Crash effects of the new Queensland Graduated Licensing System: A preliminary evaluation

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Abstract

A new Graduated Licensing System (GLS) were introduced in Queensland on July 1 2007 with key changes including doubling the minimum learner period, a mandatory minimum 100 logbook hours of supervised driving for learner drivers, a 2-phase probationary licence period, mandating display of L and P plates and late night peer passenger restrictions. The aim of this study was to evaluate the overall crash effects associated with the introduction of the new Queensland GLS. Changes in novice driver crash rates per licensed driver year of from before to after introduction of the new GLS were compared to parallel changes in 25-35 year old experienced drivers over time to measure the net crash effect associated with the new GLS. Analysis was undertaken by crash severity level at the global program level as well as for specific license phases where there was sufficient data. Introduction of the Queensland GLS was associated with a 30% reduction in novice driver fatal crashes ($p=0.025$) and a 13% reduction in novice driver fatal and serious injury crashes combined ($p<0.001$). A 30% fatal crash reduction ($p=0.03$) for first year probationary drivers and 26% reduction in fatal and serious injury learner driver crashes ($p=0.0018$) were also estimated. Analysis also provided some insight into the likely long term effects of the program. Evaluation of the new Queensland GLS has further confirmed the value of comprehensive graduated licensing systems in reducing novice driver road trauma.

Introduction & Aims

The Queensland Government made substantial changes to the Queensland Graduated Licensing System (GLS) by introducing thirteen new initiatives on July 1 2007. The key initiatives included doubling the minimum holding period for all Learners (from 6-months to 12-months), requiring that Learner drivers under 25 must accrue 100 hours of supervised on-road driving experience and record it in a Queensland Learner Logbook, dividing the probationary licence period into two phases (P1 and P2), and restricting P1 drivers to carrying no more than one peer passenger aged 16-23 years during the hours of 11pm to 5am, mandating the display of P plates and high powered vehicle restrictions.

The overall aim of the evaluation was to assess the effectiveness of changes introduced to the GLS on 1 July 2007 on police reported crashes. The definition of a novice driver within the context of this evaluation is any driver that is licensed as part of the GLS (i.e. on an L, P, P1 or P2 licence).

Data & Data Preparation

Study Groups by GLS Requirements

Development of the experimental design to evaluate the new GLS required an understanding of the requirements and restrictions on each licence phase, the age-based exemptions that existed for the new GLS, and, which conditions enabled drivers to enter the GLS on the old GLS and exit on the new GLS. This process revealed that the progression of phases on the new GLS and requirements or restrictions within each phase vary depending on a driver's age at the time of licensing and the time period in which they were licensed (i.e. entirely on the new GLS versus both the old and new GLS). These variations were translated into ten treatment groups which are described in Table 1. Each of the ten treatment groups defined in Table 1 cover drivers that were subject to the new GLS

licensing conditions during some phase of their licensing progression (L, P1 or P2 phases). In addition, those who were licensed under the old GLS constitute the treatment group for the period before the introduction of the New GLS; these are drivers who obtained their Learner and/or Probationary licence under the old-GLS. This group is considered the 'before group' in the comparison of crash rates before and after the new GLS implementation, and are therefore a critical group of drivers in the experimental design.

Table 1. Description and Progression of Treatment Groups Based on Licensing Age

	Description of defining characteristics of each group
1	Licence activity new GLS; obtained Ls aged under 22; P1 under 23; P2 under 25;
2	Licence activity new GLS; obtained Ls aged under 23; P1 aged 23; P2 between 24-25; age-based exemptions P2 hold 1 year only
3	Licence activity new GLS; obtained Ls aged under 24; P1 aged 24; age-based exemptions no P2 phase
4	Licence activity new GLS; obtained Ls aged under 25 years; P2 aged 25 years; age-based exemptions no P1 phase; age-based exemptions on the P2 period: only hold P2 for 1 year, exempt from the HPV restriction, and late night driving restriction as penalty for exceeding demerit point threshold
5	Licence activity new GLS; obtained Ls aged 25 years or over; P2 aged 25 years or above age-based exemptions no P1 phase; age-based exemptions on the Learner period: logbook is voluntary and no mobile phone restriction P2 period: only hold P2 for 1 year, exempt from the HPV restriction, and late night driving restriction as penalty for exceeding demerit point threshold.
6	Licence activity new GLS; obtained Ls but have no progressed beyond this licence phase
7	Licence activity old and new GLS; Learners on old system aged 16.5 – 23 years; P1 aged under 23 years; P2 under 25 In new GLS subject to the same requirements and restrictions as drivers in Treatment Group 1
8	Licence activity old and new GLS; Learners on old system aged 16.5 – 24 years; P1 aged 24 years; aged-based exemptions no P2 phase In new GLS period are therefore subject to the same requirements and restrictions as Treatment Group 3
9	Licence activity old and new GLS; Learners on old system aged 16.5+; P2 aged 25 years or above; age-based exemptions no P1 phase; age-based exemptions on the P2 period: only hold P2 for 1 year, exempt from the HPV restriction, and late night driving restriction as penalty for exceeding demerit point threshold. In new GLS period are therefore subject to the same requirements and restrictions as Treatment Group 4
10	Licence activity old GLS; obtained Ls but have no progressed beyond this licence phase

In order to control for confounding factors affecting novice driver crash risk other than the introduction of the new GLS, a comparison group, sometimes referred to as a control group, was defined for use in the evaluation. The comparison group was defined as Open licensed car drivers aged between 25-35 years. This group have been devised to purposefully share similarity to the treatment groups in age, and to have completed their progression through the GLS. The comparison group represents the time based changes in broad crash risk for all non-GLS related road safety initiatives, exposure and other socio-economic effects in Queensland occurring during the study period.

Licensing Data

Licence data was extracted from the Queensland Transport and Main Roads (TMR) TRAILS database for the period November 1986 – November 2011. This enabled the identification of: the comparison group drivers aged 25-35 during the period July 2004 – November 2011 and holding an open licence during that time; the old GLS treatment group drivers entering the old GLS from July 2004 until June 2007; and the new GLS treatment group drivers entering the new GLS from July 2007 until November 2011. The licence data consisted of each licensed driver's: birth date, surrogate unique reference number (used for data linking); an indicator for interstate or overseas transfer (i.e. driver held a licence in another state or country and transferred this to Queensland); information on each licensing event for each individual (a licensing event being any change in licence type or class) including start and end date, licence type (e.g. L, P1, Open) and licence class (e.g. car, motorcycle, heavy vehicle). The licensing data was prepared to identify each of the groups of drivers (pre and post treatment and comparison group) and to extract each group's exposure data.

Police-reported crash data

All police-reported crashes in Queensland from January 2004 onwards were extracted from the TMR crash database. Key variables used in the crash data were '*Crash Severity'* (killed, seriously injured, medically treated, minor injury, not injured) and '*Crash Date'* and unique driver reference number to enable licensing information matching. Data was available for the following periods by crash severity: July 2004 – December 2009 for police-reported crashes of all severity, July 2004 – December 2010 for hospitalisation police-reported crashes, July 2004 – November 2011 for fatal police-reported crashes. Crash data were merged with the licensing data to determine the license phase which the driver was in when crashing and the study group membership based on their journey through the GLS (Table 1)

Exposure and Crash Rates

Person months of licensure by treatment group (Table 1) and licence type (L, P, P1, P2 etc.) was calculated for the evaluation using the start and finish dates for each license class recorded for each treatment and control participant in the study. Total exposure was aggregated for the before and after study periods defined. Different exposure periods were calculated to relate to each crash severity levels reflecting the differing periods for which crash data were available by severity (see previous section). Crash rates per person license months of exposure were calculated by dividing the aggregate crash counts by study group and license type by the corresponding exposure estimates.

Analysis Design

The primary evaluation fundamental analysis design was quasi-experimental. Analysis estimated changes in crash rates associated with each licence level in the analysis periods from before to after implementation of the new GLS relative to changes in crash rates in the comparison group over the same time period. Comparing changes in the crash risk of the GLS treatment groups from before to after new GLS implementation with parallel changes in the comparison group gives the net crash effect associated with the GLS controlled for all other factors represented by the comparison group.

Implementation of the GLS in Queensland meant the analysis design had a degree of complexity above that typically found in a simple quasi-experiment. First, the treatment groups had to be stratified by licence level in order to recognise the significantly different crash risk in each licence level. Failing to stratify the treatment groups by licence level could potentially result in confounded estimates of crash effects due to the GLS if the distribution of licensed drivers between licence types changed significantly from before to after introduction of the new GLS. Within licence level

there were also a number of sub groups defined based on the restrictions applying which were determined by age and time of licensing which defined the 10 treatment groups described. It was of interest to be able to estimate crash effects of the new GLS within groupings of these 10 treatment groups and within licence level in each of these.

The resulting analysis design is depicted in Table 2. It shows that in the period prior to the new GLS being introduced the licence levels available were Learner (L) - designated L (old) - Probationary (P) and Open (O). The open licence holders identified for analysis were those who had been in the old GLS L or P levels sometime after January 2004. This is distinct from the comparison group open licence holders who can be considered to be more experienced open licence holders generally having obtained their Open licence some years earlier. In order to make a fair comparison with the new GLS licensing levels, the P licence group were split into 2 groups: those in their first year of holding a P licence who should be comparable to the new GLS P1 licence holders, and those in their second and subsequent years holding a of P licence who should be comparable to those in the new GLS P2 level.

Table 2. Primary Evaluation Analysis Design

	Pre New GLS		Post New GLS	
Design Group	**Licence Phase**	**Treatment Group**	**Licence Phase**	**Treatment Group**
Comparison	Open	Comparison	Open	Comparison
L	L (old)	Old GLS Group	L	TG1
			L	TG2
			L	TG3
			L	TG4
			L	TG5
			L	TG6
L7	L (old)	TG7	L (old)	TG7
L8	L (old)	TG8	L (old)	TG8
L9	L (old)	TG9	L (old)	TG9
L10	L (old)	TG10	L (old)	TG10
L			L (old)	Old GLS Group
P1	P First Year	Old GLS Group	P1	TG1
			P1	TG2
			P1	TG3
			P1	TG7
			P1	TG8
P1			P First Year	Old GLS Group
P2	P Second & sub years	Old GLS Group	P2	TG1
			P2	TG2
			P2	TG4
			P2	TG5
			P2	TG7
			P2	TG9
P2			P Second & sub years	Old GLS Group
Open	Open	Old GLS Group	Open	TG1
			Open	TG2
			Open	TG3
			Open	TG4
			Open	TG5
			Open	TG7
			Open	TG8
			Open	TG9
Open			Open	Old GLS Group

In the period post implementation of the new GLS, the available licensing levels were Learner (L), P1, P2 and Open. In addition there were also some licence holders remaining on the old GLS L and P licences with their associated restrictions under the old GLS. Table 2 shows that the evaluation design compares L licence holders under the new GLS with L licence holders under the old GLS, P1 licence holders under the new GLS with first year P licence holders under the old GLS, P2 licence holders under the new GLS with second and subsequent year P licence holders under the old GLS, and open licence holders who have progressed through the new GLS with open licence holders who have progressed through the old GLS. Each of the treatment groups defined by the new GLS in each licence category was compared to the corresponding single group of corresponding licence category in the pre new GLS period. The only exception to this was the learner group in treatment groups 7 to 10 who all obtained their learner licence under the old GLS and were hence

were able to be segregated into specific pre new GLS period groups and their crash rates compared from before to after new GLS introduction on the learner level.

Table 2 also shows L, P and Open licence groups from the old GLS carrying over to the period after the introduction of the new GLS. These are noted as belonging to the Old GLS group in the table. Since these groups are unaffected by the new GLS in terms of licence restrictions and conditions, the statistical analyses should exclude those labelled as belonging to the old GLS in the post period of Table 2. It should also exclude the learner phase for Treatment Groups 7-10 in the post new GLS period since the learner licensing conditions for these groups was also unaffected by the new GLS. However, to analyse the total impact of the new GLS on road trauma, it is necessary to consider all novice driver licensing groups in the post period regardless of whether they are progressing through the new GLS or not. The structure of Table 2 allows this assessment to be made as well as assessment of only those licence conditions in groups that have changed under the new GLS.

Statistical Methods

The outcome measure used for the crash analysis is the rate of crashes involving novice drivers with the rate being defined as the crash count divided by licence years of exposure. Each cell of the analysis design table, Table 2, was populated with the crash count and licence exposure months relating to each treatment group time period and licence type to facilitate the statistical analysis.

A Poisson log-linear regression model was applied to the analysis design to estimate the net crash effects associated with the new GLS adjusted for the effect of non GLS factors represented by the comparison group. The general form of the statistical model was:

$$\ln(y_{ijk}) = \ln(e_{ijk}) + \alpha + \beta_i + \gamma_j + \delta_{ijk} \quad \text{Equation 1}$$

In Equation 1:

i is the index for time period (before new GLS, after new GLS)

j is the index for analysis design group (comparison, L, L1, L7, L8, L9, L10, P1, P2, Open)

k is the index for treatment group within design group (comparison, old GLS group, TG1,..,TG10)

$\alpha + \beta_i + \gamma_j + \delta_{ijk}$ are parameters of the model

y_{ijk} are the cell crash counts

e_{ijk} are the cell exposures (licence months of exposure) - represented in the model as a constant offset term to convert the outcome to a rate rather than a simple crash count.

Some of the parameters in the model are redundant or aliased due to linear dependencies so it was necessary to set these to zero so the model can be estimated. It was decided to set the parameters corresponding to the before time period ($\beta_{before\,GLS}$) and the comparison group ($\gamma_{control}$) design group to zero, along with their corresponding interaction terms as this aided the direct interpretation of the δ_{ijk} as net GLS crash effects. Each interaction parameter $\delta_{afterGLS,j,k}$ represents the relative risk of a crash in analysis design group *j* and treatment group *k*. These can be converted to percentage crash reduction, Δ, in each cell using the formula:

$$\Delta_{afterGLS,j,k} = (1 - \exp(\delta_{afterGLS,j,k})\, x100\% \quad \text{Equation 2}$$

Separate models were applied to each crash severity considered (fatal crashes, fatal and serious injury crashes, all reported crashes). Crash effects were first estimated using all the post new GLS implementation data cells, including those carrying over with the old GLS licensing restrictions (L (old), P First Year (old), P Second and Subsequent Years (old) and Open (old), as well as TG7, 8, 9,

10). This measured the total impact of the new GLS program. A second analysis then assessed only those licence types where restrictions had changed under the new GLS. This measured the pure impact of the new GLS on crash risk. The form of Equation 1 gives the estimated crash effects associated with the GLS within each licence type and treatment groups. Average crash effects associated with the GLS across groups of analysis strata were measures by constraining the interaction parameters, δ_{ijk}, in the model.

Results

Results of the regression modelling are given in Table 3 including estimated crash reduction associated with the GLS, the statistical significance of the estimate and upper and lower 95% confidence limits. Crash reduction estimates which are statistically significant at the 10% level are highlighted in order to identify these results for which there is some level of statistical confidence. Results which are statistically significant at the 5% level are also shown in bold to emphasise results with the greatest statistical reliability. Analysis results are presented for some specific treatment groups and licence types as well as on average across various treatment and licence type groups as indicated in the results table. Results are presented separately for the 3 different levels or groupings of crash severity.

Overall program including old GLS: The first block of analysis results presented in Table 3 gives the estimated crash reductions associated with the Queensland GLS as an entire intervention from July 2007 onwards. It includes assessment of crash rates for all novice driver licence types both before and after introduction of the new GLS including licence phases from the old GLS that have carried over into the new GLS period. This analysis gives the total impact of the new GLS as implemented on novice driver road trauma in Queensland. As can be seen from Table 3, the greatest crash reduction was estimated for fatal crashes (31%) with the estimated crash reductions diminishing as lower severity crashes were included in the analysis. Each of the crash reductions estimated were statistically significant at the 5% level.

Overall program only new GLS: The second block of analysis results presented in Table 3 assesses the overall impact of the new GLS, only amongst those licence holders who have been through at least one licence phase under the new GLS. That is, it excludes licence holders that are still on L and P phases subject to the old GLS requirements that have carried on past July 2007 and new open licence holders who have been through only the old GLS L and P phases. This analysis gives a more pure estimate of the overall crash changes associated with the restrictions and requirements of the new Queensland GLS. The same pattern in crash reduction estimates by crash severity as observed for the first analysis are again seen here with decreasing crash reductions by crash severity. In this case the estimated reduction in all reported crashes is no longer significant and the fatal crash reduction estimate is only marginally statistically significant ($0.05 < p < 0.1$). The lower level of statistical significance for these estimates reflects both the smaller crash reductions estimated for each severity along with the smaller quantities of crash data on which the analysis are based compared to the first block of results.

The third block of analysis results estimates crash reductions associated with the new GLS by licence phase and crash severity. There is some inconsistency in estimated effects between crash severity levels in terms of relativity between the licence phases. This is partly a reflection of the different quantities of crash data available for each licence phase and crash severity manifesting in varying levels of statistical significance. Highly statistically significant crash reductions were estimated for fatal crashes amongst P1 licence holders, fatal and serious injury crashes involving learner drivers, and all crash reported crashes involving learner and P2 drivers. Marginally statistically significant crash reductions were also estimated for open licence fatal crashes, and fatal and serious injury P1 drivers.

Table 3. Estimated Net Crash Effects Associated with the Queensland GLS for crashes involving novice drivers

Analysis Level	Crash Severity	Licence Level or Group	% Crash Reduction*	Stat. Sig.**	95% Confidence Interval	
					Upper	Lower
Overall Program Including Old GLS	Fatal	All	**30.67%**	**0.0253**	49.70%	4.44%
	Fatal + SI	All	**13.23%**	**0.0000**	18.94%	7.12%
	All Crashes	All	**3.74%**	**0.0397**	7.17%	0.18%
Overall Program Only New GLS	Fatal	All	26.10%	0.0925	48.05%	-5.12%
	Fatal + SI	All	**9.13%**	**0.0113**	15.61%	2.15%
	All Crashes	All	1.27%	0.5347	5.19%	-2.80%
Only New GLS by Licence Type	Fatal	Learner	-286.72%	0.1929	49.51%	-2861.84%
		P1	**38.32%**	**0.0305**	60.18%	4.45%
		P2	-4.09%	0.9066	46.68%	-103.20%
		Open	59.03%	0.0787	84.85%	-10.77%
	Fatal + SI	Learner	**26.43%**	**0.0018**	39.30%	10.83%
		P1	7.24%	0.0994	15.18%	-1.43%
		P2	10.72%	0.1207	22.63%	-3.03%
		Open	-17.48%	0.2467	10.54%	-54.27%
	All Crashes	Learner	**12.73%**	**0.0088**	21.18%	3.36%
		P1	-2.76%	0.2503	1.90%	-7.63%
		P2	**10.32%**	**0.0068**	17.13%	2.96%
		Open	-15.32%	0.1383	4.49%	-39.25%
TG1-6 vs. TG7-10 (only new GLS)	Fatal	TG1-6	13.92%	0.4409	41.21%	-26.03%
		TG7-10	**41.48%**	**0.0165**	62.22%	9.33%
	Fatal + SI	TG1-6	-0.12%	0.9778	7.87%	-8.80%
		TG7-10	**18.78%**	**0.0000**	25.63%	11.30%
	All Crashes	TG1-6	**-9.96%**	**0.0002**	-4.59%	-15.61%
		TG7-10	**8.26%**	**0.0002**	12.38%	3.96%
TG1 by Licence Type	Fatal	Learner	37.42%	0.7408	96.11%	-905.71%
		P1	27.20%	0.1836	54.40%	-16.23%
		P2	-3.41%	0.9310	51.56%	-120.73%
	Fatal + SI	Learner	**41.00%**	**0.0000**	52.97%	25.99%
		P1	-4.23%	0.4133	5.62%	-15.10%
		P2	-2.11%	0.8255	15.18%	-22.93%
	All Crashes	Learner	**28.08%**	**0.0000**	36.08%	19.07%
		P1	**-19.22%**	**0.0000**	-12.62%	-26.21%
		P2	5.13%	0.5604	20.55%	-13.28%

** NB: Negative crash reduction estimates indicate an estimated crash increase.*

*** Significance values of 0.0000 indicate a statistical significance of less than 0.0001*

Attempts to estimate crash reductions associated with the new GLS within the 10 specific treatment groups and by licence phases within those treatment groups gave results with no statistical reliability and hence are not reported here. This reflects the limited quantity of crash data, in many instances stemming from limited licensing exposure in many of the analysis design cells. Two further analyses were undertaken based on treatment groups or specific contrasts that were likely to be of importance to understanding the mechanisms of GLS effectiveness.

TG1-6 vs. TG 7-10: The first estimated crash effects associated with those treatment groups where licence holders had completed the Learner phase under the old GLS (TG7-10) in comparison to those completing the learner phase under the new GLS (TG1-6). Contrasting average crash effects across these two grouping gave the potential to understand the impact the new learner phase restrictions under the new GLS, covering hours of experience and supervision, were likely to have on crash rates. Results of this analysis are presented in the fourth block of Table 3. Overall, the results suggest greater crash reductions associated with those who have completed the learner phase under the old GLS. Estimates of crash effects for fatal and serious injury crashes combined, as well as for all reported crashes, were statistically significantly different between the two groups as show

by the non-overlapping confidence limits on the estimates. A statistically significant increase of almost 10% in all reported crashes was estimated for TG1-6.

TG1 licence type: The final analysis undertaken was to estimate the crash effects associate with analysis Treatment Group 1. This group is of primary interest as it covers those who complete progress through the new GLS licensing phases with no age-based exemptions, and is likely to be the group most representative of the long term crash effect of the new GLS in Queensland. Given the data available it was only possible to estimate associated crash effect for this group in the L, P1 and P2 phase since there were no reported open phase crashes from their very limited licence exposure accumulated at the time of study. Table 3 shows statistically significant reductions in all reported crashes and fatal and serious injury crashes combined in the learner phase for this treatment group of 28% and 41% respectively. Estimated reductions in learner and P1 fatal crashes were of a similar magnitude although neither was statistically significant. Point estimates of crash effects associated with all other phases were around 5% or less with none being statistically significant.

Using the base crash rate data and the estimated net crash effects in Table 3, Figure 1 presents actual fatal and serious injury crash rates prior to the new GLS and fatal and serious injury crash rates post new GLS adjusted for changes in the comparison group (open licence) crash rates. Estimates for fatal and serious injury crash rates are presented as this is the crash severity grouping where the new GLS seems to be associated with the largest crash effects as well as where the estimated crash effects in Table 3 are most reliable by licence type.

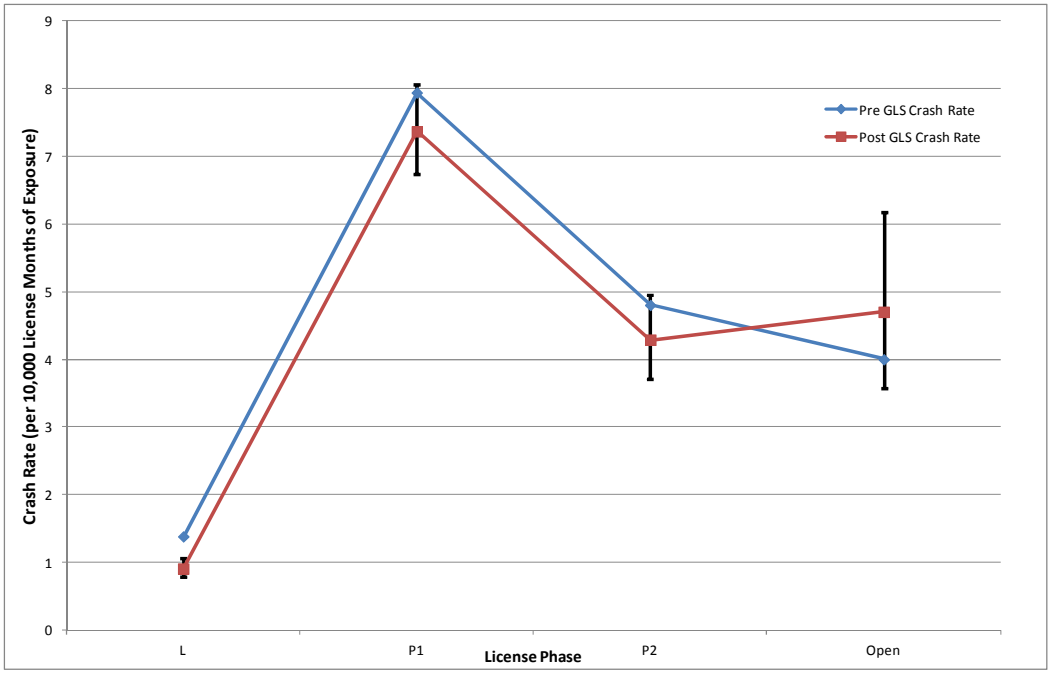

Figure 1. Fatal and Serious Injury Crash Rates Pre and Post new GLS Introduction by Licence Type (Post GLS Crash Rates Adjusted for Changes in Comparison Group Crashes)

Using the observed post new GLS crash fatal and serious injury crash counts and the estimated net crash effects associated with the new GLS in Table 3, it was also possible to estimate the absolute numbers of crashes saved by the GLS by licence type over the period from July 2007 to December 2010. The estimated total savings in fatal and serious injury crashes combined over this time period associated with the Queensland GLS was in the order of 430 of which around 260 were for learner licence holders, around 110 for P1 licence holders and around 70 for P2 licence holders.

Discussion

The aim of this study was to undertake a preliminary evaluation of the effectiveness of the changes made to the GLS by the Queensland Government in terms of their effect on rates of crashes reported to police. The analysis aimed to estimate the crash effects associated with the program both overall, within specific crash severity levels and within specific licensing phases. It was intended to contrast the crash effects amongst those that have been subject to differing requirements, restrictions and licence phase progression of the GLS resulting from different paths of progression through the new GLS due to its the phased introduction for licence holders of different ages and times of licensing. It was hoped that contrasting crash effects across these different pathway groups would enable contrast to be made which would shed light on the effectiveness of specific elements of the new GLS.

To achieve these goals, a necessarily complex but comprehensive evaluation structure was developed. A key to defining the evaluation structure was to understand the different pathways by which licence holders could progress through the new GLS systems in Queensland. These define 10 different groups based primarily on whether drivers obtained their L licence under the new or old GLS system and how old they were at various licence transition points. Two of the groups were of those who still only had a learner licence. Members of these groups will ultimately move to one of the other groups at a later time when they have progressed to the next phase of licence.

Examination of these groups revealed the potential to make a number of specific contrasts between groups that ultimately will help understand the effectiveness of specific aspects of the GLS in reducing crash rates. Aspects that have the potential for specific evaluation include the new learner log book, the effectiveness of different paths of progression (e.g. not having to hold a P1 or P2 licence and the associated restrictions), and different lengths of P2 holding period. One limitation that will always be present when making these contrasts is potential confounding. Many of the contrasts of primary interest are between groups with different age requirements. Hence any estimate of relative effectiveness related to the different requirements will necessarily be at least partially confounded with driver age at time of licensing. Despite this, these contrasts offer at least some potential to measure the relative effectiveness of different aspects of the new GLS through internal comparisons beyond what has been possible in most previous studies.

The design of the evaluation framework used in this study is quasi-experimental. The use of a comparison group in this design is the most powerful available means of controlling for the confounding effects of other factors affecting crash rates in Queensland, both measurable and un-measurable, beyond the GLS being evaluated. The population of drivers affected by the new GLS in Queensland are predominantly young with all young drivers from July 2007 being potentially influenced by the program. This meant that a comparison group could not be matched by age so the next nearest age bracket to the novice driver group, 25-35 year olds, were chosen for the comparison group. Only open licence holders were used in the comparison group as the new GLS has not influenced conditions on open licences.

A further feature of the analysis design developed is the ability to specifically compare crash outcomes of similar licensing types from before to after implementation of the new GLS. Previous studies have clearly established the variation in crash rates between different licensing types which has been confirmed here in Figure 1. This makes measuring changes in crash rates in comparable licence types imperative for a strong evaluation design. The old GLS had only a single P licence phase between L and Open compared to the new GLS which has both P1 and P2 phases for most drivers. To make the comparison as specific as possible in the evaluation design, the old P phase was segregated into first year Ps, which should be comparable to the P1 licence phase, and second and subsequent year Ps, which should be comparable to the P2 phase. One difficulty in making this assignment is that, compared to the old P phase which was fixed at 3 years, the P1 phase is not fixed

at one year, requiring the hazard perception test to be passed before progression to P2. However, the median length of P1 licence duration in the study was 12 months meaning the comparison with first year P licence holders from the old GLS should be valid.

A final feature of the analysis design is the inclusion of an exposure measure from which to calculate crash rates rather than simply crash counts as the outcome measure. With a lack of detailed information on relative travel exposure of various licence holders at the micro level not just in Queensland but internationally, the only viable and reliable measure of exposure that can be calculated is the total time exposure of various licence holders. As shown in this study, this can be readily calculated from information available in the Queensland licensing system from which high quality data was able to be provided for evaluation. It is possible that there are still confounding effects due to differential travel rates per licence months of exposure between the treatment group pre and post new GLS in the analysis. However, it is likely that changes in travel exposure are linked more to age and time from licensing which should be relatively unaffected by the new GLS. The only exception to this is for the learner group which mandates that all learners under the age of 25 must obtain a minimum of 100 hours of supervised driving experience and hold their learner licence for a minimum of 12-months (as opposed to the old GLS which did not include a mandate on number of hours of supervised driving experience and the minimum holding period was 6-months). The median length of learner licence holding under the new GLS is almost 50% longer than under the old GLS suggesting the new requirements affect length of licensing more than average monthly travel minimising the potential impact of this confounder on the crash effect estimates.

Evaluation of the crash effects of the new GLS in Queensland at the program level suggest the new GLS has been effective in its objectives of reducing crash risk amongst novice drivers. The comparison of total average crash rates amongst all novice drivers regardless of their licensing path, from before to after introduction of the new GLS against the comparison group, estimated significant crash reductions associated with new GLS implementation. In addition, the estimates suggested effects were greater for high severity crashes, which is in line with the intentions of the GLS. Estimates of global program effectiveness were similar, albeit with slightly reduced levels of statistical confidence, when those licence holders only subject to old GLS licensing conditions in the post new GLS implementation period were excluded from the analysis. These estimates are more indicative of the pure crash effects associated with the new GLS system, which might be sustained longer term as licence holders subject to the old GLS restrictions slowly progress to open licences.

Results of the evaluation become less clear when interpreting the more specific analysis results by licence phase and treatment group. Relative estimated crash effects across the different licence types were inconsistent across different levels of crash severity which is hard to reconcile. It is most likely an artefact of limited data quantities for certain licence types and crash severity levels, evidenced by the lack of statistical significance of many of the analysis results by licence type. This is a direct reflection of the relatively short after implementation crash data period on which the evaluation was based, a point that will be re-visited later on.

The one analysis that did provide some results of note was that comparing crash effects on average across groups that had completed the learner phase under the old GLS but went onto the new GLS P1 or P2 phase to those completing the learner phase under the new GLS. Contrary to expectation, this analysis showed significantly higher crash reductions associated with groups that had completed their learner phase under the old GLS. Taking this result at face value would suggest that the new learner requirements are possibly not producing the intended results. However, examining this result in detail shows it is in fact likely to be reasons other than the learner requirements contributing to this result. Those in treatment groups 7-10 generally held their learner permits for longer than those in treatment groups 1-6 and are consequently older when transitioning to a P

licence. This suggests they are not typical of the average novice driver. Furthermore drivers in treatment groups 7-10 have also spent more time on the lower risk P2 and Open licence phase meaning the overall comparison is not strictly valid. Unfortunately, attempts to compare crash risk by licence type in treatment groups 1-6 to groups 7-10 produced estimates that lacked statistical reliability. Again this is a reflection on the limited quantities of data available for analysis after the implementation of the new GLS.

Treatment Group 1 is perhaps the most representative of the path through the GLS that will be taken by most novice drivers. Total exposure in this group in the learner phase is highest of all those completing the new GLS learner phase confirming the high relevance of this group in terms of representing the likely long term crash effects of the GLS. This is further emphasised through noting that exposure in many of the other groups is currently low and will be expected to remain low given the age profile of newly licensed drivers or will dwindle to zero as the full transition to the new GLS becomes complete.

Crash effects estimated for Treatment Group 1 in Table 3 produced mixed results. They showed significant reductions in crash risk associated with the new GLS learner phase for all reported crashes and fatal and serious injury crashes combined with a suggestion this result will also follow through to fatal crashes alone based on the point estimate of crash effect for fatal crashes. Other results were inconclusive, lacking statistical significance due to insufficient data, partly an artefact of the high proportion of learner drivers in this study group with learner drivers generally having a low crash rate. However, interpretation of the confidence limits on the estimates for the P1 and P2 phases suggests maximum crash reductions associated with these phases will be in the order of 15% or less for fatal and serious injury crashes combined, a key crash group given it represents the bulk of economic cost to society. The significant increase during the P1 phase estimated for all reported crashes is also of some concern all though would not represent a major problem if the bulk of the increase was in low severity crashes. Monitoring of this group in the future will be of key importance to reflect the potential of the GLS program to reduce novice driver crashes.

Results of analysis of the new GLS for specific licence phases and key analysis groups have not provided robust scientific evidence as to the likely long term effectiveness of the new GLS in Queensland. Whilst the evaluation has estimated crash reduction benefits at the broad program level to date, it still remains to be seen whether these benefits will be sustained in the longer term as the majority of newly licensed drivers' transition wholly through the new system.

A primary reason for that lack of evidence on the likely long term effects of the GLS from this evaluation, and the inability of the evaluation to identify the relative effectiveness of different aspects of the GLS is the lack of sufficient data post implementation of the new GLS available for analysis. This is largely a product of the extreme reporting delays which are currently being faced in the release of official crash data records in Queensland. Despite data for this evaluation being provided in early-2012, fatal crash data was only available up to November 2011, serious injury crash data to December 2010 and minor and non-injury crash data to the end of 2009. The significant data lag in combination with the relatively large number of licence progression permutations possible under the Queensland GLS meant that crash data was very limited in many of the key analysis design cells. A direct consequence of this was to severely limit the scope of the analyses that could be successfully undertaken and the level of understanding about the mechanisms of effectiveness of the new Queensland GLS.

Lack of sufficient post GLS implementation data for this study meant that the statistical analyses undertaken were often underpowered (i.e. there was insufficient crash data to lead to a statistically significant crash change being identified). There was an inability to consistently detect crash effects associated with the GLS at anything but the broadest program level. Estimating statistical power and hence the amount of additional data required to produce statistically robust estimates is difficult

for the analysis methodology used in this study. Analysis of statistical confidence limits on the results obtained implies that within individual treatment groups, up to twice the data that was currently analysed would be required to be able to detect crash reductions of 20% or less with statistical reliability which equates to an additional 2-3 years of data. It is critical that analysis results in the individual treatment groups have a high statistical reliability in order to be able to identify the specific elements of the GLS which have led to crash reductions.

Based on the noted problems faced by this evaluation, a clear recommendation from the research is to undertake further evaluation of the Queensland GLS when additional crash data is available for analysis. Based on the results obtained, it is recommended that a re-analysis be conducted when 2 to 3 years of additional crash data are available. The evaluation framework that has been set up in this study offers great potential to deliver a strong understanding of the crash effects associated with the Queensland GLS program. Knowledge generated from effective application of the framework to an adequate period of after implementation data could make a significant contribution to novice driver licensing policy in Queensland and internationally.

Conclusion

This study has established an effective framework for comprehensive evaluation of the new Graduated Licensing System (GLS) introduced in Queensland on July 2007. It has the capacity to measure the effectiveness of the GLS both at the global level and within a range of specific levels of detail including by licence phase, licence phase progression groups and for specific elements of the GLS. Applying the framework estimated that implementation of the new GLS in Queensland was associated with a 31% reduction in fatal crashes, a 13% reduction in fatal and serious injury crashes combined and a 4% reduction in all reported crashes, all of which were statistically significant. Limited quantities of crash data from the period after the implementation of the new GLS on which the run the evaluation framework severely limited the range and robustness of crash effects which could be estimated for driver populations and elements of the new GLS. The results that could be obtained raised some concern that the crash reductions estimated for the GLS overall to date may not be sustained although confirmation of this will require further analysis at a future time when a longer period of data after GLS implementation are available for analysis.