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Factors influencing noncompliance with bicycle passing distance laws

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Abstract

Many jurisdictions around the world have implemented laws to require a minimum distance when motor vehicles pass cyclists, but research into the factors influencing passing distances has produced inconsistent results, indicating the need for future research. This study examined the factors influencing motorists' compliance with a legislated bicycle passing distance rule in Queensland, Australia. Unlike the earlier studies, which used volunteer riders to record passing events, this study used a naturalistic study design to record passing events where none of the motorists or the cyclists were aware of being studied. As a result, this study captured the 'true' driving and riding behaviours during passing events. The likelihood of non-compliance was greater on higher (70-80 km/h speed limits) and lower (40 km/h) speed roads than 60 km/h roads, at curved road sections, and on roads with narrower traffic lanes. Rider characteristics (age, gender, helmet status, type of clothing, type of bicycle, and individual or group riding) had no statistically significant association with compliance status. The findings indicate that efforts to improve cyclist safety during overtaking events should focus on non-rider related factors, such as roadway infrastructure characteristics.

Keywords: Bicycle passing distance; Three-foot law; One metre rule; Lateral clearance; Bicycle safety

1. Introduction

Crashes involving a motor vehicle passing a cyclist are a key concern for cyclist safety. Many bicycle-motor vehicle crashes occur while travelling in the same direction and involve rear-end and sideswipe collisions (Stone and Broughton 2003, Walker 2007, Pai 2011). In the UK, 13% of bicycle crashes involve motorists' overtaking cyclists (Walker and Jones 2005). In Australia, side-swipe collisions between cyclists and motorists account for 14% of fatal bicycle crashes (BITRE 2015). Motorists are at fault in the majority (57%) of bicycle-motor vehicle crashes (Haworth and Debnath 2013), and passing too closely is the most common incident type (40.7%) (Johnson *et al.* 2010). Researchers (Parkin *et al.* 2007) have argued that close-passing events, even those events which do not result in crashes, make cyclists feel unsafe and discourage them from riding. In response, many jurisdictions around the world (e.g., 27 states and the District of Columbia in the USA, France, Portugal, Spain, several states of Australia) have implemented laws on the minimum lateral distance a motor vehicle driver should leave when overtaking a bicycle.

The distances left when motor vehicles pass bicycles and the factors influencing this distance have been the subject of considerable research. Some studies (e.g., Walker 2007, Olivier and Walter 2013, Walker *et al.* 2014, Llorca *et al.* 2017) examined the effects of rider and/or motorist characteristics on passing distances. Others (e.g., Parkin and Meyers 2010, Love *et al.* 2012, Chapman and Noyce 2014, Shackel and Parkin 2014) focused on the effects of roadway geometric and/or traffic characteristics. Some researchers (e.g., Chuang *et al.* 2013) considered all or a selected set of these four types of characteristics.

Nevertheless, some key gaps exist in the literature. Firstly, bias might be present in the way earlier research measured passing distance. For example, the earlier studies involved volunteer cyclists or researchers themselves riding an instrumented bicycle. As these cyclists were aware of the study, their riding behaviour might have influenced the passing distance, resulting in biased measurements (Duthie *et al.* 2010). Measuring passing distances to actual cyclists, who are unaware of the study or the fact that their behaviour is being monitored or recorded, would remove this source of bias.

Secondly, studies of the factors influencing bicycle passing distances have produced inconsistent results. For example, Walker (2007) and Chuang *et al.* (2013) found differences according to rider appearance or perceived experience, while Walker *et al.* (2014) found that close passing events occurred regardless of rider appearance (although the word "POLICE witness.com" written in two separate lines on a vest with the word "POLICE" written in a larger font size seemed to increase passing distances). Walker (2007) established relationships between passing distance and helmet wearing, which was questioned in a re-analysis by Olivier and Walter (2013). Type of motor vehicle passing the cyclist was a significant predictor of passing distance in some studies (e.g., Walker 2007, Parkin and Meyers 2010, Pai 2011, Chuang *et al.* 2013), but not others (Love *et al.* 2012). These inconsistent findings in the literature indicate that there is a need for further research on the factors affecting passing distance.

Thirdly, most of the earlier research focused on studying the effects of rider and roadway characteristics in isolation. While some efforts have been made to examine the combined effects of these factors (e.g., Chuang *et al.* 2013), there is a need to comprehensively examine the effects of rider, motorist, roadway, and traffic characteristics on passing distance. An understanding of these factors will allow for countermeasures for reducing close passing distances to be developed that focus on non-rider factors, such as infrastructural, educational, and legal countermeasures, as suggested by Walker *et al.* (2014).

This paper aims to address the above mentioned gaps by examining the factors influencing motorists' compliance with a legislated passing distance rule. Unlike the earlier studies which used volunteer riders to record passing events, this study used a naturalistic study design to record passing events where none of the motorists or the cyclists were aware of being studied. The findings of this study represent the 'true' driving and riding behaviours on roads. Use of this data collection approach in the literature concerning bicycle passing distances is a key strength of this study.

2. Method

2.1 Study setting

This research was conducted in the State of Queensland, Australia. Queensland has 4.7 million inhabitants, of which 2.3 million live in the capital city, Brisbane (ABS 2017). The climate varies from sub-tropical to tropical, which allows year-round cycling. A recent national survey estimated that about 17% and 35% of the Queensland population rode a bicycle in the previous week and the previous year, respectively (Austroads 2017). Of those who cycled in the last month, 75% rode for recreation and 40% rode for transport. Most urban roads in Queensland have signed 60 km/h speed limits. Vehicles drive on the left side of the road, and cycling on the footpath is legal for riders of all ages unless there are signs prohibiting riding.

Queensland implemented a Minimum Passing Distance (MPD) rule in April 2016 after a 2-year trial. The stated purpose of the rule is to clarify any ambiguity about safe passing distances and to encourage motorists to provide a suitable amount of space between cyclists and their vehicle (TMR 2015). The rule requires motorists to maintain a minimum lateral passing distance of 1 meter (3 feet) when overtaking cyclists in a speed zone of 60 km/h (37 mph) or less, and 1.5 meters (5 feet) when the speed limit is greater than 60 km/h (37 mph). In order to comply with the law, drivers overtaking cyclists are exempt (where it is safe to do so) from the general prohibitions on driving over centre lines (including double unbroken centre lines) on 2-way roads, straddling or crossing a lane line (including a continuous lane line) on a multi-lane road, and driving on a painted island. Motorists who breach the law receive a fine of three penalty units and AU$378 fine (in July, 2017) and incur three demerit points. A maximum fine of AU$5,000 (in July, 2017) can apply if the matter goes to court.

2.2 Data collection

Video observations of cyclists were made at 15 sites that included urban and suburban locations in South East Queensland, regional Queensland, and tourist areas. The sites were selected to maximise the likelihood of observing sufficient cyclists (and therefore passing events) to allow robust data analysis, and the availability of roadside infrastructure to mount video cameras for data collection. At these sites, the number of cyclists over four days ranged from 46 to 5,968. Very few passing events (4 to15 observations per site) were observed at five of these sites, and so they were excluded from the current analysis. Table 1 summarises the characteristics of the 10 remaining sites. Among the 10 sites, 7 had posted speed limits of 60 km/h or less (minimum passing distance of 1m in the MPD rule) and the other 3 sites had speed limits of 70 km/h or more (minimum passing distance of 1.5m in the MPD rule). Examination of passing distances and cyclist volumes at these sites did not show meaningful relationship between cyclist volume and passing distance (r=-0.17). The video-based observation method meant that accurate demographic information about cyclists and motorists (e.g., age, education, income) could not be collected, and therefore, it was not possible to conduct statistical tests of the sample's representativeness.

Video data were collected using cameras attached to roadside poles or sign posts and equipped with infrared filters to enable both day and night recordings. Data were collected on 16-19 April and 7-10 May 2015 (Thursday to Sunday inclusive) after the Minimum Passing Distance rule had been in effect for more than 12 months (the trial of the rule started on 7 April 2014). Surveys conducted among cyclists and motorists at about the same time (Schramm *et al.* 2016) showed that 98.5% of cyclists and 94.8% of motorists were aware of the MPD rule.

Passing events were recorded using a camera (Eazzy Digital Video Technology Company model DC-910i) of image resolution 640 x 480 pixels mounted 3-4m above ground level. Video data were recorded at 12 frames per second, and therefore, most passing events were captured in more than one frame of video. The passing events were first identified manually by a research assistant, and then the video images were processed, in order to measure passing distances. A point-and-click custom Python script was developed to measure the distances by manually selecting the edges of the cyclists and the overtaking vehicles, from the video image when a motorist was overtaking a cyclist. The script calibrated a distance measured on the pixel-scale of the video images (the width of the traffic lane visible within the video images) by transforming it to a real-world distance (i.e., scaling with the real-world width of the traffic lane). Therefore, the measured passing distance on the video images could easily be converted to the real-world distances.

Depending on the distance between the camera and the passing event, the number of pixels on the video image filled by vehicles and cyclists – and by the passing distance - varied. On average, vehicles were 100-150 pixels wide and cyclists were 30-50 pixels wide when a passing event occurred near the camera, and about half this when a passing event occurred at mid-distance from the camera. Close to the camera, each pixel represented about 0.015-0.021m, whereas in the mid-distance each pixel represented about 0.029-0.048m. The maximum errors in passing distance measurement were estimated to be 0.045-0.064m for events near the camera and 0.080-0.132m for events in the mid-distance. To minimise estimation errors, only those passing events that were not obscured by other vehicles or vegetation and were sufficiently close to the camera to allow the edges of the cyclist and vehicle to be clearly identified were included in the analysis.

Lateral passing distance was defined as the minimum perpendicular separation measured during a passing event, when a motorist overtook a cyclist on the right side of the cyclist. Only events where at least part of an overtaking vehicle was inside the traffic lane adjacent to a bike lane (if a bike lane was present) or was in the same traffic lane where a cyclist was riding were included in this study. This was done to ensure that any non-meaningful passing events (e.g., a motorist on the right most lane of a 3 lane road overtaking a cyclist who is on the left most lane) were excluded from the study dataset.

Ethics approval for the observational study was obtained from the Queensland University of Technology (QUT) Human Research Ethics Committee (approval number 1500000220).

2.3 Data analysis

To examine the factors influencing compliance with the MPD rule, a Binary Logistic Model (BLM) was formulated where the compliance status was defined as a dichotomous variable (Non-compliant = 1; compliant = 0). A set of explanatory variables (see Table 2), which describes the characteristics of riders, passing motorists, roadway infrastructure, and traffic, were hypothesized to have significant associations with compliance status. In addition to the categorical variables that are presented in Table 2, a continuous variable expressing the average width of traffic lanes (in metres) was also included as an explanatory variable in the model.

The formulated model was calibrated using the Maximum Likelihood Estimation method in STATA 12. Before calibrating the model, each explanatory variable was examined for potential correlations with other explanatory variables. The traffic lane configuration (one/two way and number of lanes) variable was highly correlated ($r>0.60$) with several other variables related to site characteristics; therefore, it was removed from the model.

To identify the subset of explanatory variables that yielded the most parsimonious model, a backward elimination procedure was employed to eliminate the non-significant variables one by one so that the Akaike Information Criteria (AIC) was minimized. To evaluate if the covariates of the model had sufficient explanatory power, a likelihood ratio test was made.

3. Results

The results are presented in three sections. The first section summarises the general characteristics of the 1,846 passing events. The compliance rates with the MPD rule are presented next, followed by the results obtained from the regression model.

3.1 Sample characteristics

Most of the cyclists observed in the passing events appeared to be male (83%) and adults aged 16 years or more (98%). Almost all cyclists (98.8%) were wearing a helmet (mandatory in Queensland). About 70% of the riders were judged to be riding alone. Most (60%) rode a road bike, and most (56%) were wearing lycra clothing. Among the overtaking vehicles, about three quarters were passenger cars. Some large vehicles (4% buses and trucks) and motorcycles (2%) were also present in the dataset.

Weekdays (Thursday and Friday) and weekends (Saturday and Sunday) had almost equal number of passing events recorded. About half of the passing events were observed during the morning peak (5-8:59am).

A quarter of the passing events were observed on roads with a 70 km/h or more speed limit and about half were on roads with 50 km/h or lower roads. Among the data collection sites, 87% were straight road sections; 77% had no bike lane; 43% had a bicycle awareness zone (similar to a sharrow) painted on the road surface; and 63% had a parking lane.

3.2 Compliance with the minimum passing distance rule

Overall, 15.7% of the 1846 events were non-compliant with the rule. The observed mean passing distances (1.5m on 40 km/h roads, 2.0m on 60 km/h roads, and 2.4m on 70-80 km/h roads) were higher than the minimum passing distance specified in the rule. However, non-compliant events were observed in all speed zones, with the highest rate of non-compliance (22.9%) on higher speed roads. Higher non-compliance rates were also found at road curves (34% vs. 13% at straight sections), roads with bike lanes (25% vs. 13%), and roads without footpaths (34% vs. 13%).

While the non-compliance rates were similar for weekdays and weekends, lower rates were observed during the morning peak (5-8.59am) than the other parts of the day. Similar non-compliance rates were found for male and female riders or for adult and children riders, but higher rates were found for cyclists without a helmet (27% vs. 16%), although only 22 riders were not wearing a helmet. Non-compliance rates were similar across other rider characteristics, such as type of bicycle, rider clothing, or group vs individual riding. Larger overtaking vehicles were more commonly non-compliant than smaller vehicles.

3.3 Regression estimates

The calibrated results of the BLM are presented in Table 3. The likelihood ratio statistic of the model was 143.2 (13 *df*), which is well above the corresponding critical value for significance at 1% significance level.

In comparison with the morning peak (5-8:59am), the mid-afternoon (1-5pm) had a greater likelihood of non-compliance (53% higher odds). Results for the other time periods were not statistically significant at the 95% confidence level.

Motorists who overtook cyclists on higher speed roads (70-80 km/h) were more likely to be non-compliant (3.4 times higher odds) with the rule than those on 60 km/h roads. Similarly, the odds of being non-compliant on lower speed roads (40 km/h) were 1.6 times higher than the odds for 60 km/h roads.

Compared to sedan and station wagon type passenger cars, smaller vehicles (motorcycles) were less likely to be non-compliant (86% lower odds). The results for larger overtaking vehicles (e.g., bus, truck, utilities) were not significant at 95% confidence level.

Among the road geometry variables, only the presence of a road curve, the presence of a parking lane, the presence of footpath, and the average width of traffic lane variables were retained in the most parsimonious model. However, the parking lane and footpath variables were not significant at the 95% confidence level. Results showed a 6.8 times higher odds for a motorist being non-compliant if the road section was curved, compared to a straight section. Motorists were more compliant on roads with wide traffic lanes than on roads with narrow traffic lanes. A 1m increase in the average lane width was associated with 95% lower odds of being non-compliant.

None of the rider characteristics were retained in the most parsimonious model as they were not found statistically significant at the 95% confidence level. Similarly, no statistically significant differences were observed between weekend and weekdays. Among the site characteristics variables, the presence of bike lane and of bicycle awareness zone (similar to a sharrow) were not statistically significant.

4. Discussion

The compliance status of a passing event was not significantly influenced by characteristics of riders. None of the rider characteristics, such as the apparent age and gender of a rider, helmet status, type of clothing worn, type of bicycle ridden, and type of riding, were statistically significant. While some earlier studies (e.g., Walker 2007, Chuang *et al.* 2013) showed differences in passing distances related to riders' appearance or experience levels, Walker *et al.* (2014) showed that close passing events occurred regardless of the type of rider appearance. In investigating the associations between helmet status and passing distances, while Walker (2007) found significant associations, a re-analysis of the data by Olivier and Walter (2013) later questioned these associations. They argued that the effect of helmet use on passing distance is minimal, and they contested the idea of a substantive risk reduction from removing laws that require helmet use. The findings of this study suggest that rider characteristics have limited to no effects on the passing distance compliance levels. Therefore, the focus for improving cyclist safety during overtaking events should be on non-rider related factors, such as roadway infrastructure characteristics.

Road horizontal alignment, traffic lane width, and posted speed limits were among the roadway characteristics that had significant impacts on compliance status. Motorists were more likely to be non-compliant at horizontal road curves, perhaps due to motorists' poorer lane keeping behaviour at curves. A large body of research (see Das *et al.* 2015 for a review of the literature) showed that vehicle position within traffic lanes varies at horizontal curves, and often drivers do not drive in a circular path when negotiating a horizontal curve.

Greater compliance rates were observed on wider traffic lanes. This finding was in agreement with findings of Love *et al.* (2012) and Mehta *et al.* (2015). Wider lanes provide more space to motorists for lane keeping as well as for shifting laterally to avoid a hazard or another road user (e.g., a cyclist). Given this finding, a possible strategy for improving cycling safety could be to provide wider lanes on the side of the road where a bike lane is present or where most cyclists are present on road. It is, however, noted that the overtaking speed of vehicles is likely to be higher on wide lane roads than narrow lane roads (Shackel and Parkin 2014). In addition to lane widths, passing distance could also be influenced by the lane configuration of a road. While it was not possible to examine the effects of the number of traffic lanes in the current study, Shackel and Parkin (2014) found greater passing distances on dual lane roads than single lane roads. On single lane narrow roads, it is also common to see motorists following a cyclist without attempting to overtake until the passing opportunity becomes safer, such as when there is no oncoming traffic (Duthie *et al.* 2010). Heesch *et al.* (2017) also showed from a comparison of pre- and post-MPD rule periods in Queensland that cyclists were more likely to report tailgating by motor vehicles after the MPD rule was introduced than before it.

While the descriptive statistics showed that compliance rates varied by some roadway characteristics (e.g., presence of a footpath or of a bicycle lane), the results from the multivariate analysis were not statistically significant at the 95% confidence level. While this study did not find statistically significant relationships between compliance status and the presence of a bike lane, some studies (e.g., Duthie *et al.* 2010, Love *et al.* 2012, Mehta *et al.* 2015) reported greater passing distances on roads with bike lanes. However, Parkin and Meyers (2010) found greater passing distances on high-speed roads (i.e., greater than 60km/hr) without bike lanes, but not on lower speed roads (i.e., 48 km/h). Stewart and McHale (2014) argued that bike lanes have little effect on motorist passing distances, unless they are sufficiently wide (i.e., more than 1.4m). Further research is warranted to investigate the effects of bike lanes on the passing behaviours, as well as to separate the effects of bike lanes and the distance of cyclists from the kerb (as identified by Shackel and Parkin 2014).

The type of vehicle overtaking a cycling was a significant predictor of compliance with the MPD rule. Motorcyclists were less likely to be non-compliant than passenger cars (sedan, wagons) drivers. This finding was in contrast to findings of Chuang *et al.* (2013), possibly reflecting differences in traffic compositions between Australia and Taiwan. While only 2% of drivers were riding motorcycles in the dataset of this study, 48% of drivers were motorcyclists in the Chuang *et al.* (2013) study. In the current study, drivers of larger vehicles (buses, trucks, utilities, and vans) were found to leave less space while overtaking cyclists than did drivers of passenger cars; however, no statistically significance differences were observed in terms of their compliance status. Other researchers (Walker 2007, Parkin and Meyers 2010, Chuang *et al.* 2013, Llorca *et al.* 2017) have also reported that larger vehicles leave less space than do smaller vehicles when overtaking cyclists.

Compliance with the MPD rule differed by the posted speed limits of roads. Compared to 60 km/h posted speed limit roads, motorists were less compliant on lower speed roads (40 km/h) and higher speed roads (70-80 km/h). According to the MPD rule in Queensland, motorists are required to provide at least 1.5m lateral clearance when overtaking a cyclist in a 70 km/h or higher speed zone, whereas the requirement for 60 km/h or lower speed zones is 1.0m. The greater passing distance requirement on higher speed roads might be a possible reason for observing higher non-compliance levels on those roads, compared to lower speed roads. It is, however, important to note that a greater lateral clearance on higher speed roads is necessary to reduce the risk of bicycle-motor vehicle crashes at higher speed roads, as higher speeds are associated with greater turbulence and more severe crash outcomes than lower speeds. Given the minimum passing distance requirement for 40 km/h and 60 km/h roads are the same (1m), it was not clear from the data of this study why the lower speed roads had higher non-compliance than the 60 km/h roads. There were only two observation sites with 40 km/h limit in this study. Further research is warranted to investigate the effects of speed environment on the compliance status.

Non-compliance was more likely in the mid-afternoon hours (1-5pm) than the morning peak (5-9am), but no statistically significant differences were observed during the other hours. Further investigation is needed to understand the mechanism underlying these time-related differences.

While this study analysed driver compliance with the MPD rule, some aspects could not be investigated in the current study. For example, the effects of vehicle dynamics (e.g., speed of vehicle, accelerating or decelerating while overtaking) on the compliance status could not be examined. Some recent studies (Shackel and Parkin 2014, Llorca *et al.* 2017) have examined overtaking speeds in passing events. Future studies could investigate these factors as well as various traffic characteristics, such as traffic volume, bicycle volume, overall speed and composition of traffic stream. It should also be noted that while this study used a large dataset of passing events (n=1,846), these events were recorded at 10 sites in Queensland, Australia. Although no meaningful relationship between cyclist volume and passing distance were found, caution needs to be taken in interpreting the results of this study in the context of other Australian states or countries, where the riding and driving context may differ from Queensland.

5. Conclusions

This study examined the factors that are associated with non-compliance with a legislated rule on motor vehicle passing distance of cyclists. Factors examined included characteristics of the bicycle rider, motorist, and roadway infrastructure. The results showed that compliance levels are influenced by the characteristics of motorists and the roadway, but not of the rider. Greater likelihood of non-compliance with the law was observed during mid-afternoon hours than the morning peak hours, on higher speed roads (70-80 km/h speed limits) and lower speed roads (40 km/h) than 60 km/h roads, at curved road sections, and on narrower traffic lanes. Given that rider characteristics have limited to no effects on compliance with the passing distance rule, the focus for improving cyclist safety during overtaking events should be on non-rider related factors, such as the roadway infrastructure characteristics.

This study contributes to the literature on motor vehicle passing distance of cyclists by using a naturalistic study design to record passing events where none of the drivers or cyclists were aware of being studied. Use of the data collection methodology, which captured the 'true' driving and riding behaviours during passing events, is a key contribution of this research.

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References

ABS, 2017. Australian census 2016. Australian bureau of statistics. .

Austroads, 2017. National cycling participation survey 2017 queensland. Austroads, Sydney, Australia.

BITRE, 2015. Australian Cycling Safety: Casualties, Crash Types and Participation Levels. Bureau of Infrastructure, Transport and Regional Economics, Canberra, Australia.

Chapman, J., Noyce, D., 2014. Influence of roadway geometric elements on driver behavior when overtaking bicycles on rural roads. Journal of Traffic and Transportation Engineering (English Edition) 1 (1), 28-38.

Chuang, K.-H., Hsu, C.-C., Lai, C.-H., Doong, J.-L., Jeng, M.-C., 2013. The use of a quasi-naturalistic riding method to investigate bicyclists' behaviors when motorists pass. Accident Analysis & Prevention 56, 32-41.

Das, V.R., Jayashree, M., Rahul, S., 2015. Lateral placement of vehicles on horizontal curves. Transportation Research Procedia 17, 43-51.

Duthie, J., Brady, J., Mills, A., Machemehl, R., 2010. Effects of on-street bicycle facility configuration on bicyclist and motorist behavior. Transportation Research Record: Journal of the Transportation Research Board (2190), 37-44.

Haworth, N., Debnath, A.K., 2013. How similar are two-unit bicycle and motorcycle crashes? Accident Analysis & Prevention 58, 15-25.

Heesch, K., Schramm, A., Debnath, A., Haworth, N., 2017. Cyclists' perceptions of motorist harassment pre-to post-trial of the minimum passing distance road rule amendment in queensland, australia. Health Promotion Journal of Australia (doi: 10.1071/HE16119).

Johnson, M., Charlton, J., Oxley, J., Newstead, S., 2010. Naturalistic cycling study: Identifying risk factors for on-road commuter cyclists. Ann. Adv. Automot. Med . 54, 275–283.

Llorca, C., Angel-Domenech, A., Agustin-Gomez, F., Garcia, A., 2017. Motor vehicles overtaking cyclists on two-lane rural roads: analysis on speed and lateral clearance. Saf. Sci. 92, 302–310.

Love, D.C., Breaud, A., Burns, S., Margulies, J., Romano, M., Lawrence, R., 2012. Is the three-foot bicycle passing law working in baltimore, maryland? Accident Analysis & Prevention 48, 451-456.

Mehta, K., Mehran, B., Hellinga, B., 2015. Evaluation of the passing behavior of motorized vehicles when overtaking bicycles on urban arterial roadways. Transportation Research Record: Journal of the Transportation Research Board 2520, 8-17.

Olivier, J., Walter, S.R., 2013. Bicycle helmet wearing is not associated with close motor vehicle passing: A re-analysis of walker, 2007. PloS One 8 (9), e75424.

Pai, C.-W., 2011. Overtaking, rear-end, and door crashes involving bicycles: An empirical investigation. Accident Analysis & Prevention 43 (3), 1228-1235.

Parkin, J., Meyers, C., 2010. The effect of cycle lanes on the proximity between motor traffic and cycle traffic. Accident Analysis & Prevention 42 (1), 159-165.

Parkin, J., Wardman, M., Page, M., 2007. Models of perceived cycling risk and route acceptability. Accident Analysis & Prevention 39 (2), 364-371.

Schramm, A., Haworth, N., Heesch, K., Watson, A., Debnath, A., 2016. Evaluation of the queensland minimum passing distance road rule. Brisbane.

Shackel, S.C., Parkin, J., 2014. Influence of road markings, lane widths and driver behaviour on proximity and speed of vehicles overtaking cyclists. Accident Analysis & Prevention 73, 100-108.

Stewart, K., Mchale, A., 2014. Cycle lanes: Their effect on driver passing distances in urban areas. Transport 29 (3), 307-316.

Stone, M., Broughton, J., 2003. Getting off your bike: Cycling accidents in great britain in 1990–1999. Accident Analysis & Prevention 35 (4), 549-556.

Tmr, 2015. Parliamentary Inquiry into Cycling Issues. Transport and Main Roads, Brisbane, Australia.

Walker, I., 2007. Drivers overtaking bicyclists: Objective data on the effects of riding position, helmet use, vehicle type and apparent gender. Accident Analysis & Prevention 39 (2), 417-425.

Walker, I., Garrard, I., Jowitt, F., 2014. The influence of a bicycle commuter's appearance on drivers' overtaking proximities: An on-road test of bicyclist stereotypes, high-visibility clothing and safety aids in the united kingdom. Accident Analysis & Prevention 64, 69-77.

Walker, I., Jones, C., 2005. The oxford & cambridge cycling survey: A large-scale study of bicycle users in two major uk cycling cities. Oxfordshire County Council, Oxford, UK.

TABLE 1 Data Collection Sites for Observation of Passing Events

Road name	Suburb	Region	Speed limit (km/h)
Breakfast Creek Rd	Newstead	Brisbane	60
Annerley Rd	Dutton Park	Brisbane	60
Jacaranda Av	Logan	Brisbane	60
Grey St	South Brisbane	Brisbane	40
Montague Rd	West End	Brisbane	60
Sandgate Rd	Bracken Ridge	Brisbane	70
Cooroy-Noosa Rd	Tewantin	Sunshine Coast	80
Dean St	North Rockhampton	Rockhampton	60
The Esplanade	Surfers Paradise	Gold Coast	40
Hope Island Rd	Hope Island	Gold Coast	70

TABLE 2 Summary of passing events observed and compliance rates with the rule

Variables	No. of obs.	% of obs.	Passing distance (metres)		% Non-compliant passing events
			Mean	S.D.	
Rider characteristics					
Apparent gender					
Male	1527	82.7	1.90	0.96	15.5
Female	319	17.3	1.67	0.75	16.3
Apparent age					
Adult	1815	98.3	1.86	0.93	15.7
Child	31	1.70	1.99	0.88	12.9
Helmet worn					
Yes	1824	98.8	1.86	0.93	15.5
No	22	1.20	1.70	0.99	27.3
Bicycle type					
Road	1083	58.7	1.98	1.02	15.2
Mountain	750	40.6	1.69	0.75	16.0
Other	13	0.70	1.30	0.62	30.8
Rider clothing type					
Lycra	1026	55.6	1.99	1.03	15.3
Everyday	820	44.4	1.70	0.75	16.1
Type of riding					
Individual	1298	70.3	1.79	0.87	15.9
Group - Single File	298	16.1	1.88	0.89	14.8
Group - Abreast	250	13.5	2.24	1.16	15.6
Motorist characteristics					
Type of vehicle					
Passenger car (Sedan, Wagon)	1108	60.0	1.88	0.96	15.9
Passenger car (SUV, 4WD)	340	18.4	1.85	0.82	12.1
Motorcycle	33	1.80	2.10	0.80	3.0
Utilities/Van	286	15.5	1.78	0.90	18.5
Truck/Bus	79	4.30	1.82	1.08	22.8
Traffic characteristics					
Day of week					
Weekday	896	48.5	1.82	0.89	15.2
Weekend	950	51.5	1.90	0.96	16.1
Time of day					
05:00 - 08:59	872	47.2	1.90	0.89	13.9
09:00 - 12:59	512	27.7	1.91	0.99	16.4
13:00 - 16:59	331	17.9	1.77	0.97	18.7
17:00 - 04:59^	131	7.10	1.67	0.78	16.8
Roadway characteristics					
Posted speed limit					
<=50 km/h	989	53.6	1.54	0.57	14.8
60 km/h	415	22.5	2.02	0.91	10.1
>=70 km/h	442	23.9	2.43	1.23	22.9
Presence of bike lane					
No	1420	76.9	1.84	0.85	12.9
Yes	426	23.1	1.93	1.16	24.9
Bicycle Awareness Zone					
No	1049	56.8	2.08	1.06	16.1
Yes	797	43.2	1.57	0.60	15.1
Road horizontal alignment					

Straight	1612	87.3	1.79	0.82	13.0
Curve	234	12.7	2.36	1.38	34.2
Presence of parking lane					
No	675	36.6	2.04	1.13	18.8
Yes	1171	63.4	1.76	0.77	13.8
Presence of footpath					
No	231	12.5	2.50	1.48	34.2
Yes	1615	87.5	1.77	0.78	13.0
Traffic lane configuration					
One way road	211	11.4	2.37	0.87	10.4
Two way (1 lane each way)	1201	65.1	1.65	0.73	13.9
Two way (2 lanes each way)	434	23.5	2.21	1.21	23.0
Total	**1846**	**100.0**	**1.86**	**0.93**	**15.7**

^ only 1 observation between 20:00 and 04:59

Table 3 Logistic regression estimates

Model variables	**Regression estimates**		
	Coef.	O.R.	p-value
Overtaking vehicle type			
Passenger car (Sedan, Wagon)	Ref		
Passenger car (SUV, 4WD)	-0.024	0.976	0.902
Motorcycle	-1.972	0.139	0.050
Utilities/Van	0.289	1.335	0.111
Truck/Bus	0.411	1.508	0.162
Time of day (hours)			
05:00 - 08:59	Ref		
09:00 - 12:59	0.106	1.112	0.513
13:00 - 16:59	0.424	1.529	0.019
17:00 - 04:59^	0.413	1.511	0.121
Posted speed limit			
40 km/h	0.464	1.590	0.026
60 km/h	Ref		
70-80 km/h	1.219	3.382	0.004
Road curve (ref: straight)	1.920	6.818	<0.001
Parking lane (ref: no parking lane)	-0.219	0.804	0.266
Footpath (ref: no footpath)	0.917	2.503	0.141
Average traffic lane width (m)	-3.067	0.047	<0.001
Constant	7.120		<0.001
Model statistics			
Number of observations	1846		
Log-likelihood (at zero)	-801.0		
Log-likelihood (model)	-729.4		
AIC	1486.8		
G^2	143.2 (13 *df*)		<0.001

Ref: Reference category; O.R. = Odds Ratio