

Initial age of unlicensed motorcycling experience for a cohort of high school students

Tsu-Hung Yeh^{a,*}, Hsin-Li Chang^{b,1}, Hsin-Wen Chang^{b,c,2}

^a *Researcher of Institute of Transportation, Ministry of Transportation and Communications, 7F, 240 Tunhwa North Road, Taipei 105, Taiwan, ROC*

^b *Department of Transportation Technology and Management, National Chiao-Tung University, 1001, Ta Hsueh Road, Hsinchu 300, Taiwan, ROC*

^c *Department of Leisure and Recreation Planning and Management, Chung Hua University, 707, Sec. 2, WuFu Rd., Hsinchu 300, Taiwan, ROC*

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Abstract

The aim of this study is to use retrospective data to examine the initial age of unlicensed motorcycling experience for a cohort of senior high school students in Taiwan. The life-table method was applied to estimate the probability of unlicensed motorcycling at different age intervals below the minimum licensing age. The results indicated that an increase in the prevalence of unlicensed teenage motorcycling began at 10 years of age and peaked in the ages between 16 and 17 years. Only 38% of students had no motorcycle riding experience when they reached the minimum licensing age of 18 years. Gender and parental attitude were the factors that had a significant influence on the initial motorcycling age. In addition, we observed a significant difference between licensed and unlicensed students in the following areas: parental attitude, proportion of students using borrowed motorcycles, and riding and accident frequency. The results reveal a number of important implications, such as the promotion of alternative modes of transport, increased parental monitoring, and penalty enhancement, that may help to suppress the tendency of teenagers' unlicensed motorcycling.

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1. Introduction

The minimum legal licensing age for motorcycle riding in different countries reflects diverse policies of risk management. Taiwan has set a higher minimum licensing age of 18 years before gaining legal access to motorcycle riding, while the United States, Australia, New Zealand, and most European countries allow adolescents to ride a motorcycle from 15 or 16 years of age (Taiwan MTC, 2002; Schoon, 2004; Haworth and Mulvihill, 2005).

Taiwan's licensing system classes motorcycles into three types: mopeds ($\leq 50 \text{ cm}^3$), light motorcycles (from $>50 \text{ cm}^3$ to $\leq 250 \text{ cm}^3$), and heavy motorcycles ($>250 \text{ cm}^3$). The minimum licensing age for mopeds and light motorcycles is 18 years of

age. No prior experience or compulsory training is required for these two types of motorcycles before the license test except a medical examination. Therefore, almost all teenagers riding these lower-powered motorcycles gain their skills and experience through a process of self-learning and trial-and-error. In contrast, heavy motorcycle license requests a person aged over 20 years to have held a light motorcycle license for at least 1 year, and to have completed 32 h of compulsory training at a driving school before completing the tests. In Taiwan, most young people aged under 18 experience motorcycle riding prior to car driving because they have comparatively little chance to buy or borrow a passenger car and car driving has higher skill requirements.

A higher age limit, however, does not necessarily prevent adolescents from riding motorcycles while unlicensed. Curiosity, thrill-seeking, low degrees of parental monitoring, and transportation needs may result in adolescents engaging in motorcycling prior to reaching the legal licensing age. Unauthorized motorcycling by persons under the legal age appears to be prevalent in several countries. Chang (1996) reported that

* Corresponding author. Tel.: +886 2 23496856; fax: +886 2 25450429.

E-mail addresses: barryyeh7@hotmail.com, yth@iot.gov.tw (T.-H. Yeh), hlchang@cc.nctu.edu.tw (H.-L. Chang), hwchang@chu.edu.tw (H.-W. Chang).

¹ Tel.: +886 3 5731908; fax: +886 3 5712365.

² Tel.: +886 3 5186691; fax: +886 3 5372832.

approximately 38.8% of Taiwan's junior high school students and as many as 68.9% of senior high school students had ridden a motorcycle without a license at some stage. Rathinam et al. (2007) reported that boys as young as 8 years old engage in motorcycle riding in India, where underage riding is a common occurrence. Even though a learner license can be granted at the lower age of 15 years in New Zealand, Reeder et al. (1995) reported that most licensed riders (86%) had ridden on public roads before gaining their licenses.

Young riders may have a higher likelihood of being involved in an accident, especially young male riders with higher risk behavior (Chesam et al., 1993; Rutter and Quine, 1996; Lin et al., 2003). Pre-licensing riding may also involve more severe injury when accidents occur (Lin et al., 1998). The increased likelihood of an accident and greater severity of injury for young unauthorized motorcyclists may result from their lack of experience or immature mindset (Senserrick and Whelan, 2003; Chang and Yeh, 2007). This raises concerns over issues of safety for unlicensed teenagers. To address this problem and develop effective intervention strategies, it is crucial to undertake research on the prevalence of illegal riding by various age groups and determine the reasons for engaging in such behavior.

This study aimed to examine the probability of unlicensed motorcycling at different age intervals up to 18 years using retrospective self-reported data from Taiwan's senior high school students regarding when they first rode a motorcycle. We also assessed differences in initial experience related to gender and parental attitude, differences in motorcycle use, and differing behavior between licensed and unlicensed groups.

2. Methods

2.1. Data

This study used a retrospective self-reported survey of the attitudes of senior high school students to motorcycle use. The attitudinal survey of the student cohort was administered by Taiwan's Institute of Transportation (IOT) and documented their experience in motorcycle use and opinions on lowering the minimum motorcycle licensing age (IOT, 2006). Considerable attention has been focused on a cohort of senior high school students because they have a higher likelihood of experiencing unlicensed riding (Chang, 1996). In addition, the students in this education level can provide us with more complete recall experience for their motorcycling debut before the minimum licensing age of 18 years.

A stratified random sampling method was applied according to the population distribution of the age cohort from 16 to 18 years within 23 distinct administrative districts. The sampling frame was based on senior high schools within each district. A pre-designated number of questionnaires according to the population of youth aged 16–18 for each district was then distributed to the students affiliated with two randomly chosen schools in each district. A total of 1860 questionnaires were sent to 46 chosen schools and randomly sampled students in these schools were asked to respond the questionnaire. There were 1634 valid observations collected and the overall sampling error was con-

Table 1
Basic statistics of the sampled data

Variable	Category	Frequency (percentage)/ mean (S.D.)
Age	Mean (S.D.)	17.18 (0.95)
Gender	Male	939 (58.8%)
	Female	658 (41.2%)
Parental attitude	Approval	544 (33.9%)
	Neutral	653 (40.6%)
	Disapproval	409 (25.5%)
Unlicensed riding experience	Yes	868 (53.1%)
	No	766 (46.9%)
Schooling level at first unlicensed experience	Elementary stage (age 7–12)	111 (13.1%)
	Junior high stage (age 13–15)	418 (49.4%)
	Senior high stage (age 16–18)	317 (37.5%)
License type	Without license	1488 (91.6%)
	Moped	15 (0.9%)
	Light motorcycle	121 (7.5%)
	Heavy motorcycle	0 (0%)

trolled to within $\pm 3\%$. The survey showed a high response rate (87.8%) because the students completed the questionnaires in class via the assistance of the teachers in the sampled schools.

Some of the questions on which this study was based were taken from the questionnaire. The central questions were related to whether the sampled students had undertaken unlicensed motorcycle riding, and if so, their initial age and schooling level. To improve the accuracy of the recall data for the initial age of motorcycling, the schooling level at which unlicensed riding occurred was used as a time reference. Self-reported explanations of why the students had engaged in unlicensed motorcycling or not were also collected. In addition, gender and parental attitude were recorded to distinguish between demographic and family factors affecting the initial age of motorcycling.

The basic statistics of the sampled data are listed in Table 1. The mean age of the students was 17.2 ± 0.95 years (mean \pm S.D.). Fifty-nine percent of the students were male and 41% were female, while 40.6% of the sampled students perceived their parents' attitude towards their motorcycling as "neutral", 33.9% felt their parents "approved", and 25.5% perceived that their parents "disapproved". More than half of the sampled students (53.1%) had ridden a motorcycle while unlicensed. Of these, 49.4% did so at junior high level and 13.1% at a very early age in elementary school. At the time of the survey, 91.6% of the sampled students did not hold a license, 0.9% held a moped license, and 7.5% held a light motorcycle license.

2.2. The life-table method

When considering the prevalence of youths' engaging in unauthorized motorcycling at ages below the legal licensing age, the life-table method is useful in examining the probability of unlicensed motorcycling at different age intervals according to the numbers of sampled students who had experienced

motorcycle riding and their ages at initial experience. Specifically, this approach enables us to estimate the conditional probability of students experiencing unauthorized riding within different age groups and the survival probability (i.e., the term “survival” in this study means students have no motorcycling experience) for students who had not ridden a motorcycle beyond a specific age.

The observation of the initial motorcycling age in this study is a time-to-event process with two possible outcomes: an event observation or a censored observation. An event observation indicates the initial age of a sampled student engaging in unlicensed motorcycling. A censored observation, however, represents a sampled student who has yet to experience motorcycling; his/her age at the time of the survey is the censored time. As the age of motorcycling debut is retrospective data obtained through recall, the stated age may be an approximation of the real value, even though the stage of schooling was used as a supplementary question for recall. The life-table method was used because it is suitable for large data sets and imprecise timing data (Allison, 1995).

The conditional probability of events for a given age interval in the life-table provides an estimate of the probability that a student will experience motorcycling in this age interval given that the student has not yet experienced motorcycling at the start of the interval. The life-table method assumes that any cases are censoring within an interval as if they are censoring at the midpoint of the interval; therefore, they only count for half in establishing the number of cases exposed to risk (i.e., cases who have yet to experience motorcycle riding at the start of the interval). Consequently, the number of cases exposed to risk (R_i) in the i th age interval is then calculated as

$$R_i = N_i - 0.5 \times C_i \quad (1)$$

where N_i is the number of cases with no experience of motorcycling at the start of the i th interval and C_i is the number of cases censoring in the i th interval.

The conditional probability of events in the i th interval, Q_i , is defined as

$$Q_i = \frac{E_i}{R_i} \quad (2)$$

where E_i is the number of cases experiencing motorcycle riding in the i th interval.

The survival probability at the beginning of the i th interval, $S(t_i)$, which represents the probability of cases who have not yet experienced motorcycle riding up to age t_i or beyond, is calculated as

$$S(t_i) = \prod_{j=1}^{i-1} (1 - Q_j) \quad (3)$$

For $i = 1$, and hence $t_i = 0$, the survival probability is set to 1.

To compare the difference in motorcycling experience among the groups in terms of gender and parental attitude, we applied the Wilcoxon test, giving more weight to early times than late times (Allison, 1995).

3. Results

3.1. Life-table results for initial unlicensed age

The age distribution for the first motorcycling experience is examined by the life-table based on the overall samples, the classification by gender and by parental attitude respectively (see Table 2).

3.1.1. Overall life-table

An interval of 2 years was assigned to deal with the imprecise nature of the recall data. Although some students reported that they motorcycled at a very young age (from 6 to 7 years), the group who rode while less than 10 years of age was very small. The conditional probability of experiencing unlicensed riding was the highest for the ages of 16–17 years. For this age interval, approximately 41.9% of the sampled students had their first unlicensed experience. Students aged 14–15 years also had a higher probability for initial motorcycling experience; 27.1% of the students in this age interval made their motorcycling debut. The survival probability for students who had not yet experienced motorcycling declined sharply after students reached 14 years of age. The survival probability for those students without any experience of motorcycling was approximately 90.3% for those aged over 14 years, 65.8% for those aged over 16 years, and just 38.3% for those aged over 18 years. The median survival age was 17.15 years, indicating that half of the students younger than this age had ridden without a license.

3.1.2. Life-table by gender

The median survival age was 16.74 years for male students, approximately 1 year earlier than that for female students (17.84 years). This difference was statistically significant (Wilcoxon test, $\alpha = 0.05$). Approximately 30.6% of males within the age interval of 14–15 years and 49.4% of males aged 16–17 years engaged in motorcycling. The corresponding figures for female students were approximately 21.9% and 33.5%, respectively. Before reaching the licensing age of 18 years, only 31.0% of male students and 48.1% of female students had yet to ride a motorcycle. In addition, a proportion of students aged over the legal licensing age were still engaging in illegal riding. For the age category of 18–19 years, male students had a clearly higher violation percentage (36%) than female students (11.8%).

3.1.3. Life-table by parental attitude

Parental attitude was divided into three categories: “disapproval”, “neutral”, and “approval”. A pairwise comparison of the Wilcoxon test among the three groups of parental opinions indicated a significant difference between all possible pairs of groups. When parents approved the riding of a motorcycle, students had a shorter median survival age (16.65 years) than those whose parents disapproved (17.78 years) or gave a neutral opinion (17.35 years). The results indicated that the students with parents who held an “approval” attitude had an increased likelihood of engaging in motorcycling at an earlier age.

Table 2
Life-table results by different factors

Age interval	N_i	C_i	E_i	Q_i	$\hat{S}(t_{i+1})$	Median survival age (years)
Overall						
[6,8) ^a	1540	0	1	0.06%	99.94%	17.15
[8,10)	1539	0	7	0.45%	99.48%	
[10,12)	1532	0	39	2.55%	96.95%	
[12,14)	1493	0	103	6.90%	90.26%	
[14,16)	1390	67	367	27.05%	65.84%	
[16,18)	956	571	281	41.91%	38.25%	
[18,20)	104	88	14	23.33%	29.32%	
[20,22)	2	2	0	0.00%	29.32%	
By gender						
Male						
[6,8)	882	0	1	0.11%	99.89%	16.74
[8,10)	881	0	6	0.68%	99.21%	
[10,12)	875	0	28	3.20%	96.03%	
[12,14)	847	0	68	8.03%	88.32%	
[14,16)	779	50	231	30.64%	61.26%	
[16,18)	498	280	177	49.44%	30.97%	
[18,20)	41	32	9	36.00%	19.82%	
Female						
[8,10)	623	0	1	0.16%	99.84%	17.84
[10,12)	622	0	11	1.77%	98.07%	
[12,14)	611	0	35	5.73%	92.46%	
[14,16)	576	17	124	21.85%	72.25%	
[16,18)	435	273	100	33.50%	48.05%	
[18,20)	62	56	4	11.76%	42.40%	
[20,22)	2	2	0	0.00%	42.40%	
Wilcoxon statistics = 31.67, d.f. = 1, p -value = 0						
By parental attitude						
Approval						
[10,12)	511	0	14	2.74%	97.26%	16.65
[12,14)	497	0	49	9.86%	87.67%	
[14,16)	448	18	139	31.66%	59.91%	
[16,18)	291	159	108	51.06%	29.32%	
[18,20)	24	19	5	34.48%	19.21%	
[20,22)	387	0	2	0.52%	19.11%	
Neutral						
[6,8)	620	0	1	0.16%	99.84%	17.35
[8,10)	619	0	5	0.81%	99.03%	
[10,12)	614	0	16	2.61%	96.45%	
[12,14)	598	0	35	5.85%	90.81%	
[14,16)	563	33	142	25.98%	67.21%	
[16,18)	388	243	101	37.90%	41.74%	
[18,20)	44	37	5	19.61%	33.56%	
Disapproval						
[8,10)	387	0	2	0.52%	99.48%	17.78
[10,12)	385	0	8	2.08%	97.42%	
[12,14)	377	0	19	5.04%	92.51%	
[14,16)	358	16	77	22.00%	72.16%	
[16,18)	265	166	63	34.62%	47.18%	
[18,20)	36	32	4	20.00%	37.74%	
Wilcoxon statistics = 25.41, d.f. = 2, p -value = 0						

^a[6,8) represents the age range is between ≥ 6 years and < 8 years.

Approximately 51.1% of the students who had their parents' approval rode a motorcycle at the age of 16–17 years. This is higher than the probability for students whose parents disapproved (34.6%) or gave a neutral opinion (37.9%). The results also showed that before reaching the licensing age, only 29.3% of students had not experienced motorcycling if their parents

had a positive opinion, whereas 41.7% and 47.2% of students had no motorcycling experience if their parents had neutral or disapproving attitudes, respectively.

To establish why the students had ridden a motorcycle or not, we analyzed the self-reported reasons (see Table 3). "For convenience" (76.9%) and "transport needs" (70.5%) were the

Table 3
Self-reported reasons for motorcycling and not motorcycling

Self-reported reasons	Percentage
For motorcycling	100
Showing off	7.6
Other reasons	11.0
Curiosity	13.9
Lower traveling cost	19.4
Transport needs	70.5
For convenience	76.9
For not motorcycling	100
Restriction by school	18.5
Other reasons	18.6
For safety considerations	23.6
Disproval by parents	42.0
Fear of being caught	42.1
No need to	43.3

two leading explanations for students who rode a motorcycle, while “curiosity” (13.9%) and “showing off” (7.6%) did not rate highly. The students with no motorcycling experience reported “no need to” (43.3%), “fear of being caught by the police” (42.1%), and “disapproval by their parents” (42.0%) as the three leading reasons for not riding unlicensed.

3.2. Comparisons of motorcycle use between licensed and unlicensed students

Among the 876 students with riding experience, just 136 were licensed at the time of the survey. The licensed students repre-

sented 15.5% of the overall students with riding experience. Only 16 of the 136 licensed cases (11.8%) waited until formally obtaining a license before first using a motorcycle.

Table 4 shows the differences in motorcycle riding experience between licensed and unlicensed students. Licensed students had a mean age of 18.9 years, while unlicensed students had a mean age of 17.0. A higher proportion of male students engaged in motorcycle use than female students, regardless of whether they belonged to the licensed or unlicensed group, but the proportion of male and female students was not statistically different (χ^2 test, $\alpha = 0.05$).

Parental attitude tended to be associated with a difference between the unlicensed and licensed groups. Licensed students reported a higher percentage of parental approval (46.7%) than unlicensed students (38.7%), as well as a higher percentage of disapproval (26.7% compared with 21.0%). Parents of unlicensed students were more likely to have a neutral attitude (40.3%) than those of licensed students (26.7%).

The ownership of the motorcycle being used by the two groups was clearly different. Most students in both groups used a motorcycle owned by their parents (66.1% for unlicensed students and 45.4% for licensed). Very few students (2.6%) rode their own motorcycles if they did not hold a license, whereas 31.9% of licensed students used their own motorcycles.

We observed a significant difference in the frequency of motorcycle use between licensed and unlicensed students. Over half of the students with a license (53.3%) rode a motorcycle at least once a day, compared with only 17.7% of unlicensed students. The proportion of licensed students using a motorcycle

Table 4
Comparison of riding experience between unlicensed and licensed students

Variable	Category	Frequency (percentage)/mean (S.D.)		χ^2
		Unlicensed	Licensed	
Age ^a	Mean (S.D.)	17.02 (0.74)	18.86 (1.15)	–
Gender	Male	473 (64.5%)	93 (71.0%)	2.06
	Female	260 (35.5%)	38 (29.0%)	
Parental attitude	Disapproval	152 (21.0%)	36 (26.7%)	9.06 ^b
	Neutral	292 (40.3%)	36 (26.7%)	
	Approval	280 (38.7%)	63 (46.7%)	
Owner of the motorcycle usually ridden	My own	19 (2.6%)	38 (31.9%)	144.0 ^b
	Parents	480 (66.1%)	54 (45.4%)	
	Brother or sister	79 (10.9%)	14 (11.8%)	
	Classmate	59 (8.1%)	6 (5.0%)	
	Friend	60 (8.3%)	7 (5.9%)	
	Others	29 (4.0%)	0 (0%)	
Riding frequency over the past 6 months	Once/day	130 (17.7%)	64 (53.3%)	98.8 ^b
	Three times/week	123 (16.8%)	25 (20.8%)	
	Once/week	107 (14.6%)	18 (15.0%)	
	Once/month	88 (12.0%)	8 (6.7%)	
	Less than once/month	218 (29.7%)	1 (0.8%)	
	Almost never	67 (9.1%)	4 (3.3%)	
Accident frequency over the past year	None	640 (87.7%)	77 (62.1%)	60.5 ^b
	One	58 (8.0%)	22 (17.7%)	
	Two	20 (2.7%)	14 (11.3%)	
	Three or more	12 (1.6%)	11 (8.9%)	

^a The “(minimum age, maximum age)” for students without a license was (15.1, 20.0) and for students with a license was (18.0, 24.3), respectively.

^b The χ^2 test statistics were significant at $\alpha = 0.05$.

Table 5
Comparison of traffic means between unlicensed and licensed students

Traffic means	Unlicensed		Licensed	
	On weekdays	On weekends	On weekdays	On weekends
By others	1.0%	0.8%	2.5%	2.5%
Collected by car	4.2%	5.5%	1.7%	1.7%
Collected by motorcycle	7.5%	6.3%	2.5%	6.7%
By walk	10.5%	4.7%	10.9%	0.8%
By school bus	29.0%	–	20.2%	–
By motorcycle	5.2%	27.7%	31.1%	61.4%
By bicycle	12.5%	23.0%	5.0%	2.5%
By public transport	30.1%	32.0%	26.1%	24.4%

three times per week (20.8%) was also higher than that for unlicensed students (16.8%). Unlicensed students were more likely to ride a motorcycle less than once a month (29.7%) and showed two peaks in their riding frequency (at least once a day and less than once a month); however, licensed students had only one peak in riding frequency.

Accident frequency in the past year also produced a significant difference between the two groups of students. Unlicensed students (87.7%) were more likely to be accident-free than licensed students (62.1%). The unlicensed students who were involved in a crash for one, two, and three or more times a year had a lower likelihood (i.e., 8%, 2.7%, and 1.6%, respectively) than their licensed counterparts (17.7%, 11.3%, and 8.9%, respectively). This result may reflect the fact that unlicensed students report lower motorcycle use than licensed students.

The choice of transport used by students with or without a license revealed diverse patterns on both weekdays (going to school) and weekends (see Table 5). On weekdays, groups without a license were more likely to take public transport (30.1%) or a school bus (29%) to school. Less popular options for getting to school were bicycle (12.5%) and walking (10.5%). Only 5.2% of students without a license rode a motorcycle on weekdays. In contrast, students with a license were more likely to ride a motorcycle (31.1%), take public transport (26.1%), or a school bus (20.2%). Only 5% of licensed students went to school by bicycle.

On the weekends, however, students without a license increased their motorcycle riding and bicycle use to 27.7% and 23.0%, respectively. In addition, students with a license also increased their motorcycle use to 61.4% and increased their likelihood of being a pillion passenger from 2.5% on school days to 6.7% on the weekends. Compared with motorcycle use on weekdays, unlicensed students showed a greater increase rate in usage on the weekends than licensed students.

4. Discussion

In terms of advances on previous studies, the present report has detailed results on the use of motorcycles by youths at different age stages and identified factors such as gender and parental attitude that influence the age at which a young person first rides a motorcycle. In addition, comparisons of motorcycle use between licensed and unlicensed students revealed important

implications that may be useful in reducing the likelihood of illegal riding for young people.

4.1. Promotion of alternative modes of transport

The initial motorcycling age reported by the sampled cohort of Taiwan's senior high school students increased from 10 years of age, peaked at the ages of 16–17 years, and then began to decrease. The overall life-table results indicated that a young person was most likely to first ride a motorcycle at the ages of 14–15 years (27.1%) and 16–17 years (41.9%), which correspond to the years of junior and senior high school, respectively. Only 38.3% of the students had no riding experience when they reached the minimum licensing age of 18 years.

Increasing transport need appears to be a principal factor for those students engaging in illegal riding. The public transit systems in most of Taiwan's districts are underdeveloped, meaning that motorcycles are a principal mode of transport in many areas. Senior high school students are usually involved in more extra-curriculum activities, such as part-time jobs, and have longer home-to-school trips than those of junior high students; therefore, the prevalence of unlicensed riding will not be easily reduced unless the transport needs of adolescents are met, especially during the weekends and as they get older. It is important to promote alternative modes of transport that meet young people's needs, such as electric powered bicycles, rather than relying solely on penalty interventions.

4.2. Promotion of parental monitoring

Parental monitoring might be another key issue that affects the prevalence of unauthorized riding. Parental disapproval appears to delay the time at which the unlicensed adolescent first engages in motorcycling and is one of the main reasons that students in our study refrained from riding at all. It is also the parents who lent their motorcycle to the students, especially to students without a license.

Research has shown that parental monitoring affects teenagers' driving behavior and safety performance. Hartos et al. (2000) found that low parental monitoring and control were associated with higher rates of risk behavior, violation, and crashes among teenagers' driving automobiles. The effectiveness of parental management of teenage driving when their obtaining

a learner's permit or provisional license is significant, along with placing limits on teenage driving in the first few months of holding a license (Simons-Morton et al., 2002, 2003). Therefore, we propose that stricter parental monitoring may result in the prevention of illegal teenage riding or at least delay such behavior.

4.3. Prevention of early age motorcycling behavior

Unlicensed riding is prevalent and the likelihood of this behavior increases significantly from about 14 years of age. The need to reduce the level of unlicensed motorcycling among young people, especially those who ride before the age of 16, should be addressed with urgency because of their high accident risk and immaturity raised by much research. Research has shown that teen motorcyclists have a disproportionately higher likelihood of being involved in an accident (Chesham et al., 1993; Rutter and Quine, 1996; Lin et al., 2003) and that the accident will be more severe than those involving older riders (Schoon, 2004; Lin et al., 1998). As reported by Senserrick and Whelan (2003), the increased crash risk due to a low licensing age may reflect three factors: an increase in the total number of novices on the roads, less time available to gain experience, and immaturity. The immaturity of young people may be associated with their weaker cognitive ability, including the slower speed at which they process information in their short-term memory, their reduced ability to filter out irrelevant information and focus on appropriate information (Eby and Molnar, 1998), and their propensity towards risky behavior (Rutter and Quine, 1996; Mullin et al., 2000).

The fear of being caught is one of the main reasons that students in this study chose not to ride while unlicensed. On this basis, increasing penalties and ensuring their enforcement, especially for very young age groups and their parents, could prove effective.

Taiwan has set a licensing age of 18 years with the aim of delaying the age at which adolescents first ride motorcycles. The results of the present paper reveal that unlicensed teen riding is prevalent. Even though unlicensed students ride less and are less likely to be involved in an accident than licensed students, the high prevalence of unlicensed teen motorcycling is still a significant problem in the current licensing system. To reduce the probability of young people riding motorcycles while unlicensed, promotion of alternative modes of transport, increased parental monitoring, and harsher penalties have been raised by this study. The lowering of Taiwan's motorcycle licensing age together with matched countermeasures by imitating the graduated licensing system in some western countries might be another strategy to develop. However, the negative safety effects resulted from lowering licensing age is still a debatable issue in

Taiwan. We suggest that more studies need to be conducted to evaluate the overall safety effectiveness of the current licensing system.

References

- Allison, P.D., 1995. *Survival Analysis Using the SAS System: A Practical Guide*. SAS Institute Inc., Cary, NC, USA.
- Chesham, D.J., Rutter, D.R., Quine, L., 1993. Motorcycling safety research: a review of the social and behavioral literature. *Soc. Sci. Med.* 37, 419–429.
- Chang, H.L., 1996. A Survey on the Transportation Demand and Traffic Risk Perception by Adolescent Students in Taiwan. The Culture and Education Foundation of Tong-Yang Wu-Suon, Taipei, Taiwan.
- Chang, H.L., Yeh, T.H., 2007. Motorcyclist accident involvement by age, gender, and risky behaviors in Taipei, Taiwan. *Transport. Res. Part F: Traffic Psychol. Behav.* 10, 109–122.
- Eby, D.W., Molnar, L.J., 1998. Matching Traffic Safety Strategies to Youth Characteristics: A Literature Review of Cognitive Development. Commissioned by U.S. Department of Transportation National Highway Traffic Safety Administration.
- Hartos, J.L., Eitel, P., Haynie, D.L., Simons-Morton, B.G., 2000. Can I take the car? Relations among parenting practices and adolescent problem-driving practices. *J. Adolescent Res.* 15, 352–367.
- Haworth, N., Mulvihill, C., 2005. Review of Motorcycle Licensing and Training. Monash University Accident Research Center, Victoria, Australia.
- Lin, M.R., Chang, S.H., Pai, L., Keyl, P.M., 2003. A longitudinal study of risk factors for motorcycle crashes among junior college students in Taiwan. *Accid. Anal. Prev.* 35, 243–252.
- Lin, D.Y., Lin, F.F., Chang, K.K., 1998. Preliminary discussion on adolescent accident analysis and safety education. *Traffic Safety*, vol. II. Taipei, Taiwan. Ministry of Transportation and Communications, 2002. Taiwan's Road Traffic Regulations. Taipei, Taiwan.
- Mullin, B., Jackson, R., Langley, J., Norton, R., 2000. Increasing age and experience: are both protective against motorcycle injury? A case control study. *Inj. Prev.* 6, 32–35.
- Rathinam, C., Nair, N., Gupta, A., Joshi, S., Bansal, S., 2007. Self-reported motorcycle riding behavior among school children in India. *Accid. Anal. Prev.* 39, 334–339.
- Reeder, A.I., Chalmers, D.J., Langley, J.D., 1995. Young on-road motorcyclists in New Zealand: age of licensure, unlicensed riding, and motorcycle borrowing. *Inj. Prev.* 1, 103–108.
- Rutter, D.R., Quine, L., 1996. Age and experience in motorcycling safety. *Accid. Anal. Prev.* 28, 15–21.
- Schoon, C., 2004. Traffic legislation and safety in Europe concerning the moped and the A1-category (125 cm³) motorcycle. Literature and Questionnaire Study Commissioned by the Swedish National Road Administration. SWOV Institute for Road Safety Research, Leidschendam, The Netherlands.
- Senserrick, T., Whelan, M., 2003. Graduated driver licensing: Effectiveness of systems and individual components. (Report No. 209). Monash University Accident Research Centre, Melbourne, Australia.
- Simons-Morton, B.G., Hartos, J.L., Beck, K.H., 2003. Persistence of effects of a brief intervention on parental restrictions of teen driving privileges. *Inj. Prev.* 9, 142–146.
- Simons-Morton, B.G., Hartos, J.L., Leaf, W.A., 2002. Promoting parental management of teen driving. *Inj. Prev.* 8 (Suppl. II), ii24–ii31.
- Taiwan's Institute of Transportation, 2006. A Feasibility Study on Lowering Motorcycle Licensing Age. Taiwan's Institute of Transportation, Taipei, Taiwan.