Greetings, Ms. Cook and other Maine SOS officers.

I'm a vehicle lighting and safety expert located in Vancouver, British Columbia, Canada. I've become aware there's something of a kerfuffle regarding vehicles imported to the US under the 25-year rule, which Maine considers off-road vehicles. It seems there's the added complication that certain language in various communications and publications, including letters sent to owners of such vehicles, may have inadvertently caused confusion by appearing to erroneously categorize vehicles like the Mitsubishi Delica as "minitrucks". It also sounds as though vehicle enthusiasts are mobilizing in some sort of opposition.

I'm writing today to provide evidence in support of your refusal to register Japanese-specification vehicles. Here in BC we have a large number of these vehicles on our roads because of our relative proximity to Japan; that country's aggressive policies that make it difficult and costly to register older vehicles; and Canada's 15-year rule (vehicles older than 15 years may be imported regardless of noncompliance with Canada's national safety and emissions standards).

Most vehicles built to conform to Japanese specifications are right-hand-drive vehicles intended for use in Japanese left-hand traffic; as such, they pose a hazard to the vehicle occupants and the general public [viz MRS 29-A Chapter 15 §1756 (1) (D)] when operated in American right-hand traffic. Attached please find a study sponsored by our provincial vehicle insuror, the Insurance Corporation of British Columbia, looking at the crash involvement of right-hand-drive vehicles versus substantially similar left-hand-drive vehicles. The primary
finding: right-hand-drive vehicles are involved in significantly more—40 percent more—crashes than their left-hand-drive counterparts. This increased crash involvement is principally due to inadequate and improper sightlines; a driver seated on the wrong side of the vehicle cannot see to safely overtake another vehicle on a 2-lane highway, for just one of numerous examples.

That alone is a sturdy basis for refusing to register wrong-hand-drive vehicles for regular road use, but it is not the only such basis. In addition, vehicles built for use in left-hand traffic (in Japan or any other country where traffic keeps left) are equipped with headlamps producing low-beam light distributions appropriate for left-hand traffic, but not for right-hand traffic. All low beam light patterns are asymmetrical; those for use in right-hand traffic direct most of their light rightward to provide adequate seeing distance down the driver's own side of the road, while limiting leftward light to control glare toward oncoming drivers. Left-traffic headlamps are opposite: most of their light is directed leftward, while rightward light is limited. When left-traffic headlamps are used in right-hand traffic, most of their light is directed into the eyes of oncoming traffic, while the driver has inadequate seeing distance down their own side of the road—another hazard to the vehicle occupants and the general public.

Right-traffic headlamps meeting international UN Regulations exist for some vehicles popularly imported from Japan, such as certain versions of the Mitsubishi Delica which were marketed as new vehicles in countries with right-hand traffic. But for numerous other vehicles there are no right-traffic headlamps. This traffic-handedness is built into the lamp's optics—it cannot be adjusted out; it is completely separate from the vertical and horizontal aim adjustment of the lamp.

Furthermore, most vehicles built to conform to foreign standards lack certain items of lighting equipment that have been required on US-specification vehicles for many years, and therefore play a crucial role in making vehicles adequately conspicuous to other road users in North American traffic. Specifically, American regulations require amber front and red rear side marker lights and reflectors on all vehicles made since 1/1/70 (lights _and/or_ reflectors on vehicles made between 1/1/68 and 12/31/69). These must be mounted as close as practicable to the front and to the rear of the vehicle. Canadian standards, which are very nearly identical to the US standards, also require these items, but they are not required by any other country in the world (and if they are present, they are permitted to be amber front and rear).

Similarly, US regulations require a central high-mount stop lamp (CHMSL, "3rd brake light") on passenger vehicles made since September 1985, and light trucks and vans made since September 1993. The CHMSL requirement was adopted several years later in Japan and Europe, so there exist vehicles imported under the US 25-year rule which, by their construction date, would be required by US regulations to have a CHMSL but were not built with one.

Unlike the headlamp situation (if the vehicle was not offered by the manufacturer in a right-traffic market, and it does not use standard-sized headlamp units, then there are no legitimate right-traffic headlamps for it), CHMSLs and side marker lights and reflectors can readily be added to vehicles not originally equipped, in a good and durable manner with easily-available universal parts designed and built to conform to the applicable US regulations.

It is very appropriate that Maine regards Japanese "kei" vehicles—very small cars and trucks that do not meet safety standards applicable to more conventionally-sized vehicles—as off-road-only items not suitable for use in traffic.

It would also be very defensible for Maine to regard right-hand-drive vehicles in general, of any size, as unsuitable for use in general traffic—even if such a vehicle were to be retrofitted with right-traffic headlamps, a CHMSL, and side marker lights and reflectors as applicable—though it would be reasonable and appropriate to make provisions for registering such vehicles specifically for purposes where they are the most suitable and safest option, such as rural mail delivery. For adequately safe compatibility with American traffic, any such vehicle should be required to have right-traffic headlamps, and a CHMSL and side marker lights and reflectors as applicable by the vehicle's construction date.

It would be less defensible, from a public-safety standpoint, for Maine to reject left-hand-drive vehicles imported under the federal 25-year rule. Such vehicles are in virtually all cases built to conform to the UN Regulations which are recognized by the majority of countries outside North America. They differ in some details of their technical prescriptions, but on the whole they track very closely with the intent of the various US regulations in ensuring adequate safety performance in a vehicle's various systems, components, and design aspects, and in numerous analyses over many years have been found to provide safety performance at least equivalent overall to the US regulations. With the exception of the lighting incompatibilities described above, and the inherent incompatibility posed by a wrong-side driver position, the same is true of the Japanese regulations—which were brought into line with the UN Regulations some years ago. The attached ICBC vehicle safety study confirms this in its finding that while right-hand-drive vehicles crash more often in right-hand-traffic, the crashes are not more severe and not more injurious to the vehicle occupants compared to the Canadian-specification vehicles—which, again, are substantially identical to US-specification vehicles.

The same is true of UN and Japanese emissions regulations, which differ in the particular details but have been tracking closely with US emissions standards for quite a few years now.

It should also be noted that there are a great many left-hand-drive vehicles in Japan, where such vehicles are considered such a status symbol that a number of automakers market brand-new left-hand-drive vehicles there. They are equipped with left-traffic headlamps, but apparently the Japanese Government is unconcerned with the safety threat posed by wrong-hand-drive vehicles. Nevertheless, this creates a significant pool of left-hand-drive vehicles fundamentally safe to operate in American traffic (once they have been retrofitted with right-traffic headlamps and the missing conspicuity lights and reflectors).

The dismissive attitude enthusiasts fixated on specific Japanese-market vehicles tend to take toward the substantial safety issues with the vehicles they think they want is exactly why it is reasonable and proper for the state to set and enforce requirements for vehicles to be used in public traffic. The competing interests of public safety and individual freedom can best be balanced by adjusting Maine's requirements such that:

- Left-hand-drive vehicles imported under the 25-year rule are eligible for regular registration, provided they are equipped with right-hand-traffic headlamps and the conspicuity devices required on this continent (CHMSL, side marker lights and reflectors), and

- Japanese "kei" vehicles and similar miniature vehicles are not eligible for registration, and

- Right-hand-drive vehicles imported under the 25-year rule are eligible for registration only in carefully limited circumstances: rural mail or similar delivery service, and perhaps as collector vehicles with usage constrained to legitimate collector-vehicle activities and a requirement that anyone registering such a vehicle must also maintain registration and insurance on a left-hand-drive vehicle.

I hope these thoughts are helpful to you in resolving the current quagmire; perhaps the ICBC safety study can provide some sturdy backing for your decision to rescind the registration of right-hand-drive vehicles. By way of background, I was hired some years ago to write an imported-vehicle lighting inspection protocol for the province of BC, which was well received and is still in use. It was crafted specifically to handle exactly the lighting incompatibilities described in this email. I have also written extensively on the compatibility of vehicles built to UN specifications with American traffic systems designed around the assumption of vehicles built to US specifications.

I have attached my CV, and welcome your further conversation on these matters.

Cheers from across the continent,

-Daniel Stern

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PROFILE

In the field of lighting and light-signaling devices and systems on motor vehicles I wield formidable, comprehensive expertise and knowledge of the theory, practice, technology, technique, development, function, history, marketing, and regulation worldwide. I have served as an **expert witness** in legal proceedings related to vehicle lighting, an **expert resource** for articles and reports by numerous news outlets and regional automobile association chapters, and provided extensively referenced factual corrections to a white paper on headlamp safety performance and glare submitted to a government docket by a renowned national automobile association. I actively participate in **technical standards development** and research bodies, evaluate and critique relevant regulatory proposals, and have contributed materially to **vehicle lighting regulations** in several countries and territories. I participate in — and report on — the major international automotive lighting symposia and conferences, and have attended meetings of the United Nations international vehicle lighting and light signalling regulatory development working group at the invitation of its president. I maintain and curate a collection of technically and historically significant vehicle lighting devices and an apposite library of technical literature.

EXPERIENCE

Chief Editor • Driving Vision News — 2009-Present

The global automotive lighting industry's technical journal of record. I write, photo-illustrate, edit, and analyze news, conduct interviews, and produce in-depth reports. I chair the annual North American DVN Workshop technical symposium for vehicle lighting researchers, manufacturers, practitioners, regulators, designers, & suppliers.

Head of Product Development, Compliance, Retail Sales • Candlepower, Inc. — 2002-2010

I initiated retail marketing and sales, wrote promotional marketing materials, packaging text and technical literature, oversaw profitable product range expansion, responded to Federal regulatory proposals, resolved compliance issues, and devised in-house product testing protocols.

Product Development Manager • ACA Performance — 2001

I was hired to fix compliance-critical design and engineering flaws in a line of headlamps.

Proprietor & Consultant • Daniel Stern Lighting — 1996-Present

I have served as a consultant and supplier to private, commercial, and governmental end users seeking to see better while driving at night. I have successfully resolved ambiguous forensic evidence for law enforcement and investigative agencies. Under contract I have written in-depth technology reports, monographs, and analyses.

Manager, Race & Support Vehicle Lighting • University of Michigan Solar Car Team — 1998-1999

I directed the design, specification, procurement, fitment, and hookup of the lighting systems on the race vehicle and the mobile machine shop & car transporter.

[illegible]

National Academy of Sciences Transportation Research Board Visibility Committee • Appointed member, 2003–Present
Society of Automotive Engineers Lighting Systems Group • Voting member & task force chairman, 2007–Present

EDUCATION

Bachelor of General Studies • University of Michigan, Ann Arbor — 2001

The BGS program involves exceptionally broad distribution requirements and requires twice the upper-division coursework of conventional major/minor-based degree tracks.

PUBLICATIONS

Where Does the Glare Come From? — 2001 (2nd edition 2002)

This white paper on seeing performance and glare produced by various headlamp types and configurations is a permanent part of the technical libraries of North America's premier vehicle lighting and human factors research institutes.

SKILLS & SPECIALTIES

- Public speaking with great adaptability to audience and situation
- Highly precise, clear, engaging technical writing, editing, teaching
- Extremely fluent in English, competent in French; vehicle lighting-related vocabulary in German and Spanish

THE SAFETY OF RIGHT-HAND-DRIVE VEHICLES IN BRITISH COLUMBIA

Peter Cooper, Wayne Meckle, Glenyth Nasvadi, Sandi Wiggins

Abstract

The number of older, right-hand drive vehicles on BC roads has been proliferating in the last few years. Imported vehicles over 15 years of age are exempt in Canada from complying with Canadian Motor Vehicle Safety Standards (CMVSS) applicable to their years of production. This has led to a developing market for older vehicles from countries such as Japan. But while mechanical inspections are carried out on such out-of-province vehicles before they can be registered in BC, vehicles from countries that drive on the left side of the road (such as Japan) retain their right-hand-drive (RHD) control configuration.

The concern with these vehicles is two-fold:

1. Does the RHD configuration lead to increased risk of crash involvement?
2. Are these vehicles inferior in comparison with built-for-Canada vehicles of a similar age, with respect to occupant protection potential?

Very few, if any, studies have been done in other jurisdictions to address issues around driving with opposite-side controls. Some studies have been conducted to examine vehicle age effects but these mainly relate to maintenance problems and the characteristics of drivers who operate older vehicles. Nothing in the literature directly addresses the issue currently being faced in BC.

The study reported in this document was designed to fill the information gap referred to above. Three separate methodologies were utilized in approaching the two questions of vehicle compatibility with BC conditions: a relative risk analysis where RHD and LHD crash rates were compared for the same group of drivers; a "survival" analysis where time-to-first-crash was compared between RHD and LHD drivers: and a multiple regression model where RHD vehicle driver risk was compared to that of a similarly-constituted comparison group of LHD vehicle drivers.

The results of all three analyses were consistent. RHD vehicles had a greater than 40% increased risk of crashing over that of similar LHD vehicles. And this level of risk was applicable over an extended period of time for policy-holders. This would suggest that it's more than just an issue of driver unfamiliarity with RHD which should disappear in time. The incompatibility of the vehicle layout with the driver need to observe and manoeuvre in right-side traffic may cause ongoing difficulties.

However, from the perspective of occupant protection, no evidence could be found to suggest that the RHD vehicles were inferior. Crashes involving RHD vehicles were no more severe than those involving LHD vehicles only. However, there was insufficient detail on vehicle usage characteristics to rule out the possibility of different driving purposes which could impact such things as speed. A further study which attempted to obtain and match vehicle data by design elements and driving exposure quantity/quality would be required once more years of comparison were accumulated.

THE SAFETY OF RIGHT-HAND-DRIVE VEHICLES IN BRITISH COLUMBIA

1. Background

Currently, Transport Canada applies a 15-year import rule for vehicles coming into Canada from other countries in respect to the need to meet CMVSS requirements for their year of manufacture. Prior to 2005 relatively few imported vehicles fell under this classification but recently the number of Japanese imports beyond 15 years of age has been climbing noticeably. This appears to be due to the increasing regulatory and economic burden for Japanese drivers associated with licensing such older vehicles combined with a ready market in BC for relatively low-cost transportation.

The potential problem associated with this situation is two-fold. First, since the Japanese imports are right-hand-drive (RHD) vehicles designed to be operated on the left side of the road, there are possible ergonomic and visibility issues for drivers in a right-side travel environment. This could lead to a higher probability of crash involvement especially in the early period of vehicle use. Secondly, there is no guarantee that these vehicles meet all the major Canadian safety standards appropriate to their model year and thus occupants, if involved in a crash, could be at greater than desirable risk of injury. Some safety-related modifications to imported RHD vehicles are required in BC – such as headlight replacement to correct aiming – but other design components may not necessarily conform to applicable standards.

The driver-related issue is one that is relatively easy to understand and has at least some recognition in the literature. While no studies could be found that specifically dealt with the safety of RHD vehicles in a LHD environment, there were a few that examined the situation with respect to driver unfamiliarity with local road travel conventions. For example, Dobson et al (2004) found no greater risk associated with drivers born outside Australia (left-side driving convention) when compared to those native to the country but did find a greater risk for immigrant pedestrians. On the other hand, in driving simulator tests Jeon et al (2004) found that Korean drivers not accustomed to RHD performed worse in a left-side road convention (simulated environment around Yokohama, Japan) than did native Japanese drivers. The former demonstrated more lane position adjustments and less visual searching when negotiating turns across traffic lanes and, overall, exhibited twice the level of mental workload that characterized the latter.

Commercial goods movement within the European Union has given rise to situations where British heavy trucks (RHD-HGVs) regularly operate on the Continent and Continental LHD-HGVs operate in Britain. The impact of the latter situation can be assessed from reported UK crash statistics (Transport Statistics, 2006) which clearly point to an increased risk of turning and weaving collision involvements for LHD vehicles in the RHD environment. Foreign LHD-HGVs in 2005 were over 4.5 times more likely to be involved in crashes while turning, overtaking or lane-changing (537 out of 1,031 total collisions) than were domestic RHD-HGVs (2,340 out of 12,120).

And almost all (99%) of RHD-HGV side-swipe crashes involved lane changes to the right compared to 52% for LHD-HGVs. While at least some of these differences could be due to unfamiliarity with UK driving conditions, the authors of the statistical report expressed their belief that they were "a consequence of the reduced direct field of view for drivers of left hand drive HGVs to the side and rear on the right (passenger) side of the vehicle" (p.38).

In terms of visibility for the driver, it is self-evident that LHD vehicles are designed with right-hand traffic operation in mind and vice-versa for RHD. So some difficulties in mixing design and operating criteria can be expected. The "blind spot" over a driver's left shoulder is sometimes mentioned by owners of RHD vehicles operating in a right-side roadway environment (The Daily News, Nanaimo, 2007). Unfamiliarity with control positioning – such as manual gear shift – may cause some temporary adjustment problems for drivers that could be manifested in an early spike of crash involvement risk.

With respect to injury potential, very little objective information seems to exist. Lecuyer and Chouinard (2006) discussed the greater proportion of fatalities and serious injuries in crashes involving older vehicles and the greater likelihood of collisions due to mechanical failure. But these findings are generalized to all vehicles and do not specifically relate to older imports which have presumably undergone some level of safety inspection prior to re-sale. Thakore et al (2001) have suggested that blunt trauma injuries associated with RHD vehicle interior design (controls etc.) tend to more localized on the right side of a driver's body where internal injuries are apparently more difficult to detect, but this alone doesn't necessarily imply significantly greater overall casualty risk.

It would certainly seem logical in light of the recent US government study on the effectiveness of vehicle safety standards since 1960 (NHTSA, 2004; Farmer and Lund, 2006) that an influx of older vehicles into the fleet mix would tend to increase overall injury risk but, unlike the US, in Canada one important historical mitigating factor has been the use of active occupant restraints. If three-point seat belts are available for all occupant positions in the imported vehicles then the safety decrement due to less-developed other design factors may not be so much of an issue – that is, still present but masked.

In summary, while there are cogent reasons to suspect that the introduction of older RHD vehicles into a right-side traffic environment may be problematic, there is not sufficient evidence in the literature upon which to base a reliable conclusion. Therefore, a specific crash risk study comparing RHD imports to other vehicles in BC using Insurance Corporation of BC (ICBC) crash-claim data was indicated.

2. Study Design

In September of 2006, ICBC began identifying imported RHD vehicles greater than 15 years of age. During the seven-month period up to the end of March, 2007 there were 1083 such vehicles of which 578 represented passenger vehicles with active policies. In order to obtain a larger sample which would be required in order to assess crash rates compared to LHD vehicles, the ICBC policy/vehicle records were searched to identify BC-assigned VINs for vehicles of model year (MY) 1986-1992. All vehicles imported into BC from abroad are issued new VINs which begin with the character string "2BG". These VINs are also issued for various "home-made" specialty vehicles such as kit-cars and so the list resulting from the search had to be reduced to include only recognizable Japanese and British makes of passenger vehicles which should be RHD. Then this reduced list was further restricted by eliminating those for which no policy existed or for which the first policy was earlier than 2001 (1986+15) or less than 15 years after the vehicle model year.

The design of this study included three separate methodologies to assess RHD vehicle risk. The use of different methodologies – a technique known as triangulation – strengthens the results and conclusions of the study. The methodologies included: (1) a relative risk comparison of culpability for crashes of individual drivers for RHD vs. LHD vehicles; (2) survival analysis to determine if an increased risk was associated with the early driving periods for RHD vs. LHD vehicles; (3) Poisson regression analysis to compare RHD driver risk to a LHD driver control group. In addition to estimation of vehicle crash involvement risk, comparison of crash severity for RHD and LHD vehicles was undertaken as part of the first and third methodologies.

2.1 Relative Crash Culpability Risk

A procedure was designed in which RHD operators could be compared within their own group in terms of crash experience both with RHD and conventional LHD (or non-RHD) vehicles – a variation on Evan's (1986) "double-pair comparison" method which should largely remove the effect of driver differences. This was accomplished by identifying all drivers involved in crashes while operating the RHD vehicles since Jan. 1, 2001 and then examining all other crashes in which those same drivers had been involved during the same period. For 1986 MY vehicles, January of 2001 was the earliest date when they could have been 15+ years old.

To consider potential RHD drivers who had not been involved in a crash while driving the RHD vehicle, it was necessary to identify the principal operators (POs) listed for the policies (at ICBC a PO is someone who will be driving the insured vehicle more than 50% of the time and such persons must be identified in the policy records). Then the records of these POs were examined to extract all crash events involving vehicles other than the RHD ones. As with all such data matches at ICBC, key identifiers such as driver license number were deleted after the files were created and no personal information was retained. A total of 359 RHD and 1204 LHD crashes were identified. Of the latter, 880 were via the RHD PO route.

Crashes were separated into culpable and non-culpable events from the perspective of the target driver. A culpable event was one in which the driver was assigned 50% or more of the responsibility during the subsequent claim adjustment process. Events where the driver was assigned less than 50% were classed as non-culpable. The purpose in making this distinction was to employ culpable events as evidence of vehicle risk and non-culpable events as evidence of travel exposure – or "induced exposure" – as originated by Thorpe (1964) and more recently utilized by Hing et al (2003). The ratio of culpable to non-culpable crashes then becomes a risk measure and the ratio of these rates for RHD vs. LHD vehicles is a relative risk consistent with an odds ratio that can be tested using the non-parametric chi-square statistic.

Since the RHD imports in this study were all 15 or more years old, it is possible that the age itself contributes to the crash risk. Therefore, the relative risk analyses had to focus on 1986-1992 model year LHD vehicles in addition to the full sample of such vehicles operated by RHD-associated drivers.

Of course, the major assumption underlying use of the above methodology is that active driver risk-taking behaviour is characteristic of the driver and does not vary substantially among different vehicles he or she may drive. The difference in risk rate between vehicle types is then primarily reflective of the nature of the vehicles. This assumption is consistent with the notion that "people drive as they live" which is supported in Evans (1991), and by the work of Horswill and Coster (2002) and Moller (2004).

2.2 Survival Analysis

In longitudinal studies it may not be reasonable to assume that the risk of an event occurring is constant over time. Previous road safety studies have shown that in general the risk of motor vehicle collision increases over elapsed time. However, it may also be reasonable to assume that, over time, RHD drivers would become increasingly accustomed to the different vehicle configuration with the result that some mitigation of early risk levels could occur. Survival analysis allows for the analysis of crash rates without making the assumption that they remain constant with time. It focuses on the *hazard,* which is the instantaneous rate in time, and the *survivor function*, which is the probability that an individual will not crash. Comparison of the survival patterns of two groups such as RHD and LHD is expressed as a *hazard ratio*.

In this study, survival analysis was used to evaluate the risk of a culpable (at-fault) crash following the initial insurance policy purchase for each vehicle. It compared the time that RHD and LHD vehicles were driven crash-free after first insured. The method had the added advantage of controlling for the "newness" of the vehicles from the drivers' perspective.

Cox proportional hazards regression survival analysis was conducted using SPSS Version 15.0. Cox proportional hazards has the advantage over other regression methods in that it uses all the information (including crash-free driving) rather than only the event (crash) data. In addition, Cox regression allows examination of other factors that may contribute to the effect. In this study the analysis was performed for time-to-first-crash in comparing RHD with LHD vehicles. The data sample included all RHD POs aged 20 years and older at the time of first policy and all vehicles (RHD and LHD) for which they were listed as POs. Only culpable crashes (50% or more liability as with the relative risk procedure described above) were included. Time was calculated from the date of first policy to the date of first culpable crash or, for those not involved in crashes, the date of data extraction (10 April, 2007). The effects of driver age and gender were also included in the analysis.

Cox regression assumes that the hazard ratio between the two groups being compared remains constant over time – an assumption that, as discussed above, is not self-evident. However, examination of Schoenfeld residuals (Schoenfeld, 1982) showed no departure from the proportional hazard assumption.

2.3 Poisson Regression

This methodology involved a comparison between older (15+ years) imported RHD vehicles and a group of similar LHD vehicles. Because of the possibility of diminishing crash risk over time (as discussed above under "survival analysis"), vehicles were compared based on a time period covering 2 years from the effective date of their first policy with the vehicle in question. Short-term and storage policies were excluded when determining the policy years. The dependent variable in the analysis was the number of crash-claims, and Poisson regression was chosen due to the nature of the data distribution and the requirement for a relative risk measure applicable to RHD.

Vehicle model year, make, model and body style were extracted from ICBC's business information warehouse (BIW) for all RHD vehicles based on VIN, as was policy data. Because matching with an appropriate comparison group was a critical part of the methodology, a number of steps were taken to ensure that the two samples were constituted as similarly as possible. For example, the comparison group of LHD vehicles was selected to reflect the same model years, body styles and vehicle makes as the RHD vehicles. The proportion of model year and body styles existing in the RHD group was applied to the LDH vehicle group. The policy period for the purpose of counting crash occurrences was defined to commence with the first policy date representing a consistent subsequent insurance rate class (vehicle use type) and territory. Only vehicles with at least 1 policy year of insurance coverage were included in this analysis.

Since the assessment period was different for each vehicle and some could have a time equal to less than 2 years, the analysis was conducted using the GENMOD procedure with SAS Version 9.1. An offset variable of *log(policy years)* was used to control for different policy periods.

The above data extraction process resulted in an RHD group of 748 vehicles. A large comparison group consisting of all vehicles without BC-assigned VINs was extracted from the BIW using the same make, body style and model year categories as in the RHD dataset. The LHD selection process produced a dataset of 8,933 vehicles. The comparison dataset now had the same vehicle proportions as the RHD dataset. Vehicle crash involvements were counted from the first policy issued for the vehicle in question until the end of the 2-year follow-up period, or until the policy expired, was cancelled, or the end of the study (March 31, 2007) was reached. Crash counts were separated into injury and material-damage-only and, within these, into culpable and non-culpable.

To compare the crash involvements of drivers of RHD and LHD vehicles, the vehicles' principal operators (POs) were found for the 2-year vehicle policy period. POs of vehicles were determined based on their being identified in the BIW as the PO shown in the policy data. If a principal operator was not identified in the policy data, the policy holder (registered owner) was assumed to be the PO. Crashes were counted for the period of time during which each identified PO remained the PO of the vehicle (to a maximum of 2 years). Only POs with a minimum of 1 year of coverage on the vehicle were included in the analysis of driver crash involvements.

Traffic contraventions are a gauge of driver risky behaviour. Violation tickets with a guilty status issued to a driver under the BC Motor Vehicle Act or traffic offence convictions under the *Criminal Code of Canada* were also extracted from the BIW. Contraventions were counted for POs during the first 2-years of vehicle policy time. Violations that occurred on the same day as a driver crash incident were dropped. This was done to avoid confounding the driver risk. Offences were grouped into speeding tickets and all other violations. PO traffic violations were categorized into speeding and non-speeding. Speeding violations included both exceeding the posted limit and excessive (40+ km/h over) speeding and amounted to roughly half of all convictions.

3. Results

3.1 <u>Relative Crash Culpability Risk</u>

Two analyses were conducted: first, using all LHD vehicles with crashes after Jan.1, 2001; then, in order to isolate the RHD effect from that of vehicle age, no LHD vehicles were included where the model year of the vehicle predated 1986 or post-dated 1992. In both analyses, no crashes were counted which had a date of loss prior to Jan. 1, 2001, or where an involved RHD vehicle was less than 15 years old at date of first policy, and crashes were only counted where the driver of the target vehicle was over 20 years of age at the time. This last consideration was designed to limit any confounding effects of graduated licensing which was evolving over the study period. Some 40% of the sample was still between 20 and 25 years of age and 83% were males.

The LHD crashes were obtained through two different pathways as described earlier. One looked at RHD-crash-involved drivers who also had LHD crashes and the other identified LHD crashes for RHD POs who did not crash their RHD vehicles. In order to justify combining them in the same analysis it was first necessary to calculate their crash-claim risk ratios (culpable/non-culpable) independently to make sure they were comparable. In fact the ratios were very similar. Using all LHD vehicle ages the comparison gave rise to $\chi^2 = 0.176$, d.f. = 1, p = .682 and using only MY 1986-1992 vehicles the result was $\chi^2 = 0.007$, d.f. = 1, p = .937. Thus combining the two LHD data groups was considered justified.

The crash count matrix for the analysis including all ages of LHD vehicles is shown in Table 1 below.

Table 1: Crash Count Matrix for RHD vs. LHD Vehicles

	RHD	LHD	
culpable	**201**	**548**	749
	172.04	*576.96*	
non-culp.	**158**	**656**	814
	186.96	*627.04*	
	359	1204	1563

Odds Ratio = 1.52
X^2 = 12.156 d.f.=1, p= <.001

The crash count matrix for the analysis including only MY 1986-1992 vehicles is shown in Table 2 below.

Table 2: Crash Count Matrix for RHD vs. LHD Vehicles of Same Age

	RHD	LHD	
culpable	**201**	**187**	388
	184.01	*203.99*	
non-culp.	**158**	**211**	369
	174.99	*194.01*	
	359	398	757

Odds Ratio = 1.44
X^2 = 6.125 d.f.=1, p= 0.0147

The Odds Ratios from the above tables are equivalent to relative risks as illustrated below in terms of the Table 2 results:

Odds Ratio $\frac{(201).(211)}{(158).(187)}$ is equivalent to the Relative Risk $\frac{(201)/(158)}{(187)/(211)} = \frac{1.272}{0.886}$

The Odds Ratio comparing the RHD with all ages of LHD vehicles was **1.52** which means that the RHD vehicles were 52% more at risk of precipitating a crash than the LHD vehicles using the risk definition described above. With a χ^2 of over 12 and one degree of freedom, this result was highly statistically significant. When the analysis was restricted to only those LHD vehicles in the MY 1986-1992 range the Odds Ratio dropped slightly to **1.44**. This was still statistically significant but since the smaller sample size makes it more difficult to establish significance, the level was lower.

The important thing to realize from the comparison of these two results is that the effect of age appeared to be relatively small compared with the effect of the RHD. With age unaccounted for (and the LHD crash-involved vehicles averaging 1994 MY compared with 1989 for the RHD) the additional risk was 52%, but comparing RHD to LHD for the same age range of vehicles only reduced the excess risk to 44%.

In terms of average crash severity, there was no significant difference. The proportion of casualty-producing involvements amounted to 25.5% for all RHD and 26.9% for all LHD vehicles. This difference was not statistically significant ($\chi^2 = 0.520$, d.f. = 1, $p = .479$). These are both close to the average experience for all BC vehicles.

The mean incurred crash-claim cost for crashes involving the MY 1986-92 RHD vehicles was actually *less* than that for crashes involving the MY 1986-1992 LHD vehicles but with the high associated standard deviations the difference was not quite statistically significant ($t = 1.663$, $p = 0.097$). The same situation existed for the case where all ages of LHD vehicles were included although the difference was slightly greater ($t = 1.825$, $p = 0.072$). In other words, there was no evidence to suggest that crashes involving RHD vehicles in BC between 2001 and 2007 have had a *higher* dollar severity than other, LHD crashes.

3.2 Survival Analysis

A total of 23,717 drivers were included in the analysis of which 2,882 were associated with RHD vehicles. Chi-square tests showed that RHD vehicles were significantly more likely than LHD vehicles to be involved in a culpable collision during the study period ($\chi^2 = 53.887$, d.f. = 1, $p < .001$).

Results of baseline Cox regression revealed an unadjusted hazard ratio for risk of a culpable crash in RHD versus LHD vehicles of 4.16 (B = 1.424, SE = .098, $p < .001$; 95% CI = 3.43-5.03). This means that drivers of RHD vehicles had a four-fold chance of causing a crash sooner than drivers of LHD vehicles. The average time-to-crash was 223 days for the RHD vehicles and 705 days for the LHD vehicles.

Figure 1 below is a graphical representation of the numbers of RHD and LHD (or non-RHD) vehicles that did not crash (i.e. "survived") over time. The plot shows that after one year 99% of LHD vehicles remained culpable-crash-free as compared to 96% of RHD vehicles. By three years the gap had widened to 98% vs. 91.5% respectively. These differences were highly statistically significant ($p < .001$).

Figure 1: Proportion of Vehicles Remaining Crash-Free

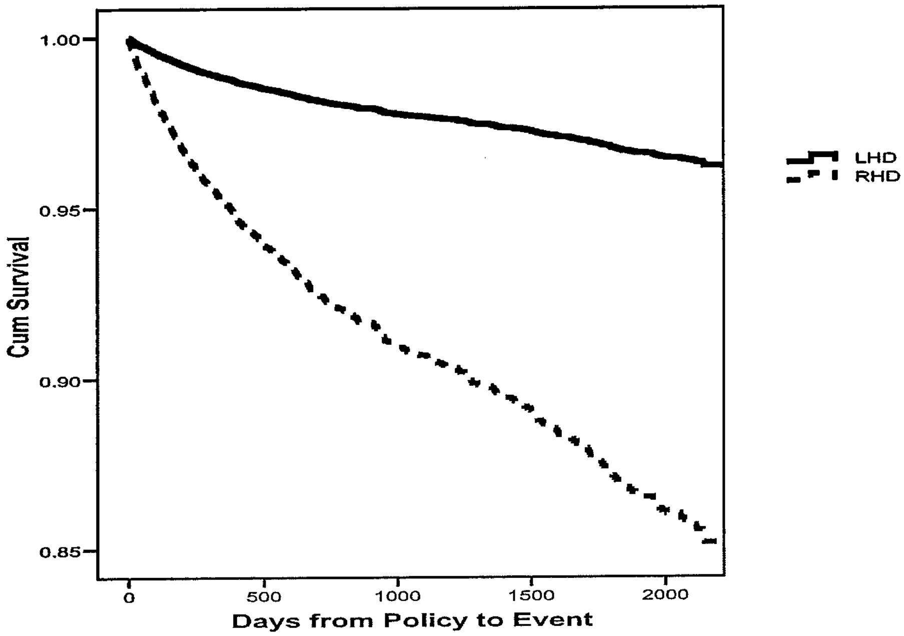
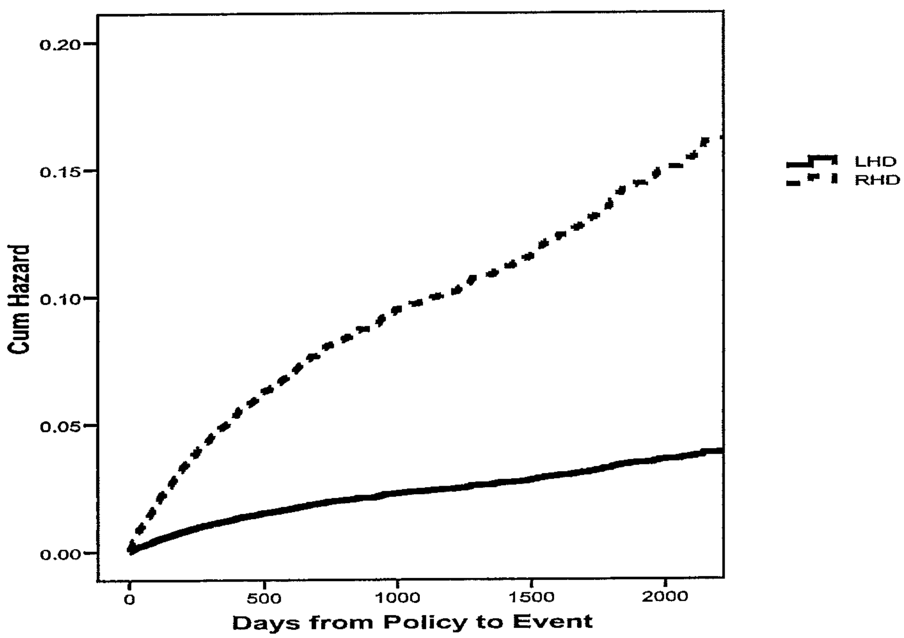


Figure 2: Instantaneous Risk of Collision at Time 't'



Instantaneous risk of collision (the hazard function) is represented in Figure 2. As can be seen from the graph, the risk of crash in a RHD vehicle is substantially higher (significant at $p<.001$) than in a LHD vehicle.

Age at the time of purchase of the vehicle policy, and gender of the PO were entered into the regression model. Results are presented in Table 3. All variables added significantly to the model ($p < .001$). The odds of men crashing earlier in a RHD vehicle was almost double that for women, and for each year of increase in driver age, the odds of crashing earlier in a RHD vehicle decreased by 2%. However, results of cross-tabulation showed the sample of RHD drivers contained significantly more men, and the drivers were significantly younger than the sample of non-RHD vehicles. Interaction effects were found between the vehicle and age but not gender. Mean age at crash was younger for RHD compared to non-RHD vehicles (33.07 versus 36.96 years, $t = 3.344, p = .001$). The adjusted hazard ratio for crashes in RHD versus non-RHD vehicles declined slightly from the unadjusted value (from 4.115 to 3.928) after controlling for the age and gender of the PO.

Table 3: Adjusted odds of crashing earlier in a RHD vehicle

	B	SE	Wald	df	Sig.	Exp(B)
Age at Policy	-.021	.003	39.407	1	.000	.979
Gender	.655	.109	36.148	1	.000	1.925
RHD	1.368	.098	194.586	1	.000	3.928

3.3 Poisson Regression

Region of driving (territory) was the only additional independent variable included in the initial Poisson regression. Region was defined based on rating territory as either "Lower Mainland" of BC or "outside Lower Mainland" since such a distinction represented the principal risk differential. Rate class was initially examined as a potential variable in terms of the distinction between business (commercial) and the pleasure/commuting categories, but it was found not to add significantly to the variance explained and thus was dropped from the final model.

Table 4 shows the estimated two-year vehicle crash involvement rates, relative risks and percentage differences for the RHD and LHD vehicle comparison groups. As can be seen, the relative risk of crash involvement was significantly higher for RHD than LHD vehicles for all crashes (by 30%), material damage only crashes (by 48%) and for liable crashes (by 45%). RHD vehicles had a lower risk of injury crash involvement (by 21%). However, the difference observed for injury crashes did not reach statistical significance.

Table 4: Estimated Adjusted Rates+ and Relative Risks for RHD & LHD Vehicle Crash Involvements After Adjustment for Rating Territory

Crash Type by Vehicle Configuration	Estimated Adjusted Rate (95% Confidence Interval)	RR (95% Confidence Interval)	% Change (from REF)
All Crashes			
RHD Vehicles	18.94 (16.47-21.41)	1.30 (1.13,1.48)	+30%*
LHD Vehicles	14.58 (14.00-15.16)	1.00 (REF)	-
Injury			
RHD Vehicles	2.94 (1.97-3.91)	0.79 (0.55,1.09)	-21%
LHD Vehicles	3.72 (3.43-4.01)	1.00 (REF)	-
Material Damage Only			
RHD Vehicles	16.02 (13.75-18.29)	1.48 (1.27,1.71)	+48%*
LHD Vehicles	10.83 (10.33-11.33)	1.00 (REF)	-
Culpable (At-Fault)			
RHD Vehicles	9.59 (7.83-11.35)	1.45 (1.20,1.75)	+45%*
LHD Vehicles	6.59 (6.20-6.98)	1.00 (REF)	-

*P< 0.0001 **P<0.005 ***P<0.05

+ Per 100 policy-years

The analysis above is based on vehicles only and does not account for the influence of drivers in determining crash rates. Since driver characteristics have a significant impact on crash rates, the vehicles' principal operators were also examined in order to investigate the differences between RHD and LHD configured vehicles at the driver level.

The final regression model provides the relative risk of drivers in RHD vehicles in comparison to LHD POs during the first 2 year policy period while controlling for:

- gender,
- driver age,
- region of BC,
- contraventions – speeding
- and contraventions – non-speeding.

The PO groups consisted of 574 and 7,988 drivers with ≥1 year policy connection for the RHD and LHD vehicles respectively. Table 5 below shows that approximately 20% of the POs of RHD vehicles were under age 25, while in the LHD group the POs under 25 made up only 9% of the group.

Table 5: Principal operator count by age at first policy and vehicle configuration

Age of driver at first policy	Principal operator count by age at first policy			
	RHD Drivers		LHD Drivers	
	N	%	N	%
16-18	12	2.1	117	1.5
19-21	59	10.3	244	3.1
22-24	41	7.1	356	4.5
>= 25	462	80.5	7,271	91.0
Total	574	100.0	7,988	100.0

Age group by vehicle configuration: Chi-Square = 95.28; df =3; P=0001

Principal operators of imported older RHD vehicles were most likely to be male. Table 6 below shows that less than 15% of drivers of these vehicles were female. The LHD group, however, was approximately 45% female.

Table 6: Principal operator count by gender and vehicle configuration

Gender	Principal operator count by gender			
	RHD Drivers		LHD Drivers	
	N	%	N	%
Female	84	14.6	3,576	44.8
Male	490	85.4	4,412	55.2
Total	574	100.0	7,988	100.0

Gender by vehicle configuration: Chi-Square = 198.68.; df =1; P=0001

Table 7 shows the two-year PO crash involvement rates, relative risks and percentage differences for the RHD and LHD driver comparison groups. Looking at all crashes during the follow-up period it can be seen that RHD drivers have a higher crash rate (12.56 crash involvements / 100 policy-years compared to 9.59 crash involvements / 100 policy-years). RHD drivers were thus 31% more likely to be involved in a crash than the LHD drivers in the first 2 years. Injury crash rates were also slightly higher for the RHD group, but the results were not statistically significant. The RHD drivers were 37% more likely to have a material damage crash than the comparison group of LHD drivers. These material damage crashes may well be the result of low speed crashes which occur while exiting parking or entering traffic. These kinds of crashes are consistent with drivers having difficulty in seeing traffic due to the configuration of the vehicle.

Table 7: Estimated Adjusted Rates+ and Relative Risks of Crash Involvement for Principal Operators of RHD and LHD Vehicles After Adjustment for Age, Gender, Rate Territory, Speeding Contraventions, and Other Contraventions

Crash Type by Vehicle Configuration	Estimates Adjusted Rate (95% Confidence Interval)	RR (95% Confidence Interval)	% Change (from REF)
All Crashes			
RHD Drivers	12.56 (10.17-14.95)	1.31 (1.09,1.56)	+31**
LHD Drivers	9.59 (9.08-10.10)	1.00 (REF)	-
Injury			
RHD Drivers	2.43 (1.38-3.48)	1.12 (0.74,1.65)	+12
LHD Drivers	2.16 (3.43-4.01)	1.00 (REF)	-
Material Damage Only			
RHD Drivers	10.13 (7.98-12.28)	1.37 (1.11,1.67)	+37%**
LHD Drivers	7.40 (6.95-7.85)	1.00 (REF)	-
Culpable (At-Fault)			
RHD Drivers	5.83 (4.20-7.46)	1.46 (1.12,1.91)	+46%***
LHD Drivers	4.01 (3.68-4.34)	1.00 (REF)	-

*P< 0.0001 **P<0.005 ***P<0.05

+Per 100 policy-years

The greatest percentage difference between the estimated rates of the two groups was for culpable crashes. Culpable or at-fault crash rates were 46% higher for RHD drivers when compared to the LHD group. The estimated relative risk of 1.46 for RHD drivers was very similar to the value estimated in the relative crash culpability analysis reported earlier.

4. Discussion and Conclusions

Three very different approaches were taken in attempting to determine if RHD vehicles imported into BC since Jan. 1, 2001 have demonstrated higher risk of crash involvement or severity. One approach sought to cancel out the effects of operator characteristics by examining crash involvements in RHD and LHD vehicles by the same drivers. Another focussed on the time to first crash event following initial policy date for RHD vs. LHD vehicles. And the third methodology compared RHD drivers and vehicles in crashes to a comparison group of drivers in the general population in a multiple regression model using a number of driver/vehicle control variables.

The results of the all three analyses in terms of relative risk for crash involvement associated with RHD vehicles were very similar. From the relative crash culpability risk analysis, the RHD vehicles had a 44% increased risk, compared to LHD vehicles, of crashing over a 4-year period (the average time from first policy date to data extraction). For their first two years, the increased risk of culpable crash causation from the Poisson regression was 46% and, based on survival analysis, the average time to first culpable crash for the RHD vehicles was 223 days (68% sooner) when compared to the time for the LHD vehicles which was 705 days. These results, taken together, clearly point to a driver-vehicle issue that produces high initial risk and which does not appear to ameliorate to any extent over a number of subsequent years. The problem would thus seem to be more than driver adjustment to a new control configuration and may reflect a continuing operational hazard.

On the other hand, there was no evidence to suggest that crashes involving the RHD vehicles were any more severe than those involving LHD vehicles. Of course, in spite of the non-significance of the insurance rate class in the regression, some of the lack of severity effect might be explained by differences in vehicle use or purpose and where, when, how or how much the vehicles are driven. This could still leave room for the presence of an underlying risk associated with sub-standard design or maintenance although one could argue that such differences might be relatively inseparable from the way these vehicles are utilized and that a self-correcting mechanism could therefore be in operation. In the final analysis, the results of this study do not support the suggestion that the imported vehicles may represent a greater occupant injury risk but the caveat with respect to vehicle use differences is germane here and, to a lesser extent, also with the results concerning crash occurrence rates.

It is reasonable, from the results obtained in this study, to conclude that the important issue in BC with respect to imported RHD vehicles is driver performance as opposed to vehicle safety per se. Of course, the driver performance issue presumably results from the inappropriate configuration of the vehicle but there was no indication beyond this of sub-standard vehicle crash performance as reflected in higher claim severities. In other words, driver unfamiliarity with the RHD configuration coupled with operational or visibility problems associated with manoeuvring such vehicles in a right-side driving environment probably predisposes them to a higher-than-expected collision causation rate. And this increased risk appears to be substantial.

More research on crash severity would be in order so as to explore in greater detail the relationship between LHD and RHD vehicles in BC with respect to injury probability and cost. Specifically, material damage and occupant injury associated with crash-involved RHD and LHD vehicles could be assessed in conjunction with such things as crash configuration and roadway type (e.g. posted speed limit category) by equivalent level of applicable safety-related vehicle design. However, more years of crash record than were available at the time the study was conducted would be necessary to explore this issue in a comprehensive manner.

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