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# Understanding Emerging Motorcyclist Segments in Crashes using Florida Crash Data and Statewide Survey

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**Abstract**

The United States experienced a continued sharp increase in motorcycle fatalities between 1997 and 2008, with a 9% average annual increase, which resulted in a rapid doubling of motorcycle fatalities within a decade. After a major decline in both the number of fatalities and the fatality rate between 2008 and 2009, motorcycle fatalities and fatality rates have been fluctuating. It was discovered that the demographics of motorcyclists involved in fatal motorcycle crashes have changed because of an increase in the number of motorcyclists under age 30 and over age 50 during the past 10 years. As a result, motorcyclists in the United States can be clustered into three distinct segments by age in crash experiences. This study used motorcycle crash data in Florida that observed similar demographic changes and explored characteristics of the three segments. Descriptive analyses including Chi-square tests showed that each segment had different crash outcomes and different levels of exposure to common risk factors. Crash injury models were developed to understand variables that increase the level of injury severity in each segment. A statewide survey was completed to explore the sociodemographic characteristics of the three motorcyclist segments in Florida, which often are not available through crash data. Overall, the three motorcycle segments identified in this study have unique riding characteristics and crash outcomes. This is essential information for developing and managing motorcycle safety programs in an effective and efficient manner.

The United States experienced a continued sharp increase in motorcycle fatalities between 1997 and 2008, with a 9% average annual increase, which resulted in a rapid doubling of motorcycle fatalities within a decade. Although the United States also observed a somewhat similar increasing trend in motorcycle registrations during the same period, the rate of increase in motorcycle fatalities far exceeded the rate of increase in motorcycle registrations. As a result, motorcycle fatalities per 100,000 registered motorcycles increased from 55 fatalities in 1996 to 69 fatalities in 2008. As shown in Figure 1, a major decline in motorcycle fatalities was observed in both the number of fatalities and the fatality rate between 2008 and 2009, which also coincided with a recession in the US economy. Since the decline, motorcycle fatalities and fatality rates in the United States have been fluctuating, but it is notable that motorcycles have consistently represented 14% of motor-vehicle fatalities for the past 5 years. During the same period, motorcycles represented 3% of all annual motor-vehicle registrations and accounted for less than 1% of yearly vehicle miles traveled (VMT). (*1*)

Although motorcycles remain one of the focus areas in the Strategic Highway Safety Plan (SHSP) in many states, it is challenging to promote motorcycle safety in an effective and efficient manner for various reasons, including limited resources. First, it is well-known that motorcycles are vehicles with significant inherited risk compared to passenger cars. Motorcycles provide very limited protection to their occupant(s), and motorcyclists often are ejected from the vehicle in traffic crashes. Therefore, efforts to improve motorcycle safety in the United States often focus on improving motorcyclist skills, attitudes, and behaviors.

Second, motorcyclists represent a small portion of the motoring public in the United States; however, it is a group that has a well-developed and diverse subgroup culture. Therefore, it is important to comprehend various motorcycling population segments that are highly associated with motorcycle type and unique values to develop

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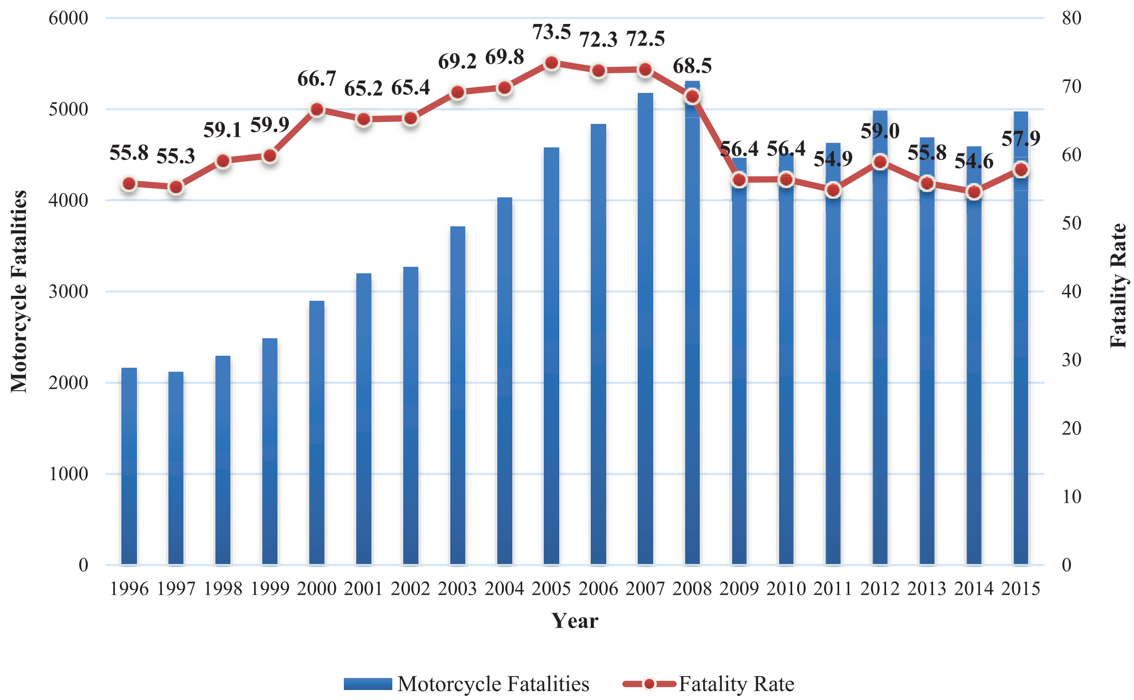


**Figure 1.** Motorcycle fatalities and fatality rates (per 100,000 registered vehicles) in the United States.

effective behavioral safety intervention programs for motorcyclists. Third, the demographics of motorcyclists who have crashed in the United States are changing over time, which may require a timely update of messages and intervention approaches. Figure 2 shows two sets of three years of motorcycle fatalities in the United States by age for 2003–2005 and 2013–2015. Although there was a slight change in the total number of motorcycle fatalities between 2005 and 2015, it is interesting to note that the changing demographics of motorcycle fatalities has been significant during the past 10 years. It is somewhat expected to see two peaks in motorcycle fatalities, which is different from a typical single peak in young drivers in passenger car fatalities. However, the figure shows that the two peaks have become much more obvious, with a significant increase in fatalities of motorcyclists age 50 and over.

This study aimed to understand the characteristics of motorcycle crashes of three age groups (under 30, 30–49, 50 or older) and to extend the knowledge about motorcycle riding and lifestyles in each group. However, it was difficult to obtain nationwide motorcycle crash data that include non-fatal crashes, and conducting a nationwide survey with a representative sample was not feasible because of limited resources. At the same time, Florida experienced a very similar demographic change in motorcycle crashes. Figure 3 shows the demographic changes in seriously or fatally injured motorcyclists in Florida during the same period. Florida represents about 10% of US motorcycle registrations and US motorcycle fatalities. In Florida in 2015, there were 584 motorcycle crash fatalities and 9,045 injury-related motorcycle crashes. Therefore, the scope of study was limited to the state of Florida.

As of July 1, 2015, Florida had 1,185,787 drivers with motorcycle endorsements and 601,191 registered motorcycles, representing about 3.4% of Florida-registered vehicles (not including mobile homes and vessels). Although it is difficult to measure the actual usage of motorcycles because of limitations in counting them with existing traffic detectors, it is estimated that motorcycles represent less than 1% of traffic on Florida's roadways, based on Florida vehicle classification information. However, motorcycle fatalities represented about 20% of Florida traffic fatalities in 2015.

## Literature Review

During the past 10 years, numerous reports have warned of the alarming increase in motorcycle fatalities in the United States (*1–3*). Many efforts have been made to investigate motorcycle crashes and explore potential countermeasures. The following summarizes previous motorcycle safety studies that are relevant to motorcyclist characteristics by age.

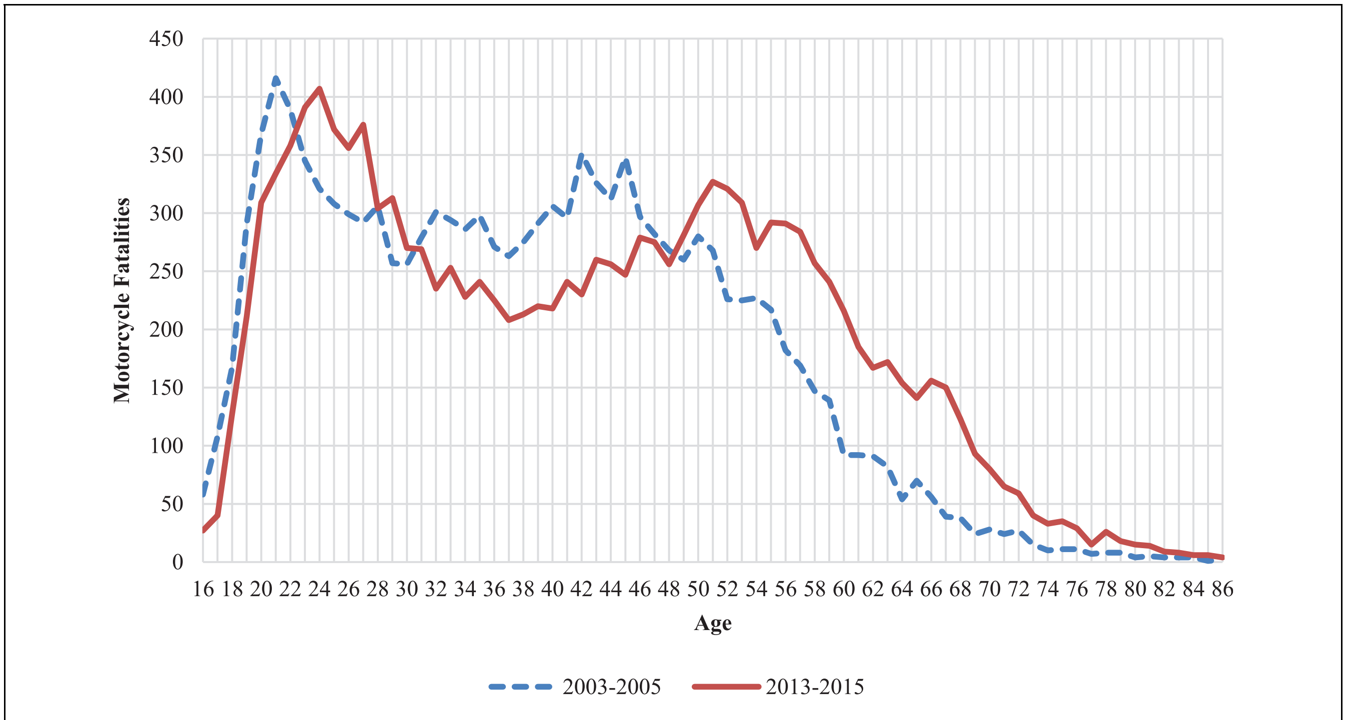


**Figure 2.** Changing demographics of motorcycle fatalities in the United States.

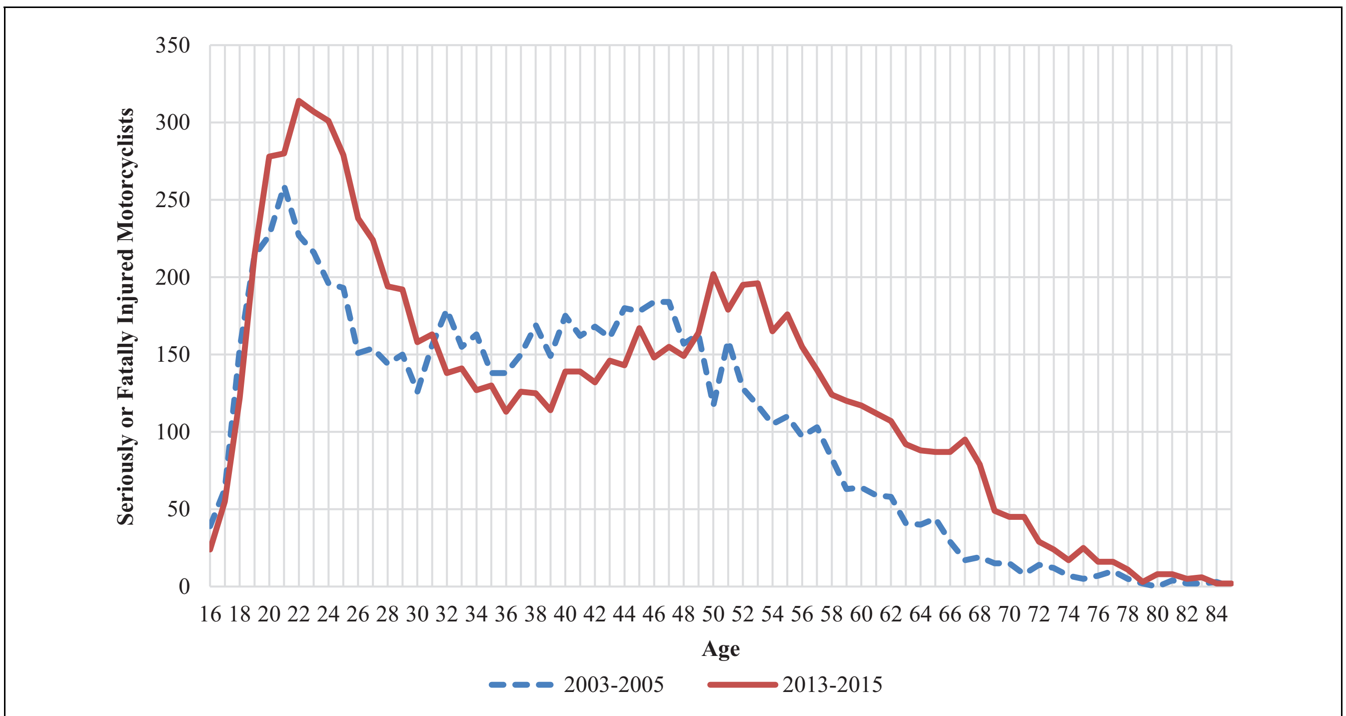


**Figure 3.** Changing demographics of seriously or fatally injured motorcyclists in Florida.

### Riding Experience

In the United States, more than half of active motorcyclists age 50 or older returned to riding after taking a continuous break of at least 2 years (average length 11 years), and 20% returned after taking a break of 20 years or longer (*4*). Increasing age is positively associated with increasing annual VMT in the United States, such that motorcyclists ages 18–29 and 50–59 ride an average of 4,268 and 6,437 miles per year, respectively (*4*). Nearly half (46%) of all fatally injured motorcyclists aged 20 or younger are improperly licensed compared to only 18% and 9% of motorcyclists ages 40–49 and 50 or older, respectively, in the United States (*5*).

### Motorcycle Choice

Larger motorcycles are associated with higher fatality rates than smaller motorcycles (*6–8*), and older motorcyclists own larger motorcycles than younger motorcyclists (*8–10*). According to Teoh and Campbell (*8*), the average age of touring riders is 51 and the average age of sport-type motorcycle riders is 27. Only 2% of touring and 12% of cruiser or standard motorcycle riders were younger than 30 in the study. In the United States, nearly three-quarters (72%) of all fatally injured motorcyclists who had been riding bikes with engine sizes 1,001–1,500 cc at the time of the crash were age 40 or older (*5*). Further, among motorcyclists age 40 or older, motorcyclists on bikes with an engine capacity of 1,000 cc or larger were four times more likely to be killed in a crash than riders on bikes with smaller engine capacities (*11*).

### Purpose of Riding

Younger motorcyclists are more likely to ride for commuting purposes and less likely to ride for recreational purposes than are older motorcyclists (*4*, *10*). Lee et al. (*12*) found that riders of all ages surveyed in Florida were most likely to report riding for "the thrill of riding and the freedom of the open road," but the second most-common reason for riding among riders ages 45–64 was "I want to ride with friends"; "inexpensive means of transportation" was cited by riders ages 18–44.

### Speeding

Older motorcyclists are significantly less likely to have positive attitudes toward risk-taking than younger motorcyclists, and positive attitudes toward risky behaviors are the greatest predictor of behaving in a risky manner (*9*). In the United States, more than half of all motorcycle fatalities among riders ages 20–29 are attributed to speeding compared to approximately one-quarter of fatalities among riders age 40 or older (*5*), and riders age 45 or older are only one-third as likely to be traveling 60 mph or faster at the time of a crash compared to younger riders (*13*).

### Helmet Use

Younger motorcyclists (ages 18–29) are more likely to believe that helmets keep riders safe and to favor universal helmet legislation than are riders of any other age group (*4*). Younger motorcyclists also appear to be more likely to wear helmets than middle-age motorcyclists. Although data on helmet use by age are somewhat inconsistent, data from both a national survey of motorcyclists in the United States and the Fatality Analysis Reporting System (FARS) indicate that helmet use and age have a curvilinear relationship, such that usage rates are highest among the youngest and oldest motorcyclists and lowest among middle-age motorcyclists (*4*, *5*).

### Alcohol Use

Studies that dichotomized motorcyclists as older (i.e., age 40 and older) or younger (i.e., age 39 and younger) found no difference in alcohol-related crash involvement by age (*11*, *14*). Studies that examine differences in alcohol-related crash involvement between clustered age groups (e.g., ages younger than 20, 20–29, 30–39, 40–49, 50–59, 60+ ), however, reveal that middle-age riders (ages 30–59) account for a disproportionately large share of crashes, with riders ages 40–49 and 30–39 at greatest and second-greatest risk, respectively (*5*, *15–18*).

### Crash Outcomes

Older age is a significant predictor of fatality in the event of a crash (*13*, *19*), such that fatality rates among motorcyclists consistently increase by 1.1–1.5% with each one-year increase in age (*20*, *21*), and the risk of serious injury increases by 4.2% with each one-year increase in age (*22*). Older motorcyclists are significantly more likely to sustain a severe injury than a minor injury in the event of a crash (*23–25*), and motorcyclists ages 55–65 are overrepresented among serious injury crashes (*26*). Crash deaths are significantly more likely among riders under the age of 40 than among riders age 40 or older, and riders under the age of 29 sustain the most serious motorcycle damage in the event of a crash (*11*, *27*).

## Motorcycle Crashes in Three Age Groups

Data from the Florida Department of Transportation's (Florida DOT) Crash Analysis Reporting System (CARS) for 2013–2015 were used to conduct a descriptive analysis of motorcycle crashes by age group. The three age groups consisted of motorcycle operators age

**Table 1.** Motorcycle Crashes in Florida by Injury Severity and Age Group

| Injury severity | Group A (under age 30) | Group B (ages 30–49) | Group C (age 50 or older) | Total |
|---|---|---|---|---|
| None | 14.9% (1,654) | 16.9% (1,675) | 16.8% (1,531) | 16.1% (4,860) |
| Possible | 19.9% (2,209) | 19.9% (1,970) | 19.1% (1,745) | 19.7% (5,924) |
| Non-incapacitating | 39.8% (4,412) | 37.2% (3,687) | 35.8% (3,267) | 37.7% (11,366) |
| Incapacitating | 20.4% (2,262) | 21.7% (2,152) | 23.6% (2,157) | 21.8% (6,571) |
| Fatal | 4.9% (548) | 4.3% (430) | 4.8% (436) | 4.7% (1,414) |
| Total | 100% (11,085) | 100% (9,914) | 100% (9,136) | 100% (30,135) |

*Note*: Numbers in parentheses are frequency.

**Table 2.** Incapacitating/Fatal Injury Motorcycle Crashes by At-Fault and Age Group

| Crash type | Group A (under age 30) | Group B (ages 30–49) | Group C (age 50 or older) | Total |
|---|---|---|---|---|
| Single-vehicle crash | 32.7% (919) | 38.6% (997) | 39.1% (1,014) | 36.7% (2,930) |
| Multi-vehicle crash (motorcycle at fault) | 28.9% (813) | 22.7% (588) | 22.4% (580) | 24.8% (1,979) |
| Multi-vehicle crash (other vehicle at fault) | 38.4% (1,078) | 38.7% (999) | 38.5% (999) | 38.5% (3,076) |
| Total | 100% (2,810) | 100% (2,582) | 100% (2,583) | 100% (7,985) |

*Note*: Numbers in parentheses are frequency

30 and under (Group A), ages 30–49 (Group B), and ages 50 or older (Group C), which were determined based on age thresholds of the increase/decrease in serious and fatal motorcycle crashes during the past 10 years in Florida. As shown in Table 1, the three age groups divided Florida motorcycle crash data into three comparably sized clusters. A Chi-square test shows that the relationship between injury severity and age group is significant, $\chi^2(\text{df} = 8, N = 30,135) = 68{,}668$, $p < .01$.

Table 2 divides motorcycle crashes with incapacitating or fatal injury into single- and multi-vehicle crashes. It appears that single-vehicle crashes represent about one-third of crashes in each group. A Chi-square test shows that the relationship between "crash type by at-fault" and age group is significant, $\chi^2(\text{df} = 4, N = 7,985) = 49.089$, $p < .001$. Groups B and C are more involved in single-vehicle crashes compared to Group A, and Group A had more motorcyclist at-fault crashes compared to the other two groups.

Three common risk factors in motorcycle crashes include lack of helmet use, riding under the influence of alcohol, and speeding. As shown in Table 3, Chi-square tests show that each group is associated with these risk factors at different levels. The proportion of motorcyclists with risk factors increased for all three groups in fatal crashes compared to all crashes. It seems that more motorcyclists in Group C wear no motorcycle helmet compared to the other two groups, and Group B has more impaired-riding crashes. It is notable that the proportion of Group A in fatal crashes that exceeded 20 mph over the posted speed limit is significantly higher than in the other two groups.

It is known that motorcycle type is highly associated with motorcyclist age, which is important for explaining riding behaviors and attitudes, as well as crash outcomes. However, many crash databases do not include motorcycle-type information, although it can be obtained by decoding the vehicle identification number (VIN) of motorcycles in police crash reports. In this study, 120 police crash reports for fatal motorcycle crashes were randomly selected and reviewed, including narrative and crash diagrams, to establish motorcycle crashes with motorcycle-type information. In summary, Group A crashes consisted mainly of sport bikes operated almost exclusively by males in the 20–29 age group. The principal operation error was excessive speed. In these crashes, sport bikes often exceeded the speed limit by a minimum of 20 mph (i.e., speed limit 55 mph, motorcycle traveling 75 mph) and reached $\geq$100 mph. With other drivers expecting a motorcycle to operate at a normal approach speed, this creates "failure to yield" charges for motorists violating the motorcyclist's right-of-way as a result of a crash and results in serious or fatal injury of the motorcyclist. This high-speed operation also leads to stop-sign and traffic-signal violations by motorcyclists.

Group B crashes are still dominated by sport bikes, but cruiser-style motorcycle representation has increased; this cluster includes males ages 30–50. The operators of sport motorcycles in this group reflect the same type of

**Table 3.** Common Risk Factors in Motorcycle Crashes (No Helmet, Drinking, Speeding)

| Injury type | Category | Group A (under age 30) | Group B (ages 30–49) | Group C (age 50 or older) | Total | df | $\chi^2$ (*p*-value) |
|---|---|---|---|---|---|---|---|
| Helmet use | | | | | | | |
| All crashes[a] | DOT-compliant motorcycle helmet | 64.7% | 48.5% | 47.2% | 54.1% | 4 | 769.679 (<.001) |
| | Other helmet | 1.9% | 2.1% | 2.7% | 2.2% | | |
| | No helmet | 33.4% | 49.4% | 50.1% | 43.7% | | |
| | Total | 100% (10,538) | 100% (9,386) | 100% (8,722) | 100% (28,646) | | |
| Fatal crashes | DOT-compliant motorcycle helmet | 64.9% | 44.5% | 38.5% | 50.5% | 4 | 82.917 (<.001) |
| | Other helmet | 1.5% | 3.1% | 6.3% | 3.5% | | |
| | No helmet | 33.6% | 52.4% | 55.2% | 46.0% | | |
| | Total | 100% (536) | 100% (422) | 100% (431) | 100% (1,389) | | |
| Suspected alcohol use | | | | | | | |
| All crashes[a] | No | 91.9% | 89.5% | 91.3% | 90.9% | 4 | 72.528 (<.001) |
| | Yes | 3.2% | 5.4% | 4.5% | 4.3% | | |
| | Unknown | 4.9% | 5.1% | 4.3% | 4.8% | | |
| | Total | 100% (11,099) | 100% (9,924) | 100% (9,146) | 100% (30,169) | | |
| Fatal crashes | No | 49.4% | 41.6% | 53.7% | 48.3% | 4 | 18.041 (<.001) |
| | Yes | 12.1% | 18.1% | 10.8% | 13.5% | | |
| | Unknown | 38.6% | 40.2% | 35.6% | 38.1% | | |
| | Total | 100% (547) | 100% (430) | 100% (436) | 100% (1,413) | | |
| Speeding (posted speed limit – estimated vehicle speed) | | | | | | | |
| All crashes[a] | Stopped | 8.6% | 12.0% | 12.7% | 11.0% | 8 | 928.829 (<.001) |
| | At/under posted speed limit | 71.1% | 74.7% | 81.0% | 75.3% | | |
| | 1–10 mph above | 8.5% | 6.4% | 4.0% | 6.4% | | |
| | 11–20 mph above | 5.8% | 3.7% | 1.5% | 3.8% | | |
| | 21 mph or higher | 6.0% | 3.2% | 0.8% | 3.5% | | |
| | Total | 100% (10,912) | 100% (9,814) | 100% (9,074) | 100% (29,800) | | |
| Fatal crashes | Stopped | 13.9% | 9.7% | 9.3% | 13.9% | 8 | 134.725 (<.001) |
| | At/under posted speed limit | 38.6% | 52.0% | 72.4% | 38.6% | | |
| | 1–10 mph above | 8.2% | 8.7% | 7.9% | 8.2% | | |
| | 11–20 mph above | 15.6% | 14.2% | 5.1% | 15.6% | | |
| | 21 mph or higher | 23.7% | 15.4% | 5.3% | 23.7% | | |
| | Total | 100% (539) | 100% (423) | 100% (431) | 100% (1,393) | | |

*Note*: numbers in parentheses are frequency.
[a]All crashes also includes fatal crashes.

speed violations as their younger riding cohorts. Cruiser riders in this group, on the other hand, depart from the traveled portion of the roadway on curves or strike median curbs and traffic islands while under the influence. Group C consists mainly of cruiser and touring models, along with a fair number of scooters. Crashes in this group do not necessarily involve excessive speed; in addition to the common left turn across path (LTAP) scenario, they are often involved in sideswipe-type crashes with vehicles traveling in the same direction or striking the rear of a slowing or stopped vehicle. The number of intoxicated motorcyclists in this group is not greater than the other groups; however, there was a larger number of intoxicated "other vehicle" operators in the crashes.

## Crash Injury Severity Modeling

The descriptive analysis of motorcycle crash data confirmed that each group has a different frequency of various motorcycle crash types and is associated with various risk factors at different levels. In other words, each group has a different magnitude in many variables that are associated with crash outcomes. To further investigate the effects of these risk factors, including other environmental factors on crash injury severity in each group, injury severity models were developed by using an ordered logit (OL) model.

### Methodology

Motorcyclist injury severity was divided into five ordinal categories: none, possible, non-incapacitating, incapacitating, and fatal. The injury severity as an ordinal variable was modeled with an OL model. Let $S_p$ be the discrete injury severity level of motorcyclist $p$. Then, $S_p^*$, the associated latent utility of injury severity $S_p$, is assumed to be:

$$S_p^* = \alpha' z_p + \omega_p \tag{1}$$

where $z_p$ is the vector of observable independent covariates; $\alpha$ is the vector of coefficients to be estimated; and $\omega_p$ is the error term that follows standard logistic distribution with cumulative distribution function $G(.)$.

Let $\delta_k$ be cutoff points that divide $S_p^*$ into $K$ $(k = 1, 2, \ldots, K)$ discrete injury severity levels. Then, from Equation 1 it can be concluded that injury severity is equal to crash severity level $k$ when

$$\delta_{k-1} < \alpha' z_p + \omega_p \leq \delta_k \tag{2}$$

where $\delta_{i,0} = -\infty$ and $\delta_{i,K} = +\infty$.

The probability that motorcyclist $p$ is involved in a crash with severity level $k$ can be written as:

$$\begin{aligned} P(S_p = k) &= P(\delta_{k-1} < \alpha' z_p + \omega_p < \delta_k) \\ &= P(\delta_{k-1} - \alpha' z_p < \omega_{pi} < \delta_k - \alpha' z_p) \\ &= G(\delta_k - \alpha' z_p) - G(\delta_{k-1} - \alpha' z_p) \end{aligned} \tag{3}$$

Finally, the parameters of the model are estimated by maximizing the following log-likelihood function:

$$\text{LL} = \sum_{p=1}^{N} \sum_{k=1}^{K} \text{q}_{p,k} * \log P(S_p = k) \tag{4}$$

where $N$ is the total number of motorcyclists in the sample; and $\text{q}_{p,k} = 1$ when motorcyclist $p$ was involved in a crash with severity level $k$, and 0 otherwise.

The parameters of the model are estimated with SAS econometrics software. The parameters to be estimated include $\alpha$ vector and cutoff points $\delta_k$ $(k = 1, 2, \ldots, K)$.

### Data

Florida DOT's CARS data from 2013 to 2015 were used to estimate crash injury severity models. The CARS dataset includes all reported crashes with a fatality, an injury, or high property damages, and provides information about motorcyclist characteristics, roadway attributes, environmental factors, temporal and spatial attributes, and crash characteristics.

## Estimation Results

Descriptive statistics of variables used in the models are presented in Table 4. The model is composed of the wide range of variables described previously. Table 5 shows the final estimation results. The injury severity level, as the dependent variable, was modeled as an ordinal variable using the OL model. The estimated parameters for each motorcycle type are presented under a separate column. The likelihood ratio test of the models showed that all estimated models are statistically significant at a level less than.0001. Positive (negative) coefficients increase (decrease) the level of injury severity. For example, riding a motorcycle under the influence of alcohol is a factor that increases the injury severity of motorcyclists in all three groups.

The factors that increase the level of injury severity across all age groups are: riding under the influence, using no safety equipment, curve segment of roadway, intersection, driveway access, and cloudy weather. Generally, as the speed limit increases, the risk of a severe injury increases, especially on highways with speed limits of 45 and 50 mph. Riding a motorcycle when impaired increases the likelihood of a more severe injury. Based on the estimated thresholds, a motorcyclist with a positive DUI (driving under the influence) and no safety

**Table 4.** Descriptive Statistics of Variables Used in Final Models

| Variable | Definition | Group A (under age 30) | | Group B (ages 30–49) | | Group C (age 50 or older) | |
|---|---|---|---|---|---|---|---|
| | | Mean | Std. dev. | Mean | Std. dev. | Mean | Std. dev. |
| Driver characteristics | | | | | | | |
| DUI status | | | | | | | |
| Positive DUI | 1 if motorcyclist is under the influence of alcohol or drugs, 0 otherwise | 0.02 | 0.12 | 0.03 | 0.17 | 0.03 | 0.16 |
| Number of safety equipment | | | | | | | |
| 0 | 1 if motorcyclist has no safety equipment, 0 otherwise | 0.18 | 0.39 | 0.20 | 0.40 | 0.16 | 0.37 |
| Roadway attributes | | | | | | | |
| Shoulder width (ft) | | | | | | | |
| 0 | 1 if there is no shoulder, 0 otherwise | 0.67 | 0.47 | 0.63 | 0.48 | 0.63 | 0.48 |
| 1–2 | 1 if shoulder width is between 1 ft and 2 ft, 0 otherwise | 0.07 | 0.25 | 0.08 | 0.26 | 0.06 | 0.23 |
| Speed limit (mph) | | | | | | | |
| $\leq$30 | 1 if speed limit is 30 mph or less, 0 otherwise | 0.28 | 0.45 | 0.25 | 0.43 | 0.24 | 0.43 |
| 35 and 40 | 1 if speed limit is 35/40 mph, 0 otherwise | 0.28 | 0.45 | 0.27 | 0.44 | 0.25 | 0.44 |
| 45 and 50 | 1 if speed limit is 45/50 mph, 0 otherwise | 0.32 | 0.47 | 0.33 | 0.47 | 0.34 | 0.48 |
| $\geq$55 | 1 if speed limit is 55 mph or more, 0 otherwise | 0.12 | 0.33 | 0.15 | 0.35 | 0.16 | 0.37 |
| Traffic way character | | | | | | | |
| Curve, level | 1 if road segment is level curve, 0 otherwise | 0.10 | 0.30 | 0.11 | 0.31 | 0.10 | 0.29 |
| Curve, up and down grade | 1 if road segment is upgrade/downgrade curve, 0 otherwise | 0.03 | 0.16 | 0.03 | 0.16 | 0.02 | 0.15 |
| Straight, up and down grade | 1 if road segment is upgrade/downgrade straight, 0 otherwise | 0.04 | 0.19 | 0.04 | 0.19 | 0.04 | 0.19 |
| Traffic control | | | | | | | |
| Stop sign | 1 if site location is an intersection with stop-sign control, 0 otherwise | 0.10 | 0.30 | 0.10 | 0.30 | 0.10 | 0.30 |
| Signal | 1 if site location is an intersection with traffic-signal control, 0 otherwise | 0.17 | 0.38 | 0.19 | 0.39 | 0.19 | 0.39 |
| Environmental factors | | | | | | | |
| Light condition | | | | | | | |
| Daylight | 1 if it is daylight, 0 otherwise | 0.60 | 0.49 | 0.61 | 0.49 | 0.73 | 0.44 |
| Dark without street lighting | 1 if it is dark and without street lighting, 0 otherwise | 0.08 | 0.27 | 0.09 | 0.28 | 0.07 | 0.26 |
| Weather condition | | | | | | | |
| Cloudy | 1 if it is cloudy, 0 otherwise | 0.15 | 0.36 | 0.14 | 0.35 | 0.15 | 0.35 |
| Road surface condition | | | | | | | |
| Wet and slippery | 1 if road surface is wet and slippery, 0 otherwise | 0.10 | 0.30 | 0.10 | 0.30 | 0.09 | 0.28 |
| Temporal attributes | | | | | | | |
| Time of day | | | | | | | |
| 1–4 a.m. | 1 if crash occurs between 1 and 4 a.m., 0 otherwise | 0.06 | 0.23 | 0.05 | 0.22 | 0.02 | 0.14 |
| Weekday | | | | | | | |
| Sunday | 1 if crash occurs on Sunday, 0 otherwise | 0.16 | 0.37 | 0.18 | 0.39 | 0.20 | 0.40 |
| Tuesday | 1 if crash occurs on Tuesday, 0 otherwise | 0.13 | 0.34 | 0.12 | 0.32 | 0.12 | 0.32 |
| Thursday | 1 if crash occurs on Thursday, 0 otherwise | 0.14 | 0.35 | 0.14 | 0.35 | 0.12 | 0.33 |
| Month | | | | | | | |
| April | 1 if crash occurs in April, 0 otherwise | 0.09 | 0.29 | 0.09 | 0.28 | 0.10 | 0.29 |
| June | 1 if crash occurs in June, 0 otherwise | 0.08 | 0.27 | 0.07 | 0.26 | 0.06 | 0.25 |

*(continued)*

**Table 4.** (continued)

| Variable | Definition | Group A (under age 30) | | Group B (ages 30–49) | | Group C (age 50 or older) | |
|---|---|---|---|---|---|---|---|
| | | Mean | Std. dev. | Mean | Std. dev. | Mean | Std. dev. |
| July | 1 if crash occurs in July, 0 otherwise | 0.08 | 0.27 | 0.08 | 0.26 | 0.07 | 0.25 |
| Spatial characteristics | | | | | | | |
| District | | | | | | | |
| District 3 | 1 if location of crash is in District 3, 0 otherwise | 0.07 | 0.25 | 0.07 | 0.26 | 0.06 | 0.25 |
| District 7 | 1 if location of crash is in District 7, 0 otherwise | 0.18 | 0.38 | 0.17 | 0.38 | 0.18 | 0.39 |
| County | | | | | | | |
| Bay | 1 if location of crash is in Bay County, 0 otherwise | 0.01 | 0.11 | 0.02 | 0.13 | 0.02 | 0.12 |
| Broward | 1 if location of crash is in Broward County, 0 otherwise | 0.08 | 0.27 | 0.08 | 0.28 | 0.06 | 0.24 |
| Citrus | 1 if location of crash is in Citrus County, 0 otherwise | 0.00 | 0.07 | 0.01 | 0.09 | 0.02 | 0.13 |
| Escambia | 1 if location of crash is in Escambia County, 0 otherwise | 0.02 | 0.12 | 0.02 | 0.13 | 0.01 | 0.12 |
| Duval | 1 if location of crash is in Duval County, 0 otherwise | 0.07 | 0.25 | 0.08 | 0.26 | 0.06 | 0.23 |
| Lake | 1 if location of crash is in Lake County, 0 otherwise | 0.01 | 0.09 | 0.02 | 0.13 | 0.02 | 0.15 |
| Manatee | 1 if location of crash is in Manatee County, 0 otherwise | 0.01 | 0.12 | 0.01 | 0.12 | 0.02 | 0.15 |
| Marion | 1 if location of crash is in Marion County, 0 otherwise | 0.01 | 0.12 | 0.02 | 0.13 | 0.02 | 0.14 |
| Miami-Dade | 1 if location of crash is in Miami-Dade County, 0 otherwise | 0.15 | 0.36 | 0.14 | 0.35 | 0.08 | 0.27 |
| Monroe | 1 if location of crash is in Monroe County, 0 otherwise | 0.04 | 0.19 | 0.04 | 0.20 | 0.05 | 0.22 |
| Okaloosa | 1 if location of crash is in Okaloosa County, 0 otherwise | 0.01 | 0.10 | 0.01 | 0.11 | 0.01 | 0.10 |
| Palm Beach | 1 if location of crash is in Palm Beach County, 0 otherwise | 0.05 | 0.23 | 0.04 | 0.19 | 0.04 | 0.20 |
| Pasco | 1 if location of crash is in Pasco County, 0 otherwise | 0.03 | 0.16 | 0.02 | 0.15 | 0.03 | 0.18 |
| Pinellas | 1 if location of crash is in Pinellas County, 0 otherwise | 0.06 | 0.24 | 0.05 | 0.22 | 0.06 | 0.24 |
| Site location | | | | | | | |
| Intersection | 1 if site location is intersection, 0 otherwise | 0.28 | 0.45 | 0.29 | 0.45 | 0.30 | 0.46 |
| Driveway access | 1 if site location is driveway access, 0 otherwise | 0.04 | 0.21 | 0.04 | 0.20 | 0.05 | 0.21 |
| Parking lot | 1 if site location is parking lot, 0 otherwise | 0.02 | 0.15 | 0.02 | 0.14 | 0.02 | 0.16 |
| Motorcycle characteristics | | | | | | | |
| Body class | | | | | | | |
| Cruiser | 1 if motorcycle body class is cruiser, 0 otherwise | 0.19 | 0.39 | 0.39 | 0.49 | 0.49 | 0.50 |
| Scooter | 1 if motorcycle body class is scooter, 0 otherwise | 0.10 | 0.29 | 0.09 | 0.29 | 0.10 | 0.30 |
| Sport | 1 if motorcycle body class is sport, 0 otherwise | 0.15 | 0.36 | 0.09 | 0.28 | 0.02 | 0.14 |
| Supersport | 1 if motorcycle body class is supersport, 0 otherwise | 0.42 | 0.49 | 0.20 | 0.40 | 0.02 | 0.13 |
| Number of observations | | 10,344 | 8,845 | 7,594 | | | |

**Table 5.** Estimated Injury Severity Models for Age Group

| Variable | Group A (under age 30) | | | Group B (ages 30–49) | | | Group C (age 50 or older) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coeff. | *t*-stat | Odds ratio | Coeff. | *t*-stat | Odds ratio | Coeff. | *t*-stat | Odds ratio |
| Threshold parameters | | | | | | | | | |
| Injury severity | | | | | | | | | |
| None to possible | −2.89 | −35.24 | – | −3.55 | −40.45 | – | −3.18 | −36.56 | – |
| Possible to non-incapacitating | −0.95 | −13.22 | – | −1.40 | −19.07 | – | −1.00 | −13.93 | – |
| Non-incapacitating to incapacitating | 0.84 | 11.67 | – | 0.31 | 4.32 | – | 0.63 | 8.84 | – |
| Incapacitating to fatal | 2.02 | 26.95 | – | 1.47 | 19.73 | – | 1.73 | 23.39 | – |
| Driver characteristics | | | | | | | | | |
| DUI status | | | | | | | | | |
| Positive DUI | 0.46 | 3.09 | 1.58 | 0.48 | 4.11 | 1.62 | 0.35 | 2.53 | 1.42 |
| Number of safety equipment | | | | | | | | | |
| 0 | 0.34 | 6.78 | 1.40 | 0.23 | 4.63 | 1.26 | 0.13 | 2.29 | 1.14 |
| Roadway attributes | | | | | | | | | |
| Shoulder width (ft) | | | | | | | | | |
| 0 | 0.14 | 2.96 | 1.16 | 0.16 | 3.51 | 1.17 | – | – | – |
| 1–2 | −0.19 | −2.75 | 0.83 | – | – | – | −0.21 | −3.12 | 0.81 |
| Speed limit (mph) | | | | | | | | | |
| ≤30 | −0.74 | −10.85 | 0.48 | −0.43 | −7.66 | 0.65 | −0.49 | −8.02 | 0.61 |
| 35 and 40 | −0.52 | −7.93 | 0.59 | −0.19 | −3.72 | 0.83 | −0.24 | −4.41 | 0.79 |
| 45 and 50 | −0.30 | −4.85 | 0.74 | – | – | – | – | – | – |
| ≥55 | – | – | – | 0.33 | 5.36 | 1.39 | 0.32 | 5.02 | 1.37 |
| Traffic way character | | | | | | | | | |
| Curve-level | 0.51 | 8.52 | 1.67 | 0.58 | 9.06 | 1.79 | 0.72 | 9.85 | 2.05 |
| Curve, up and down grade | 0.78 | 6.75 | 2.18 | 0.73 | 6.20 | 2.08 | 0.59 | 4.15 | 1.81 |
| Straight, up and down grade | 0.20 | 2.13 | 1.22 | – | – | – | – | – | – |
| Traffic control | | | | | | | | | |
| Stop sign | – | – | – | – | – | – | 0.22 | 3.00 | 1.25 |
| Signal | −0.16 | −3.16 | 0.85 | −0.28 | −5.37 | 0.75 | −0.17 | −2.87 | 0.85 |
| Environmental factors | | | | | | | | | |
| Light condition | | | | | | | | | |
| Daylight | −0.19 | −5.02 | 0.82 | −0.14 | −3.21 | 0.87 | −0.18 | −3.23 | 0.84 |
| Dark without street lighting | – | – | – | 0.26 | 3.43 | 1.30 | 0.27 | 2.85 | 1.31 |
| Weather condition | | | | | | | | | |
| Cloudy | 0.24 | 4.71 | 1.27 | 0.26 | 4.60 | 1.30 | 0.19 | 3.22 | 1.22 |
| Road surface condition | | | | | | | | | |
| Wet and slippery | −0.32 | −5.24 | 0.72 | −0.25 | −3.75 | 0.78 | −0.20 | −2.67 | 0.82 |
| Temporal attributes | | | | | | | | | |
| Time of day | | | | | | | | | |
| 1–4 a.m. | 0.29 | 3.56 | 1.33 | 0.40 | 4.26 | 1.50 | – | – | – |
| Weekday | | | | | | | | | |
| Sunday | 0.13 | 2.45 | 1.14 | 0.21 | 4.02 | 1.24 | – | – | – |
| Tuesday | – | – | – | – | – | – | −0.15 | −2.27 | 0.86 |
| Thursday | 0.12 | 2.34 | 1.13 | – | – | – | – | – | – |
| Month | | | | | | | | | |
| April | – | – | – | – | – | – | 0.16 | 2.17 | 1.17 |
| June | – | – | – | −0.17 | −2.28 | 0.84 | – | – | – |
| July | – | – | – | 0.20 | 2.68 | 1.22 | – | – | – |
| Spatial characteristics | | | | | | | | | |
| District | | | | | | | | | |
| District 3 | – | – | – | −0.22 | −2.74 | 0.80 | – | – | – |
| District 7 | 0.28 | 4.91 | 1.32 | – | – | – | – | – | – |
| County | | | | | | | | | |
| Bay | −0.45 | −2.78 | 0.64 | – | – | – | −0.41 | −2.48 | 0.67 |
| Broward | – | – | – | – | – | – | −0.38 | −4.27 | 0.68 |
| Citrus | – | – | – | 0.62 | 2.99 | 1.87 | – | – | – |
| Duval | −0.23 | −3.15 | 0.79 | −0.35 | −4.68 | 0.70 | −0.34 | −3.78 | 0.71 |
| Escambia | −0.30 | −2.03 | 0.74 | – | – | – | – | – | – |
| Lake | – | – | – | – | – | – | −0.36 | −2.70 | 0.70 |

*(continued)*

**Table 5.** (continued)

| Variable | Group A (under age 30) | | | Group B (ages 30–49) | | | Group C (age 50 or older) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coeff. | *t*-stat | Odds ratio | Coeff. | *t*-stat | Odds ratio | Coeff. | *t*-stat | Odds ratio |
| Manatee | – | – | – | 0.61 | 3.84 | 1.84 | – | – | – |
| Marion | – | – | – | – | – | – | −0.58 | −3.99 | 0.56 |
| Miami-Dade | −0.26 | −4.70 | 0.77 | −0.45 | −7.33 | 0.64 | −0.57 | −6.81 | 0.56 |
| Monroe | – | – | – | 0.29 | 2.67 | 1.34 | 0.24 | 2.26 | 1.28 |
| Okaloosa | −0.44 | −2.64 | 0.65 | 0.40 | 2.02 | 1.49 | – | – | – |
| Palm Beach | 0.18 | 2.22 | 1.20 | – | – | – | – | – | – |
| Pasco | – | – | – | 0.44 | 3.59 | 1.56 | 0.48 | 4.22 | 1.62 |
| Pinellas | −0.32 | −3.51 | 0.73 | – | – | – | – | – | – |
| Site location | | | | | | | | | |
| Intersection | 0.43 | 9.70 | 1.54 | 0.38 | 7.84 | 1.46 | 0.24 | 4.69 | 1.27 |
| Driveway access | 0.37 | 4.14 | 1.45 | 0.47 | 4.92 | 1.60 | 0.36 | 3.56 | 1.44 |
| Parking lot | −0.47 | −3.77 | 0.62 | −0.76 | −5.34 | 0.47 | −0.46 | −3.14 | 0.63 |
| Motorcycle characteristics | | | | | | | | | |
| Body class | | | | | | | | | |
| Cruiser | −0.12 | −2.35 | 0.89 | 0.14 | 2.74 | 1.15 | 0.26 | 5.89 | 1.30 |
| Scooter | – | – | – | 0.35 | 4.46 | 1.42 | 0.41 | 5.26 | 1.51 |
| Sport | – | – | – | 0.41 | 5.36 | 1.51 | 0.39 | 2.61 | 1.47 |
| Supersport | 0.18 | 4.51 | 1.20 | 0.35 | 5.88 | 1.42 | – | – | – |

equipment, assuming other variables are zero, puts his/her life at a high risk of incapacitating injury. Roadways with no shoulder increase the chance of more severe injury. Controlling traffic with a signal lowers the chance of severe injuries. Intersection or drive access increase the odds of serious injury in traffic crashes; this may be related to common right-of-way violations by other vehicles in which motorcyclists may not have enough time to react. The motorcycle injury severity level also changes both temporally and spatially. Florida DOT District 7 and some Florida counties (Pasco and Monroe) yield to a higher level of injury severity. Riding a motorcycle in early morning and/or on weekends puts young and middle-age motorcyclists (Groups A and B) at a higher risk of serious injury.

## Stated Preference Survey

Whereas understanding the demographic characteristics of the population for traffic safety is essential, crash data provide very limited information about drivers and passengers. In this study, a survey was used to explore the characteristics of the motorcyclist segments identified by the motorcycle crash data.

A web-based survey with address-based sampling (ABS) was adopted to conduct a statewide survey. A total of 30,000 postcards were sent to randomly selected motorcyclists with a valid motorcycle endorsement who had registered at least one motor vehicle in Florida. In total, 976 survey responses, including partially completed surveys, were collected.

Table 6 summarizes the results of Chi-square tests and shows that there is a statistically significant association among the three groups and motorcycle use/riding/motorcycle types. Group A is more likely to ride sport/supersport-style motorcycles, and commuting is the primary purpose for riding compared to the other two groups. Of note is that about 17–25% of respondents indicated that they own a motorcycle but do not ride it regularly; this proportion is significantly higher in Group B compared to the other two groups.

The actual data of motorcycle use in the United States, such as VMT, is not readily available or the quality of existing information is questionable (*28*). Under current circumstances, it is difficult to collect adequate motorcycle exposure information by age group in the United States based on actual observation. This study used a series of questions to collect motorcycle exposure information of the three groups. Although the information is limited for estimating actual VMT for motorcycles in Florida, it provides insights to compare motorcycle exposure information, including riding frequency of the three groups. Table 7 shows the percentage within each cross-tab. For example, 18.3% of Group A reported riding a motorcycle more than 10,000 miles during the past 12 months, and riding almost every day. Cells with darker shading represent the higher percentages within the table. Motorcyclists in Group A rode more frequently than those in the other two groups, but almost the same proportion of Groups A and C reported that they rode 5,000 miles or more in the past 12 months. The majority of Group B rode more than once per week but not every

**Table 6.** Motorcycle Types and Primary Purpose of Riding by Age Group

| | Group A (under age 30) | Group B (ages 30–49) | Group C (age 50 or older) | df | $\chi^2$ (*p*-value) |
|---|---|---|---|---|---|
| Motorcycle riding | | | | | |
| I have a motorcycle and ride regularly | 57.7% | 59.1% | 65.0% | 8 | 17.737 (<.027) |
| I do not have a motorcycle but ride regularly as a passenger | | 0.6% | 1.0% | | |
| I have a motorcycle but do not ride a motorcycle regularly | 17.5% | 24.5% | 19.5% | | |
| I have a motorcycle endorsement but do not have a motorcycle and do not ride regularly | 13.4% | 11.6% | 11.0% | | |
| Total | 100% (97) | 100% (335) | 100% (517) | | |
| Primary purpose of riding | | | | | |
| Commuting | 57.7% | 25.2% | 10.8% | 8 | 120.838 (<.001) |
| Task-related trips | | 2.1% | 3.8% | | |
| Recreation | 40.2% | 67.8% | 80.1% | | |
| Competition | | 0.6% | | | |
| Other | 2.1% | 4.3% | 5.4% | | |
| Total | 100% (97) | 100% (326) | 100% (502) | | |
| Motorcycle type | | | | | |
| Cruiser | 28.4% | 41.4% | 37.5% | 14 | 229.202 (<.001) |
| On-/off-road | 6.3% | 1.5% | 3.0% | | |
| Scooter | | 3.9% | 2.2% | | |
| Sport/supersport | 61.1% | 26.1% | 6.0% | | |
| Standard | 2.1% | 3.3% | 7.2% | | |
| Touring/sport-touring | | 18.9% | 37.1% | | |
| Trike | | 0.9% | 3.2% | | |
| Other | 2.1% | 3.9% | 3.8% | | |
| Total | 100% (95) | 100% (333) | 100% (501) | | |

**Table 7.** Riding Frequency and Estimated Annual Mileage

| Group | Miles | Almost every day | More than $1\times$ week | $1\times$ per week | A few times a month | A few times per year | Total |
|---|---|---|---|---|---|---|---|
| Group A (under age 30) | $\leq$1,000 mile | | | 4.9% | 2.4% | 20.7% | 28.0% |
| | 1,001–3,000 mile | 2.4% | 4.9% | 4.9% | 8.5% | 2.4% | 23.2% |
| | 3,001–5,000 mile | 2.4% | 7.3% | | 2.4% | | 12.2% |
| | 5,001–10,000 mile | 11.0% | 4.9% | 2.4% | | | 18.3% |
| | $\geq$10,001 mile | 18.3% | | | | | 18.3% |
| | Total | 34.1% | 17.1% | 12.2% | 13.4% | 23.2% | 100.0% |
| Group B (ages 30–49) | Didn't ride in past 12 months | | | 0.3% | | 5.3% | 5.6% |
| | $\leq$1,000 mile | 0.3% | 1.7% | 4.3% | 7.0% | 14.3% | 27.6% |
| | 1,001–3,000 mile | 0.3% | 5.6% | 3.3% | 11.0% | 2.0% | 22.3% |
| | 3,001–5,000 mile | 2.7% | 4.7% | 4.3% | 3.7% | | 15.3% |
| | 5,001–10,000 mile | 5.6% | 7.6% | 5.0% | 1.0% | | 19.3% |
| | $\geq$10,001 mile | 6.3% | 2.7% | 0.3% | 0.7% | | 10.0% |
| | Total | 15.3% | 22.3% | 17.6% | 23.3% | 21.6% | 100.0% |
| Group C (age 50 or older) | Didn't ride in past 12 months | 0.2% | 0.2% | 0.2% | | 1.9% | 2.6% |
| | $\leq$1,000 mile or less | 0.2% | 0.9% | 2.1% | 7.5% | 9.8% | 20.6% |
| | 1,001–3,000 mile | 1.9% | 6.1% | 4.2% | 10.5% | 1.2% | 23.8% |
| | 3,001–5,000 mile | 1.9% | 6.3% | 4.4% | 4.0% | 0.2% | 16.8% |
| | 5,001–10,000 mile | 5.8% | 12.9% | 3.3% | 3.0% | 0.5% | 25.5% |
| | $\geq$10,001 mile | 4.9% | 4.9% | 0.2% | 0.5% | 0.2% | 10.7% |
| | Total | 15.0% | 31.3% | 14.5% | 25.5% | 13.8% | 100.0% |

**Table 8.** Attitude Toward Training, Helmet Use, and Drinking

| | Group A (under age 30) | Group B (ages 30–49) | Group C (age 50 or older) | df | $\chi^2$ (*p*-value) |
|---|---|---|---|---|---|
| Did you complete formal motorcycle training to obtain your motorcycle endorsement? | | | | | |
| Yes | 95.9% | 82.6% | 60.7% | 4 | 77.318 (<.001) |
| No | 4.1% | 17.1% | 38.5% | | |
| I do not have a motorcycle endorsement | | 0.3% | 0.8% | | |
| Total | 100% (97) | 100% (327) | 100% (499) | | |
| In your opinion, how important is it for motorcyclists to be formally trained? | | | | | |
| Very important | 71.1% | 70.2% | 69.6% | 8 | 13.985 (0.082) |
| Fairly important | 17.5% | 12.2% | 11.9% | | |
| Important | 4.1% | 8.2% | 11.9% | | |
| Slightly important | 7.2% | 7.0% | 4.3% | | |
| Not important at all | | 2.4% | 2.2% | | |
| Total | 100% (97) | 100% (329) | 100% (494) | | |
| Which of the following best describes your use of a motorcycle helmet in Florida? | | | | | |
| I always wear a helmet when riding a motorcycle | 80.4% | 70.6% | 65.7% | 6 | 20.863 (0.002) |
| I wear a helmet most of the time | 13.4% | 15.5% | 12.8% | | |
| I wear a helmet on limited occasions (long-distance trips, winter season, and so forth) | 6.2% | 8.4% | 11.2% | | |
| I seldom or never wear a helmet | | 5.6% | 10.4% | | |
| Total | 100% (97) | 100% (323) | 100% (492) | | |
| In your opinion, how important is it for a motorcyclist to wear a helmet? | | | | | |
| Very important | 80.2% | 68.1% | 60.9% | 8 | 33.213 (<.001) |
| Fairly important | 15.6% | 9.6% | 9.1% | | |
| Important | 2.1% | 12.4% | 14.4% | | |
| Slightly important | 2.1% | 5.3% | 9.3% | | |
| Not important at all | | 4.6% | 6.4% | | |
| Total | 100% (96) | 100% (323) | 100% (486) | | |
| What kind of motorcycle helmet do you wear? | | | | | |
| Full-face | 81.3% | 54.6% | 28.0% | 10 | 119.001 (<.001) |
| Three-quarter | 2.1% | 14.4% | 22.7% | | |
| Modular | | 4.2% | 7.5% | | |
| Half | 14.6% | 22.4% | 35.3% | | |
| Off-road | | 0.6% | 0.4% | | |
| Other | 2.1% | 3.8% | 6.0% | | |
| Total | 100% (97) | 100% (323) | 100% (492) | | |
| In the past 30 days, how many times did you ride a motorcycle within 2 hours of drinking an alcoholic beverage? | | | | | |
| 5 or more times | | 1.8% | 1.6% | 6 | 4.963 (.549) |
| 3–4 times | | 2.4% | 2.6% | | |
| 1–2 times | 11.3% | 8.5% | 8.8% | | |
| Never | 88.7% | 87.2% | 87.0% | | |
| Total | 100% (97) | 100% (328) | 100% (491) | | |

day. It is also notable that more than 20% of Groups A and B reported that they rode just a few times per year.

Table 8 shows motorcyclist attitudes toward training, helmet use, and drinking by age group. Motorcyclists in all three groups strongly supported formal training, and approximately 96% of Group A stated that they obtained a motorcycle endorsement with formal motorcycle training. (Florida became a mandatory training state in July 2008; anyone seeking a new motorcycle endorsement in Florida is required to take a basic rider course.) The reported helmet usage and attitudes toward the importance of helmets are quite different among the three groups. It is notable that 95% of respondents in Group A stated that the use of a helmet is very important or fairly important, and 81% of respondents in this group reported wearing a full-face helmet. These measures (helmet usage and perceived safety value of helmet use) are lower in Group C compared to the other two groups. No difference was found in drinking and riding experience among the three groups.

As shown in Table 9, each age group displays significant differences in motorcycle club membership and bike event attendance. More than half of motorcyclists in Groups A and B have not attended a major bike event during the past 12 months, but 30% of Group C stated that they attended at least two or more bike events. Of

**Table 9.** Motorcycle Club Membership, Bike Events, and Preferred Means of Contact

| | Group A (under age 30) | Group B (ages 30–49) | Group C (age 50 or older) | df | $\chi^2$ (*p*-value) |
|---|---|---|---|---|---|
| Are you a member of a riding group? | | | | | |
| Yes | 11.1% | 11.3% | 28.0% | 2 | 38.810 (<.001) |
| No | 88.9% | 88.8% | 72.0% | | |
| Total | 100% (90) | 100% (320) | 100% (485) | | |
| Did you attend any major bike events in Florida during the past 12 months? | | | | | |
| Never | 52.0% | 54.0% | 43.5% | 4 | 28.002 (.002) |
| Once | 25.5% | 23.4% | 27.2% | | |
| Twice | 14.7% | 13.6% | 12.1% | | |
| More than twice | 7.8% | 8.9% | 17.1% | | |
| Total | 100% (90) | 100% (320) | 100% (485) | | |
| What would be the best way to reach you about motorcycle safety information in Florida? | | | | | |
| Direct mail | 34.0% | 23.2% | 19.5% | 20 | 80.114 (<.001) |
| Billboards | 6.4% | 7.7% | 5.6% | | |
| Electronic overhead highway sign | 18.1% | 12.1% | 7.7% | | |
| Television | 6.4% | 12.7% | 20.1% | | |
| Radio | 7.4% | 6.2% | 1.7% | | |
| Telephone | | 0.6% | 1.0% | | |
| Social network websites | 11.7% | 15.8% | 8.5% | | |
| E-mail | 13.8% | 15.5% | 25.5% | | |
| Online rider forums | | 1.9% | 2.9% | | |
| Newspaper | | | 1.7% | | |
| Other | 2.1% | 4.3% | 6.0% | | |
| Total | 100% (94) | 100% (323) | 100% (483) | | |
| How often do you log into social media networks (e.g., Facebook, Google + , and so forth)? | | | | | |
| More than once per day | 50.0% | 44.4% | 31.3% | 8 | 29.641 (<.001) |
| About once per day | 26.7% | 20.9% | 21.6% | | |
| A few times per week | 10.0% | 11.6% | 19.4% | | |
| A few times per month | | 5.0% | 6.2% | | |
| Less than a few times per month | 13.3% | 18.2% | 21.6% | | |
| Total | 100% (90) | 100% (320) | 100% (485) | | |

note is that all three groups expressed significant interest in getting information by direct mail. Although more than 50% of respondents in all three groups indicated that they log into social media at least once per day, they indicated that social media was not the best way to receive information about motorcycle safety.

The results of the survey demonstrated that the three groups are significantly different in many categories, such as riding purpose, exposure, attitudes toward risk factors, and common activities. Although the survey adopted random sampling, the interpretation of findings is limited by the low response rate and the particularly small sample size of Group A.

## Discussion

Considering that motorcycles have significantly higher fatality rates per registered vehicle or per estimated VMT compared to passenger cars, they are the most dangerous means of transportation in the United States, and the sharp increase in motorcycle registrations has resulted in a significant increase in motorcycle fatalities as well as major changes in the demographics of motorcyclists. Florida has about 10% of all motorcycle registrations in the United States and saw similar demographic changes. In this study, Florida motorcycle crash data were divided into three clusters based on the age of motorcycle operators. The age range for each cluster was determined based on age thresholds of the increase/decrease in serious and fatal motorcycle crashes during the past 10 years. Descriptive analyses including Chi-square tests were used to evaluate crash characteristics of the three groups. Each group has diverse crash characteristics as well as different levels of exposure to common risk factors, including no helmet use, suspected alcohol use, and speeding.

Crash injury models were developed to understand variable increases in the level of injury severity in each group. Risk factors such as no helmet use and suspected alcohol use appeared in all three models as a significant contributing factor. In addition, curves with level terrain, curves with rolling terrain, intersections, and drive access are common variables that increase the level of injury severity in all three age groups. Speeding (riding a motorcycle 20 mph over the posted speed limit) was much more prevalent in Group A, but motorcyclists in Groups B and C were more likely to suffer increased injury severity by riding a motorcycle on a roadway with a higher posted speed limit (55 mph or higher). Similarly, riding a motorcycle in dark conditions without street lighting increased injury severity for Groups B and C only. Overall, the crash injury models confirmed that many variables that increased the level of injury severity in motorcycle crashes were applicable to all three groups, whereas the frequency of some behaviors varied by group.

A survey was conducted to collect information not available in crash data, such as attitudes and behavioral characteristics of each segment. The three groups are significantly different in riding purpose, primary motorcycle type, riding frequency, and annual miles. Although there is a significant difference in formal training experience among groups, all three demonstrated positive attitudes toward formal motorcycle training. All three groups were very different concerning type of helmet, reported helmet use, and attitudes toward wearing a helmet. The three groups were also different in motorcycle club membership, bike event attendance, and preferred means of communication.

Overall, the three motorcycle segments identified in this study have distinctive riding characteristics, crash outcomes, and attitudes toward risk factors. This is essential information for developing and managing motorcycle safety programs in an effective and efficient manner. Current and past motorcycle safety interventions have been limited to general public campaigns, which target the whole population of either motorcyclists or motorists. Consideration of a tailored approach based on target audience segmentation warrants further investigation, given its widespread success in other areas of public health. Targeted segmentation has been used in public health settings to develop effective messages and intervention strategies and to choose the most appropriate communication channels for each segment. Target audience segmentation requires planners to divide the general target population into homogeneous subgroups, as each resulting subgroup or segment has unique characteristics compared to other segments, and shared beliefs, attitudes, and behaviors about a topic. Individuals within a segment are likely to show a similar response to an intervention approach tailored for that segment. Grier and Kumanyika (*29*) call for a targeted marketing approach for the promotion of public health products with proven benefits, such as motorcycle helmets. The field of marketing has moved beyond universal campaigns to develop techniques to target specific groups of consumers with shared attributes. When marketing messages are customized for subgroups of the population that have been segmented according to relevant demographic and behavioral characteristics, these messages are more favorably received and more likely to elicit the intended response than mass-marketed messages.

## Conclusion

The primary focus of many previous motorcycle safety studies has been investigating and identifying contributing factors to motorcycle crashes and injury outcomes. These study findings are useful but can be limited for developing effective behavioral traffic safety programs, as they do not include a complete understanding of the primary target audience. A possible explanation is that most researchers work with crash data that often provide detailed information about motorcycle crashes but only limited information about vehicle operators.

This study showed that motorcycle fatalities have increased in both Group A (under age 30) and Group C (age 50 or older), both of which have undergone significant demographic changes during the past 10 years. A statewide survey was used to explore the characteristics of motorcyclists in each segment; the stated preference survey was an effective tool to investigate the attitudes and behavioral information of motorcyclists in each segment. The findings were compared and incorporated with the analysis of crash data. All three motorcyclist segments have different riding styles and behavioral characteristics, which can affect crash outcomes at different levels. This study examined motorcyclist age as an important evaluation variable for classifying motorcyclists, and demonstrated that the selected age thresholds establish three significant motorcyclist segments.

Further research is needed to understand motorcycle segments beyond age, direct relationships between segments to crash outcomes, and effective intervention programs reflecting each segment's unique characteristics.

### Author Contributions

The authors confirm contribution to the paper as follows: study conception and design: CL; data collection: CL, BK; analysis and interpretation of results: CL, BK, SJ; draft manuscript preparation: CL, BK, SJ, VS. All authors reviewed the results and approved the final version of the manuscript.

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