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October 7, 2013

ICBC 2013 REVENUE REQUIREMENTS EXHIBIT A2-3

Ms. June Elder
Manager, Corporate Regulatory Affairs
Insurance Corporation of British Columbia
151 West Esplanade
North Vancouver, BC V7M 3H9

Dear Ms. Elder:

Re: Insurance Corporation of British Columbia
Order G-141-13/Project No. 3698726
2013 Revenue Requirements Application

Commission staff submit the following document for the record in this proceeding:

Cell Phone Use and Traffic Crash Responsibility: A Culpability Analysis.

Yours truly,

Erica Hamilton

/kbb
Enclosure
cc: Registered Interveners
(ICBC-2013RR-RI)

Cell Phone Use and Traffic Crash Responsibility: A Culpability Analysis

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ABSTRACT

Purpose: The use of a cell phone or communication device while driving is illegal in many jurisdictions. The evidence used to support these policies demonstrates that: i) cell phone use by motorists is on the rise, ii) a greater proportion of crashes appear to involve cell phone use, and iii) cell phone use negatively affects cognitive functions, visual fields, and reaction times, as well as overall driving performance. Only a handful of studies have evaluated the crash risk associated with cell phone use in naturalistic settings. These studies have found an increased crash risk associated with cell phone use, but most suffer from methodological flaws that include a lack of appropriate control groups and poor exposure measures that do not adequately capture cell phone use prior to the crash event. The current study aims to compare culpability in drivers who crashed while using a cell phone with those who did not use a cell phone. Culpability studies approximate case-control studies and overcome difficulties with constructing control groups (i.e. crash free drivers). The premise is that if cell phones increase crash risk, their use should be detected more often in culpable drivers.

Method: The Canadian Culpability Scale (CCS) was used to determine crash culpability from police reports drawn from the Insurance Corporation of British Columbia (ICBC) Traffic Accident System data. The CCS is an automated scale that accounts for Canadian driving conditions and agrees well with expert crash assessors (kappa =0.83). Culpability was assessed in 312 crashes in British Columbia (2005 – 08) where police reported cell phone use and in 936 matched (crash type, date, time of day, geographic location) crashes without cell phone use. Crashes where culpability was indeterminate (n=60) were removed from the analysis. Statistical analysis involved logistic regression methods to assess crude rates, with additional analyses to adjust for driver age, driver sex, graduated license status (novice driver or full license), police suspicion of alcohol or drug impairment, and interaction terms.

Results: A comparison of crashes with versus without cell phones revealed a crude odds ratio of 2.03 (95% CI: 1.44-2.86). This association remained after adjusting for age, sex, license status, and suspected alcohol or drug impairment (OR=1.82, 95% CI: 1.27-2.62), while sensitivity analysis demonstrated a consistent association regardless of crash severity. Younger drivers, novice drivers, and drivers suspected of alcohol or drug impairment also had significantly higher odds of a culpable crash. No significant interactions between cell phone use

and covariates were observed.

Conclusions: Crash culpability was found to be strongly associated with driver cell phone use. Drivers using cell phones had nearly double the odds of a culpable crash compared to those drivers who did not use a cell phone, lending much needed evidence to existing policies directed at restricting the use of cell phones and other devices while driving.

Résumé

***Objectif*:** L'utilisation d'un téléphone cellulaire ou d'autre type d'appareil de communication est illégale en plusieurs juridictions. L'évidence utilisé pour supporter ces politiques démontre que: i) le nombre de motoristes utilisant des téléphones cellulaires augmente, ii) une plus grande proportion d'accidents d'automobile semble impliquer l'utilisation des téléphones cellulaires, et iii) l'utilisation des téléphones cellulaires affecte les fonctions cognitives négativement, champs de vision, et les temps de réaction, ainsi que la performance de conduite. Seulement une poignée d'études ont évalué le risque de crash associé avec l'utilisation des téléphones cellulaires dans un cadre naturaliste. Ces études ont trouvés un risque d'accident plus élevé associé avec l'utilisation de téléphones cellulaires, mais la plupart d'entre suivent des méthodes inexactes qui incluent un manque de control groups appropries et faibles méthodes d'exposition que ne capturent pas adéquatement l'utilisation de téléphones cellulaires avant l'accident. L'étude actuelle vise à comparer la culpabilité des drivers qui ont eu des accidents en utilisant un téléphone cellulaire avec la culpabilité de ceux qui n'ont pas. Des études de culpabilité approximatif des études de cas-témoins et surmonte les difficultés de construire des groupes de control (i.e. des conducteur qui n'ont pas d'accidents). La prémisse est que si les téléphones cellulaires augmentent les chances d'avoir un accident, l'utilisation des téléphones devrait être détectée plus fréquemment dans les drivers coupables.

Méthode: le Canadian Culpability Scale (L'Échelle de Culpabilité Canadienne - CSS) a été utilisé pour déterminer la culpabilité de crash avec les renseignements de police prises du data de l'Insurance Corporation of British Columbia (la Corporation d'Assurance du Colombie-Britannique - ICBC) concernant les accidents de trafic. Le CSS est une échelle automatisée qui représente les conditions de conduite canadiennes et qui est en accord avec des assesseurs d'accident expertes (kappa =0.83). La culpabilité de 312 accidents a été évalué en Colombie-Britannique (2005 ' 08) out la police a reporté l'utilisation d'une téléphone cellulaire et dance 936 accidents similaires (en fonction du type d'accident, de la date, de l'heure, et de la location géographique) qui n'étaient pas liés à l'utilisation de téléphones cellulaires. Les accidents out la culpabilité n'était pas déterminé (n=60) ont été enlevés de l'analyse. L'analyse statistique incluait des méthodes de régression logistiques pour évaluer des taux approximatives, ainsi que l'analyse additionnelle pour pouvoir adjuster pour l'âge et le sexe du motoriste, le statu de licence gradué (motoriste débutant ou avec licence complète), suspension par la police pour la dépréciation par l'alcool ou la drogue, et les termes d'interaction.

Résultats: Une comparaison entre des accidents avec et sans les téléphones cellulaires a relevé un ratio de cotes brut de 2.03 (95% CI: 1.44-2.86). Cette association a resté pareil après avoir ajuste les figures pour âge, sexe, statu de permis de conduire, et des suspects de conduite soûl (OR =1.82, 95 CI: 1.27-2.62), tandis que l'analyse de sensibilité a démontré une association constante, peu

importe la sévérité de l'accident. Des conducteurs plus jeunes, des conducteurs débutants, et les conducteurs sous suspicion de conduite sous l'influence des drogues ou de l'alcool ont aussi des chances plus élevés d'être coupable d'un accident. Aucune interaction signifiant n'a été observé entre l'utilisation d'un téléphone cellulaire et les co-variables.

Conclusions: La culpabilité des accidents a été relevée d'être fortement associé avec l'utilisation des téléphones cellulaires par le conducteur. Les motoristes qui utilisent les téléphones cellulaires doublent leurs chances d'avoir un accident, compare à ceux qui ne les utilisent pas, qui renforce l'évidence de la nécessité d'avoir des politiques pour limiter l'utilisation des téléphones cellulaires et de tels appareils de communication en conduisant.

INTRODUCTION

While policies restricting driving while "distracted" have been in place in most provinces for many years, more recently, a number of Canadian jurisdictions have introduced legislation specifically banning the use of cell phones and other mobile devices while driving a motor vehicle. Province-wide bans have been enacted in Quebec, Ontario, Nova Scotia, Manitoba, Prince Edward Island, Newfoundland and Labrador, British Columbia and Saskatchewan, focusing specifically on hand held devices, and levying considerable fines to violators. These restrictions follow the lead of nearly 50 other countries that have enacted national or regional bans on cell phone use while driving [1]. Coupled with the widespread growth in the use of cell phones and other mobile devices by Canadians, and strong public support for bans on their use while driving [2], evidence supporting the enactment of policies restricting cell phone use while driving has come from a large body of population-based observation studies and experimental research.

Population-based studies have shown that the self-reported prevalence of cell phone use while driving is on the rise, particularly texting while driving [3,4]. Data from the 2008 Canadian Community Health Survey indicate that approximately 11% of Canadian drivers surveyed reported using a cell phone "often" while driving with an additional 15% indicated they "sometimes" did so. In a survey of 1347 licensed drivers in Australia, 57% reported ever having used a cell phone while driving [5]. Similarly, a US national survey found that drivers were talking, on average, 7% of the time while they were driving, and that a full ban on cell phone use while driving would have prevented approximately 22% of crashes in 2008 [6]. Seo and Torabi [7], in a self-report survey of college students, found that 86% of drivers with a cell phone reported using it while driving, with 21% indicating that they had been involved in a crash or near crash while using their cell phone. Meanwhile, roadside surveys indicate that roughly 5% of drivers were found using a cell phone behind the wheel [8,9]. Employing an alternative methodology that measured driving events, Johnson and colleagues [10] analysed 40,000 digital photographs, randomly taken, of vehicles and drivers on the New Jersey Turnpike, and noted that approximately 1.5% of drivers were using a cell phone. They noted that cell phone use was greatest during weekdays and lower on weekends and at night. Moreover, while crash rates in many jurisdictions remain stable or have declined, the proportion of crashes in which a cell phone has been involved has risen [11].

Other studies have examined the factors associated with using a cell phone while driving, and

found that it is more common among drivers who also engaged in other risky driving activities (i.e. drinking and driving, not wearing a seatbelt, speeding, aggressive driving). Moreover, cell phone drivers report greater lifetime crash involvement than non cell phone drivers [12]. In terms of sociodemographic factors, cell phone use while driving is found to be higher in males, young people, novice drivers, and urban drivers, and lower in vehicles where a front-seat passenger is present, vehicles being driven by individuals over the age of 45, and non-white drivers [5,10].

Considerable experimental research has examined the effects of cell phone use on driving. Experimental studies, largely applying cognitive tests to small groups of drivers in a laboratory setting or driving simulator, have demonstrated that cell phone use negatively affects driving performance, with a particular impact on cognitive function, physical function, and reaction times [3,13]; deficits that compare to those observed in drivers with a blood alcohol level of 80 mg/100 ml [14,15]. Three recent meta analyses have synthesized the copious body of experimental research [3,16,17], and concluded that cell phone use produces significant deficits in reaction times of drivers, and that these deficits are equivalent for hand held and hands-free devices, and across age groups [18]. Additional deficits were observed with respect to tracking performance and attention.

While it is important to note that the prevalence of cell phone use while driving is on the rise, and that their use affects driving ability, comparatively little epidemiologic research has examined the relationship between cell phone use and crash risk. The most important outcome associated with cell phone use while driving is not use, per se, but whether or not use leads to an increase in the risk of a crash and, in turn, crash-related injury. Experimental studies, while excellent at examining the causal pathways between specific human factors, like cell phone use, and driving performance, have certain limitations. One such limitations is the small N designs, which affects study generalizability as experimental studies typically draw subjects who are non-representative of the general driving population. Moreover, experimental studies are not able to fully mimic the complexity of real-naturalistic driving conditions which the majority of drivers experience daily [19-21].

Only a handful of epidemiologic studies have examined the crash risk associated with cell phone use while driving in naturalistic settings [22]. This is due to the difficulties associated with obtaining precise measurements of the key exposure, cell phone use prior to the crash, and the ability to collect data on an appropriate crash-free control group. As Elvik [23] notes, naturalistic studies can therefore be divided into two groups – those with reasonably precise measures of pre-crash cell phone use, as determined by billing records, collision reports and police reports, and studies where cell phone use before the crash is unknown.

In a meta analysis of epidemiologic studies of cell phone use and crash risk, Elvik [23], focusing on seven studies that included a reasonable measure of pre-crash cell phone use, found an increased in odds of a crash to be 2.86 (95% CI: 1.72- 4.75). Of these seven studies, five are of particular interest to the current study. Two studies employed a case-crossover design [24,25], two adopted modified case-control designs [26,27], and one involved observations of cell phone use by camera as part of the 100-car naturalistic study [28]. The other two studies [29,30] relied on driver self-reported cell phone use at the time of the crash, as part of a retrospective account of events in the preceding year. As such, they suffer from potential recall and self-report biases.

The case-crossover methodology is a variation of the case-control design used for studying the effects of transient exposures. In the case-crossover design, each subject serves as their own control and researchers compare exposure to a transient risk factor (e.g. cell phone use) at the time the outcome of interest (e.g. a crash) occurred, with exposure during a control time period. Employing this design, Redelmeier and Tibshirani [24] interviewed 699 Toronto drivers who owned cell phones and were involved in a crash. They also collected data from cell phone records at the time of the crash and during the control periods. Adjusting for other covariates, they found a four-fold increase in the odds of a MVC when a cell phone was used than when a cell phone was not being used (OR=4.3; 95% CI: 3.0-6.5). Following the same design, McEvoy and colleagues [25] examined 456 crash-involved drivers presenting to three emergency departments in Western Australia who owned a cell phone. Again, examining driver cell phone records at the time of the crash and during the control periods, they found a four-fold increase in the odds of a crash while a cell phone was being used compared to when a cell phone was not being used (OR=4.1; 95% CI: 2.2 to 7.7).

Violanti [26], examining 223,137 traffic crashes occurring between 1992 and 1995, examined the role of cell phones in a comparison of fatal crash with non-fatal crash. Adjusting for other covariates (age, gender, alcohol use, speed, inattention), they found that cell phone use led to a nine-fold increased risk of a fatal crash compared to non-fatal crash. Wilson and colleagues [27] captured snapshots of 3869 drivers observed from the road side, split evenly between those using a cell phone and those who were not using a cell phone. Based on the license plate number, data were obtained from records of insurance claims and police-reported crashes and violations. Adjusting for age and gender, they found that cell phone users had a higher risk of having been involved in an at-fault crash in their lifetime, though there were no significant gender effects. Finally, in the 100-car naturalistic study [28], where driver behaviour was recorded by an in-car camera, cell phone use (talking and dialing) was associated with a nearly three-fold (RR=2.79) increased risk of crashes and near-crashes combined. However, as noted by Backer-Grøndahl and Sagberg [30], crashes differ from near-crashes and thus a larger naturalistic study is required to confirm the impact of cell phone use on crash risk.

Despite varying designs, the epidemiologic research demonstrates a consistent association between driving while using a cell phone and crash risk; and as in the experimental research, epidemiologic studies found no benefit to the use of hands-free devices. As noted above, however, methodological flaws in some studies limit applicability and findings, and open up the need for additional research. These limitations include, but are not limited to, the: 1) lack of a crash-free control group required to estimated risk; 2) imprecise measures of cell phone use and/or crash involvement; 3) the inability to link cell phone use at the time of the crash; and 4) an inability to control for important confounders.

The above case-crossover studies offer the most careful design for examining crash risk. In particular, they provide the most precise measures of cell phone use through cell phone provider records, and the within-person design of a case-crossover approach eliminates confounding from most known and unknown sources, including age, gender, driving experience and ability, driving record, personality characteristics, sociodemographic characteristics, and any other fixed effects, and eliminates the problem of control-selection bias [31,21]. However, the selection of a fixed control period does not always coincide with whether the individual was driving, and thus the opportunity for exposure (cell phone use) and outcome (crash) are not possible. Not all confounding can be controlled for, particularly differences in driving

environment, road type, time of day, and weather between exposure and control periods. Finally, despite the use of a pseudo case and control design, these studies lack a “true” crash-free control group, as all drivers must have been in a crash to be included (recruit from crash centres or emergency departments). As such, there may be unmeasured human factors (risk profiles) that make them susceptible to crash involvement which would inflate their baseline risk (above the 1.0 which is typically assigned to crash-free controls), and bias risk estimates [27].

These limitations can be minimized with the use of crash culpability analysis. Culpability analysis draws on in-depth data collected from police or traffic engineering reports to assign responsibility or fault to a driver involved in a crash. These assessments are based on driver actions, the driving environment, traffic flow, weather and other indicators. As such, drivers deemed not culpable or responsible for their crash are likely to have done everything correctly during the driving event and that the crash was entirely out of their control. Employing a harsh culpability scale, non-culpable drivers are deemed to be equivalent to a crash-free control [33,34].

THE CURRENT STUDY

The primary aim of the current study is to build on the epidemiologic research estimating the impact of cell phone use on crash risk in naturalistic driving conditions. Further evidence from high quality epidemiologic studies is warranted to allow for more precise estimates of crash risk associated with cell phone use [17,35,36]. In order to examine this question, data will be drawn from the Insurance Corporation of British Columbia (ICBC) database, for the years 2005 to 2008. To address some of the weakness of previous epidemiologic studies, we employ a culpability analysis of a series of drivers involved in a crash who had used a cell phone, and a matched sample of cell-phone free drivers who had also been involved in a crash.

METHODS

Data: The British Columbia Traffic Accident System (TAS) contains data from all police attended traffic accidents in BC. This database is maintained by the Insurance Corporation of British Columbia (ICBC) and collects data on approximately 50,000 crashes per year. When police investigate a traffic crash, they fill out a structured two page form where they document details of the crash including the type of crash, the pre-crash action of each vehicle, the location of damage on each vehicle, weather conditions, and road type. Police also document factors which they conclude contributed to the crash. These include “human condition”, “human action”, “environmental condition”, and “vehicle condition”. Each entry is selected from a list of possible choices.

ICBC data for the current study are from the years 2005-2008, totaling over 180,000 crashes. From this data pool a number of inclusion criteria were applied. First, crashes must involve a driver of a passenger vehicle, including passenger car (with and without trailer), sport utility vehicle (with and without trailer), panel van 4500 kg and under (includes mini vans) with and without trailer, single unit truck / light pickup truck, truck / camper / trailer, and motor home. Excluded were motorcycles, large vehicles (Trucks), and off-road vehicles. Second, crashes

must not have involved a hit and run. Third) No missing data in any fields used to determine culpability, exposure status, or covariates. This left a pool of 121,838 crashes.

Culpability analysis employs a case-control design [37]; however, we modified the design by first selecting drivers based on exposure status (cell phone use) prior to determining crash culpability. This was done, in part, due to the small number of crashes in which cell phone use was explicitly noted (less than 0.5% of passenger vehicle crashes in our data), and the impracticality of performing a culpability analyses on all crashes.

Exposed: Exposed drivers are identified by police as having used a cell phone or other communication device at the time of the crash. The identification of cell phone use is derived from the section on contributing factors, which is defined as those circumstances, events or behaviors that the attending police officer judges to contribute to a traffic crash. A total of 312 drivers were identified as having used a cell phone or communication device and who satisfied the above inclusion criteria. According to observational studies completed by ICBC, almost all crashes involving "communication devices" involve cell phones [38]. There were several thousand drivers who were identified with an internal distraction where no specific details were provided (unrecorded), and many other cell phone users were likely missed by police and witnesses (undetected). As such, our exposed group represents those drivers explicitly identified as using a device at the time of the crash. No distinction was made for hands-free devices.

Unexposed: A 3-to-1 matching approach was used to select 936 crashes where the driver did not use a cell phone, drawn from a pool of 121,526 driver crashes meeting the inclusion criteria. Employing a matching algorithm, cell phone and non cell phone drivers were matched on four factors:1) Crash date; 2) Crash time (between 5am and midnight and between midnight and 5am); 3) Number of vehicles in the crash (1, 2, or more than 2 vehicles); and 4) Type of Road (highway, urban road, rural road). There were 89 unexposed drivers without a perfect match, with a plus/minus 1 category difference for crash date and time, and no differences for number of vehicles and road type.

Culpability: Driver culpability was assigned using the Canadian Culpability Scale (CCS - see Brubacher, Chan, and Asbridge) [39]. The CCS is a modified version of the standard "Robertson-Drummer" [40] scale, employed in Australia and France that accounts for Canadian wintery driving conditions. Additionally, unlike previous culpability scales, the CCS was automated, removing subjective assessments of culpability while allowing for its application to large datasets – both of which have been identified as weakness of culpability studies [41]. The CCS considers seven categories when determining responsibility for the crash: 1) road type, 2) driving condition (road surface, visibility, and weather), 3) vehicle conditions, 4) unsafe driving actions, 5) contribution from other parties, 6) type of collision, 7) task involved. The goal of the CCS is to separate drivers who were involved in a crash because of external factors from drivers who contributed to the crash in some way. With this in mind, human factors such as driver fatigue or illness are not considered to reduce the responsibility of crash involved drivers in the CCS. Each category is given a score ranging from 1 (favourable conditions) to 5 (unfavourable conditions) (see Brubacher, Chan, and Asbridge for details). Scores for these categories are added and used to assign drivers to one of three categories denoting their level of responsibility for the crash. Low total scores (13 and lower) indicate that there is no apparent

reason for the crash beyond poor driver performance and the driver is deemed culpable. Scores from 13.1 to 15.9 are considered to be indeterminate. Scores of 16 or more indicate that the crash was due to factors other than performance of the injured driver and the driver is deemed not responsible. The CCS was validated on a set of 73 crashes with 134 drivers by comparison with the assessment of two experienced crash assessors from Transport Canadian. The expert assessors reviewed the crashes and, for each driver, provided their opinion as to whether or not the driver could reasonably have avoided the crash. The final Kappa score between crash assessors' consensus rating and the CCS were high (kappa > 0.83, indicating excellent agreement).

For this study, the Canadian Culpability Scale was applied to the 312 exposed and 936 unexposed drivers employing the standard categories for assessing culpability. Overall, 72.4% (n=903) of drivers were deemed culpable for their crash, 22.8% (n=285) were deemed non-culpable, and 4.8% (n=60) were indeterminate, a distribution in line with culpability studies employing harsh scales [34,42]. Indeterminates were removed from the analysis; given the matching design, when exposed drivers were removed, matching unexposed drivers were also removed. This left a final dataset of 1,154 crashes (300 exposed, 854 unexposed).

Analytic Approach: To access the impact of cell phone use on crash culpability we estimated odds ratios, employing a logit regression model with the robust cluster variance estimators given exposure matching. Additional analyses adjusted for driver age (dummy coded: < 25, 25 to 39, 40 to 54, ≥ 55), driver sex, license status (graduated/learner license versus full license), and suspected alcohol or drug impairment. Interaction effects between cell phone use and covariates, and sensitivity analysis was performed comparing injury to non-injury crashes, and with the inclusion of matching variables. All analyses were completed using Stata11.1 (StataCorp, LP, College Station, TX).

RESULTS

Table 1 provides descriptive statistics comparing driver characteristic by cell phone use. Cell phone drivers were younger, more likely to hold a graduated license, more often suspected by police of being impaired by alcohol or drugs, and were more likely to be culpable for their crashes. There were no differences between cell phone drivers and non cell phone drivers with respect to sex and whether the crash involved an injury.

Table 2 presents logit regression results for the association between cell phone use and crash culpability. The odds of a culpable crash were significantly higher for drivers who had used a cell phone (unadjusted OR=2.03; 95% CI: 1.44-2.86). This increased in the odds of a culpable crash remained after adjusting for sex, age, license status and suspected alcohol or drug impairment, though age and license status were analyzed separately due to issue of collinearity (OR=1.82; 95% CI: 1.27-2.62 with age; OR=1.83; 95% CI: 1.29-2.61 with license status). An increase in the odds of a culpable crash was also associated with graduated license status, driver age under 25 years old, and suspected alcohol or drug impairment. Analysis of a continuous measure of age, and age squared, suggests a curvilinear effect with younger and older drivers being at increased odds of a culpable crash. Odds ratios for the association between cell phone use and crash culpability across subgroups are presented in Figure 1.

Interactions between cell phone use and covariates were also examined with no significant associations. Additional sensitivity analysis examined whether the relationship remained consistent across more or less severe crashes, defined by whether an injury was involved. The association between cell phone use and crash culpability remained for injury (OR=1.88, 95% CI: 1.17-3.01) and non-injury (OR=2.21, 95% CI: 1.34-3.61) crashes.

	Exposed (cell phone)	Unexposed (no cell phone)	$\chi 2$
Male	193 (64%)	548 (64.2%)	p=0.959
Age Less than 25 years old 25 to 39 years old 40 to 54 years old 55 years and older	 99 (33%) 106 (35%) 64 (21.3%) 31 (10.3%)	 205 (24%) 255 (29.9%) 215 (25.2%) 179 (21%)	p=0.002
License Status Graduated Drivers License Full License	 68 (22.7%) 232 (77.3%)	 129 (15.1%) 725 (84.9%)	p=0.003
Suspected Alcohol/Drugs	58 (19.3%)	96 (11.2%)	p=0.000
Injury Crash	143 (47.6%)	375 (43.9%)	p=0.261
Number of Vehicles in Crash One Two Three or more	 131 (43.6%) 144 (48%) 25 (8.3%)	 389 (43.8%) 426 (47.9%) 73 (8.2%)	p=0.998
Time Block Between 5:00am-11:59pm Between Midnight-4:59am	 258 (86%) 42 (14%)	 791 (89%) 97 (11%)	p=0.155
Road Type Provincial Highway City/Municipal Road Rural Road	 80 (27%) 198 (66%) 22 (5%)	 233 (26%) 615 (69%) 40 (4.5%)	p=0.15
Culpable Crash	254 (84.6%)	625 (73.2%)	p=0.000
Mean Culpability Score (se)	10.8 (0.21)	12.0 (0.15)	p=0.000

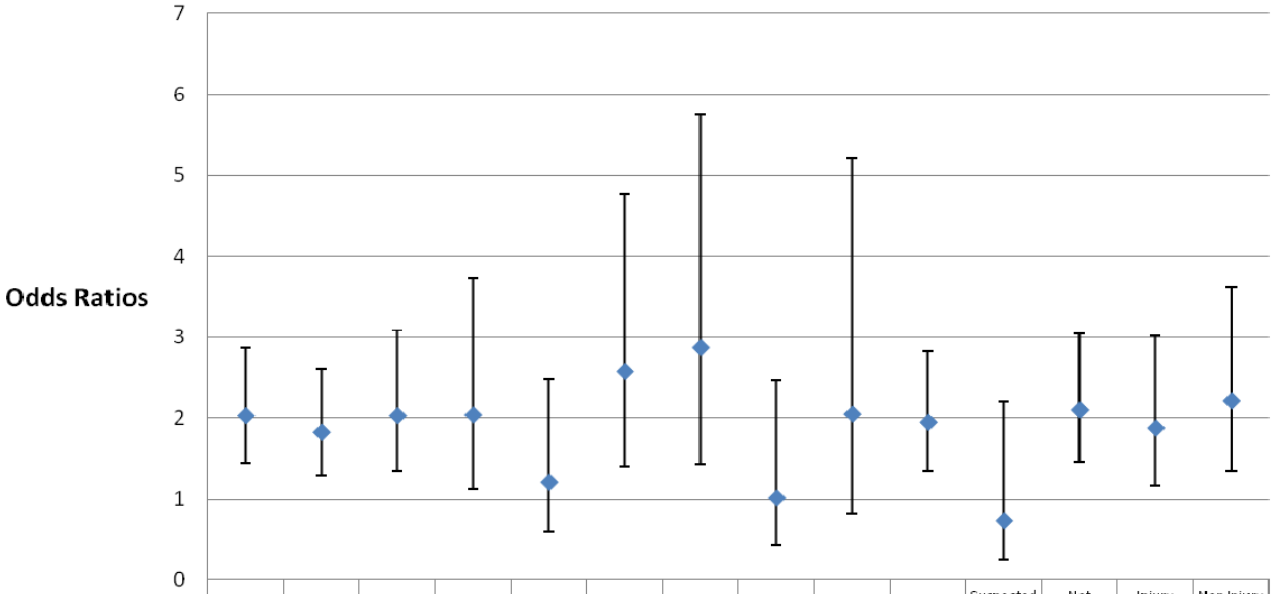
Table 1. Descriptive Statistics for Cell Phone and Non-Cell Phone Crashes

	Unadjusted Model	Adjusted Model (with age)	Adjusted Model (with license status)
Cell Phone Use	2.03 (1.44-2.86)	1.82 (1.27-2.62)	1.83 (1.29-2.61)
Male	0.96 (0.73-1.25)	0.88 (0.67-1.16)	0.91 (0.69-1.20)
Age Less than 25 years old 25 to 39 years old 40 to 54 years old 55 years and older	 2.06 (1.30-3.26) 1.04 (0.71-1.52) 0.81 (0.55-1.20) 1.00	 1.77 (1.11-2.82) 0.87 (0.58-1.29) 0.73 (0.49-1.09) 1.00	
License Status Graduated Drivers License Full License	 1.79 (1.19-2.70) 1.00	 ---	 1.76 (1.15-2.71) 1.00
Suspected Alcohol/Drugs	3.76 (2.15-6.58)	3.68 (2.05-6.58)	3.69 (2.07-6.60)

*Adjusted models also include matching variables (not reported)

Table 2. Logit Regression of Crash Culpability on Cell Phone Use and Covariates (OR and 95% CIs presented)

Figure 1. Odds Ratios of Crash Culpability With Versus Without Cell Phone Use in Different Population Subgroups (Odds Ratios and 95% Confident Intervals)



	Crude	Adjusted	Male	Female	Age <25	Age 25-39	Age 40-54	Age 55+	GDL	Non GDL	Suspected Impaired	Not Impaired	Injury Crash	Non Injury Crash
◆ Odds Ratio	2.03	1.83	2.03	2.04	1.21	2.58	2.87	1.02	2.05	1.95	0.73	2.1	1.88	2.21
Upper CI	2.86	2.61	3.08	3.72	2.49	4.77	5.75	2.47	5.2	2.82	2.2	3.04	3.01	3.61
Lower CI	1.44	1.29	1.34	1.12	0.59	1.4	1.42	0.43	0.81	1.35	0.25	1.45	1.17	1.34

DISCUSSION

The primary aim of this study was to assess the impact of cell phone use while driving on crash risk in a naturalistic driving setting. It was determined that, adjusting for key covariates, cell phone use increased the odds of a culpable crash by 82 per cent. This association was persistent across most population subgroups, and irrespective of suspected driver impairment by alcohol or drugs, and crash severity. Expressed as an attributable fraction, just under 12% of culpable crashes were a result of driver cell phone use.

These findings lend support to the limited body of epidemiologic evidence showing the cell phone use while driving increases crash risk. Our observed increased risk of a culpable crash best approximates the findings of Laberge-Nadeau and colleagues' [22] cohort study, with adjusted relative risks of 1.1 (men) and 1.2 women), and considerably less than the increase observed in the two case-crossover studies [24,25]. However, as noted above, the use of a harsh culpability scale ensures that non-culpable drivers identified in our study are nearly identical to a crash-free driver, and, thus, our estimates are likely to represent a true reflection of crash risk in the general driving population when compared to studies employing case-crossover designs.

A next step will be to replicate the current study in data from more recent years (2009-2011), and with a larger pool of crashes where cell phone use has been identified. As identified in the ICBC data from 2005 to 2008, the proportion of passenger vehicle crashes in British Columbia in which a cell phone was reported to be involved was less than one percent (312/121828). This low figure is largely due to the concealment of devices by drivers involved in crashes, a lack of detection by victims, witnesses, and other parties, and under-recording by police. However, with the introduction of a ban on hand-held cell phone use while driving in British Columbia in January 2010, we are likely to observed better recording by police of cell phone related crashes in subsequent years.

Finally, our findings also add important support to the many existing policies already in place in jurisdictions across Canada, and internationally, restricting cell phone use while driving. The task now is to increase driver compliance in those jurisdictions that already have a ban in place [3]. Evidence has been mixed regarding whether rates of cell phone use while driving has decreased in jurisdictions with a ban. Some studies suggest only a limited change in behaviour, while others have reported significant decreases with fewer cell phone related crashes post-legislation over the long-term [43,11]. There is a need to identify those policies that have been successful and those that have not, both in terms of compliance and with respect to reductions in crash rates. As Jacobsin and Gostin [36] recently suggested in JAMA, "Additional research is therefore needed to determine whether reduced cell phone use actually lowers crash rates or whether distracted driving legislation simply fails to significantly reduce driver distraction."

CONCLUSIONS

The use of a cell phone while driving nearly doubled the odds of a culpable motor vehicle crash, and this association remained across population subgroups (age, sex), whether the driver was suspected of alcohol or drug impairment, and by crash severity. These findings suggest that legislative bans on cell phone and other mobile device use while driving are well justified.

REFERENCES

[1] CELLULAR-NEWS. Countries that ban cell phone use while driving. Retrieved February 25, 2011 and available at: http://www.cellular-news.com/car bans/.

[2] ANGUS REID STRATEGIES. Almost 90% of Canadians Would Ban Hand-Held Cell Phones While Driving, 2008. Retrieved February 10, 2011 and available at: http://angusreidstrategies.com/uploads/pagess/pdfs/2008.06.17_CellPhones.pdf.

[3] MCCARTT, A.T., HELLINGA, L.A., BRATIMAN, K.A. Cell phones and driving: review of research. *Traffic Inj Prev*. 7(2): 89-106, 2006.

[4] WILSON, F.A., STIMPSON, J.P. Trends in fatalities from distracted driving in the United States, 1999 to 2008. *Am J Public Health*. 100(11): 2213-9, 2010.

[5] MCEVOY, S.P., STEVENSON, M.R., WOODWARD, M. Phone use and crashes while driving: a representative survey of drivers in two Australian states. *MJA*; 185: 630–634, 2006.

[6] FARMER, C.M., BRATIMAN, K.A., LUND, A.K. Cell phone use while driving and attributable crash risk. *Traffic Inj Prev*.; 11(5): 466-70, 2010.

[7] SEO, D.C., TORABI, M.R. The Impact of In-Vehicle Cell-Phone Use on Accidents or Near-Accidents Among College Students. *J Am Coll Health* 53(3): 101-07, 2004.

[8] MCCARTT, A., HELLINGA, L.A., STROUSE, L.M. and FARMER, C.M. Long-term effects of hand-held cell phone laws on driver hand-held cell phone use. *Insurance Institute for Highway Safety*, Arlington, VA, 2009.

[9] DEPARTMENT FOR TRANSPORT. Mobile phone use by drivers: 2009. Survey results for England. *Department for Transport*, London, 2010.

[10] JOHNSON, M.B., VOAS, R., LACY, J.H, MCKNIGHT, A.S. LANGE, J. Living Dangerously: Driver Distraction at High Speed. *Traffic Inj Prev*. 5: 1–7, 2004.

[11] CONSTANT, A., SALMI, L.R., LAFONT, S., CHIRON, M., LAGARDE, E. Road casualties and changes in risky driving behavior in France between 2001 and 2004 among participants in the GAZEL cohort. *Am J Public Health* 99(7):1247-53, 2009.

[12] BECK, K.H, YANG, F., WANG, M.Q. Cell phone users, reported crash risk, unsafe driving behaviors and dispositions: a survey of motorists in Maryland. *J Safety Res*. 38(6): 683-8, 2007.

[13] HUANG, D., KAPUR, A.K., LING, P., PURSSELL, R., HENNEBERRY, R.J., CHAMPAGNE, C.R. et al. CAEP position statement on cellphone use while driving. *CJEM*. 12(4): 365-76, 2010.

[14] BURNS, P.C., PARKES, A., BURTON, S., SMITH, R.K., BURCH, D. How Dangerous is Driving with a Mobile Phone? Benchmarking the Impairment to Alcohol. *Transport Research Laboratory*, Crowthorne, United Kingdom, 2002.

[15] STRAYER, D.L., DREWS, F.A., CROUCH, D.J. A comparison of the cell phone driver and

the drunk driver. *Hum Factors* 48(2): 381-91, 2006.

[16] HORREY, W.J., WICKENS, C.D. Examining the Impact of Cell Phone Conversations on Driving Using Meta-Analytic Techniques. *Hum Factors* 48(1): 196-205, 2006.

[17] CAIRD, J.K., WILLNESS, C.R., STEEL, P., SCIALFA, C. A meta-analysis of the effects of cell phones on driver performance. *Accid Anal Prev*. Jul; 40(4): 1282-93, 2008.

[18] STRAYER, D.L., DREWS, F.A. Profiles in driver distraction: effects of cell phone conversations on younger and older drivers. *Hum Factors* 46(4): 640–649, 2004.

[19] HAIGNEY, D., WESTERMAN, S.J. Mobile (cellular) phone use and driving: a critical review of research methodology. *Ergonomics*; 41(2): 132-143, 2001.

[20] SHINAR, D., TRACTINSKY, N., COMPTON, R. Effects of practice, age, and task demands, on interference from a phone task while driving. *Accid Anal Prev*. 37, 315–326, 2005.

[21] PHILIP, P., SAGASPE, P., TAILLARD, J., VALTAT, C., MOORE, N., AKERSTEDT, T., et al. Fatigue, Sleepiness, and Performance in Simulated Versus Real Driving Conditions. *Sleep* 28(12): 1511-1516, 2005.

[22] LABERGE-NADEAU, C., MAAG, U., BELLAVANCE, F., LAPIERRE, S.D., DESJARDINS, D., MESSIER, S., et al. Wireless telephones and the risk of road crashes. *Accid Anal Prev*. 35(5): 649-60, 2003.

[23] ELVIK, E. The effects on accident risk of using mobile phones: problems of meta-analysis when studies are few and bad. *Transportation Research Board 2011 Annual Meeting*, 2010.

[24] REDELMEIER, D.A., TIBSHIRANI, R.J. Association Between Cellular-Telephone Calls and Motor Vehicle Collisions, *New Engl J Med*. 336(7): 453-58, 1997.

[25] MCEVOY, S.P., STEVENSON, M.R., MCCARTT, A.T., WOODWARD, M., HAWORTH, C., PALAMARA, P., et al. Role of mobile phones in motor vehicle crashes resulting in hospital attendance: a case-crossover study. *BMJ* 331, 428, 2005.

[26] VIOLANTI, J.M. Cellular phones and fatal traffic collisions. *Accid Anal Prev*. 30(4): 519-24, 1998.

[27] WILSON, J., FANG, M., WIGGINS, S., COOPER, P. Collision and violation involvement of drivers who use cellular telephones. *Traffic Inj Prev.* 4(1): 45-52, 2003.

[28] KLAUER, S.G., DINGUS, T.A, NEALE, V.L., SUDWEEKS, J.D., RAMSEY, D.J. The impact of driver inattention on near-crash/crash risk: An analysis using the 100-car naturalistic driving study data. *Report DOT HS 810 594*. Washington, 2006.

[29] SAGBERG, F. Accident risk of car drivers during mobile telephone use. *Int J Vehicle Des*. Vol. 26: 57-691, 2001.

[30] BACKER-GRONDAHLI, A., SAGBERG, F. Driving and telephoning: Relative accident risk when using hand-held and hands-free mobile phones. *Saf Sci.* (in press) 49: 324-330, 2011.

[31] MACLURE, M., MITTLEMAN, M.A. Should we use case-crossover design? *Annu Rev Publ Health 21*: 193-221, 2000.

[32] ROTHMAN, K.J., GREENLAND, S. *Modern Epidemiology* (2nd ed.). Lippincott-Raven Publishers, Philadelphia, PA, 1998.

[33] AF WAHLBERG, A.E., DORN, L. Culpable versus non-culpable traffic accidents; what is wrong with this picture? *J Safety Res.* 38: 453-9, 2007.

[34] AF WAHLBERG, A.E. The determination of fault in collisions. In: DORN, L., MATTHEWS, G., GLENDON, I., editors. *Driver Behaviour and Accident Research Methodology: Unresolved problems*. Surrey, England: Ashgate Publishing Limited; p. 101-.20, 2009.

[35] MCEVOY, S.P., STEVENSON, M.R., WOODWARD, M. The prevalence of, and factors associated with, serious crashes involving a distracting activity. *Accid Anal Prev*. 39: 475–482, 2007.

[36] JACOBSON, P.D., GOSTIN, L.O. Reducing Distracted Driving. Regulation and Education to Avert Traffic Inuries and Fatalities. *JAMA* 303: 1419-1420, 2010.

[37] LENGUERRAND, E., MARTIN, J-L., MOSKAL, A., GADEGBEKU, B., LAUMON, B., THE SAM GROUP. Limits of the quasi-induced exposure method when compared with the standard case-control design: Application to the estimation of risks associated with driving under the influence of cannabis or alcohol. *Accid Anal Prev*. 40: 861-868, 2008.

[38] WORKSAFE B.C. Cell Phone Usage and Motor Vehicle Accidents. *Policy and Research Division Report*. WorkSafe BC, 2009.

[39] BRUBACHER, J., CHAN, H., ASBRIDGE, M. 2011. Development and Validation of a Canadian Culpability Scale. *Canadian Multidisciplinary Road Safety Conference*, May 2011.

[40] ROBERTSON, M.D., DRUMMER, O.H. Responsibility analysis: a methodology to study the effects of drugs in driving. *Accid Anal Prev.* 26: 243-7, 1994.

[41] MOVIG, K., MATHIJSSEN, M., NAGEL, P., VAN EGMONDD, D., DE GIER, J., LEUFKENS, H., et al. Psychoactive substance use and the risk of motor vehicle accidents. *Accid Anal Prev.* 36: 631-36, 2004.

[42] AF WAHLBERG, A.E. The relation of non-culpable traffic incidents to bus drivers' celebration behavior. *J Safety Res*. 39: 41-46, 2008.

[43] MCCARTT, A.T., HELLINGA, L.A. Longer term effects of Washington DC, law on drivers' hand-held phones. *Traffic Inj Prev*. 8 (2), 199–204, 2007.