Accident Analysis and Prevention 43 (2011) 1385–1391

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

# Driving behaviors and accident risk under lifetime license revocation

Hsin-Li Chang[a,1], T. Hugh Woo[a,2], Chien-Ming Tseng[b,*], I-Yen Tseng[c,3]

[a] Department of Transportation Technology and Management, National Chiao Tung University, 1001 University Road, Hsinchu 30010, Taiwan, ROC
[b] Ministry of Transportation and Communications, 6 Shengfu Road, Chung-Shin Village, Nantou City 54045, Taiwan, ROC
[c] Department of Information Engineering, Beijing University of Posts and Telecommunications, 10 XiTuCheng Road, HaiDian District, Beijing City 100876, China

ARTICLE INFO

*Article history:*
Received 12 January 2010
Received in revised form 14 February 2011
Accepted 15 February 2011

*Keywords:*
License revocation
Driving behaviors
Crash rate
Logistic regression model

ABSTRACT

This study explored the driving behaviors and crash risk of 768 drivers who were under administrative lifetime driver's license revocation (ALLR). It was found that most of the ALLR offenders (83.2%) were still driving and only a few (16.8%) of them gave up driving completely. Of the offenders still driving, 67.6% experienced encountering a police roadside check, but were not detained or ticketed by the police. Within this group, 50.6% continued driving while encountering a police check, 18.0% of them made an immediate U-turn and 9.5% of them parked and exited their car. As to crash risk, 15.2% of the ALLR offenders had at least one crash experience after the ALLR had been imposed. The results of the logistic regression models showed that the offenders' crash risk while under the ALLR was significantly correlated with their personal characteristics (personal income), penalty status (incarceration, civil compensation and the time elapsed since license revocation), annual distance driven, and needs for driving (working, commuting and driving kids). Low-income offenders were more inclined to have a crash while driving under the ALLR. Offenders penalized by being incarcerated or by paying a high civil compensation drove more carefully and were less of a crash risk under the ALLR. The results also showed there were no differences in crash risk under the ALLR between hit-and-run offences and drunk driving offences or for offenders with a professional license or an ordinary license. Generally, ALLR offenders drove somewhat more carefully and were less of a crash risk (4.3 crashes per million km driven) than legal licensed drivers (23.1 crashes per million km driven). Moreover, they seemed to drive more carefully than drivers who were under short-term license suspension/revocation which previous studies have found.



## 1. Introduction

In traffic safety research, it is often of interest to explore driving behaviors and quantify the risk of crash involvement of certain groups of drivers. Many studies have focused on exploring the effectiveness of license suspension/revocation (S/R) (Hagen et al., 1980; Williams et al., 1984; Ross and Gonzales, 1988; Smith and Maisey, 1990; Deyoung, 1999; Malenfant et al., 2002), and have consistently demonstrated that this sanction is effective for reducing the subsequent accident and traffic conviction rate of high-risk drivers over a short term (McKnight and Voas, 1991; Mann et al., 1991; Peck, 1991; Siskind, 1996; DeYoung et al., 1997). Some studies have found that such disqualified drivers who venture out on the road are likely to drive in such a way as to avoid attracting the attention of the police (Ross and Gonzales, 1988; Smith and Maisey, 1990), drive less, and drive somewhat more carefully (Hagen et al., 1980; Ross and Gonzales, 1988; Voas and DeYoung, 2002). Hence, license S/R was by far the most effective treatment for both accidents and violations. Since one of the objectives of license S/R is to eliminate driving for the period of the suspension, it is possible that much or all of the effect is due to reduced exposure and/or more careful driving during the suspension interval (Masten and Peck, 2004). Siskind (1996) found that the accident rate of these suspension offenders during periods of disqualification is about one third of the rate during periods of legal driving; however it is difficult to distinguish between reduced driving levels and more cautious traffic behavior during periods of license restriction.

In the face of serious traffic violation problems, a common deterrent has been to increase the penalties for offenders. However, driving while under a short term S/R is difficult to detect, it can only be reached when the driver of a vehicle has been stopped by the police for committing another traffic offence (Voas and DeYoung, 2002). License S/R is usually implemented within a few years. It seems more difficult to gather an available empirical data for long term license S/R. Therefore, few studies have explored the effectiveness of administrative license revocation over the long term

* Corresponding author. Tel.: +886 4 27011026; fax: +886 4 23588039.
*E-mail addresses:* hlchang@cc.nctu.edu.tw (H.-L. Chang), thwoo@mail.nctu.edu.tw (T.H. Woo), tsengcm168@yahoo.com.tw (C.-M. Tseng), pennyenen@hotmail.com (I.-Y. Tseng).
[1] Tel.: +886 3 5731908; fax: +886 3 5712365.
[2] Tel.: +886 3 5731998; fax: +886 3 5720844.
[3] Tel.: +886 7 3115845.

0001-4575/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.aap.2011.02.013

**Table 1**
Legal driver, ALLR population and its components.

| | Legal driver population in 2002 | | ALLR population (1993–2002) | | Respondents | | Non-respondents (includes invalid questionnaires) | |
|---|---|---|---|---|---|---|---|---|
| | *N* = 9611,677 | % | *N* = 2554 | % | *N* = 768 | % | *N* = 1786 | % |
| Gender | | | | | | | | |
| Male | 5,853,511 | 60.9 | 2517 | 98.6 | 755 | 98.3 | 1762 | 98.7 |
| Female | 3,758,166 | 39.1 | 37 | 1.4 | 23 | 1.7 | 24 | 1.3 |
| *License category* | | | | | | | | |
| Professional license[a] | 479,541 | 5.0 | 536 | 21.0 | 128 | 23.7 | 408 | 22.8 |
| Ordinary license | 9,132,136 | 95.0 | 2018 | 79.0 | 640 | 76.3 | 1378 | 78.2 |

[a] Professional license is defined as a license which qualified a driver to dedicate driving as a job, including driving a car, truck and bus according to these different driving vehicles' requirements distinctively.

(Siskind, 1996), especially focusing on driving behavior or accident risk over a long term S/R. It appears only Chang et al. (2006) explored administrative lifetime driver's license revocation (ALLR) and found that the percentage of such offenders who continue to drive is higher than those with short-term license S/R that may introduce one more societal inequity.

This study is a serial research of Chang et al. (2006). While Chang et al. (2006) explored the effectiveness of the ALLR and highlighted the appropriateness of the ALLR policy and its impact on offenders, the present study emphasized the driving behaviors and crash risk of the ALLR offenders after the ALLR had been imposed. For those offenders who were still driving, driving behaviors included driving alterations, reactions to encountering a police roadside check, and receiving a penalty such as a ticket were explored in this study. For offenders who completely gave up driving, transportation alternatives were also investigated. As to the crash risk under the ALLR, two objectives were highlighted. First, the punishment for an ALLR offender is much more severe than for a short term S/R offender, so the research question asked if drivers who drove under the ALLR penalty were more cautious and were a relatively lower crash risk than drivers who drove under a short term S/R penalty. Therefore, the present study quantified the crash rate under the ALLR and investigated the safety improvement that resulted from the effects of the ALLR. A general comparison of the safety effects between present ALLR and prior short-term S/R studies located in the literature demonstrated whether the ALLR drivers drive more carefully than short-term S/R drivers. Second, this study investigated all the ALLR offenders' driving crash records to explore what kinds of ALLR offenders were higher crash risks and what kinds of ALLR offenders were less of a crash risk. Therefore, logistic regression models were then employed to show how an offenders' crash risk was associated with their characteristics, penalty status, annual distance driven, and needs for driving. Finally, a general effectiveness of the ALLR, the opinion of the Taiwan constitutional court on this punishment, and the current development of the ALLR policy are discussed in this paper.

## 2. Methods

### 2.1. Data

The data source was the same as the previous study (Chang et al., 2006) that collected data from offenders who had been punished by ALLR as a result of being involved in either a hit-and-run offence causing death/or injury, or a drunk driving offence causing death/or serious injury in Taiwan from 1993 to 2002. There were 2554 drivers punished by ALLR. The ALLR population is shown in Table 1. Since these ALLR offenders were expelled from the Department of Motor Vehicles, objective records of driving behaviors and crash information were not available. Self-report data came from a two-stage survey collected from the ALLR offenders. In the first stage, a questionnaire census for all ALLR offenders from 1993 to 2002 was conducted in September of 2003. The information of the ALLR offenders' characteristics and their driving status were collected which included: (1) Basic personal characteristics: gender, age, marital status, income, education, and license category before revocation; (2) Penalty status: criminal penalty, civil compensation, and the time elapsed since license revocation; (3) Driving status: driving alterations, reactions of encountering police roadside checks (not stopped), penalty received when stopped by the police, transportation alternatives, and crash occurrence after the ALLR; and (4) Driving needs: the reasons for driving under the ALLR, including job activities (e.g. working and commuting) and family activities (e.g. shopping, traveling for touring/or leisure, visiting relatives/or friends and driving kids). In the second stage, annual distance driven was collected by a telephone interview by trained personnel. In addition, in order to determine a more accurate crash rate, crash information was further stated deeply by offenders in the second stage interview and compared with the first stage questionnaire. The percentage of questionnaires returned unclaimed by the postal service due to invalid addresses was 32%. A total of 895 questionnaires were collected. When the questionnaire return rate was corrected for those returned unclaimed, the actual return rate was 52%. There were 768 offenders who completed the two-stage survey, and this data was used in the final analysis (Table 2).

### 2.2. Measures and variables

Offenders' driving information included driving behaviors and crash events. For the driving behaviors while driving under the ALLR, responses when encountering a police roadside check (but not stopped), penalties for having been stopped by a police roadside check, driving alterations for offenders still driving, and transportation alternatives for offenders who completely gave up driving were collected with the questionnaire. For the accident risk under the ALLR, the research focused on two points. First, from a macro view, this study quantified the accident risk of the ALLR policy and compared these offenders' crash risk with that of previous short-term license S/R findings. Prior short-term studies quantified the drivers' driving risk performance based on a measure of fatality, injury, or property damage. Siskind (1996) found that the crash rate of short-term suspension offenders during periods of disqualification was about one third of the rate during legal driving. In this study, we quantified the crash rate of the ALLR offenders and compared it to the crash rate of legal driving. Then, the crash risk performance under the influence of the ALLR policy was analyzed. By comparing the crash risk performance between the ALLR policy and short term S/R that the previous study found, our hypothesis that drivers who drove under the ALLR might drive more carefully and have relatively higher safety performance records than drivers who drove under a short term S/R can be demonstrated. Second, from a micro view, this research investigated all the ALLR offenders' crash rate to explore the crash risk factors and identify what kinds of ALLR offenders drove unsafely and experienced more crashes,

**Table 2**
Basic results of the respondent ALLR offenders ($N = 768$).

| | Respondents | |
|---|---|---|
| | *N* | % |
| *Offenders' personal characteristics* | | |
| Gender | | |
| Male | 755 | 98.3 |
| Female | 13 | 1.7 |
| Age | | |
| ≤40 | 538 | 70.1 |
| >40 | 230 | 29.9 |
| Married | | |
| Yes | 498 | 64.8 |
| No | 270 | 35.2 |
| Income (NTD/month)[a] | | |
| ≤30,000 | 537 | 69.9 |
| >30,000 | 231 | 30.1 |
| Education | | |
| No college | 631 | 82.2 |
| College and up | 137 | 17.8 |
| License category | | |
| Professional | 128 | 23.7 |
| Ordinary | 640 | 76.3 |
| Having dependents to take care of | | |
| Yes | 628 | 81.8 |
| No | 140 | 18.2 |
| Offence category | | |
| Hit-and-run causing death/injury | 545 | 70.9 |
| Drunk driving causing death/serious injury | 223 | 29.1 |
| Penalty status | | |
| Incarcerated | | |
| Yes | 71 | 9.3 |
| No | 697 | 90.7 |
| Civil compensation (Thousand NTD) | | |
| <300 | 380 | 49.5 |
| 300–1500 | 200 | 26.0 |
| >1500 | 188 | 24.5 |
| The time elapsed since license revocation | | |
| ≤3 years | 283 | 36.8 |
| >3 years | 485 | 63.2 |
| Driving classes (annual distance driven under ALLR) | | |
| Class 0 (Completely gave up driving) | 129 | 16.8 |
| Class 1 (≤1000 km) | 213 | 27.7 |
| Class 2 (1001–5000 km) | 151 | 19.7 |
| Class 3 (5001–20,000 km) | 194 | 25.3 |
| Class 4 (>20,000 km) | 81 | 10.5 |
| Needs for driving under ALLR[b] | | |
| Working | 390 | 61.1 |
| Commuting | 184 | 28.8 |
| Shopping | 123 | 19.3 |
| Leisure travel | 138 | 21.6 |
| Visiting relatives/friends | 142 | 22.3 |
| Driving kids | 188 | 29.4 |

[a] 30 NTD = 1 USD.
[b] Respondent, $n = 639$, excluding offenders who had completely given up driving 16.8%, $n = 129$.

and what kinds of ALLR offenders drove carefully and experienced fewer crashes.

The crash rates (total numbers of crashes divided by total distance driven for all ALLR or a certain group of ALLR offenders) are expressed by per crash kilometer and crash per million kilometers driven. This study employed a logistic regression model to show how offender characteristics (gender, age, income, education, license category), penalty status (incarceration, civil compensation and the time elapsed since license revocation), annual distance driven, and driving purposes (working, commuting, shopping, traveling for leisure, visiting relatives/friends and driving kids etc.) influenced their crash rate. For the purpose of formulating the binary problem and to distinguish the crash experiences after the ALLR, the indicator variable was set to one if the offender had experienced a crash and to zero for the others. Explanatory variables are classified into different groups respectively (Table 2). Personal income was classified into two groups by 30,000 NTD (around three quarters of average monthly personal income of Taiwan, 30 NTD = 1 USD) and education was grouped by having attended college or not. Since ALLR is due to either a hit-and-run causing physical injury/or a death or drunk driving causing serious physical injury/or death offence, many ALLR cases involved penalties of incarceration or civil compensation or both. Thus, incarceration was divided into two groups according to whether or not the offender was incarcerated. Civil compensation was categorized into three groups that included under 300 thousand NTD (10 thousand USD), 300–1500 thousand NTD, and over 1500 thousand NTD. The amount of 300 thousand NTD was an averaged levied amount of ALLR cases involving physical injury cases and the amount of 1500 thousand was an average levied amount that involved a death. The time elapsed since license revocation was classified into two groups divided by 3 years. Since annual distance driven is one of the stronger predictors of accident involvement (Peck and Kuan, 1983; Massie et al., 1997) and some previous study showed that high-mileage drivers have a lower accident risk per mile driven than low-mileage drivers (Maycock, 1985). In the present study, annual distance driven was classified into five groups from class 0 to class 4 which represented the annual distance driven of 0 (completely gave up driving), ≤1000 km, 1001–5000 km, 5001–20,000 km, and >20,000 km, respectively.

## 3. Study results

Among the respondent offenders, only 1.7% of them were female, 23.7% held a professional license (Table 1). Compared with such ratios of the ALLR population and the non-respondents, it shows that they share the similar distribution in gender and license category. It is believed that respondents represented the population. Table 2 shows the characteristics of the study respondents at the time of the survey. There were 70.9% committed a hit-and-run offence causing physical injury/or death. As to driving classes, 16.8% of the offenders completely gave up driving, 27.7% of them drove with an annual distance driven not over 1000 km, 19.7% drove between 1001 km and 5000 km, 25.3% drove from 5001 km to 20,000 km, and 10.5% of them drove more than 20,000 km.

### 3.1. Driving behaviors under ALLR

#### 3.1.1. Driving alteration for still driving offenders

After the ALLR, the offenders who continued to drive altered their driving behavior (Fig. 1). A reduction in driving frequency was indicated by 74.8%; 37.0% of them said that they had dodged police roadside checks; 22.2% said they had changed their travel routes; 13.4% said they had changed their driving time during which they drove; and a few of them said that they avoided daytime driving.

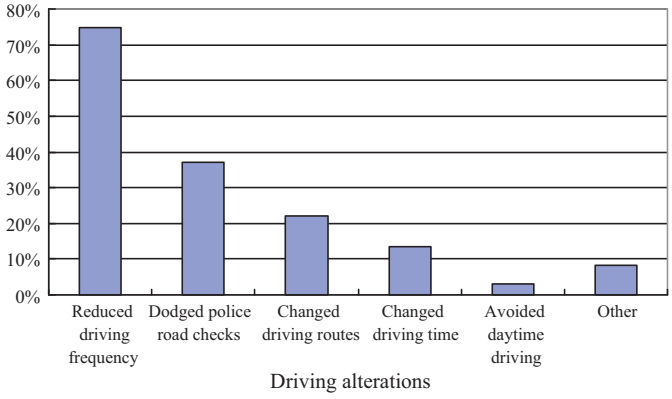


**Fig. 1.** Driving alterations under ALLR.

**Table 3**
Experience of encountering police under ALLR ($N = 639$[a]).

| | N | % |
|---|---|---|
| Had experience of encountering police (not stop) and it's responses | | |
| Yes | 432 | 67.6 |
| Kept driving | 219 | 50.6 |
| Made an immediate U-turn | 78 | 18.0 |
| Parked and got out of the car | 41 | 9.5 |
| Accelerated and sped off | 13 | 3.0 |
| Other | 81 | 18.9 |
| No | 207 | 32.4 |
| Had been stopped by police road check and received penalty | | |
| Yes | 333 | 52.1 |
| Received penalty | 154 | 43.1 |
| Received no penalty | 179 | 56.9 |
| No | 306 | 47.9 |

[a] Respondent, $n = 639$, excluding offenders who had completely given up driving 16.8%, $n = 129$.

#### 3.1.2. Responses of encountering police under ALLR

Of the respondent offenders, 67.6% had the experience of encountering police roadside checks (but not stopped). Among these, 50.6% kept on driving, 18.0% made an immediate U-turn, 9.5% parked and got out of the car, and 3.0% accelerated and sped off. Of the respondent offenders, 52.1% had the experience of being stopped by a police roadside check, and of these, 43.1% had received at least one penalty (Table 3). On average, an ALLR offender had been stopped by a police roadside check once after driving 35,230 km, or once every 4.0 years and received a penalty after driving 63,612 km, or once during a period of 7.3 years. Both these incidents, being stopped by the police and receiving a penalty, are statistically low.

### 3.2. Alternatives of no more driving

For the respondent offenders who stopped driving (16.8%), their traveling alternatives showed that 45.7% of them drove or rode motorcycles, 30.2% of them were taken by others, 14.0% of them used the bus, 5.4% of them rode bicycles, and 4.7% of them chose other alternatives (Table 4). However, according to the ALLR regulations, the privileges of operating a motorcycle as well as other motor vehicles were revoked at the same time. Nearly half of the no more driving offenders were operating their motorcycles illegally. Since motorcycles are one of the most popular transportation tools in a developing country such as Taiwan, this result is not surprising and was expected before the study investigation.

### 3.3. Crash rate under the ALLR

Except 16.8% of the respondent offenders who completely gave up driving, the other 83.2% were still driving on the road. Of all respondent offenders, 15.2% of them had a crash (a few of them had more than one). The period of time since their licenses had been revoked varied from 6 to 120 months, with an average of 53.8 months. During their license revocation period, 129 crashes happened totally.

**Table 4**
Alternatives of completely gave up driving.

| | N | % |
|---|---|---|
| Alternatives | | |
| Motorcycle | 59 | 45.7 |
| Taken by Others | 39 | 30.2 |
| Bus | 18 | 14.0 |
| Bicycle | 7 | 5.4 |
| Others | 6 | 4.7 |
| Total | 129 | 100 |

Generally, each ALLR offender experienced 4.3 crashes per million km driven during the ALLR period. Specifically, offenders who drove an annual distance driven from 5001 km to 20,000 km experienced 3.0 crashes per million km driven. These offenders drove relatively safer than the other driving classes. Offenders who drove over 20,000 km yearly experienced 3.6 crashes per million km driven, which also showed they drove relatively safer. Those who drove between 1001 km and 5000 km experienced 12.8 crashes per million km driven. Offenders who drove under 1000 km experienced 21.6 crashes per million km driven. Both of these two groups drove relatively unsafe. In other words, relatively high mileage offenders (class 3 and class 4) had a safer driving outcome than relatively low mileage offenders (class 1 and class 2). Furthermore, class 3 was better than class 4 showing that too much or too little mileage driven may be unsafe (Table 5).

### 3.4. Crash risk influential factors—who drove safely and who did not?

Driving mileage is one of the most important factors influencing crash rates. However, mileage is not the only factor that influences crash rates. Other factors such as personal characteristics, penalty status, or driving purpose may also influence crash rates. For example, an offender who had been incarcerated or paid a high civil compensation may drive more carefully than before because the punishment for an offence is too severe to endure for the second time. As to driving needs, offenders who drive kids may drive more cautiously than while driving for other needs. Hence, in this section, we want to explore the determinant factors affecting the offenders' crash rate.

Among the candidate variables, the results showed that the factors of personal characteristics (personal income, penalty status: incarceration, civil compensation, and the time elapsed since license revocation), annual distance driven and driving needs (working, for commuting and driving kids) were significant in the logistic regression model (Table 6). Offenders who had a monthly income over 30,000 NTD were approximately 52% less likely (odds ratio = 0.482) to have a crash compared to the offenders who had a monthly income under 30,000 NTD. Offenders who had been incarcerated were around 45% less likely (odds ratio = 0.554) to have a crash compared to offenders who had never been incarcerated. Those offenders whose civil compensation was greater than 1,500,000 NTD had 67% less likelihood (odds ratio = 0.331) to have a crash, compared to offenders whose civil compensation amounted to less than 300,000 NTD. Offenders whose licenses had been revoked for more than 3 years were around three times more likely (odds ratio = 2.895) to have a crash than offenders whose licenses had been revoked for less than 3 years.

For annual distance driven, class 2 who drove between 1001 km and 5000 km, class 3 who drove between 5001 km and 20,000 km, and class 4 who drove over 20,000 km were 4.9, 4.6 and 11.6 times respectively more likely (odds ratio = 4.924, 4.610 and 11.636) to have a crash compared to class 1 who drove under 1000 km. As to driving needs, offenders who drove for work and commuting had an odds ratio of 1.857 and 2.237, respectively for having a crash when compared to offenders who had none of these respective driving purposes. Offenders who had the need of driving kids were around 56% less likelihood (odds ratio = 0.441) to have a crash compared to offenders who had no such driving need.

There were no significant differences for having a crash between offenders whose age was over 40 and not over 40 as well as between offenders who held college degree and no-college degree. There were also no significant differences in having a crash between professional license offenders and ordinary license offenders as well as between hit-and-run causing death/injury offences and drunk driving causing death/serious injury offences.

**Table 5**
Number of offenders and crash rate in different driving classes of annual mileage.

| Driving classes | Annual distance driven (km) | Number of offenders (%) | Average time elapsed since ALLR (months) | Total crashes[a] | Annual distance driven (km) | Per offender crashes[b] | Crashes per million km |
|---|---|---|---|---|---|---|---|
| 0[c] | 0 | 129(16.8%) | 39.7 | 0 | 0 | – | – |
| 1 | ≤1000 | 213(27.7%) | 59.5 | 10 | 438 | 0.05 | 21.6 |
| 2 | 1001–5000 | 151(19.7%) | 60.3 | 32 | 3307 | 0.21 | 12.8 |
| 3 | 5001–20000 | 194(25.3%) | 53.7 | 34 | 12957 | 0.18 | 3.0 |
| 4 | >20,000 | 81(10.5%) | 49.4 | 53 | 44613 | 0.65 | 3.6 |
| Total | | 768(100%) | 53.8 | 129 | 8750 | 0.17 | 4.3 |

[a] Crash occurred in the duration of ALLR.
[b] Total crashes divided by numbers of offenders.
[c] Offenders who had completely given up driving.

**Table 6**
Estimated results for logistic regression model ($N = 639$[a]).

| Explanatory variables | Had crash experience group vs. the others | | | | |
|---|---|---|---|---|---|
| | $\beta$ | S.E. | Wald | $p$-value | O.R. (95%C.I.) |
| *Offenders' personal characteristics* | | | | | |
| Age | | | | | |
| ≤40 | | | | | Reference |
| >40 | −0.116 | 0.350 | 0.109 | 0.741 | 0.891 (0.449–1.768) |
| Education | | | | | |
| No-collage | | | | | Reference |
| Collage | −0.171 | 0.373 | 0.210 | 0.646 | 0.843(0.406–1.750) |
| Income | | | | | |
| ≤30,000 NTD | | | | | Reference |
| >30,000 NTD | −0.729 | 0.329 | 4.905 | 0.027* | 0.482 (0.253–0.920) |
| License category | | | | | |
| Professional | 0.058 | 0.395 | 0.022 | 0.883 | 1.060(0.488–2.300) |
| Ordinary | | | | | |
| Offence category | | | | | |
| Hit-and-run causing death/injury | 0.090 | 0.428 | 0.045 | 0.833 | 1.095(0.473–2.533) |
| Drunk driving causing death/serious injury | | | | | Reference |
| Penalty status | | | | | |
| Incarcerated | | | | | |
| Yes | −0.591 | 0.284 | 4.326 | 0.038* | 0.554 (0.318–0.967) |
| No | | | | | Reference |
| Civil compensation (Thousand NTD) | | | | | |
| >1500 | −1.104 | 0.481 | 5.263 | 0.022* | 0.331(0.129–0.851) |
| 300–1500 | −0.012 | 0.348 | 0.001 | 0.972 | 0.988(0.500–1.953) |
| <300 | | | | | Reference |
| Time elapsed since license revocation | | | | | |
| ≤3 years | | | | | Reference |
| >3 years | 1.063 | 0.402 | 6.991 | 0.008** | 2.895(1.317–6.366) |
| Driving class (annual distance driven under ALLR) | | | | | |
| Class 1 (≤1000 km) | | | | | Reference |
| Class 2 (1001–5000 km) | 1.594 | 0.499 | 10.209 | 0.001** | 4.924(1.852–13.090) |
| Class 3 (5001–20,000 km) | 1.528 | 0.487 | 9.854 | 0.002** | 4.610(1.775–11.970) |
| Class 4 (>20,000 km) | 2.454 | 0.513 | 22.903 | 0.000** | 11.636(4.259–31.791) |
| Needs for driving under ALLR | | | | | |
| Working | | | | | |
| Yes | 0.619 | 0.302 | 4.192 | 0.041* | 1.857 (1.027–3.360) |
| No | | | | | Reference |
| Commuting | | | | | |
| Yes | 0.805 | 0.325 | 6.145 | 0.013* | 2.237 (1.184–4.227) |
| No | | | | | Reference |
| Shopping | | | | | |
| Yes | 0.008 | 0.476 | 0.000 | 0.987 | 1.008 (0.397–2.560) |
| No | | | | | Reference |
| Traveling | | | | | |
| Yes | −0.149 | 0.519 | 0.082 | 0.774 | 0.862(0.311–2.383) |
| No | | | | | Reference |
| Visiting relatives/friends | | | | | |
| Yes | 0.250 | 0.501 | 0.249 | 0.618 | 0.779(0.292–2.080) |
| No | | | | | Reference |
| Driving kids | | | | | |
| Yes | −0.818 | 0.368 | 4.935 | 0.026* | 0.441(0.214-0.908) |
| No | | | | | Reference |
| Constant | 0.115 | 1.205 | 0.009 | 0.924 | 1.121 |

* Significant at $\alpha = 0.05$.
** Significant at $\alpha = 0.01$.
[a] Respondent, $n = 639$, excluding offenders who had completely given up driving 16.8%, $n = 129$.

## 4. Discussion

After the ALLR had been imposed, most of the offenders (83.2%) chose to violate the no-driving restriction and still operate their vehicles. Within these still driving offenders, around three quarters of them expressed that they decreased their driving frequency and many of them expressed that they drove but dodged police road checks or changed driving times/or driving route. This finding implies that ALLR offenders canceled their unnecessary driving activities and reduced their driving frequency. However, once they chose to operate a car, the most important thing that they were concerned with before deciding to drive was to avoid the police. Therefore, police enforcement may be one of the key factors that influence the offenders' driving habits after the ALLR. Nearly 70% of the offenders still driving had the experience of encountering a police roadside check (not stopped). Of these, half (50.6%) expressed that it had no influence on their driving and kept on operating their vehicles. However, there were approximately 30% who responded with variously dangerous actions including nearly one fifth (18%) of them making an immediate U-turn, nearly one tenth (9.5%) parking and exiting the car, and a few (3.0%) who accelerated and sped off. These numbers imply that police enforcement not only influenced the offenders' decision to drive and their driving level, but also affected their driving behavior while on the road.

Of the respondent offenders still driving, over half (52.1%) had experienced being stopped by a police roadside check. Of these, the majority (56.9%) perceived that nothing had happened because they received no penalty. In general, an ALLR offender had been stopped by a police roadside check once after a distance driven of 35,230 km or every 4 years, and received a penalty after a distance driven of 63,612 km or a period of 7.3 years. Both these incidents, being stopped by police and receiving a penalty, are statistically low. These results are similar to the previous findings that it is difficult to enforce suspension laws because it is basically an "invisible" offence, and rates of detection, prosecution, and conviction of drivers who violate their license suspension orders are very low (DeYoung, 1990) and driving while S/R can only be detected when the police stop the driver of a vehicle for committing another traffic offence (Voas and DeYoung, 2002).

Previous study has demonstrated that annual distance driven is one of the stronger predictors of crash involvement (Peck and Kuan, 1983) and high-mileage drivers have a lower crash risk per mile driven than low-mileage drivers (Stewart, 1972; Burg, 1973; Maycock, 1985; Grime, 1987). Therefore, more experienced drivers are thought to be more expert in the driving task and more likely to avoid crashes, leading to a lower crash rate (Massie et al., 1997). A simple explanation for such a result was suggested by Janke (1991) who stated that low-mileage drivers drive their miles mainly on busy streets in developed areas with two-way traffic of different types. High-mileage drivers collect their miles mostly on relatively safe highways with limited accessibility and separated lanes. Another possible explanation is that high-mileage drivers have better driving and safety skills than low-mileage drivers. The present study showed that ALLR offenders who belong to driving class 3, drove between 5000 km and 20,000 km annually, experienced 3.0 crashes per million km driven and class 4, drove over 20,000 km, experienced 3.6 crashes per million km driven. Such a crash rate is lower than the crash rate of class 1 21.6 crashes per million km driven, and class 2 12.8 crashes per million km driven. Distance driven shows that relatively high mileage drivers such as class 3 and class 4 offenders had a relatively safe driving record compared to offenders who belonged to the relatively low mileage driving class 1 and class 2. This result is similar to previous finding that high-mileage drivers have a lower crash risk per mile driven than low-mileage drivers.

Generally, the result of this study showed that 3.7% of respondent offenders reported being involved in at least one crash per year. Moreover, on average they experience 4.3 crashes per million kilometers driven. That average is much lower than 23.1 crashes per million kilometers traveled for normal legal drivers in Taiwan (Ministry of Transportation and Communications, 2002a). This low self-reported crash rate was consistent with the finding that the S/R drivers drove more carefully (Williams et al., 1984; Sadler, 1987; Stewart and Gruenewald, 1989; Malenfant et al., 2002). This finding is also consistent with prior findings that most people who lose their license continue to drive; license revocation does, however, seem to decrease subsequent reported crashes – probably because driving is reduced and is undertaken with greater caution in order to avoid detection (Ross and Gonzales, 1988; Smith and Maisey, 1990). Calculated crash rates under the ALLR were about one fifth (18.6%) of the rates for other legal drivers while driving during similar periods. In comparison, the rate is lower than prior S/R results that calculated rates during periods of suspension as one third of the rates during legal driving (Siskind, 1996). Although, Siskind (1996) based the study on the same drivers and the present study was not, it is our belief that the risk of crashes for ALLR offenders before the ALLR had been imposed may not be less than that of other legal drivers. Therefore, it appears as if drivers who drive under a very long-term license S/R such as ALLR drive more carefully and defensively than short-term S/R drivers.

As to the influential factors of crash risk, the results of the logistic regression model showed that an offender's personal characteristic of income was significantly correlated with their crash risk. An explanation for such may be that, first, the amount of the offender's monthly income under 30,000 NTD (1000 USD) is around one fourth less than the average monthly personal income of Taiwan and low income offenders financial ability distracts them from operating their vehicle safely leading to a higher crash risk through their inability to cope with financial problems. Offenders who had been incarcerated or levied a high civil compensation seem to drive more carefully either because they drive less or because of the fear of paying a second high compensation. Offenders whose licenses had been revoked for less than 3 years seemed to drive more carefully than those offenders' licenses that had been revoked for more than 3 years. This implies that: first of all, offenders may drive much less mileage and more carefully during the foregoing period of the ALLR because the crash had more impact on the beginning periods. Secondly, complying with a short revocation of their drivers' license may be relatively easy for most offenders, while a very long suspension of their driving privileges may be too much for them to endure. Thirdly, they may find there is little chance to be caught by the police while driving under the ALLR. This result was consistent with the idea that drivers may drive more defensively immediately after being involved in an accident (Chandraratna et al., 2006).

Regarding the driving need factors such as driving for work, commuting and driving kids, the crash rates are significantly correlated with their crash risk. However, the effects of these three factors are different. Driving needs for working and commuting are positively correlated with the crash risk. Offenders who had such working or commuting needs were around two times more likely to be in a crash compared to those offenders who had no such needs. The factor of driving kids was an exception. Offenders who had this need seemed to drive more carefully and have approximately 56% less likelihood to be in a crash when compared to offenders who did not have this driving need.

One unexpected finding in this study is not central to its initial objectives. From the data of the MOTC, Taiwan, the ratio of males to females licensed for actual car use is 74:26 (Ministry of Transportation and Communications, 2002b). However, the female ALLR offender ratio in the study population is only 1.7%. Previous studies have demonstrated that there has been a sig-

nificant increase in the number of women licensed to drive and in their annual amount of travel during the past several decades (Rosenbloom, 1996; Hu and Young, 1999; Mayhew et al., 2003). Females were becoming involved in a greater number of motor vehicle collisions (Beirness, 1988) and driving more aggressively than they used to in the past (Kostyniuk et al., 1998). However, the results of the present study showed that females committing a serious traffic violation such as hit-and-run offence causing injury/death or a drunk driving offence causing serious injury/death were few. Females have substantially increased the amount of their driving activities as well as their traffic violations but not in the area of very serious traffic offences.

In summary, this study has found that the ALLR policy has made offenders drive less frequently, more carefully and defensively, leading to a lower crash rate. Although, ALLR offenders are in the worst situation possible, as they have no chance of rehabilitation of having their driving privileges reinstated, no matter how much they improve their attitudes and behaviors. We believed that most of respondent offenders feel desperate and have little to lose by disregarding their sentence, and may not under-report their driving and crash incidence. However, prior studies showed that participants usually under-represented their own driving behaviors (e.g. Lajunen and Parker, 2001) and incidences while under license S/R (e.g. Malenfant et al., 2002). As always with the limitation of self-reports of behavior, social desirability might still have biased this self-report data and the bias cannot completely be neglected. Thus, follow-on studies using more objective methods, e.g. a naturalistic driving analysis (Hanowski et al., 2009), are necessary to further strengthen our findings. Finally, the privilege to drive is highly valued, and withdrawal of the privilege feared (DeYoung and Gebers, 2004). Even for a short-term S/R, one-fifth of the US states rejected the adoption of administrative S/R because it could lead to loss of employment, in turn impacting the offender's dependents and subsequent social welfare costs (Knoebel and Ross, 1997; Voas and DeYoung, 2002). In 2001, the transportation authority has been requested by the Taiwan Constitutional Court to seriously reconsider whether ALLR offenders should be allowed to re-enter the licensing system if they can demonstrate their ability and willingness to follow the regulations of the road and society. In 2006, the ALLR policy was revised by a license revocation for eight, ten, or twelve years according to the same offence causing injury, serious injury or death, respectively. ALLR may not be implemented in developed countries; however, it may be implemented in developing countries. This study provides an empirical experience that a sound re-enter licensing system must be take into account.

## Acknowledgements

This study was approved by and conducted with the assistance of the Department of Motor Vehicles, Ministry of Transportation and Communication, Taiwan. Participants were volunteers and without any payment. Financial support was gratefully provided by the Department of Transportation Technology and Management, National Chiao Tung University.

## References

Beirness, D.J., 1988. Female Drivers in Canada: Trends in Accident Involvement. Viewpoint (newsletter). Insurance Bureau of Canada, Ottawa, Ont., Canada.
Burg, A., 1973. The effects of exposure to risk on driving record Report No. UCLA-ENG-7350. Institute of Transportation and Traffic Engineering, University of California Los Angeles.
Chandraratna, S., Stamatiadis, N., Stromberg, A., 2006. Crash involvement of drivers with multiple crashes. Accident Analysis and Prevention 38, 532–541.
Chang, H.L., Woo, T.H., Tseng, C.M., 2006. Is rigorous punishment effective? A case study of lifetime license revocation in Taiwan. Accident Analysis and Prevention 38, 269–276.
DeYoung, D.J., 1990. Development Implementation and Evaluation of a Pilot Project To Better Control Disqualified Drivers. California Department of Motor Vehicles, Sacramento, CA.
DeYoung, D.J., Peck, R.C., Helander, C.J., 1997. Estimating the exposure and fatal crash rates of suspended/revoked and unlicensed drivers in California. Accident Analysis and Prevention 29 (1), 17–23.
Deyoung, D.J., 1999. An evaluation of the specific deterrent effects of vehicle impoundment on suspended, revoked, and unlicensed drivers in California. Accident Analysis and Prevention 31, 45–53.
DeYoung, D.J., Gebers, M.A., 2004. An examination of the characteristics and traffic risks of driver's suspended/revoked for different reasons. Journal of Safety Research 35, 287–295.
Grime, G., 1987. Handbook of Road Safety Research. Buterworths, London.
Hagen, R.E., McConnell, E.J., Williams, R.L., 1980. Suspension and revocation effects on the DUI offender. California Department of Motor Vehicles, Sacramento, CA.
Hanowski, R.J., Hickman, J.S., Olson, R.L., Bocanegra, J., 2009. Evaluating the 2003 revised hours-of-service regulations for truck drivers: the impact of time-on-task on critical incident risk. Accident Analysis and Prevention 41, 268–275.
Hu, P.S., Young, J.R., 1999. Summary of travel trends. 1995 Nationwide Personal Transportation Survey. US Department of Transportation, Washington, DC. Available: http://www-cta.ornl.gov/npts/.
Janke, M.K., 1991. Accident, mileage, and exaggeration of risk. Accident Analysis and Prevention 23, 183–188.
Knoebel, K.Y., Ross, H.L., 1997. Effects of administrative license revocation on employment. Accident Analysis and Prevention 29 (5), 595–611.
Kostyniuk, L., Molnar, L.J., Eby, D.W., 1998. Are women taking more risks while driving? A look at Michigan drivers. In: Proceedings of the Second National Conference in Women's Travel Issues , US Department of Transportation, Washington, DC, pp. 502–516.
Lajunen, T., Parker, D., 2001. Are aggressive people aggressive drivers? A study of the relationship between self-reported general aggressiveness, driver anger and aggressive driving. Accident Analysis and Prevention 33, 243–255.
Malenfant, J.E.L., Van Houten, R.V., Jonah, B., 2002. A study to measure the incidence of driving under suspension in the Greater Moncton area. Accident Analysis and Prevention 34, 439–447.
Mann, R.E., Vingilis, E.R., Gavin, D., Adlaf, E., Anglin, L., 1991. Sentence severity and the drinking driver: relationship with traffic safety outcome. Accident Analysis and Prevention 23, 483–491.
Massie, D.L., Green, P.E., Campbell, K.L., 1997. Crash involvement rates by driver gender and the role of average annual mileage. Accident Analysis and Prevention 29 (5), 675–685.
Masten, S.V., Peck, R.C., 2004. Problem driver remediation: a meta-analysis of the driver improvement literature. Journal of Safety Research 35, 403–425.
McKnight, J.A., Voas, R.B., 1991. The effect of license suspension upon DUI recidivism. Alcohol Drugs and Driving 7, 43–54.
Ministry of Transportation and Communications, 2002a. Taiwan's Survey Report on the Usage of Passenger Cars. ISBN 957012052-5.
Ministry of Transportation and Communications, 2002b. Survey on car using condition in Taiwan. http://www.motc.gov.tw.
Mayhew, D.R., Ferguson, S.A., Desmond, K.J., Simpson, H.M., 2003. Trends in fatal crashes involving female drivers, 1975–1998. Accident Analysis and Prevention 35, 407–415.
Maycock, G., 1985. Accident liability and human factor—researching the relationship. Traffic Engineering and Control 26, 330–335.
Peck, R.C., Kuan, J., 1983. A statistical model of individual accident risk prediction using driver record, territory and other biographical factors. Accident Analysis and Prevention 15, 371–393.
Peck, R.C., 1991. The general and specific deterrent effects of DUI sanctions: a review of California's experience. Alcohol Drugs and Driving 7, 13-31.
Rosenbloom, S., 1996. Trends in women's travel patterns. In: Proceedings of the Second National Conference in Women's Travel Issues , US Department of Transportation, Washington, DC, pp. 15–34.
Ross, H.L., Gonzales, P., 1988. Effects of license revocation on drunk-driving offenders. Accident Analysis and Prevention 20, 379-291.
Sadler, D.D., 1987. An Evaluation of the California Drunk Driving Countermeasure System. An Evaluation of the Process Efficiency and Traffic Safety Impact of the California Implied Consent Program, vol. 4. Department of Motor Vehicles, Sacramento, CA.
Siskind, V., 1996. Does license disqualification reduce reoffence rates? Accident Analysis and Prevention 28 (4), 519–534.
Smith, D.I., Maisey, G., 1990. Survey of driving by disqualified and suspended drivers in Western Australia. In: Road Safety Trends. Western Australia Department of Transport, Perth, WA, pp. 3–4.
Stewart, J.R., 1972. An Analysis of Annual Mileage Self Reported by Renewal Applicants. University of North Carolina Highway Safety Research Center, Chapel Hill.
Stewart, K., Gruenewald, P.A., 1989. An Evaluation of Administrative per se Laws. National Institute of Justice, United States Department of Justice, Washington, DC.
Voas, R.B., DeYoung, D.J., 2002. Vehicle action: effective policy for controlling drunk and other high-risk drivers? Accident Analysis and Prevention 34, 263–270.
Williams, R.L., Hagen, R.E., McConnell, E.J., 1984. A survey of suspension and revocation effects on the drink-driving offender. Accident Analysis and Prevention 16 (5/6), 339–350.