure 23. Primary Collision Factor for Drivers At Fault in Fatal/Injury Collisions by Age, California 1995**



Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento CA.

**Figure 24. Primary Collision Factor for Drivers At Fault in Fatal Collisions by Age, California 1995**



Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

## Driver Movement Preceding Collision

---

### General Patterns

Regardless of fault or crash severity, most drivers in casualty collisions were proceeding straight before their crash. As many as 52.9% of drivers aged 16 or older in fatal/injury collisions, and 57.9% of drivers aged 16 or older in fatal collisions, were proceeding straight (Table 19). Among drivers at fault in fatal/injury collisions, a similarly high percentage, 50.4%, were heading straight before crashing; this figure drops to 35.3% among drivers at fault in fatal collisions (Table 20).

Despite this modal pattern, the directional movements of drivers vary with crash severity and fault. One significant difference is that drivers in fatal crashes (especially those at fault) are more likely than drivers in total casualty crashes to have run off the road or to have crossed an opposing lane before crashing; they are less likely, however, to be turning left.

Although running off the road is less common among drivers in fatal/injury collisions than among those in fatal collisions, in total casualty collisions it is about twice as likely among at-fault drivers as among all involved drivers. At-fault drivers in fatal/injury collisions also demonstrate a greater propensity than all involved drivers to be turning left before crashing; as might be expected, though, they are substantially less likely to be stopped (not moving) before the crash (only 1.4% of drivers aged 16 or older who are at fault in fatal/injury collisions were stopped before a crash, as compared to 15.2% of all drivers aged 16 or older who are involved in these crashes).

### Age Differences

Regardless of crash severity or culpability, senior drivers are significantly more likely than teens or all drivers to be turning left before a crash. Especially problematic for seniors are left turns at intersections (Figures 25-28); this movement, particularly prominent among older drivers at fault in casualty collisions, likely reflects age-related difficulties in judging speed and distance. Close to 20% of drivers aged 60 or older responsible for fatal/injury collisions were making a left turn at an intersection before crashing. This compares to 11.9% of both teens aged 16-19 and all drivers aged 16 or older who are at fault in fatal/injury crashes (Figure 27).

Left turns at intersections are an even greater problem for drivers in the advanced old ages. By age 80, drivers in fatal collisions are more than four times as likely as all drivers aged 16 or older in

fatal collisions to be turning left at an intersection before crashing; in fatal/injury collisions, they are more than twice as likely as all involved drivers to be engaged in this movement (Tables 19 and 20).

More characteristic of teen drivers in casualty collisions, by contrast, is running off the road before crashing. Teens in crashes are more likely than are all drivers aged 16 or older or seniors to have driven off the road, regardless of fault or crash severity (Figures 25-28).

**Table 19. Percentage of Drivers in Fatal/Injury and Fatal Collisions by Driver Movement  
Preceding Collision and Age, California 1995**

Preceding Driver Movement	% of Drivers in Collisions								
	Total <sup>a</sup>	16-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
<b>Fatal/Injury</b>									
Proceeding straight	52.94	52.97	54.90	53.28	51.39	51.30	51.30	50.29	49.17
Stopped	15.23	9.16	13.36	17.02	18.75	18.47	16.01	11.36	6.44
Left turn at intersection	7.85	9.36	7.16	6.84	6.98	7.74	9.90	13.97	18.69
Other left turn	2.88	3.29	2.72	2.53	2.64	2.94	3.39	4.48	6.35
Ran off road	4.58	7.77	5.27	4.04	3.71	3.42	3.21	3.32	3.23
Slowing - stopping	5.21	4.20	4.71	5.46	6.07	5.92	5.56	4.55	3.10
Making right turn	2.46	2.42	2.22	2.38	2.66	2.80	2.69	2.77	2.82
Changing lanes	1.97	2.15	2.16	1.95	1.84	1.76	1.82	1.58	1.26
Entering traffic	1.45	1.68	1.33	1.30	1.23	1.39	1.92	2.68	3.49
Crossed opposing lane	0.88	1.27	0.95	0.89	0.77	0.59	0.59	0.73	0.73
Making U turn	0.74	1.06	0.76	0.63	0.56	0.70	0.84	1.20	0.94
Backing	0.52	0.45	0.50	0.56	0.52	0.53	0.47	0.64	0.78
Passing other vehicle	0.56	0.86	0.71	0.49	0.47	0.38	0.34	0.30	0.25
Other unsafe turning	0.69	1.16	0.77	0.64	0.55	0.49	0.47	0.46	0.85
Traveling wrong way	0.13	0.10	0.15	0.13	0.09	0.07	0.12	0.17	0.50
All other <sup>b</sup>	1.92	2.10	2.33	1.85	1.76	1.50	1.38	1.53	1.38
Total (%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
n	342,585	34,941	96,671	87,099	59,102	30,926	17,487	11,999	4,360
<b>Fatal</b>									
Proceeding straight	57.92	51.19	58.79	59.83	61.01	57.82	60.93	51.67	38.17
Stopped	3.17	1.51	2.66	3.67	3.77	3.85	5.38	1.67	1.53
Left turn at intersection	3.92	4.54	3.07	3.06	2.59	4.71	5.73	6.67	16.79
Other left turn	1.36	1.30	0.95	0.77	1.30	1.93	2.15	3.33	5.34
Ran off road	15.91	21.60	16.76	15.91	13.31	14.56	13.62	15.00	14.50
Slowing - stopping	1.02	0.86	0.48	0.99	1.65	2.57	1.08	0.00	0.00
Making right turn	0.75	0.43	0.61	0.54	1.53	0.86	1.08	0.42	0.00
Changing lanes	1.84	0.86	2.18	1.84	1.65	1.93	1.08	2.92	2.29
Entering traffic	0.73	0.86	0.27	0.38	0.59	1.07	1.08	2.92	3.82
Crossed opposing lane	5.51	6.26	5.72	6.12	4.95	3.43	3.58	7.08	6.87
Making U turn	0.54	0.65	0.41	0.23	0.47	0.21	0.00	2.50	3.82
Backing	0.31	0.22	0.34	0.23	0.59	0.00	0.00	0.00	1.53
Passing other vehicle	1.38	3.24	1.70	0.61	1.53	1.07	0.72	1.25	0.76
Other unsafe turning	1.52	2.38	1.50	1.53	1.06	2.36	1.43	0.00	1.53
Traveling wrong way	0.88	0.43	0.89	0.84	0.47	1.28	0.72	2.08	2.29
All other <sup>b</sup>	3.23	3.67	3.68	3.44	3.53	2.36	1.43	2.50	0.76
Total (%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
n	5,204	463	1,468	1,307	849	467	279	240	131

<sup>a</sup> Excludes drivers in collisions who are under age 16 or for whom age is not reported.

<sup>b</sup> "All other" consists of parking, merging, other and "not stated."

Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Table 20. Percentage of Drivers At Fault in Fatal/Injury and Fatal Collisions by Driver Movement Preceding Collision and Age, California 1995**

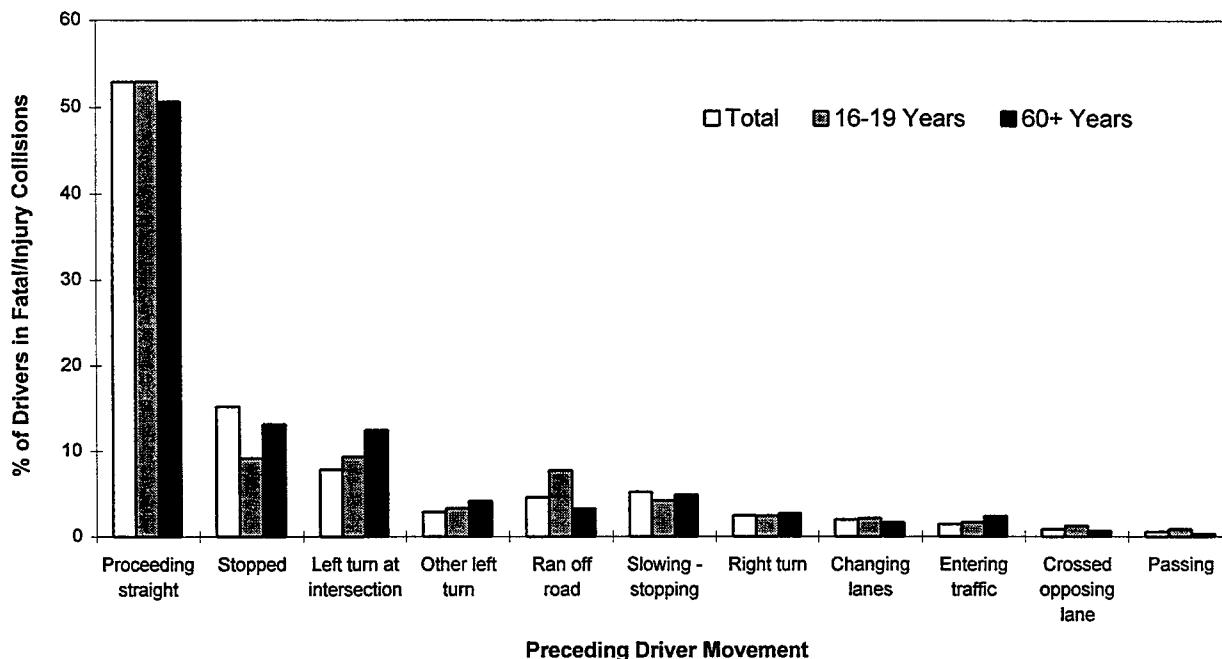
Preceding Driver Movement	% of Drivers At Fault in Collisions								
	Total <sup>a</sup>	16-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
<b>Fatal/Injury</b>									
Proceeding straight	50.41	48.83	51.37	52.02	50.36	49.91	47.90	46.25	44.77
Stopped	1.38	1.04	1.27	1.44	1.71	1.50	1.41	1.64	0.96
Left turn at intersection	11.94	11.89	10.18	10.58	11.61	13.34	16.56	20.16	23.70
Other left turn	4.70	4.43	4.15	4.30	4.78	5.39	6.17	7.01	8.14
Ran off road	9.39	12.16	10.37	9.13	8.84	8.02	6.52	5.16	4.10
Slowing - stopping	3.24	2.99	3.14	3.42	3.69	3.48	3.26	2.49	1.85
Making right turn	2.73	2.68	2.50	2.60	3.08	3.27	2.84	2.86	2.98
Changing lanes	3.76	3.20	3.93	4.06	4.03	3.82	3.78	2.55	1.68
Entering traffic	2.66	2.51	2.30	2.48	2.47	2.87	4.04	4.41	4.69
Crossed opposing lane	1.82	2.02	1.89	2.03	1.85	1.39	1.24	1.30	1.09
Making U turn	1.40	1.59	1.33	1.28	1.18	1.58	1.66	2.02	1.33
Backing	0.87	0.64	0.75	0.98	1.01	1.03	0.90	0.92	0.99
Passing other vehicle	0.99	1.19	1.26	0.92	0.91	0.70	0.57	0.42	0.34
Other unsafe turning	1.45	1.87	1.54	1.50	1.34	1.17	1.05	0.75	1.13
Traveling wrong way	0.26	0.16	0.28	0.28	0.23	0.20	0.26	0.28	0.68
All other <sup>b</sup>	2.99	2.81	3.73	2.97	2.91	2.32	1.84	1.77	1.57
Total (%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
n	151,961	20,567	45,530	35,318	22,305	11,594	7,330	6,393	2,924
<b>Fatal</b>									
Proceeding straight	35.34	34.26	39.02	34.86	34.24	27.04	40.94	32.85	26.80
Stopped	0.26	0.00	0.12	0.33	0.82	0.51	0.00	0.00	0.00
Left turn at intersection	4.62	4.15	3.34	2.62	3.53	7.65	7.09	8.03	19.59
Other left turn	1.88	2.08	1.07	0.82	2.17	3.06	3.15	3.65	7.22
Ran off road	28.80	30.45	28.16	31.75	28.53	33.16	25.98	21.90	16.49
Slowing - stopping	0.34	0.69	0.24	0.33	0.27	0.51	0.79	0.00	0.00
Making right turn	0.79	0.69	0.95	0.33	1.36	0.00	2.36	0.73	0.00
Changing lanes	3.08	1.38	3.34	3.27	2.99	3.57	2.36	5.11	2.06
Entering traffic	1.01	0.35	0.36	0.49	1.09	1.02	2.36	4.38	5.15
Crossed opposing lane	10.33	9.69	9.90	12.27	10.87	7.65	7.09	11.68	9.28
Making U turn	0.98	1.04	0.60	0.49	0.82	0.51	0.00	4.38	5.15
Backing	0.34	0.35	0.36	0.33	0.54	0.00	0.00	0.00	1.03
Passing other vehicle	2.44	5.19	2.86	1.31	2.72	2.55	0.79	0.73	1.03
Other unsafe turning	2.93	3.81	2.63	3.11	2.45	5.61	3.15	0.00	2.06
Traveling wrong way	1.61	0.69	1.55	1.47	1.09	3.06	1.57	2.92	3.09
All other <sup>b</sup>	5.26	5.19	5.49	6.22	6.52	4.08	2.36	3.65	1.03
Total (%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
n	2,663	289	838	611	368	196	127	137	97

<sup>a</sup> Excludes drivers in collisions who are under age 16 or for whom age is not reported.

<sup>b</sup> "All other" consists of parking, merging, other and "not stated."

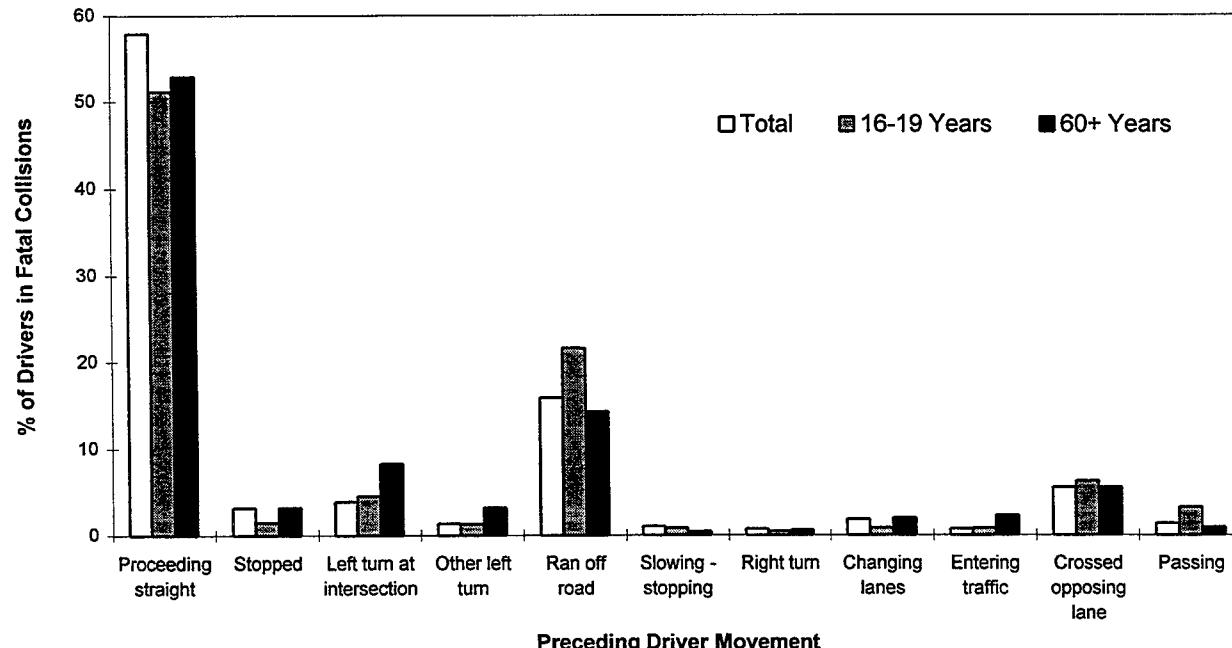
Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Figure 25. Percentage of Teen and Senior Drivers in Fatal/Injury Collisions by Driver Movement Preceding Collision, California 1995**



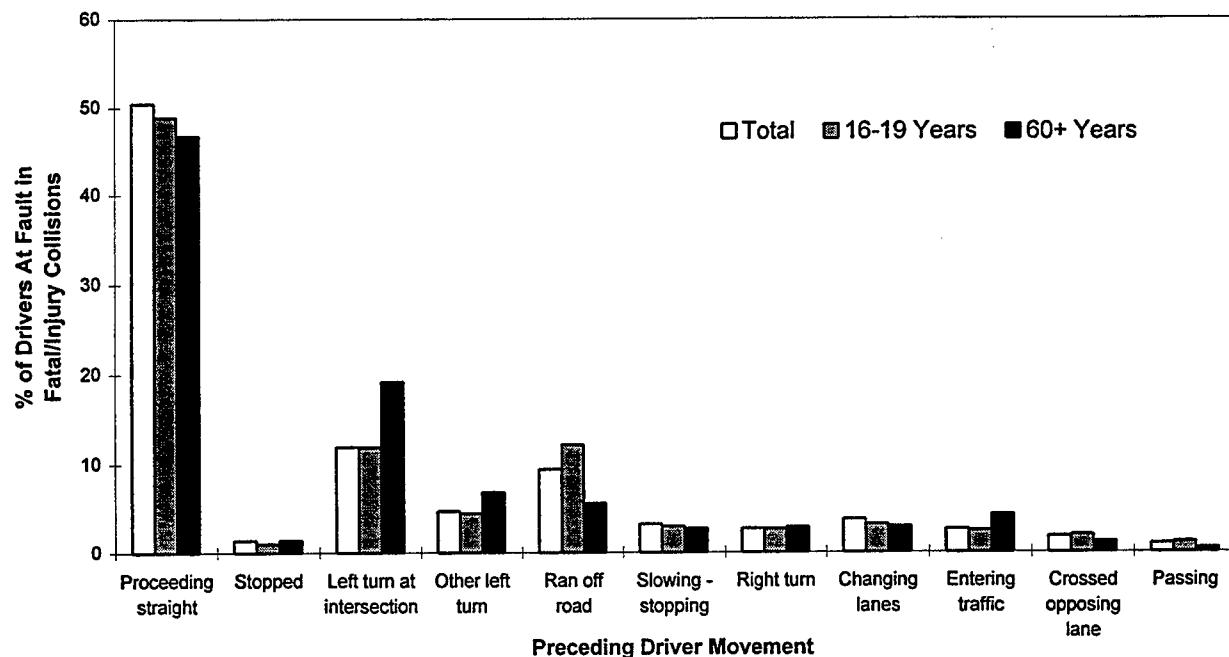
Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Figure 26. Percentage of Teen and Senior Drivers in Fatal Collisions by Driver Movement Preceding Collision, California 1995**



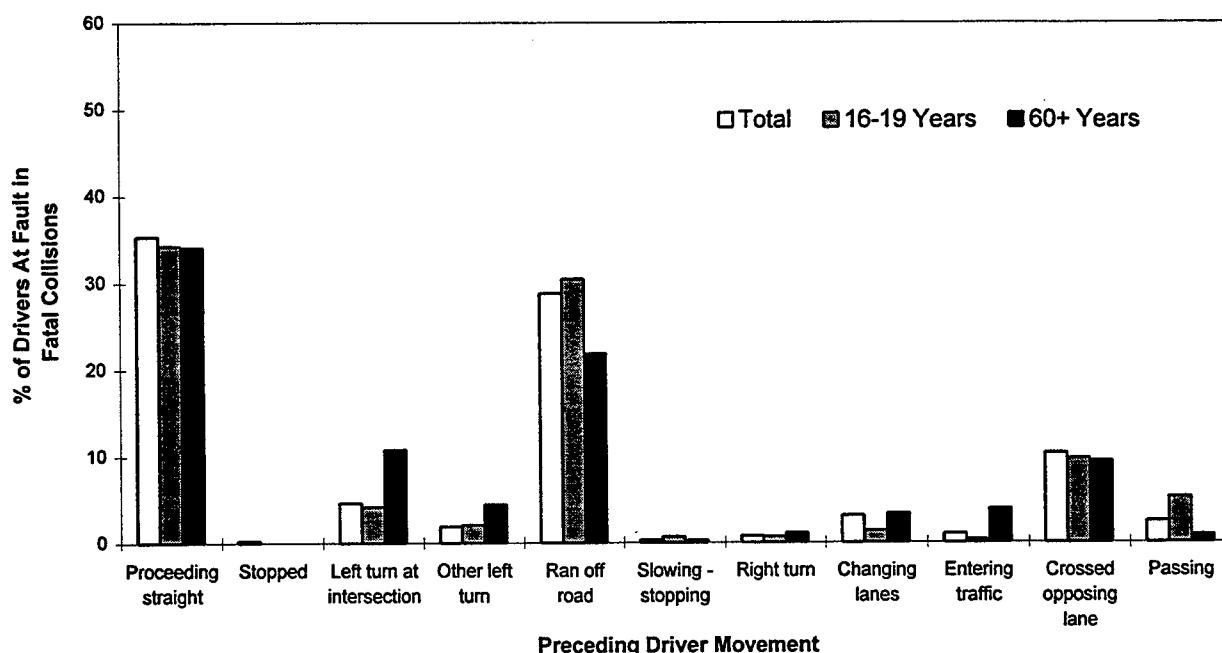
Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Figure 27. Percentage of Teen and Senior Drivers At Fault in Fatal/Injury Collisions by Driver Movement Preceding Collision, California 1995**



Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Figure 28. Percentage of Teen and Senior Drivers At Fault in Fatal Collisions by Driver Movement Preceding Collision, California 1995**



Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

## Type of Collision

---

### General Patterns

Drivers in fatal/injury collisions tend to be involved in different types of collisions than drivers in fatal collisions. In total casualty collisions, rear-end and broadside impacts are by far most common. Each of these types of collisions occurs for about one-third of drivers in fatal/injury collisions, regardless of culpability (Tables 21 and 22).

By contrast, rear-end collisions are relatively infrequent among drivers in fatal crashes. Rather, these drivers are most at risk for a broadside impact or for hitting an object. About 25% of drivers aged 16 or older who are in fatal crashes have broadside impacts, and an additional 21.1% hit an object. If at fault, drivers are even more likely to have hit an object; as many as 34.3% of drivers aged 16 or older who are responsible for fatal crashes hit an object, while 20.8% had broadside impacts.

Crashes that are head-on, involve a pedestrian or result in an overturned vehicle tend to be more serious and occur proportionately more often among drivers in fatal crashes than among those in total casualty crashes.

### Age Differences

While broadside impacts are a leading type of collision for drivers in all age groups, they are especially prevalent among seniors (Figures 29-32). In fatal/injury collisions, for example, 44.2% of at-fault drivers aged 60 or older had broadside impacts as compared to 29.4% of teens aged 16-19, and 30.9% of all drivers aged 16 or older, at fault in these collisions (Figure 31).

Within the senior population, the likelihood of having a broadside impact climbs steadily and rapidly with advancing age (Tables 21 and 22). In the case of fatal collisions, for example, 42.8% of drivers aged 80 or older had broadside impacts, compared to 24.0% of drivers aged 60-69.

Relatively more common among teens, by contrast, are collisions in which an object is hit. This type of collision occurs proportionately more often among teens aged 16-19 than among seniors and all drivers aged 16 or older, regardless of crash severity or fault (Figures 29-32).

**Table 21. Percentage of Drivers in Fatal/Injury and Fatal Collisions by Type of Collision and Age, California 1995**

Collision Type	% of Drivers in Collisions								
	Total <sup>a</sup>	16-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
<b>Fatal/Injury</b>									
Rear-end	36.19	31.76	34.94	38.19	39.28	38.28	35.41	29.41	24.43
Broadside	32.36	32.81	32.30	31.19	30.21	31.95	35.84	41.67	46.24
Hit object	8.61	13.50	10.11	7.70	7.07	6.63	5.80	6.27	6.54
Sideswipe	7.20	6.10	7.31	7.48	7.63	7.39	7.10	5.78	5.32
Head-on	6.03	6.58	6.10	5.89	5.86	5.69	5.76	6.49	7.43
Auto/pedestrian	3.51	3.23	3.24	3.38	3.56	3.81	4.08	4.83	5.14
Overturned	1.93	2.78	2.26	1.91	1.70	1.57	1.02	0.78	0.55
All other <sup>b</sup>	4.17	3.26	3.74	4.24	4.69	4.67	4.98	4.78	4.36
Total (%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
n	342,585	34,941	96,671	87,099	59,102	30,926	17,487	11,999	4,360
<b>Fatal</b>									
Rear-end	7.92	3.46	8.04	8.34	7.89	10.71	8.60	7.08	8.40
Broadside	25.17	26.35	25.82	22.80	22.97	22.70	24.01	36.25	42.75
Hit object	21.10	27.86	23.02	19.97	18.73	19.70	18.28	17.08	20.61
Sideswipe	5.50	3.89	4.56	6.04	5.89	6.00	7.17	7.08	5.34
Head-on	16.81	15.33	15.05	18.59	18.73	15.85	18.64	15.42	13.74
Auto/pedestrian	13.18	12.96	13.22	13.31	14.96	13.49	12.90	10.00	6.11
Overturned	5.84	6.26	6.06	6.81	5.18	5.57	5.73	3.33	2.29
All other <sup>b</sup>	4.48	3.89	4.22	4.13	5.65	6.00	4.66	3.75	0.76
Total (%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
n	5,204	463	1,468	1,307	849	467	279	240	131

<sup>a</sup> Excludes drivers in collisions who are under age 16 or for whom age is not reported.<sup>b</sup> "All other" consists of other and "not stated."

Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

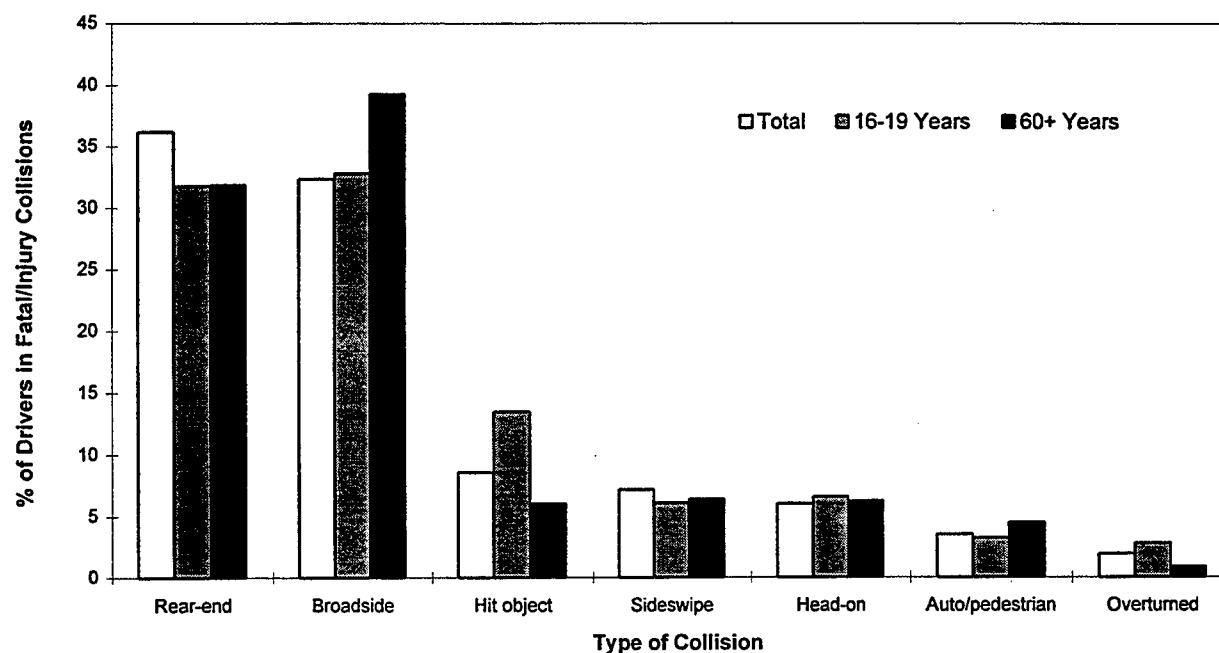
**Table 22. Percentage of Drivers At Fault in Fatal/Injury and Fatal Collisions by Type of Collision and Age, California 1995**

Collision Type	% of Drivers At Fault in Collisions								
	Total <sup>a</sup>	16-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
<b>Fatal/Injury</b>									
Rear-end	31.75	30.19	32.08	34.46	33.20	31.28	28.38	23.87	21.51
Broadside	30.87	29.41	28.55	28.51	29.46	33.33	40.19	46.24	49.49
Hit object	15.66	20.10	17.99	14.98	14.14	12.86	10.01	8.90	8.11
Sideswipe	6.41	5.59	6.57	6.74	6.90	6.43	6.22	5.02	5.23
Head-on	6.02	6.48	5.88	5.61	5.98	5.95	6.18	7.04	7.87
Auto/pedestrian	2.91	2.08	2.40	2.96	3.44	3.71	3.55	4.19	4.17
Overturned	3.56	4.16	4.04	3.78	3.53	3.00	1.95	1.20	0.75
All other <sup>b</sup>	2.83	2.00	2.48	2.95	3.34	3.44	3.52	3.54	2.87
<b>Total (%)</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>
<i>n</i>	151,961	20,567	45,530	35,318	22,305	11,594	7,330	6,393	2,924
<b>Fatal</b>									
Rear-end	6.83	2.77	8.11	6.71	6.25	5.10	10.24	8.03	8.25
Broadside	20.84	23.18	21.00	15.88	16.30	15.31	20.47	40.88	44.33
Hit object	34.25	41.52	36.16	34.53	32.88	37.24	25.98	22.63	20.62
Sideswipe	4.17	1.73	3.58	5.07	5.16	6.12	2.36	4.38	5.15
Head-on	14.38	14.19	13.60	14.08	15.76	15.82	17.32	13.14	13.40
Auto/pedestrian	7.02	5.88	5.61	8.67	10.33	6.63	7.87	3.65	4.12
Overturned	9.24	7.96	8.35	12.27	8.97	9.69	11.81	5.84	3.09
All other <sup>b</sup>	3.27	2.77	3.58	2.78	4.35	4.08	3.94	1.46	1.03
<b>Total (%)</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>
<i>n</i>	2,663	289	838	611	368	196	127	137	97

<sup>a</sup> Excludes drivers in collisions who are under age 16 or for whom age is not reported.<sup>b</sup> "All other" consists of other and "not stated."

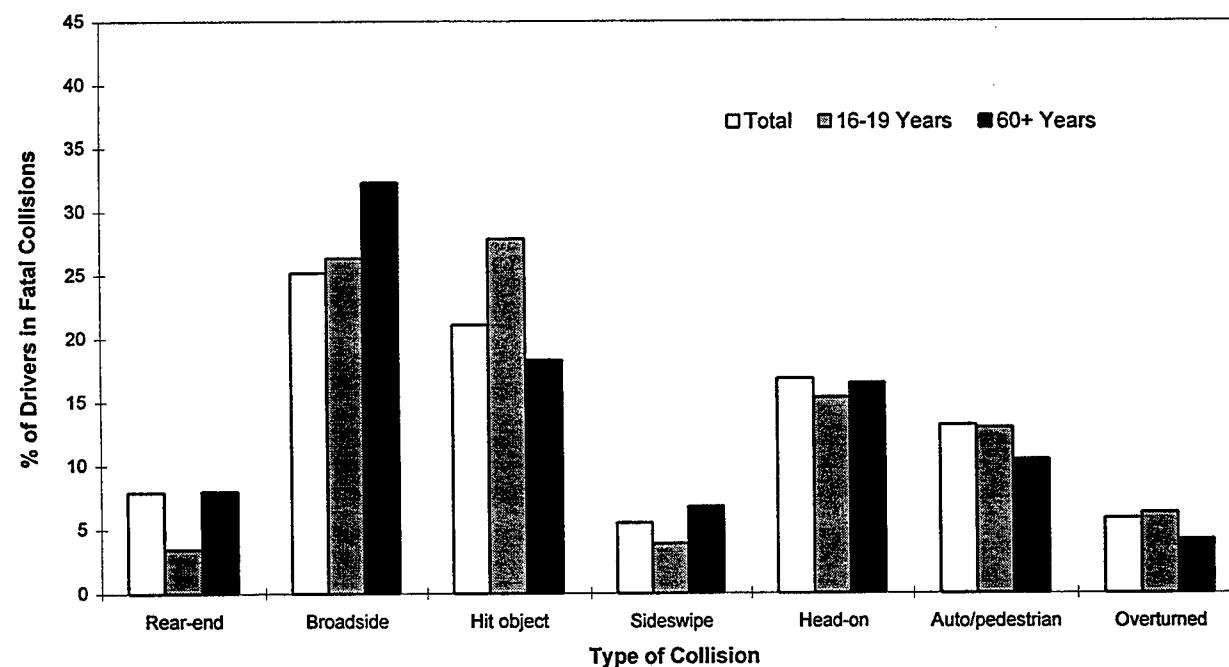
Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Figure 29. Percentage of Teen and Senior Drivers in Fatal/Injury Collisions by Type of Collision, California 1995**



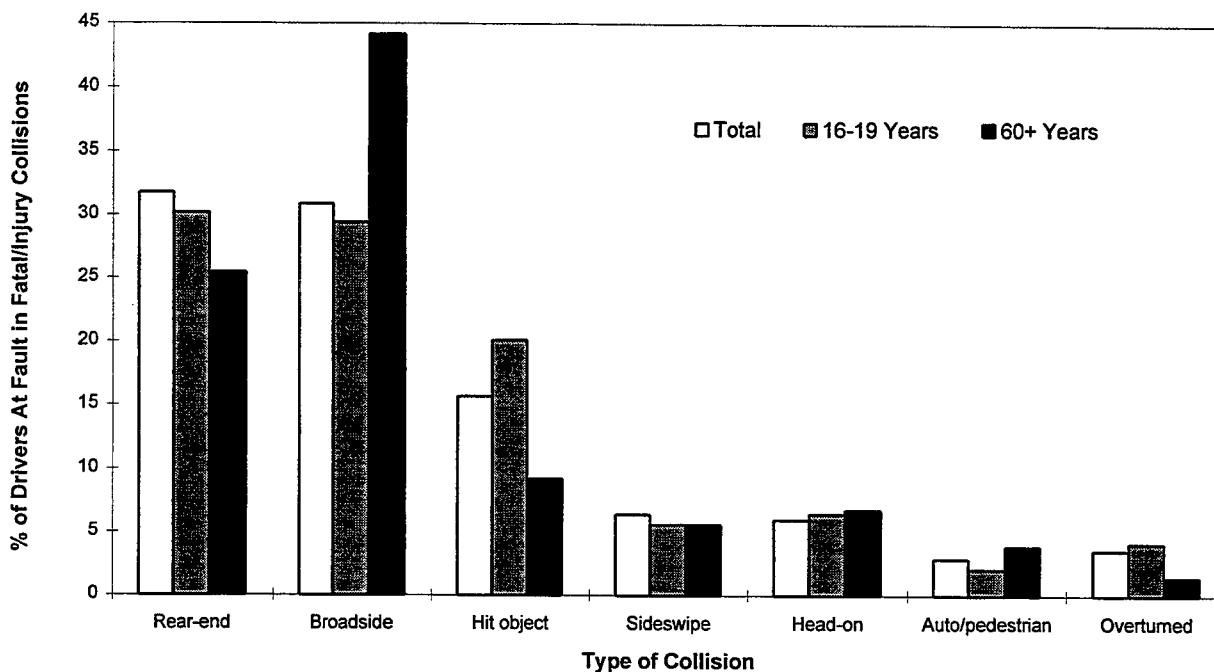
Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Figure 30. Percentage of Teen and Senior Drivers in Fatal Collisions by Type of Collision, California 1995**



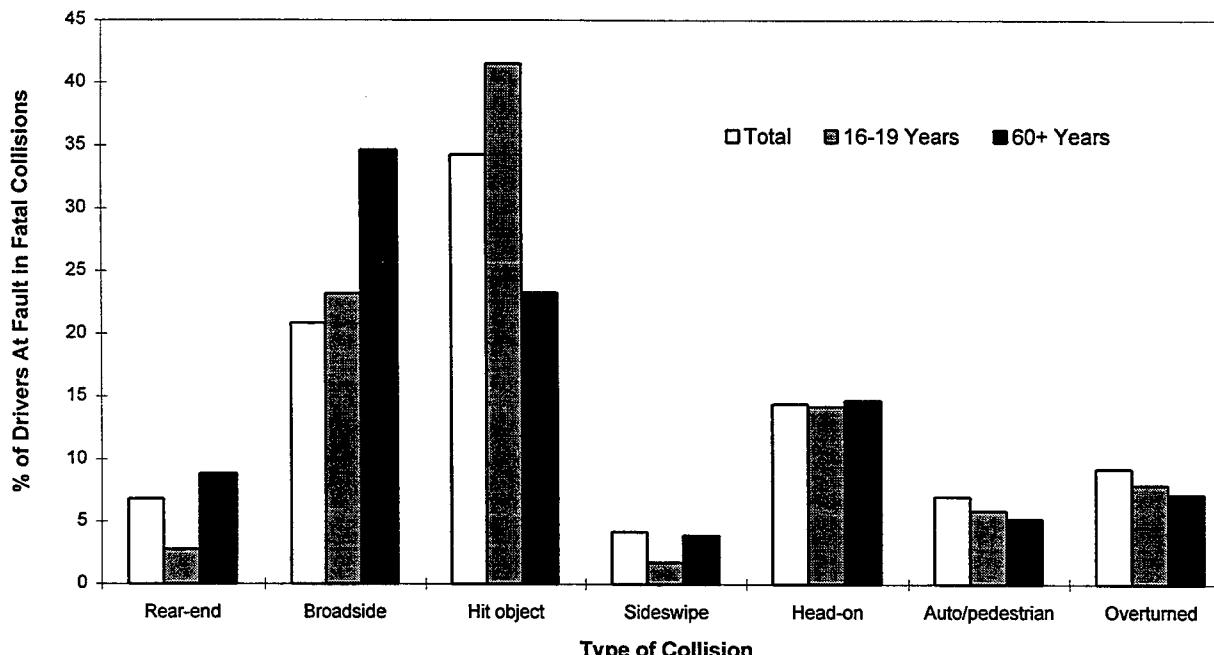
Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Figure 31. Percentage of Teen and Senior Drivers At Fault in Fatal/Injury Collisions by Type of Collision, California 1995**



Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Figure 32. Percentage of Teen and Senior Drivers At Fault in Fatal Collisions by Type of Collision, California 1995**



Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

## Time of Collision

### General Patterns

Since most miles are accumulated during the afternoon and evening (Federal Highway Administration, 1993), significantly more drivers are involved in collisions during these periods (Tables 23-26). Regardless of fault, about twice as many drivers aged 16 or older are in fatal/injury collisions from noon to 11:59 p.m. as from midnight to 11:59 a.m. (Tables 23 and 25).

Fatal/injury and fatal collisions peak during the rush hours. The riskiest one-hour period is from 5:00 to 5:59 p.m., regardless of driver fault.

Proportionately more drivers in fatal collisions than in fatal/injury collisions crash during the early morning hours, especially from midnight to 2:59 a.m. Of drivers aged 16 or older who are in fatal collisions, 10.6% crashed between midnight and 2:59 a.m., compared to 3.6% of their counterparts in fatal/injury collisions.

### Age Differences

Teens and all drivers aged 16 or older are considerably more likely than senior drivers to have collisions during the evening (6:00 p.m. to 11:59 p.m.) and early morning hours (midnight to 5:59 a.m.) (Figures 33-36). They are especially prone to be involved or at fault in fatal crashes during the early morning hours (Figures 34 and 36). Of teens and all drivers at fault in fatal collisions, 20.6% crashed from midnight to 5:59 a.m., compared to 4.5% of seniors (aged 60 or older) at fault in fatal collisions (Figure 36). Because seniors are less likely to be on the road during these hours, their crash involvement is lower.

Older adults accumulate most of their miles during daylight hours, which is when a disproportionate share of their collisions occur. Regardless of crash severity or fault, they are more likely than teens and all drivers aged 16 or older to crash from noon to 5:59 p.m. About half of seniors (aged 60 or older) in collisions crash during this period.

**Table 23. Percentage of Drivers in Fatal/Injury Collisions by Time of Day and Age, California 1995**

Time of Day of Collision	% of Drivers in Fatal/Injury Collisions								
	Total <sup>a</sup>	16-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
Midnight - 12:59 A.M.	1.35	2.09	1.89	1.29	0.98	0.83	0.43	0.25	0.18
1:00 - 1:59	1.14	1.49	1.77	1.14	0.76	0.55	0.25	0.17	0.18
2:00 - 2:59	1.11	1.22	1.85	1.10	0.69	0.48	0.28	0.12	0.18
3:00 - 3:59	0.57	0.78	0.93	0.53	0.34	0.27	0.11	0.05	0.09
4:00 - 4:59	0.53	0.56	0.73	0.52	0.49	0.44	0.21	0.04	0.23
5:00 - 5:59	0.95	0.55	0.98	1.07	1.05	1.25	0.76	0.35	0.28
6:00 - 6:59	2.15	1.32	2.13	2.46	2.51	2.57	1.63	0.95	0.78
7:00 - 7:59	5.10	5.03	4.69	5.53	5.93	5.59	4.02	2.85	2.09
8:00 - 8:59	5.20	3.67	4.73	5.89	5.88	5.52	5.30	4.77	3.74
9:00 - 9:59	4.08	2.68	3.55	4.04	4.44	4.81	5.42	6.33	6.11
10:00 - 10:59	4.45	3.01	3.83	4.34	4.54	5.26	6.29	7.68	8.47
11:00 - 11:59	5.45	4.22	4.78	5.33	5.41	5.89	7.76	9.38	9.72
<b>Total A.M. (%)</b>	<b>32.09</b>	<b>26.60</b>	<b>31.87</b>	<b>33.24</b>	<b>33.02</b>	<b>33.45</b>	<b>32.47</b>	<b>32.93</b>	<b>32.06</b>
<i>n</i>	109,794	9,283	30,763	28,905	19,486	10,339	5,675	3,947	1,396
Noon - 12:59 P.M.	6.57	6.22	6.07	6.30	6.43	7.21	7.97	9.24	10.40
1:00 - 1:59	6.36	5.81	5.81	6.05	6.47	6.58	8.08	9.38	10.73
2:00 - 2:59	7.14	7.50	6.42	6.87	7.09	7.39	8.96	9.38	10.63
3:00 - 3:59	8.32	9.00	7.53	8.02	8.61	8.69	9.43	10.22	10.43
4:00 - 4:59	8.23	8.24	7.95	8.31	8.31	8.71	8.15	8.24	8.47
5:00 - 5:59	9.19	8.96	9.33	9.24	9.58	9.49	8.62	7.49	6.73
6:00 - 6:59	6.78	6.95	7.05	6.94	6.90	6.43	5.98	5.38	4.32
7:00 - 7:59	4.58	5.44	4.99	4.68	4.25	4.07	3.75	3.13	2.32
8:00 - 8:59	3.30	4.25	3.76	3.29	3.04	2.69	2.26	1.77	1.56
9:00 - 9:59	3.04	4.48	3.60	2.93	2.61	2.30	1.97	1.44	1.33
10:00 - 10:59	2.50	3.71	3.12	2.32	2.16	1.76	1.47	0.95	0.62
11:00 - 11:59	1.90	2.86	2.49	1.82	1.51	1.23	0.88	0.45	0.39
<b>Total P.M. (%)</b>	<b>67.91</b>	<b>73.40</b>	<b>68.13</b>	<b>66.76</b>	<b>66.98</b>	<b>66.55</b>	<b>67.53</b>	<b>67.07</b>	<b>67.94</b>
<i>n</i>	232,339	25,616	65,764	58,064	39,530	20,566	11,803	8,038	2,958
<b>Total (%)</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>
<i>n</i>	342,133	34,899	96,527	86,969	59,016	30,905	17,478	11,985	4,354

<sup>a</sup> Excludes drivers under age 16 or for whom age or time of collision is not reported.

Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Table 24. Percentage of Drivers in Fatal Collisions by Time of Day and Age, California 1995**

Time of Day of Collision	% of Drivers in Fatal Collisions								
	Total <sup>a</sup>	16-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
Midnight - 12:59 A.M.	3.65	5.00	4.47	3.65	3.21	4.73	0.72	0.83	0.00
1:00 - 1:59	3.45	3.91	5.23	3.34	2.14	2.80	2.87	0.42	0.78
2:00 - 2:59	3.51	3.70	5.99	3.42	2.14	2.58	0.36	0.83	0.00
3:00 - 3:59	1.63	1.74	2.68	1.48	1.66	0.86	0.00	0.00	0.00
4:00 - 4:59	1.92	2.39	2.34	2.10	1.54	1.72	0.72	0.00	3.10
5:00 - 5:59	2.85	1.96	2.48	3.42	3.56	3.66	1.79	2.08	0.78
6:00 - 6:59	2.44	1.96	2.62	2.87	2.97	1.94	1.08	0.83	2.33
7:00 - 7:59	3.63	3.91	3.17	3.88	4.75	2.80	3.58	3.33	1.55
8:00 - 8:59	2.89	1.96	2.48	2.64	3.56	3.23	4.30	2.50	5.43
9:00 - 9:59	3.32	2.83	2.48	2.95	4.04	2.58	6.09	6.67	3.88
10:00 - 10:59	3.41	3.26	3.30	2.17	3.44	3.87	6.81	5.83	3.88
11:00 - 11:59	4.29	2.61	3.10	4.19	4.04	4.30	8.60	7.08	11.63
<b>Total A.M. (%)</b>	<b>36.99</b>	<b>35.22</b>	<b>40.33</b>	<b>36.10</b>	<b>37.05</b>	<b>35.05</b>	<b>36.92</b>	<b>30.42</b>	<b>33.33</b>
<i>n</i>	1,907	162	586	465	312	163	103	73	43
Noon - 12:59 P.M.	4.64	2.39	3.37	5.43	3.09	7.74	6.45	8.33	6.98
1:00 - 1:59	4.95	3.48	3.92	4.89	5.58	4.52	6.81	7.08	11.63
2:00 - 2:59	4.48	3.70	3.37	4.43	3.33	3.23	5.73	12.92	13.95
3:00 - 3:59	6.03	6.30	4.89	5.28	6.41	6.88	6.45	10.42	10.85
4:00 - 4:59	5.62	4.57	5.51	5.28	5.82	6.45	6.09	5.83	8.53
5:00 - 5:59	6.46	6.74	5.09	6.13	7.72	9.03	7.53	5.83	5.43
6:00 - 6:59	6.13	5.22	5.85	5.98	6.53	6.88	7.53	7.08	3.88
7:00 - 7:59	5.62	6.96	5.23	5.43	6.06	6.88	5.38	4.58	2.33
8:00 - 8:59	5.02	4.57	5.02	6.60	5.70	3.44	4.30	1.67	0.00
9:00 - 9:59	5.61	8.26	7.09	6.60	3.92	3.87	1.43	2.92	0.78
10:00 - 10:59	4.42	5.87	4.54	4.27	5.23	3.44	4.30	2.50	1.55
11:00 - 11:59	4.03	6.74	5.78	3.57	3.56	2.58	1.08	0.42	0.78
<b>Total P.M. (%)</b>	<b>63.01</b>	<b>64.78</b>	<b>59.67</b>	<b>63.90</b>	<b>62.95</b>	<b>64.95</b>	<b>63.08</b>	<b>69.56</b>	<b>66.67</b>
<i>n</i>	3,249	298	867	823	530	302	176	167	86
<b>Total (%)</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>
<i>n</i>	5,156	460	1,453	1,288	842	465	279	240	129

<sup>a</sup> Excludes drivers under age 16 or for whom age or time of collision is not reported.

Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Table 25. Percentage of Drivers At Fault in Fatal/Injury Collisions by Time of Day and Age, California 1995**

Time of Day of Collision	% of Drivers At Fault in Fatal/Injury Collisions								
	Total <sup>a</sup>	16-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
Midnight - 12:59 A.M.	1.75	2.33	2.41	1.77	1.26	1.01	0.41	0.27	0.17
1:00 - 1:59	1.61	1.76	2.44	1.70	1.10	0.81	0.29	0.16	0.17
2:00 - 2:59	1.61	1.50	2.70	1.66	0.99	0.61	0.30	0.14	0.10
3:00 - 3:59	0.93	1.04	1.53	0.88	0.56	0.41	0.19	0.05	0.10
4:00 - 4:59	0.77	0.77	1.12	0.72	0.71	0.48	0.23	0.06	0.24
5:00 - 5:59	1.15	0.79	1.34	1.25	1.29	1.34	0.68	0.41	0.31
6:00 - 6:59	2.30	1.60	2.47	2.64	2.60	2.74	1.83	1.00	0.79
7:00 - 7:59	4.93	5.22	4.66	5.18	5.81	5.35	4.01	3.04	2.02
8:00 - 8:59	5.02	3.70	4.51	5.79	5.74	5.56	5.53	5.19	3.77
9:00 - 9:59	4.10	2.79	3.61	3.92	4.58	5.11	5.83	6.44	6.03
10:00 - 10:59	4.40	3.11	3.79	4.33	4.48	5.26	6.06	7.68	8.25
11:00 - 11:59	5.29	4.15	4.55	5.20	5.21	5.77	7.96	9.12	9.69
<b>Total A.M. (%)</b>	<b>33.86</b>	<b>28.77</b>	<b>35.14</b>	<b>35.04</b>	<b>34.33</b>	<b>34.46</b>	<b>33.32</b>	<b>33.54</b>	<b>31.64</b>
<i>n</i>	51,376	5,910	15,971	12,352	7,645	3,992	2,441	2,141	924
Noon - 12:59 P.M.	6.33	5.97	5.86	5.97	6.26	6.85	7.67	8.93	10.10
1:00 - 1:59	6.15	5.59	5.38	5.96	6.21	6.42	8.26	8.93	11.34
2:00 - 2:59	6.84	7.25	6.09	6.30	6.67	7.27	8.90	9.70	10.31
3:00 - 3:59	7.85	8.70	6.94	7.40	8.16	8.39	8.91	9.62	10.21
4:00 - 4:59	7.78	7.81	7.51	7.78	7.82	8.09	7.90	8.43	8.60
5:00 - 5:59	8.56	8.58	8.44	8.66	8.90	9.31	8.12	7.47	7.02
6:00 - 6:59	6.45	6.80	6.39	6.37	7.03	6.28	6.13	5.87	4.38
7:00 - 7:59	4.54	5.31	4.77	4.70	4.06	4.23	3.96	3.23	2.67
8:00 - 8:59	3.37	4.10	3.75	3.50	3.13	2.86	2.22	1.49	1.75
9:00 - 9:59	3.20	4.31	3.53	3.24	2.93	2.43	2.22	1.36	1.27
10:00 - 10:59	2.76	3.71	3.35	2.68	2.43	1.98	1.51	1.00	0.38
11:00 - 11:59	2.32	3.09	2.87	2.41	2.06	1.44	0.87	0.42	0.34
<b>Total P.M. (%)</b>	<b>66.14</b>	<b>71.23</b>	<b>64.86</b>	<b>64.96</b>	<b>65.67</b>	<b>65.54</b>	<b>66.68</b>	<b>66.46</b>	<b>68.36</b>
<i>n</i>	100,358	14,632	29,485	22,901	14,623	7,593	4,886	4,242	1,996
<b>Total (%)</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>
<i>n</i>	151,734	20,542	45,456	35,253	22,268	11,585	7,327	6,383	2,920

<sup>a</sup> Excludes drivers under age 16 or for whom age or time of collision is not reported.

Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

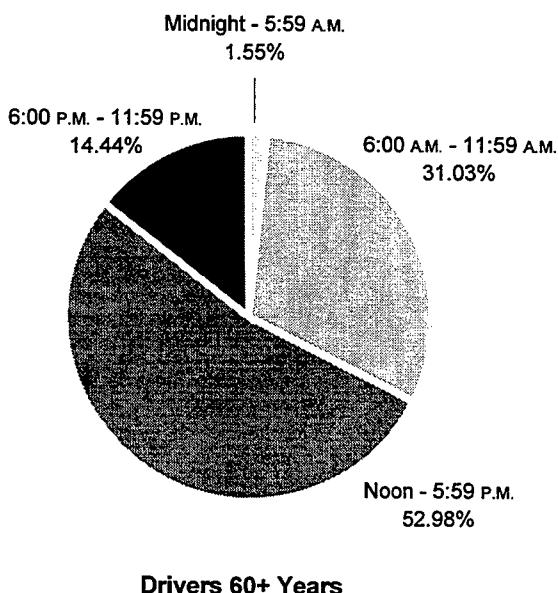
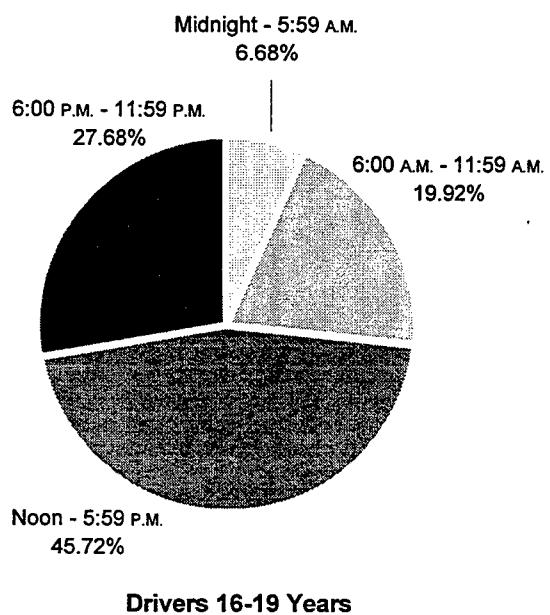
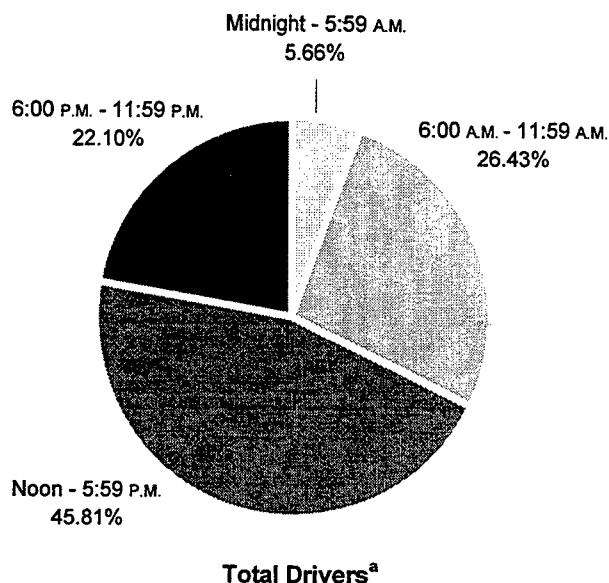
**Table 26. Percentage of Drivers At Fault in Fatal Collisions by Time of Day and Age, California 1995**

Time of Day of Collision	% of Drivers At Fault in Fatal Collisions								
	Total <sup>a</sup>	16-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
Midnight - 12:59 A.M.	4.31	4.90	5.57	4.87	3.87	4.12	0.00	1.46	0.00
1:00 - 1:59	4.39	4.20	6.78	4.54	2.21	3.09	3.94	0.73	0.00
2:00 - 2:59	4.73	3.85	8.23	4.54	3.04	3.61	0.00	0.00	0.00
3:00 - 3:59	2.36	2.10	3.87	1.68	3.04	1.55	0.00	0.00	0.00
4:00 - 4:59	2.48	2.80	3.27	2.52	1.66	3.09	0.79	0.00	2.11
5:00 - 5:59	2.97	2.80	2.78	3.87	3.59	3.09	2.36	0.73	1.05
6:00 - 6:59	2.71	2.45	2.78	2.86	4.14	2.58	0.79	0.73	2.11
7:00 - 7:59	3.89	3.85	3.75	3.70	5.25	4.12	2.36	4.38	2.11
8:00 - 8:59	2.75	1.75	2.30	2.86	2.76	2.58	6.30	2.19	5.26
9:00 - 9:59	2.94	2.45	2.66	2.69	3.04	1.55	5.51	5.11	4.21
10:00 - 10:59	3.32	4.55	3.03	2.18	2.49	4.64	7.09	5.11	2.11
11:00 - 11:59	3.85	2.10	2.54	3.53	3.04	3.09	8.66	8.76	13.68
<b>Total A.M. (%)</b>	<b>40.69</b>	<b>37.76</b>	<b>47.58</b>	<b>39.83</b>	<b>38.12</b>	<b>37.11</b>	<b>37.80</b>	<b>29.20</b>	<b>32.63</b>
<i>n</i>	1,067	108	393	237	138	72	48	40	31
Noon - 12:59 P.M.	4.69	2.10	3.27	5.21	4.70	6.70	8.66	8.76	6.32
1:00 - 1:59	4.35	4.20	3.15	4.54	3.87	3.61	3.15	8.03	13.68
2:00 - 2:59	4.39	3.15	3.03	3.36	3.59	1.55	6.30	16.79	14.74
3:00 - 3:59	5.49	5.94	4.48	4.03	6.08	8.25	7.87	7.30	8.42
4:00 - 4:59	4.92	3.85	4.48	4.87	4.42	6.19	5.51	5.11	10.53
5:00 - 5:59	5.95	6.99	4.12	4.87	8.01	7.73	10.24	7.30	6.32
6:00 - 6:59	5.72	5.94	4.36	5.21	8.56	6.70	7.87	6.57	3.16
7:00 - 7:59	5.30	8.04	4.24	4.87	6.08	7.73	4.72	4.38	3.16
8:00 - 8:59	4.73	4.55	4.84	7.06	4.42	3.09	3.94	1.46	0.00
9:00 - 9:59	5.19	6.29	6.17	7.23	3.04	4.12	0.79	2.19	1.05
10:00 - 10:59	3.97	4.55	4.00	4.20	4.97	4.12	2.36	2.92	0.00
11:00 - 11:59	4.61	6.64	6.30	4.71	4.14	3.09	0.79	0.00	0.00
<b>Total P.M. (%)</b>	<b>59.31</b>	<b>62.24</b>	<b>52.42</b>	<b>60.17</b>	<b>61.88</b>	<b>62.89</b>	<b>62.20</b>	<b>70.80</b>	<b>67.37</b>
<i>n</i>	1,555	178	433	358	224	122	79	97	64
<b>Total (%)</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>
<i>n</i>	2,622	286	826	595	362	194	127	137	95

<sup>a</sup> Excludes drivers under age 16 or for whom age or time of collision is not reported.

Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

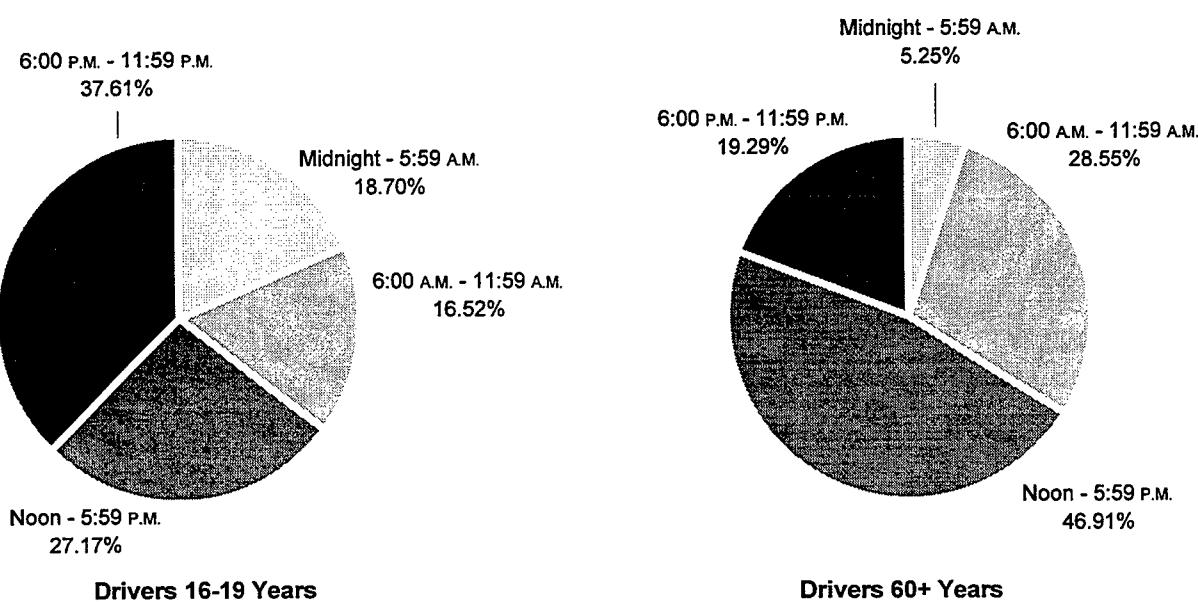
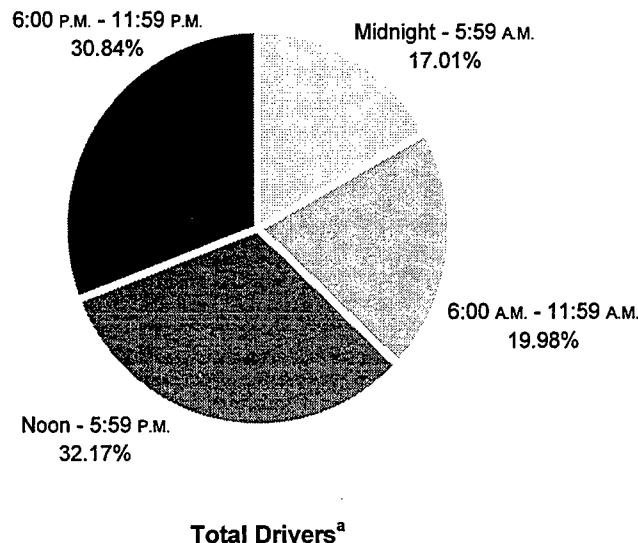
**Figure 33. Percentage of Teen and Senior Drivers in Fatal/Injury Collisions by Time of Day of Collision, California 1995**



<sup>a</sup> Excludes drivers under age 16 or for whom age or time of collision is not reported.

Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

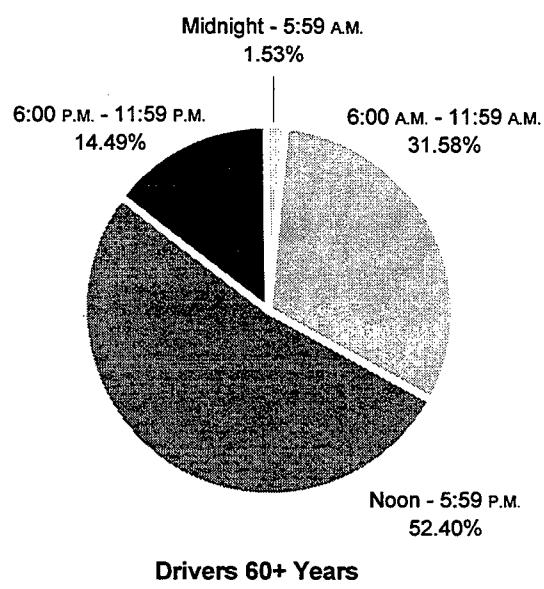
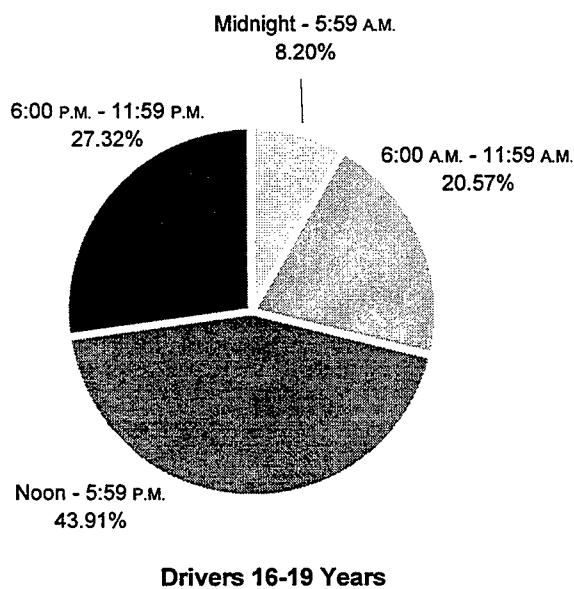
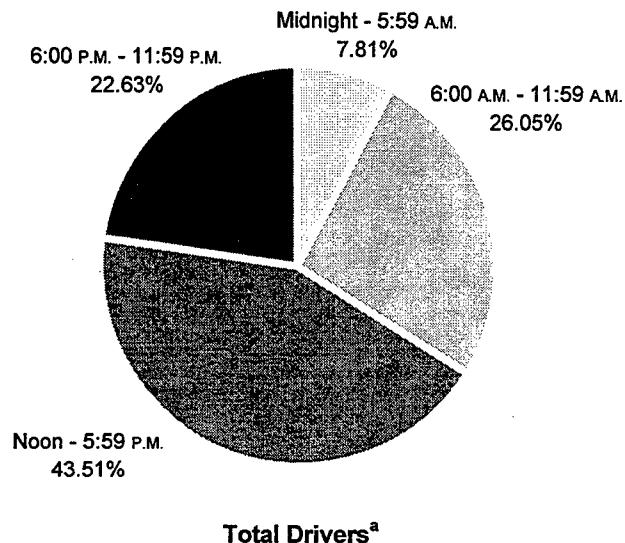
**Figure 34. Percentage of Teen and Senior Drivers in Fatal Collisions by Time of Day of Collision, California 1995**



<sup>a</sup> Excludes drivers under age 16 or for whom age or time of collision is not reported.

Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

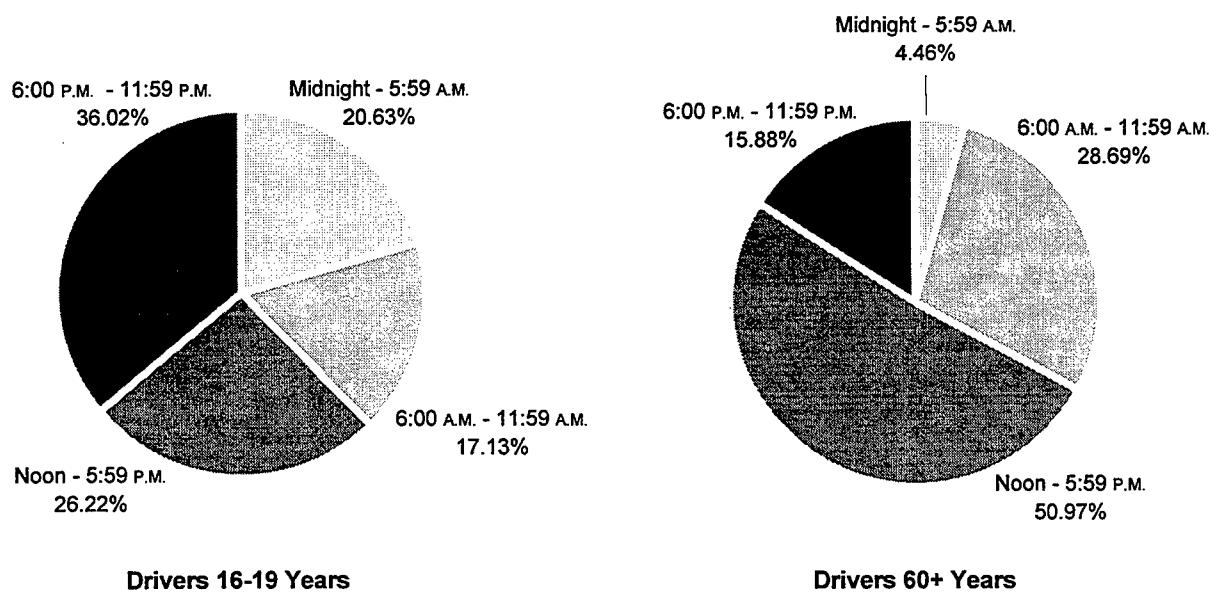
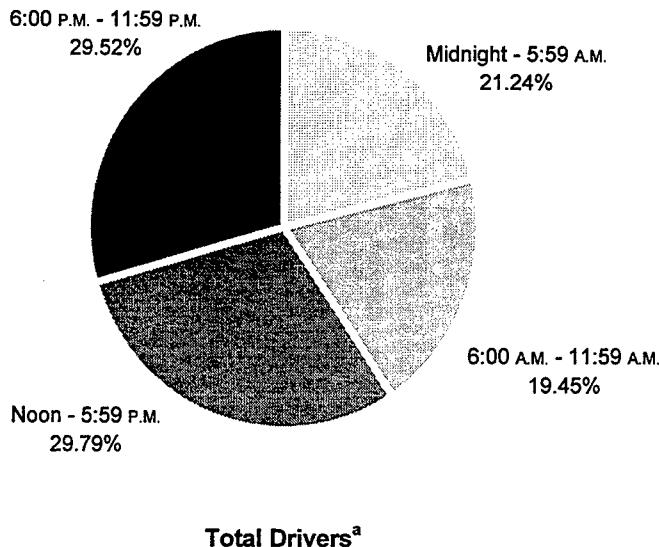
**Figure 35. Percentage of Teen and Senior Drivers At Fault in Fatal/Injury Collisions by Time of Day of Collision, California 1995**



<sup>a</sup>Excludes drivers under age 16 or for whom age or time of collision is not reported.

Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.

**Figure 36. Percentage of Teen and Senior Drivers At Fault in Fatal Collisions by Time of Day of Collision, California 1995**



<sup>a</sup>Excludes drivers under age 16 or for whom age or time of collision is not reported.

Source: California Highway Patrol, 1995 Statewide Integrated Traffic Records System, Sacramento, CA.



## SECTION 2

# RESEARCH AND COUNTERMEASURES

### YOUNG DRIVERS

#### Collision Involvement Factors

A number of causative or confounding variables have been examined in previous research to account for the overinvolvement of young drivers in traffic collisions. Included among these variables are personality structure and attitudinal traits such as risk-taking propensity, risk perception, driving inexperience and alcohol consumption.

#### Risk Taking and Risk Perception

Most evidence suggests that risk taking is a – if not *the* – major factor underlying the high collision rate among teens (Jonah, 1986). Compared to other male drivers, young male drivers are found to be more willing to take risks and to perceive hazardous situations as being less dangerous than they actually are (Finn and Bragg, 1986). Mathews and Moran (1986) similarly indicated that teens tend to underestimate the danger in high-risk driving situations; however, they overestimate the danger in low- to medium-risk situations.

Tränkle, Gleau and Metker (1990) documented changes in risk perception that come with age and experience, finding that young male drivers rate certain traffic situations – especially situations involving darkness, graded or curved roadways, and rural environments – as less risky than do middle-aged and older male drivers. In the same study, young female drivers rate only situations involving darkness and intersections as less dangerous than do middle-aged and older female drivers.

Although drivers under age 25 have the fastest simple reaction and choice reaction times (Quimby and Watts, 1981), they respond to filmed traffic hazards more slowly than middle-aged drivers. The study authors attributed this to the frequent failure by young drivers to recognize potentially hazardous situations.

Male drivers aged 18-24 perceive themselves as being less likely than other drivers their age to be involved in a collision, while other male drivers perceive their collision risk to be similar to that of their age peers (Finn and Bragg, 1986). This suggests that young male drivers overestimate their capabilities.

Simpson (1995) makes the point that the concept of risk taking is independent from that of risky driving. Risk taking does not necessarily result in risky driving, and risky driving may not result from risk taking. For example, a driver may engage in tire squealing as a result of risk-taking behavior, even though the behavior is not necessarily risky. On the other hand, some young drivers may engage in such risky driving behaviors as following too close, because their inexperience makes them less aware of the risks.

In a study of risk-taking behaviors not confined to the driving environment, Lang, Waller and Shope (1996) documented a significant relationship between single-vehicle crashes and the tendency toward cigarette smoking among young women drivers, and substance availability (cigarettes, smokeless tobacco, alcohol and marijuana), frequency of driving, alcohol misuse, and a tendency toward marijuana use among young male drivers. Race, alcohol misuse and having friends who use or talk about using alcohol and marijuana are also found to be significantly related to injury crashes among young women. Living arrangements (lived with parents or others), substance availability and a tendency toward marijuana use are related to injury crashes among young men.

Teens who engage in higher-risk activities outside the driving situation tend to have a higher incidence of traffic collision involvement, whether they are driving the vehicle or riding as a passenger (Beirness and Simpson, 1988). This suggests that risky driving may be part of a more general syndrome of risk-taking behavior. Williams and Wells (1995) found that among teens, deaths as passengers are nearly as common as deaths as drivers, and that passenger deaths as a percentage of passenger vehicle occupant deaths are nearly twice as high for teenagers (48%) as for older people (27%).

### **Driving Inexperience**

Levy (1990) found that driving experience, unadjusted for mileage, played a minor, but significant, role in the overinvolvement of teen drivers in fatal traffic collisions. In another study by Simpson and Mayhew (1992) that looked at the relationship between age, years of experience and accident rates for 20- and 30-year-old drivers, experience was found to be associated with decreased collision rates for both age groups. The authors suggested that some of the benefits of experience are counterbalanced by age-related risk factors, such as thrill seeking, peer pressure and feelings of immortality. For these reasons, the effects of age, adjusted for experience, were stronger than the

effects of experience, adjusted for age, for the range of ages studied.

### Alcohol

Alcohol consumption is another causal factor in the collision overinvolvement of teens. Being below the legal drinking age in most states (including California), teens are less likely than drivers in older age groups to drink and drive. But those who do drink and drive are at much greater risk of serious collisions than are older drivers who have the same concentrations of alcohol in their blood (Mayhew, Donelson, Beirness and Simpson, 1986; Simpson, 1985).

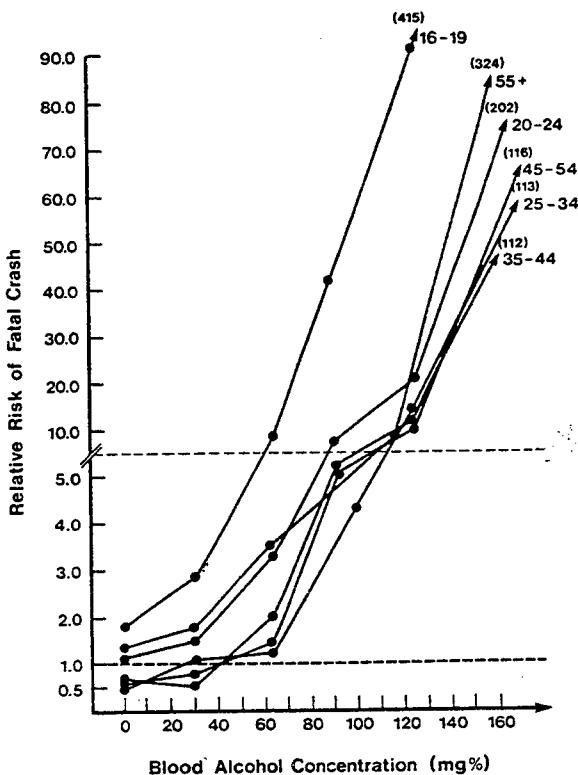
Earlier research indicates that young drivers are overinvolved in alcohol-related driving fatalities, in part because they are overrepresented among those who drive at night, when alcohol-caused collisions are more likely to occur. They are also more socially active than others, especially at night, and have more opportunities to drink and then drive (Carlson, 1972).

Teen drivers identified as had-been-drinking (HBD) have, on average, a lower blood alcohol concentration (BAC) than other HBD drivers (Zylman, 1973), possibly because young drivers learning to drive and learning to drink are at greater risk when participating in these activities at the same time. This suggests that they are more likely than other drivers to show impairment at relatively low BAC levels.

Figure 37 shows the relative risk of fatal crashes as a function of BAC and age. The plot, taken from a Canadian study by Simpson (1985), illustrates that:

- At all BAC levels, teens have a higher risk of a fatal crash than other age groups.
- As BAC increases, the relative risk of a fatal crash increases within each age group.
- Risk of a fatal crash rises with BAC more steeply for teens than for other age groups.

**Figure 37. Relative Risk of a Fatal Crash as a Function of BAC and Age**



Source: H. Simpson, 1985, Polydrug Effects and Traffic Safety, *Alcohol, Drugs, and Driving: Abstracts and Reviews*, 1(1-2), p. 23.

## Collision Countermeasures

Many jurisdictions have implemented countermeasures to improve driving practices and attitudes of young novice drivers. Key among these countermeasures are driver education and training, licensing changes, BAC limits and Curfew laws.

### Driver Education and Training

Harrington (1971) evaluated three types of countermeasures: (1) raising the licensing age to 18; (2) identifying the collision-prone driver prior to licensing; and (3) providing formal driver training and education. Although no alternative was very effective, there is some evidence that driver training reduces the rate of fatal/injury collisions for licensed female drivers. A more recent study in Oregon (Jones and McCormac, 1989) also found that while there is no overall evidence of a significant driver training effect, young women receiving behind-the-wheel driver training show a trend toward lower collision rates.

Dreyer and Janke (1979) studied randomly assigned high school students given, in addition to standard training components, eight hours of practice on an off-road driving range (same number of total training hours). The range group had significantly (33%) fewer total collisions during the year following the beginning of training, as compared to students undergoing standard training with no range practice. There was no difference in licensure rate or time to licensure. However, the sophisticated driving range used was very costly, and the authors acknowledge that the general use of such facilities might be infeasible.

Stock, Weaver, Ray, Brink and Sadof (1983) evaluated two types of high school driver training against a no-training condition and found significant (though small) collision and violation reductions for the training groups when the analysis is limited to those licensed during the first 6 months following training. However, this difference diminished over the next 18 months. Training was found to have caused earlier licensing and, consequently, increased collision exposure among participants in general (both licensed and unlicensed), which counteracted any overall traffic safety benefit of training. The tendency for driver training to increase licensure of teenagers is also documented in earlier studies by Robertson and Zador (1977) and Robertson (1980).

### **Provisional Licensing**

Assessing the Maryland Provisional License Program inaugurated in January 1979, McKnight, Hyle and Albrecht (1983) reported that nighttime driving restrictions failed to reduce collisions during the curfew hours. However, daytime collisions fell by 5% and traffic convictions declined 10% among young drivers operating on a provisional license.

In their study of California's Provisional Driver Licensing Program implemented in October 1983, Hagge and Marsh (1988) found, among other positive outcomes, evidence suggesting that provisional licensing reduced by 5.3% the rate of traffic collisions among the statewide population of 15-17-year-olds.

New Zealand and Victoria, Australia, have graduated licensing programs for novice drivers that gradually and systematically lift initial licensing restrictions (Traffic Injury Research Foundation of Canada, 1991). The Victoria program applies to all new drivers, whereas the New Zealand system applies to novice drivers under age 26. Firth and Perkins (1991) reported a significant reduction in collisions following New Zealand's program when comparing monthly collision frequencies for 15-19-year-olds with those for

the population aged 25 and above. Langley, Wagenaar and Begg (1996) found that the introduction of this program was followed by a substantial decrease in crash injuries among all ages, but the decrease was more pronounced among the 15-19-year-olds. Published data on the impact of Australia's program are not yet available (Traffic Injury Research Foundation of Canada, 1991).

The Canadian provinces of Ontario (Walker, 1996) and Nova Scotia (Vance, 1996) have also implemented graduated licensing programs, but no evaluation data are available on these programs either.

#### BAC Limits

Hingson, Heeren, Howland and Winter (1991) found lowering BAC limits for teen drivers in Maine, New Mexico, North Carolina and Wisconsin reduced nighttime fatal collisions among adolescents in these states.

The National Highway Traffic Safety Administration (NHTSA) evaluated a "zero-tolerance" law in Maryland that made it illegal for drivers under age 21 (i.e., below the legal "drinking age") to operate a motor vehicle at a BAC level of .02% or higher (cited in Kedjidjian, 1993). (The standard was set at .02% rather than zero because of practical measurement limitations.) NHTSA reported that, statewide, there was an 11% reduction in collisions involving drivers under 21 who had been drinking after "zero tolerance" went into effect. Additionally, NHTSA reported that in six Maryland test counties implementing public awareness campaigns, the number of alcohol-related traffic collisions involving young drivers dropped an additional 30% beyond the statewide reduction.

#### Driving Curfews

Analyzing data from three large cities with curfew ordinances limiting late-night activities in public places by persons under age 18, Preusser, Williams, Lund and Zador (1990) found a 23% reduction in motor vehicle injuries for 13-17-year-olds as passengers, drivers, pedestrians and bicyclists during the curfew hours.

In their study of four states with driving curfews, Preusser, Williams, Zador and Blomberg (1982) found that collisions during curfew hours involving 16-year-old drivers dropped 69% in Pennsylvania, 62% in New York, 40% in Maryland and 25% in Louisiana. The study also showed that longer curfew hours produce greater reductions in collisions involving young drivers.

## Conclusion

Countermeasures directed toward young drivers often result in only marginal reductions in collision rates. Perhaps the most important highway safety research question is why some youths are, and others are not, amenable to changing their driving behaviors in different contexts.

Peck (1985) offered the following rationale for the failure of driver training to result in demonstrable collision reduction:

*Risk perception and risk choice implicitly involve an attitude or sense of personal vulnerability and, in fact, recognition of vulnerability may be the single most important mechanism underlying risk taking .... By invoking "personal vulnerability" as a maturational characteristic which increases with age, one might explain why risky driving decreases substantially at age 25-30. Unless one has a sufficient sense, cognitively and affectively, of being vulnerable to catastrophic events, there is little motivation to drive cautiously and defensively. If this conjecture has any validity, it leads to the pessimistic conclusion that not much can be done to short-circuit the process. In other words, it may not be possible for any feasible countermeasure to make most 18-year-olds respond to the driving tasks like most 30-year-olds other than the passage of 12 years.* (p. 60)

Based on a review of current literature on age versus experience as related to risk of crash involvement, Mayhew and Simpson (1990) reached a conclusion that appears to substantiate Peck's conjecture. They found that increased experience is more likely to be related to decreased collision rates among elderly drivers than among younger drivers, with age being more important than driving experience in predicting collision risk among younger drivers, particularly males. The authors suggest that the negative effects of greater risk taking, aggressiveness, and competitiveness characteristic of young drivers, especially men, may actually counterbalance any positive effect of experience.

## SENIOR DRIVERS

### Collision Involvement Factors

A growing body of research exists on how age-related physical and cognitive changes affect driving skills and contribute to the increase in collision involvement in the older ages. Studies addressing the relationship between aging and collision risk have found that a substantial number of collisions involving senior drivers are at least partially attributable to worsening vision,

cognitive confusion and perception, medical impairments or other age-related physical and mental impairments (Transportation Research Board, 1988; U. S. Department of Transportation, 1989). Importantly, though, chronological age per se is not a reliable measure of collision risk. Older adults vary considerably in driving skills, physical/mental abilities, point of onset of decline and rate of decline.

### Vision

Worsening vision is a major factor contributing to the increase in collision rates in the older ages, since most of the sensory input required for driving is visual (Bailey and Sheedy, 1988). Numerous studies have determined that older adults typically have reduced peripheral vision, a decline in nighttime acuity and increased difficulty in accommodation (focusing on close objects). The vision of many elderly people has been characterized as roughly equivalent to what a young person with normal vision would see while wearing dark sunglasses at night (Allen, 1985).

Declines in visual acuity generally accelerate after age 50 (Corso, 1971), slowing the elderly driver's reaction to traffic signals, signs and other driving-related visual events. Older people also tend to perceive lower levels of light intensity, due to browning of the lens and reduction in the diameter of the pupil (Allen, 1985). As people age, they are less able to adapt to changes in light intensity (Kalish, 1982) or distinguish visual detail (Fozard, Wolf, Bell, McFarland and Podolsky, 1977). Both of these limitations create problems for older drivers when entering or exiting poorly lighted tunnels (Winter, 1985). Glare sensitivity, which increases between ages 40 and 70, causes slower recovery from headlights and other reflecting sources (Fozard et al., 1977).

Peripheral vision impairments also increase in the later years (Kalish, 1982). Drivers with impairments in peripheral vision have more self-reported collisions and make more driving errors in simulated driving than normally sighted drivers. In addition, collision risk increases as a function of severity of visual field loss (Szlyk, Severing and Fishman, 1991).

For all these reasons, elders commonly voluntarily limit or stop night driving and driving under conditions of reduced visibility (Planek, Condon and Fowler, 1968). In a more recent study, Kosnik, Sekuler and Kline (1990) questioned elderly people about problems they encounter in performing routine visual tasks and found that most of them admitted their visual deficiencies. Additionally, elders who had recently given up driving report more visual problems than their age peers who continue to drive.

**Cognition and Perception**

Driving involves a complex decision-making process which is influenced by numerous cognitive and perceptual factors. Many studies have found that the ability to process information slows as people age, making it more difficult for elderly drivers to perceive and react to hazardous driving situations.

With advancing age, people have greater difficulty in organizing information from multiple sources, due to declining short-term memory (Milone, 1985). Quimby and Watts (1981) found that elderly drivers have slower responses to filmed hazards than middle-aged drivers. They attribute this to elderly drivers' having a combination of slower motor functions and impaired perceptual and cognitive skills (i.e., difficulty both in identifying relevant cues and in ignoring irrelevant information).

With respect to visual attention, Owsley, Ball, Sloane, Roenker and Bruni (1991) measured the three primary mechanisms underlying a restricted useful field of view (UFOV): (1) reduced speed of processing visual information; (2) reduced ability to ignore distractors; and (3) reduced ability to divide attention. They found that drivers with a restricted UFOV have three to four times the collision risk, and are 15 times more likely to be involved in an intersection crash, than other drivers.

In a study involving vision testing of license renewal applicants in California, Hennessy (1995) found that poor performance on tests of two vision functions – contrast sensitivity and perceptual reaction time – are predictive of crashes for some driver groups, particularly drivers aged 70 or older and those with poor static acuity.

In examining collision culpability, Cooper found the overrepresentation of older drivers in at-fault collisions may be due largely to errors in perception, judgment, decision making, maneuvering, and reaction to hazards, even though almost all elderly drivers report their driving ability to be average or above average (Cooper, 1990).

**Reaction Time**

In assessing driving performance with an interactive computer-video, Schiff and Oldak (1993) found very little overall difference between age groups in response time when reacting to an expected event, but drivers aged 65 or older generally required significantly more time to respond when the event was unexpected.

**Medical Impairments**

With advancing age, drivers tend to have a greater frequency of medical problems that increase their collision risk or influence them to stop driving. Examples are dementia, cardiovascular disease, diabetes, stroke, episodes of loss of consciousness, Parkinson's disease, and ailments that affect flexibility, including arthritis and bursitis. Also, medications prescribed for some health problems can have an adverse effect on driving ability.

Elderly drivers with dementia are involved in over twice as many crashes and are more often judged to be at fault in collisions than their age peers without dementia. Additionally, the vast majority of dementia patients involved in crashes continue to drive, and over one-third of these drivers have at least one more crash (Cooper, Tallman, Tuokko and Beattie, 1993).

Stewart, Moore, Marks, May and Hale (1993) found that a brief loss of vision, macular degeneration (deterioration of central vision and color perception), stroke, Parkinsonism, and eye problems caused by declining general health are significantly related to cessation of driving. They also found that irregular heartbeat, cold feet or legs, bursitis, and protein in the urine (a common sign of renal disease) are significantly related to collision involvement for those who continue to drive.

Elderly drivers perform worse on maneuvers, vehicle handling, safe practices, observing, and driver processing (i.e., gap selection, lane changes and speed control) compared to younger drivers. This difference in performance is due largely to elders' loss of joint and skeletal flexibility, particularly in the shoulders, torso and neck (Shaffron, Ostrow and McPherson, 1991). Fortunately, many older drivers can improve shoulder flexibility and trunk rotation through exercise (Ostrow, Shaffron and McPherson, 1992).

**Collision Countermeasures**

Although many elderly drivers have deficiencies that impair their driving, most are able to effectively limit their collision risk by driving more slowly and cautiously and by limiting the amount and conditions of their driving. However, if not adequately compensated for, these deficiencies do increase collision liability. This, together with the great increase that is projected in the number of elderly drivers, has led to proposals and to the implementation of collision countermeasure programs targeting older drivers. Included among these countermeasures are driver

improvement programs, licensing controls, and vehicle and highway engineering changes.

**Driver Improvement**

Several states, including California, have initiated mature driver improvement (MDI) programs that allow drivers aged 55 and above to update their driving skills by completing a driver improvement course. A series of annual studies of California's program (Berube, 1994; Berube and Hagge, 1990; Foster, 1991, 1992; Stylos and Janke, 1989) have shown no consistent evidence that MDI participants represent a lower collision risk than corresponding comparison drivers. However, the MDI program may have reduced the rate of traffic violation convictions of course graduates. A follow-up study by Berube (1995) found evidence that home-study MDI courses are no less effective than in-person MDI courses in reducing rates of fatal/injury crashes or total citations.

McKnight, Simone and Weidman (1982) evaluated a training program for elderly drivers in four states, including California. The program content included such topics as rules of the road, adverse driving conditions and common hazards, elderly driver characteristics and collision experience, and physical conditions that relate to driving performance (e.g., vision, hearing, reaction time and medication). The program was effective in increasing knowledge of safe driving practices, traffic rules and regulations, hazardous driving situations and the effects of aging on driving. However, no significant differences in collision and violation rates were found between the training and control groups.

**Driver Testing**

Lange and McKnight (in press) found that drivers tested in states requiring age-based road testing have significantly lower total collision-involvement rates than their untested peers in neighboring states without age-based license testing. However, no significant difference is found between the groups' rates of single-vehicle collisions.

Levy, Vernick and Howard (1995) found that states with license renewal procedures that include vision tests are associated with fewer fatal crashes for drivers 70 or older. However, states requiring knowledge tests and vision tests only for senior drivers do not have lower rates of fatal collisions involving older drivers than other states.

In an interim report of a study partially funded by the National Highway Traffic Safety Administration, Janke and Eberhard (in press) stated that most nondriving tests used, as well as road tests,

distinguish elderly drivers referred to the DMV for reexamination from volunteers of similar age. Moreover, road test scores are moderately predictable from nondriving (simulator) test scores. This in-progress study has the goal of developing a model test battery for use by licensing agencies in identifying impaired older drivers and evaluating their competency to drive. Its emphasis is on dementia and combinations of medical conditions resulting in "frailty." Of the shorter, simpler tests, the ones showing most promise were: (1) the Pelli-Robson Chart, measuring low-contrast static acuity; (2) Auto-Trails, an automated visual scanning test in which examinees must touch, in numerical order as rapidly as possible, 14 numbers randomly arranged against the background of a driving scene; and (3) an observational measure made by the test administrator of the number of observable "problems" shown by the driver, such as tremors, impaired balance or inability to understand test instructions.

California DMV administers a special drive test (SDT) to applicants who cannot pass the regular drive test, have a known or suspected physical or mental condition that may affect their driving, or for some other reason are believed to have diminished driving abilities. Hagge (1995) found that drivers referred for an SDT had prior citation and collision rates two and three times higher, respectively, than licensed drivers of the same age and sex in the general driving population. The same study also found that the SDT is not effective in discriminating between collision-free and collision-involved drivers. The California DMV is currently in the process of replacing the SDT with a more reliable and valid drive test modeled after the Driving Performance Evaluation road test developed for novice drivers (Hagge, 1994; Romanowicz and Hagge, 1995).

#### **Mail Renewals**

Kelsey, Janke, Peck and Ratz (1985) found that clean-record drivers aged 70 or older who were offered a two-year license extension by mail, thereby avoiding all renewal tests, had significantly *fewer* crashes than a comparison group of age peers who were required to go to DMV field offices and take these tests. At the very least, this finding indicates no adverse effect of omitting renewal testing for elderly drivers, given the tests then current. (It should be noted that considerations other than driving performance led to the placing of an age ceiling of 69 on eligibility for license extension [or renewal] by mail in California.)

#### **Graded Licensing**

Malfetti and Winter (1990) proposed guidelines for a graded license for selected elderly drivers that would be similar to a restricted license and would be adapted to the driver's mode of

living, driving needs and driving ability. The graded license would allow impaired elders to operate a motor vehicle only under conditions that would not exceed their abilities. This system would identify and treat high-risk drivers without penalizing safe drivers of the same age.

**Driving Record**

Gebers and Peck (1992) found that a record of collisions and convictions is associated with a higher risk of subsequent collisions for elderly drivers. The authors recommend that the initiation of license control actions against such drivers be based on fewer driver record incidents than for younger drivers. They also suggest that a point system based on age could serve as an early warning system for identifying drivers who may have physical or mental problems requiring investigation and possible reexamination.

**Self-Reports**

Janke (1980) found that the collision involvement rate of self-reported medically impaired drivers is significantly higher than that of a random sample of all drivers. Additionally, medically impaired drivers who report having lapses of consciousness have a collision involvement rate greater than the impaired group as a whole. Results of this study suggest that requiring driver license applicants to report whether they have an existing medical condition has a beneficial traffic safety effect in identifying high risk drivers.

**Medical Review**

Popkin, Stewart and Lacey (1983) examined the impact of an initial medical review on the driver records of individuals identified with medical impairments. The results indicate that persons in most impairment groups (cardiovascular diseases, diabetes/endocrine illnesses, vision impairments, and mental problems) are at a significantly lower collision risk following the medical review.

**Vehicle/Highway Factors**

The human-factors problems of aging may, to some extent, have technological solutions. Since all drivers, regardless of age, sometimes function well below an optimal level of mental alertness and physical efficiency, it can be expected that technological advances designed to counteract the impairments of aging will make the driving task easier and safer for all drivers (Malfetti, 1985).

Improvements in the driving environment, such as better lighting and clearer, more strategically placed signs and signals, would go a long way toward making the roadway safer for elderly drivers (Allen, 1985).

A Highway Safety Forum sponsored by the National Safety Council in 1989 resulted in recommendations to enhance vehicle controls and displays, improve occupant protection, and perhaps tailor vehicles—“corrective cars”—especially to the response characteristics of older adults (Rogers, 1989). Also recommended are larger letter sizes on signs and redundant use of traffic signs for drivers with memory impairment (Michael, 1989).

### **Conclusion**

A longitudinal study by Evans (1993) found that fatality rates for male drivers of a given age systematically decline with increasing birth year (e.g., 20-year-olds born in 1970 have a lower fatality rate than 20-year-olds born in 1960). Although the same decline is not found for female drivers, Evans expects this trend to emerge as the percentage of women with driver licenses approaches that for men. He predicts that the fatality rates of a group of presently young male drivers will generally decline as they age and will not show any measurable increase until they reach about 70 years of age. Evans (1991) expects the risk level of drivers in general to decline in response to positive changes in factors that contribute to traffic safety, such as roadway and vehicle designs, legislation, law enforcement, education, social norms, and medical and emergency care. He also speculates that additional improvements in highway safety will come from behavioral changes regarding hygiene, diet, exercise, and alcohol and tobacco use.

Another study by Janke (1993) provides evidence for a marked decline in fatal/injury collision risk for the oldest (90+) drivers over a period of 10 years. This may be taken as supporting the commonly expressed opinion that “elderly people are not as old as they used to be.”

## BIBLIOGRAPHY

- Allen, M. J. (1985). Vision of the elderly driver: Implications for vehicle and highway design and for driver testing. In J. Malfetti (Ed.), *Drivers 55+: Proceedings of the Older Driver Colloquium* (pp. 1-7). Orlando, FL.
- Bailey, I. L. & Sheedy, J. E. (1988). Vision screening for driver licensure. In *Transportation in an aging society: Improving mobility and safety for elderly persons*, 2 (Special Report No. 28), pp. 294-324. Washington, DC: Transportation Research Board.
- Beirness, D. J. & Simpson, H. M. (1988). Lifestyle correlates of risky driving and accident involvement among youth. *Alcohol, Drugs and Driving*, 4(3-4), 193-204.
- Berube, E. (1994). *Annual tabulations of mature driver program driving record comparisons - 1993* (Report No. 140). Sacramento: California Department of Motor Vehicles.
- Berube, E. (1995). *Evaluation of mature driver improvement program home study courses* (Report No. 157). Sacramento: California Department of Motor Vehicles.
- Berube, E. & Hagge, R. A. (1990). *Annual tabulations of mature driver program driving record comparisons - 1990* (Report No. 125). Sacramento: California Department of Motor Vehicles.
- Brainin, P. A. (1980). *Safety and mobility issues in licensing education of elderly drivers* (Report No. DOT HS-805 492). Darien, CT: Dunlap and Associates.
- California Business, Transportation and Housing Agency. (1985). *1984 accident data on California state highways (road miles, travel, accidents, accident rates)*. Sacramento: Department of Transportation, Division of Traffic Engineering.
- California Department of Finance. (Undated). *1981 and 1985 projected total population of California*. Sacramento: Author.
- California Department of Finance. (1995). *Projected total population of California counties: 1990-2040* (Report 93 P-1). Sacramento: Author.
- California Department of Justice. (1996). *1995 statewide criminal justice profile*. Sacramento: Author.
- California Department of Motor Vehicles. (1981-1995). *Age and sex report* (mid-year reports). Sacramento: Author.
- California Highway Patrol. (1982-1996). *Annual reports of fatal and injury motor vehicle traffic accidents* (Volumes 1981-1995). Sacramento: Author.
- Carlson, W. L. (1972). Alcohol usage of the nighttime driver. *Journal of Safety Research*, 4, 12-25.

- Cooper, P. J. (1990). Elderly drivers' views of self and driving in relation to the evidence of accident data. *Journal of Safety Research*, 21, 103-113.
- Cooper, P. J., Tallman, K., Tuokko, H. & Beattie, B. L. (1993). Vehicle crash involvement and cognitive deficit in elderly drivers. *Journal of Safety Research*, 24, 9-17.
- Corso, J. F. (1971). Sensory processes and age effects in normal adults. *Journal of Gerontology*, 26, 90-105.
- Dreyer, D. R. & Janke, M. K. (1979). The effects of range vs. non-range driver training on the accident and conviction frequencies of young drivers. *Accident Analysis and Prevention*, 11, 179-198.
- Evans, L. (1991). Older-driver risks to themselves and to other road users. *Transportation Research Record*, 1325, 34-41.
- Evans, L. (1991). *Traffic safety and the driver*. New York: Van Nostrand Reinhold.
- Evans, L. (1993). How safe were today's elderly drivers when they were younger? *American Journal of Epidemiology*, 137(7).
- Federal Highway Administration. (1991). *Highway statistics*. Washington, DC: U.S. Department of Transportation.
- Federal Highway Administration. (1992). *1990 nationwide personal transportation survey: Travel behavior issues in the 90's*. Washington, DC: U.S. Department of Transportation.
- Federal Highway Administration. (1993). *1990 nationwide personal transportation survey databook*. Washington, DC: U.S. Department of Transportation.
- Finn, P. & Bragg, B. W. E. (1986). Perception of the risk of an accident by young and elderly drivers. *Accident Analysis and Prevention*, 18(4), 289-298.
- Firth, W. J. & Perkins, W. A. (1991). *The New Zealand graduated driver licensing system*. Wellington, New Zealand: Ministry of Transport, Land Transport Division.
- Foster, K. (1991). *Annual tabulations of mature driver program driving record comparisons - 1991* (Report No. 130). Sacramento: California Department of Motor Vehicles.
- Foster, K. (1992). *Annual tabulations of mature driver program driving record comparisons - 1992* (Report No. 136). Sacramento: California Department of Motor Vehicles.
- Fozard, J. L., Wolf, E., Bell, B., McFarland, R. A. & Podolsky, S. (1977). Visual perception and communication. In J. E. Birren and K. W. Schaie (Eds.), *Handbook of the psychology of aging* (pp. 497-534). New York: Van Nostrand Reinhold Co.

- Gebers, M. A. (1990). *Traffic conviction and accident-record facts* (Report No. 127). Sacramento: California Department of Motor Vehicles.
- Gebers, M. A. & Peck, R. C. (1992). The identification of high-risk elderly drivers through age-mediated point systems. *Journal of Safety Research*, 23, 81-93.
- Gebers, M. A., Romanowicz, P. A. & McKenzie, D. M. (1993). *Teen and senior drivers* (Report No. 141). Sacramento: California Department of Motor Vehicles.
- Hagge, R. A. (1994). *The California driver performance evaluation project: An evaluation of a new driver licensing road test*. Sacramento: California Department of Motor Vehicles.
- Hagge, R. A. (1995). *Evaluation of California's special drive test program* (Report No. 160). Sacramento: California Department of Motor Vehicles.
- Hagge, R. A. & Marsh, W. C. (1988). *The traffic safety impact of provisional licensing* (Report No. 116). Sacramento: California Department of Motor Vehicles.
- Harrington, D. M. (1971). *The young driver follow-up study: An evaluation of the role of human factors in the first four years of driving* (Report No. 38). Sacramento: California Department of Motor Vehicles.
- Hennessy, D. F. (1995). *Vision testing of renewal applicants: Crashes predicted when compensation for impairment is inadequate* (Report No. 152). Sacramento: California Department of Motor Vehicles.
- Hildebrand, E. & Wilson, F. R. (1990). *An assessment of elderly driver accident patterns*. New Brunswick: University of New Brunswick.
- Hingson, R., Heeren, T., Howland, J. & Winter, M. (1991). Reduced BAC limits for young people (impact on night fatal crashes). *Alcohol, Drugs and Driving*, 7(2), 117-127.
- Huston, R. E. (1986). *Teen driver facts* (Report No. 81 [2nd ed.]). Sacramento: California Department of Motor Vehicles.
- Huston, R. E. & Janke, M. K. (1986). *Senior driver facts* (Report No. 82 [2nd ed.]). Sacramento: California Department of Motor Vehicles.
- Janke, M. K. (1980). *Accident records of self-reporting medically impaired drivers*. Sacramento: California Department of Motor Vehicles.
- Janke, M. K. (1991). Accidents, mileage, and the exaggeration of risk. *Accident Analysis and Prevention*, 23(2-3), 183-188.
- Janke, M. K. (1993). *For traffic safety purposes, when does old age start?* Unpublished manuscript. Sacramento: California Department of Motor Vehicles.

- Janke, M. K. & Eberhard, J.W. (In press). Assessing medically impaired older drivers in a licensing agency setting. *Accident Analysis and Prevention*.
- Johnson, C. A. & Keltner, J. L. (1983). Incidence of visual field loss in 20,000 eyes and its relationship to driving performance. *Archives of Ophthalmology*, 101, 371-375.
- Jonah, B. A. (1986). Accident risk and risk-taking behavior among young drivers. *Accident Analysis and Prevention*, 18(4), 255-271.
- Jones, B. & McCormac, K. (1989). *Effectiveness of student driver training in Oregon: Driving record comparisons after one year*. Salem: Oregon Motor Vehicles Division.
- Kalish, R. A. (1982). *Late adulthood: Perspective on human development* (2nd ed.). Monterey, CA: Brooks/Cole.
- Kedjidian, C. B. (1993). Get young drivers BAC to zero. *Traffic Safety*, 93(5), 16-18.
- Kelsey, S. L., Janke, M. K., Peck, R. C. & Ratz, M. (1985). *License extensions for clean-record drivers: A four-year follow-up* (Report No. 93). Sacramento: California Department of Motor Vehicles.
- Kosnik, W. D., Sekuler, R. & Kline, D. W. (1990). Self-reported visual problems of elderly drivers. *Human Factors*, 32(5), 597-608.
- Lang, S. W., Waller, P. F. & Shope, J. T. (1996). Adolescent driving: Characteristics associated with single-vehicle and injury crashes. *Journal of Safety Research*, 27(4), 241-257.
- Lange, J. E. & McKnight, A. J. (In press). *Age-based road testing policy evaluation*.
- Langley, J. D., Wagenaar, A. C. & Begg, O. J. (1996). An evaluation of the New Zealand graduated driver license system. *Accident Analysis and Prevention*, 28(2), 139-146.
- Levy, D. T. (1990). Youth and traffic safety: The effects of driving age, experience, and education. *Accident Analysis and Prevention*, 22(4), 327-334.
- Levy, D. T., Vernick, J. S. & Howard, K. A. (1995). Relationship between driver's license renewal policies and fatal crashes involving drivers 70 years or older. *Journal of American Medical Association*, 274, 1026-1030.
- Malfetti, J. L. (Ed.). (1985). *Drivers 55+: Proceedings of the Older Driver Colloquium*. Orlando, FL.
- Malfetti, J. L. & Winter, D. J. (1990). *A graded license for special elderly drivers: Premise and guidelines*. Washington, DC: AAA Foundation for Traffic Safety.
- Matthews, M. L. & Moran, A. R. (1986). Age differences in male drivers' perception of accident risk: The role of perceived driving ability. *Accident Analysis and Prevention*, 18(4), 299-313.

- Mayhew, D. R., Donelson, A. C., Beirness, D. J. & Simpson, H. M. (1986). Youth, alcohol, and relative risk of crash involvement. *Accident Analysis and Prevention*, 18(4), 273-287.
- Mayhew, D. R. & Simpson, H. M. (1990). *New to the road. Young drivers and novice drivers: Similar problems and solutions?* Ottawa, Ontario: Traffic Injury Research Foundation.
- McKelvey, F. X. & Stamatiadis, N. (1989). *Highway accident patterns in Michigan related to elderly drivers* (Paper No. 88-0374). East Lansing: Michigan State University, Department of Civil and Environmental Engineering.
- McKnight, A. J., Hyle, P. & Albrecht, L. (1983). *Youth license control demonstration project* (Report No. DOT HS-806 616). Washington, DC: National Highway Traffic Safety Administration.
- McKnight, A. J., Simone, G. A. & Weidman, J. R. (1982). *Elderly driver retraining* (Report No. DOT HS-806 336). Alexandria, VA: National Public Services Research Institute.
- Michael, H. L. (1989). Roadway environment and elderly drivers. In *Commitment to action: Conclusions and recommendations of the Highway Safety Forum on Older Drivers and Pedestrians and Younger Drivers*, Linthicum, Maryland. Chicago, IL: National Safety Council.
- Milone, A. M. (1985). Training and retraining the elderly driver. In J. Malfetti (Ed.), *Drivers 55+: Proceedings of the Older Driver Colloquium* (pp. 38-44). Orlando, FL.
- National Highway Traffic Safety Administration. (1993). *Addressing the safety issues related to younger and older drivers: A report to Congress January 19, 1993 on the research agenda of the National Highway Traffic Safety Administration*. Washington, DC: U.S. Department of Transportation.
- National Safety Council. (1996). *Accident facts, 1995 edition*. Chicago, IL: Author.
- Ostrow, A., Shaffron, P. & McPherson, K. (1992). The effects of a joint rate-of-motion physical fitness training program on the automobile driving skill of elderly adults. *Journal of Safety Research*, 23, 207-219.
- Owsley, C., Ball, K., Sloane, M. E., Roenker, D. L. & Bruni, J. R. (1991). Visual/cognitive correlates of vehicle accidents in elderly drivers. *Psychology and Aging*, 6, 403-415.
- Peck, R. C. (1985). The role of youth in traffic accidents: A review of past and current California data. In H. Moskowitz (Ed.), *Alcohol, Drugs and Driving: Abstracts and Reviews*, 1(1-2), 45-68.
- Planek, T., Condon, M. & Fowler, R. (1968). *An investigation of the problems and opinions of aged drivers* (Report No. 5/68). Chicago: National Safety Council.

- Popkin, C. L., Stewart, J. R. & Lacey, J. H. (1983). An examination of the driving performance of medically evaluated drivers. *Proceedings of the Twenty-Seventh Conference of the American Association for Automotive Medicine* (pp. 263-274). San Antonio, TX: American Association for Automotive Medicine.
- Preusser, D. F., Williams, A. F., Lund, A. K. & Zador, P. L. (1990). *City curfew ordinances and teenage motor vehicle injury*. Norwalk, CT: Dunlap and Associates.
- Preusser, D. F., Williams, A. F., Zador, P. L. & Blomberg, R. D. (1982). *The effect of curfew laws on motor vehicle crashes*. Washington, DC: Insurance Institute for Highway Safety.
- Quimby, A. R. & Watts, G. R. (1981). *Human factors and driving performance* (Report No. 1004). Berkshire, England: Transport and Road Research Laboratory.
- Research Triangle Institute. (1991). *1990 Nationwide Personal Transportation Survey: User's guide to the public use tapes*. Washington, D.C.: U.S. Department of Transportation, Federal Highway Administration.
- Robertson, L. S. (1980). Crash involvement of teenaged drivers when driver education is eliminated from high school. *American Journal of Public Health*, 70(6), 599-603.
- Robertson, L. S. & Zador, P. (1977). *Driver education and fatal crash involvement of teenaged drivers*. Washington, DC: Insurance Institute for Highway Safety.
- Rogers, R. (1989). Vehicle design and elderly drivers. In *Commitment to action: Conclusions and recommendations of the Highway Safety Forum on Older Drivers and Pedestrians and Younger Drivers, Linthicum, Maryland*. Chicago, IL: National Safety Council.
- Romanowicz, P. A. & Gebers, M. A. (1990). *Teen and senior drivers* (Report No. 126). Sacramento: California Department of Motor Vehicles.
- Romanowicz, P. A. & Hagge, R. A. (1995). *An evaluation of the validity of California's driving performance evaluation road test* (Report No. 154). Sacramento: California Department of Motor Vehicles.
- Schiff, W. & Oldak, R. (1993). *Functional screening of elderly drivers using interactive computer-video scenarios*. Washington, DC: AAA Foundation for Traffic Safety.
- Shaffron, P., Ostrow, A. & McPherson, K. (1991). Older driver performance and joint flexibility. *Journal of Traffic Safety Education*, 39(2), 10-15.
- Simpson, H. M. (1985). Polydrug effects and traffic safety. In H. Moskowitz (Ed.), *Alcohol, Drugs and Driving: Abstracts and Reviews*, 1(1-2), 17-44.

- Simpson, H. M. (1995). Summary of key findings: Research and information needs, program and policy priorities. In H. Simpson (Ed.), *Proceedings of the Conference on New to the Road: Reducing the Risks for Young Motorists* (pp. 1-17). Los Angeles: Youth Enhancement Service, University of California.
- Simpson, H. M. & Mayhew, D. R. (1992). *Reducing the risk for new drivers: A graduated licensing system for British Columbia*. Victoria, B.C.: Motor Vehicle Branch, Ministry of the Attorney General.
- Stewart, R. B., Moore, M. T., Marks, R. G., May, F. E. & Hale, W. E. (1993). *Driving cessation and accidents in the elderly: An analysis of symptoms, diseases, cognitive dysfunction and medications*. Washington, DC: AAA Foundation for Traffic Safety.
- Stock, J. R., Weaver, J. K., Ray, H. W., Brink, J. R. & Sadof, M. G. (1983). *Evaluation of safe performance secondary school driver education curriculum demonstration project* (Report No. DOT HS-806 568). Washington, DC: National Highway Traffic Safety Administration.
- Stylos, L. & Janke, M. K. (1989). *Annual tabulations of mature driver program driving record comparisons - 1989* (Report No. 119). Sacramento: California Department of Motor Vehicles.
- Szlyk, J. P., Severing, K. & Fishman, G. A. (1991). *Peripheral visual field loss and driving performance*. Washington, DC: AAA Foundation for Traffic Safety.
- Traffic Injury Research Foundation of Canada. (1991). *New to the road: Prevention measures of young or novice drivers* (pp. 24-29). Halifax, Nova Scotia: Insurance Bureau of Canada.
- Tränkle, U., Gelau, C. & Metker, T. (1990). Risk perception and age-specific accidents of young drivers. *Accident Analysis and Prevention*, 22(2), 119-125.
- Transportation Research Board, National Research Council. (1988). *Transportation in an aging society: Improving mobility and safety for elderly drivers*, 1(Special Report 218). Washington, DC: Author.
- U. S. Department of Transportation. (1989). *Conference on research and development needed to improve safety and mobility of older drivers*. Bethesda, MD: Author.
- Vance, J. (1996). Graduated driver licensing in Nova Scotia. *Transportation Research Circular*, 458, 36-39.
- Walker, M. (1996). The Ontario experience with graduated licensing. *Transportation Research Circular*, 458, 31-35.
- Williams, A. F. & Carsten, O. (1989). Driver age and crash involvement. *American Journal of Public Health*, 79, 326-327.

- Williams, A. R. & Wells, J. K. (1995). Deaths of teenagers as motor-vehicle passengers. *Journal of Safety Research*, 26(3), 161-167.
- Winter, D. (1985). Learning and motivational characteristics of elderly people pertaining to traffic safety. In J. Malfetti (Ed.), *Drivers 55+: Proceedings of the Older Driver Colloquium* (pp. 77-86). Orlando, FL.
- Zylman, R. (1973). Youth, alcohol, and collision involvement. *Journal of Safety Research*, 5(2), 58-72.

## APPENDIX A

### STATISTICAL CURVE SMOOTHING TECHNIQUE

The mileage data presented in Section 1 are estimates derived by Gebers, Romanowicz and McKenzie (1993) by applying a smoothing technique to California data collected in the 1990 Nationwide Personal Transportation Survey (NPTS) conducted by the Federal Highway Administration. Upon examining the statewide age/sex mileage rates from the NPTS, Gebers et al. determined that the data, for each of the sexes separately as well as combined, could be best described as reflecting a cubic polynomial trend. A cubic trend describes a relationship in which there are two "bends" in the data. Therefore, they decided to apply curvilinear regression models to the data to obtain "smoothed" mileage estimates for each age and sex group. The advantages of this approach over using the raw age group means is that the estimates tend to be more accurate and stable.

The following polynomial regression equations were applied to the NPTS data to obtain the estimated mileage shown in Table 10 and Figure 13 (see Section 1). Figure 38 plots the actual and modeled mileage rates for males and females combined.

$$\text{Estimated mileage for both sexes} = 7,966.07 + 3,680.11(X) - 477.01(X^2) + 13.91(X^3)$$

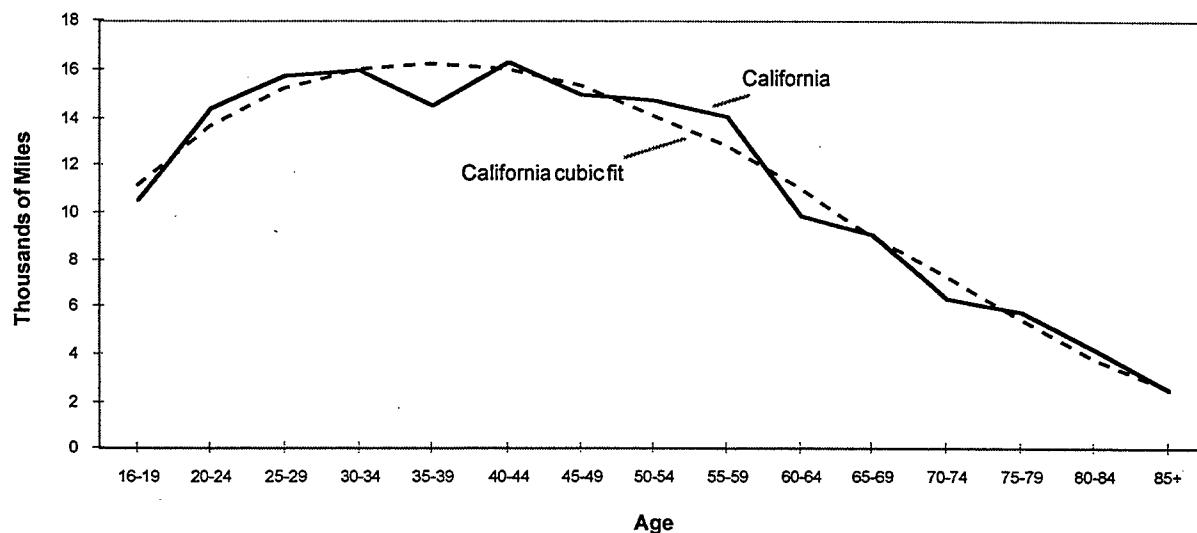
$$\text{Estimated mileage for males} = 9,336.73 + 4,109.20(X) - 423.11(X^2) + 6.61(X^3)$$

$$\text{Estimated mileage for females} = 6,483.70 + 3,043.18(X) - 471.73(X^2) + 17.18(X^3)$$

where, X is an integer representing a specific observation point or age group (identified on the abscissa or horizontal axis of Figure 38); and  $X^2$  and  $X^3$  are the values of X raised to the 2nd and 3rd powers, respectively.

For example, the estimated mileage rate for males aged 30-34 (the fourth age group) is computed as follows:  $9,336.73 + 4,109.20(4) - 423.11(16) + 6.61(64) = 19,427$  miles.

The small number of male and female licensed drivers within the older age groups in California necessitated collapsing the data into a 75 or older category for the separate sexes. To obtain mileage estimates for total drivers in the older five-year age groups (i.e., 75-79, 80-84 and 85 or older), the national data were substituted for the sparser California data.

**Figure 38. Actual and Modeled Average Annual Miles Driven by Age, California 1990**

Note: Mileage estimates are based on data from Federal Highway Administration, 1992, 1990 Nationwide Personal Transportation Survey: *Travel Behavior Issues in the 90's*. Washington, DC: U.S. Department of Transportation.

Source: Gebers, Romanowicz and McKenzie (1993), Teen and Senior Drivers, Sacramento: CA Department of Motor Vehicles.