The safety of bicycles being overtaken by cars: What do we know and what do we need to know?

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Abstract

Many cyclist deaths and serious injuries result from rear-end or sideswipe collisions involving a car or heavy vehicle. As a consequence, minimum passing distance laws (often referred to as 'one metre rules') have been introduced in a number of U.S. states along with European countries such as France, Belgium and Spain. A two-year trial of a minimum passing distance rule is underway in Queensland. The international studies show that while the average passing distance is more than one metre, significant proportions of passes occur at less than this distance. Average passing distances are greater with wider lanes, when bicycle lanes are present, for cars rather than vans or trucks, and (possibly) at higher speed limits. Perceived characteristics of the cyclist (other than gender) appear to have little effect on passing distances. The research questions the ability to judge lateral distance and whether nominated distances predict on-road behaviour. Cyclists have strong concerns about drivers passing too close but the extent to which this behaviour reflects deliberate intimidation versus an inability to judge what is a safe passing distance is not clear. There has been no systematic evaluation of the road safety benefits of minimum passing distance laws. These laws have received little police enforcement but it is unclear whether enforcement is necessary for them to be effective.

Introduction

Many cyclist deaths and serious injuries result from rear end or sideswipe collisions involving a car or heavy vehicle travelling in the same direction. While timely national data are not available, an analysis of Coronial data showed that 46 of the 220 cyclist fatalities from 1996-2000 involved a motor vehicle travelling in the same direction in the same lane hitting the cyclist from behind (ATSB, 2006). These crash types were particularly prevalent in rural areas, accounting for 29 of 69 rural fatalities. More recent Queensland data (2003-2010) shows that 11% of Police-reported cyclist crashes were sideswipes and 5% were rear-end crashes (Transport, Housing and Local Government Committee, 2013).

Concern about dangers to cyclists from motor vehicle passing too close has led to the introduction of minimum passing distance laws in:

- 24 American states[1] (Arizona, Arkansas, California[2], Colorado, Connecticut, Delaware, District of Columbia, Florida, Georgia, Illinois, Kansas, Louisiana, Maine, Maryland, Minnesota, Mississippi, Nevada, New Hampshire, Oklahoma, Pennsylvania, Tennessee, Utah, Virginia, Wisconsin), and a number of US cities

[1] National Conference of State Legislatures, (2014). *Safely Passing Bicyclists*. http://www.ncsl.org/research/transportation/safely-passing-bicyclists.aspx
[2] USA Today (2013). *New Calif. Law: keep 3-foot gap between bike, car*. http://www.usatoday.com/story/news/nation/2013/12/29/new-california-bicycle-law/4244283/

- Nova Scotia, Canada
- Netherlands
- France
- Portugal
- Belgium
- Spain
- Western Cape Province, South Africa

The Queensland Parliamentary Transport, Housing and Local Government Committee, delivered the report of its Inquiry into Cycling Issues on 29 November 2013 (Transport, Housing and Local Government Committee, 2013). One of the 68 recommendations of the Inquiry was to amend the Queensland road rules to introduce a minimum passing distance for cyclists. In line with this recommendation, the Queensland Minister for Transport and Main Roads announced a trial of a rule that requires motor vehicles to allow at least a one-metre lateral distance when overtaking cyclists. The new rule, effective for two years from 7th April 2014, requires motor vehicles to provide cyclists a minimum lateral passing distance of one metre when overtaking cyclists in speed zone of 60 km/h or less, and a metre and a half when the speed limit is greater than 60 km/h. The following text was added to s144A Keeping a safe lateral distance when passing bicycle rider:

> (2) A sufficient distance from the bicycle is–
>
> > (a) if the applicable speed limit is not more than 60km/h– a lateral distance from the bicycle of at least 1m; or
> >
> > (b) if the applicable speed limit is more than 60km/h– a lateral distance from the bicycle of at least 1.5m.
>
> (3) For subsection (2), the lateral distance is the distance between the following points–
>
> > (a) the furthermost point to the left on the driver's vehicle or any projection from the vehicle (whether or not attached to the vehicle);
> >
> > (b) the furthermost point to the right on the bicycle, any bicycle trailer towed by the bicycle, the rider or any passenger in or on the trailer.
> >
> > Example of what is part of a bicycle for paragraph (b)–
> >
> > > a basket or pannier bags attached to the bicycle
> >
> > Example of what is not part of a bicycle for paragraph (b) –
> >
> > > a flag or stick, whether or not flexible, attached to the bicycle, that projects sideways from the bicycle

As part of the rule, motor vehicles can cross centre lines, even on roads with double unbroken lines, straddle lane-lines and drive on painted islands in order to pass cyclists as long as it is safe to do so (Queensland Government, 2014). The penalty for breaching the law is three demerit points and a fine of $341. A maximum fine of $4,554 can apply if the matter goes to court.

Despite the introduction of these laws, there is little understanding of what separation distances are currently adopted, what distances are safe and comfortable, and what effects such laws may have on cyclist and motorist safety and the performance of the road system. This paper reviews what is known – and what is not known – about these issues, drawing on literature reviews and discussions conducted as part of developing an evaluation framework for the Queensland minimum passing distance rule (Haworth, Schramm, Kiata-Holland, Vallmuur, Watson & Debnath, 2014).

Method

The literature review focused on studies of motor vehicles overtaking bicycles. It examined current academic journal publications, conference papers, government and non-government reports and other relevant literature. Relevant research findings were identified by searching electronic publications databases, by checking proceedings of recent conferences and by internet searches (including websites of organisations that may have sponsored recent research). Members of the Project Team either have attended recent relevant conferences or have direct contacts with the researchers undertaking the work. As a result, the Project Team had ready access to much of the current research literature in this field.

The literature was reviewed critically with regard to relevance to Australia, including research conducted within Australia and in comparable countries (taking into account cultural, transport and traffic differences). The comparable jurisdictions included other Australian states, New Zealand, the United Kingdom, the United States, and Canada.

Rider perceptions

Many cyclists feel uncomfortable and threatened by drivers passing too close and consider that can be a deliberate form of intimidation. Two Australian surveys of members of bicycling organisations (mostly experienced cyclists) have found that “deliberately driving too close” is commonly reported by riders. The first survey was emailed to a random sample of 10,000 adult members and contacts of Bicycle Victoria with 2,403 respondents (Garrard, Crawford & Hakman, 2006). Two-thirds of respondents reported experiencing intentional harassment from motorists or their passengers in the previous year. Of the seven categories of harassment listed in the questionnaire, “deliberately driving too close” was the most frequently reported, followed by “shouting abuse”; “sounding the horn in an aggressive manner”; “obscene gestures”; and “blocking your path”. Females felt harassment was a greater constraint to cycling, but males reported experiencing more harassment. Younger riders were also more likely to report experiencing harassment (although O’Connor & Brown 2010 reported that experienced riders aged under 25 years were less concerned for their safety when vehicles passed than older riders). A later survey was emailed to 4469 Bicycle Queensland member households and completed by 2356 respondents (1862 of responses were eligible for analysis) (Heesch, Sahlqvist & Garrard, 2012). Among these respondents, 65.6% reported drivers “deliberately driving too close”. This was more commonly reported than “shouting abuse”, “throwing objects”, “deliberately blocking your path”, “making obscene gestures”.

Similar findings were reported by the US National Survey of Bicyclist and Pedestrian Attitudes and Behaviour (NHTSA, 2008). In a population survey, 13% of cyclists reported feeling threatened for their personal safety the last time they rode their bike, of whom 88% felt threatened due to motorist actions. Among that group, the two leading actions were:

driving too close to the bicyclist (40%) and driving too fast (32%). Other reasons (including open ended responses) include: driver not seeing the bicyclist (16%), presence of the motorist was threatening (11%), motorist was rude (8%) and motorist did not obey traffic laws (7%). No differences between responses of male and female cyclists were found.

Cyclist and driver abilities to estimate passing distances

While cyclists may interpret drivers passing too close as deliberate intimidation, it may (at least part of the time) reflect drivers' inability to judge what is a safe passing distance, and specifically, to judge a metre. No specific studies of this ability were identified by the literature review. There is a considerable body of research relating to drivers' ability to judge gaps in the longitudinal direction which has generally concluded that they underestimate gaps (e.g. Nilsson, 2000; Baumberger, Flückiger, Paquette, Bergeron & Delorme, 2005) but little that relates to estimation of lateral distances in the context of driving. Baumberger et al. (2005) note that drivers are likely to experience difficulty in judging lateral distances because the vehicle body can partially occlude lateral vision when the vehicle is approaching an object on the kerbside. In a psychophysical experiment, Levin and Haber (1993) reported that viewers are likely to overestimate perpendicular distances (both absolutely and relative to distances parallel to the line of sight).

In addition to many of the previous studies not being in the context of lateral separation driving, they also did not ask participants to estimate an absolute distance, with most of the tasks requiring a relative response (e.g. place your car halfway between the leading and following vehicle). It is possible that a driver may be able to do this, but be less accurate at a task of, for example, placing their vehicle 3 metres behind the lead vehicle. Clearly not enough is known about the ability of drivers to judge the separation distance when they are passing a cyclist. There are also no studies of how well cyclists can judge distances to passing vehicles. It would be valuable to conduct experimental studies regarding this issue.

Cyclist and driver perceptions of the level of safety of various separation distances

Several studies have asked cyclists and drivers what they consider to be a safe passing distance. In a recent yet-to-be-published survey, 758 members of CARRS-Q's community research panel were emailed or posted a survey of attitudes to road safety which included an item asking what they believed was the safe distance to leave between their car and a bicycle in a 60 km/h zone. Among the 440 respondents, 15% indicated they rode a bicycle at least once or more in an average week and were categorized as "cyclists". The remaining 85% were categorized as "non-cyclists". Cyclists were more likely to nominate safe distances of under 1.5 metres and less likely to nominate larger distances than non-cyclists. For example, less than 10% of cyclists selected safe distances of more than 1.5 metres, compared to almost a quarter of non-cyclists. There was no significant difference in the responses of those who completed the online survey emailed prior to the introduction of the minimum passing distance law compared to those who completed survey by post after the law was introduced. In response to another item, about 80% of cyclists and non-cyclists agreed with the statement that motorists should stay a minimum of 1 metre away when passing a cyclist at 60 km/h and 1.5 metres when passing at 100 km/h.

While the larger safe distances nominated by non-cyclists may appear unexpected, they are consistent with the results of an earlier CARRS-Q study (Haworth, Rakotonirainy, Wilson, Darvell, & Haines, 2013) which asked 69 car drivers:

"When a car overtakes a bicycle rider at 60 km/h, what size distance should be left between the side of the car and the bicycle in order to remain safe?"

Those car drivers with no bicycle or motorcycle experience (n=19) were more likely to nominate that the safe distance for a car passing a bicycle was 2 metres or more than drivers with bicycle (n=15) or motorcycle experience (n=18) or both (n=17). However, the drivers' responses to this question did not predict their later behaviour in the driving simulator for an interaction where a car driver turned right across the path of a cyclist. While further analyses and larger samples are needed, these preliminary results question the validity of simplistic self-reports of safe distances to pass a bicycle and suggest that more contextual information may need to be supplied in order to understand driver and cyclist perceptions and behaviour in relation to safe passing distances.

The actual distances between cyclists and passing motor vehicles

Actual lateral distances from a bicycle to a passing car have been measured in studies from Britain (Parkin & Meyers, 2010; Walker, 2007; Walker, Garrard & Jowitt, 2014) and the United States (Chapman & Noyce, 2012; Love, Breaud, Burns, Margulies, Romano & Lawrence, 2012). Parkin and Meyers (2010) collected passing distances using a bicycle which had a video camera mounted to the rear pannier. The mean passing distance for cars varied from 112.7 cm at one site (with cycle lane, 40 mph (64 km/h) speed limit) to 169.9 cm at another site (without cycle lane, 50 mph (80 km/h) speed limit). While the paper presents standard deviations of passing distances (which ranged from 17.7 cm to 28.3 cm), it does not explicitly state how many cars passed within 1 metre (100 cm). Passing distance was influenced by vehicle type, road width, the presence of a cycle lane and speed limit (discussed in a later section).

In another UK study, Walker et al. (2014) used an ultrasonic distance sensor mounted on a bicycle to measure the space left by overtaking vehicles. The study captured 5,690 overtaking events occurring during a large number of peak-hour commuting trips by the same rider (although the clothing worn by the rider was deliberately varied). The mean passing distance was 117.5 cm, with a range of 2 cm to 274 cm. Between 24% and 43% of passing distances measured were less than one metre.

Love et al. (2012) measured passing distances as part of their evaluation of the Maryland "3-foot bicycle passing law" (approximately 90 cm). They used bicycles fitted with video cameras to measure lateral clearances between the bicycle and the overtaking vehicle. Five participants recorded morning and evening bicycle commutes, mostly on streets with posted speed limits of 25-35 mph (40-56 km/h). Vehicle passing distances were determined on video playback, with each cyclist measuring the lateral separation (in one foot intervals), with cross-validation undertaken. A total of 586 vehicle-overtaking-bicycle events were recorded in 10.8 hours of riding, with 91 (16%) having a lateral separation of 90 cm or less.

Effect of cyclist characteristics on driver perceptions and behaviours

There has been ongoing interest in whether the characteristics of the cyclist (as perceived by the driver) influence the distance left when overtaking a bicycle. In an early British study (Basford, Reid, Lester, Thomson & Tolmie, 2002), participants were shown three different uncaptioned images representing everyday, stunt (unicycle rider), and professional cyclists and were asked which (if any) they would: give more space to, slow down, or treat with caution when overtaking. Drivers indicated they would be more likely to award space, speed reduction and more caution to the stunt cyclist. Drivers were more likely to concede speed than space when near everyday and professional cyclists, and more likely to concede space than caution.

The first on-road study by Walker (2007) reported that drivers left more room when passing a cyclist who appeared to be a woman and less room when the cyclist was riding towards the centre of the lane or was wearing a helmet. The finding of greater passing distances has been replicated with real women in Florida and Taiwan (as reported in Walker et al., 2014). However, the finding of leaving less room to riders wearing helmets (interpreted as more experienced by Walker, 2007) has been questioned by later studies (Olivier & Walter, 2013; Walker et al., 2014). Olivier and Walter (2013) pointed out that the average passing distances in Walker's (2007) study were larger than one metre and that the sample size was very large, suggesting that a significant difference may have been found even though a meaningful difference did not truly exist. They re-analysed the data from Walker (2007) by incorporating multivate analyses and dichotomising distance according to the one metre rule. The multivariate analyses using passing distance as a continuous variable confirmed that passing distance was smaller for large vehicles, for greater distances from the kerb and when wearing a helmet (but the univariate effect of time of day was no longer significant). However, the multivariate analysis with passing distance dichotomised (close passing=<1 metre), found that the effect of helmet wearing was no longer significant (and a significant effect of city emerged). Using various cut-points to dichotomise the data showed that the effect of helmet wearing was only evident for passing distances of greater than 1.5 metres or 2.0 metres.

In a later, more systematic study (Walker et al., 2014), passing distances were measured for the same cyclist dressed in seven different outfits which had been judged by survey respondents to represent different levels of experience, skill or likelihood of wobbling. Pairwise t-tests (corrected for multiple comparisons) showed that the police/video recording jacket (mean passing distance of 122.1 cm) was the only outfit which was had significantly greater mean passing distances (although the difference between it and the high visibility jacket was not statistically significant). The percentage of overtakes when the distance was less than one metre (100 cm) differed significantly according to the outfit worn, with the lowest percentage again being associated with the police/video recording jacket, but still this approached 25%. For other outfits, the percentage of passes at distances of less than one metre ranged from 29.6% to 43.1%.

Roadway and speed limit influences on cyclist and driver perceptions and behaviours

Most studies measuring passing distance have found that passing distance increases with lane width and in the presence of bicycle lanes (summarised by Love et al., 2012). Love et al. (2012) found that close passing (lateral separation of 3 feet or less) was more common when cycling in standard traffic lanes (17% of the 451 recorded passes on this type of road) and traffic lanes with shared lane markings (23% of the 47 recorded passes on this type of road). No close passing was recorded on roads with marked bicycle lanes. Factors that were found to be significantly related to increased lateral separation were wider traffic lanes and the presence of bicycle lanes (but not sharrows). There were also significant differences in the mean passing distances among the 5 cyclists in the study and some of the streets. The multiple linear regression model explained only 26% of the variability in lateral separation, suggesting that other unexplained influences affected the outcome (e.g. distance from the cyclist to the kerb). It has not been established whether the greater passing distance where bicycle lanes are present reflects the physical presence of the road markings or whether it may be an influence of the greater expectancy of seeing cyclists (since volumes of cyclists are likely to be higher where bicycle lanes are present).

There are a number of roadway elements that can temporarily reduce lane width, thus creating a potential “pinch point” for cyclists. One example is a pedestrian refuge. Basford et al. (2002) showed their respondents an image of driving behind a cyclist, as the cyclist approached a pedestrian refuge on a road with a 40 mph (64 km/h) speed limit. When asked what they would do, 75% of participants reported they would slow and wait behind the cyclist, 24% reported they would check if there was enough room to overtake and then do so, and 1% said they would attempt to overtake even if the room were tight. It would be interesting to investigate what behaviours are exhibited by drivers in the real-world situation.

The roadway speed limit appears to influence passing distances but there is limited research with conflicting results. In a UK study, Parkin and Meyers (2010) found that on high-speed roads (>64 km/h), motorists stayed within the boundaries of their lanes, regardless of the presence of cyclists in adjacent lanes. In contrast, an analysis of 1,151 bicycle passing events in rural Wisconsin (Chapman & Noyce, 2012) found only six violations of the state’s “3-ft rule”, with an average passing distance of 6.3 feet (1.9 metres) without a bicycle lane (6.4 feet with a bicycle lane). Less than a quarter of cars, 30% of rigid truck and pickups and nearly half of all vehicles with trailers committed an offence by crossing centrelines to pass a bicycle. Violations were much less common when there was a paved shoulder.

In addition to roadway and speed limit characteristics influencing real or reported passing distances, type of overtaking vehicle also appears to be important. Some studies (Walker, 2007; Parkin & Meyers, 2010) showed that smaller passing distances were left by larger vehicles (buses and trucks) but this was not found by Love et al. (2012). In Basford et al.’s (2002) study, professional drivers of larger vehicles were more likely than private car drivers to report they would drive cautiously when overtaking any of the three types of cyclists portrayed. In the pedestrian refuge scenario, professional drivers of large vehicles were more likely than private car drivers to report that they would act cautiously. It is not clear, however, whether the caution would result in increased passing distances or in slower passing speeds.

The effects of minimum passing distance laws on both cyclist and driver behaviours and attitudes

A search of the literature has identified only two evaluations of the effectiveness of minimum passing distance laws: an impact evaluation in Baltimore, Maryland and a process evaluation of the implementation of minimum passing distance laws in US states. No evaluations measuring safety outcomes were identified by the literature search.

Impact evaluation in Baltimore, Maryland

A “three-foot” (90 cm) passing distance law was introduced in Baltimore, Maryland in October 2010. Love et al. (2012) used bicycles fitted with video cameras to measure lateral clearances between bicycles and overtaking vehicles during morning and evening bicycle commutes in September and October 2011 (post-implementation). As noted earlier, 16% of the observed overtaking manoeuvres had a lateral separation of 3 feet or less. While this result demonstrates that there was not complete compliance with the law, the lack of pre-implementation data means that it is not clear how much the law had changed driver behaviour.

Process evaluation across several US states

Brown, Farley, Hawkins and Orthmeyer (2012) conducted a process evaluation of US minimum passing laws. Interviews were conducted with relevant stakeholders in 20 states (Arizona, Arkansas, Colorado, Connecticut, Delaware, Florida, Georgia, Illinois, Kansas, Louisiana, Maine, Maryland, Minnesota, Mississippi, Nevada, New Hampshire, Oklahoma, Tennessee, Utah and Wisconsin) that had implemented minimum passing distance laws (3-feet laws). The interviews did not identify any evaluations of the effectiveness of the laws in terms of reducing bicycle crashes or actual changes in passing distances.

A number of issues were explored in the research, including the work of bicycle and pedestrian advocacy groups and the role of legislators (in promoting or hindering legislation). The stance of state and local police departments towards the law was found to vary between locations. In some jurisdictions the police departments supported the introduction of minimum passing distance laws, while in others police departments were neutral or were opposed to the law (in some cases a barrier to implementation). Police departments opposed to the introduction of minimum passing distance laws considered the law unenforceable and a burden to implement.

The evaluation identified that a cyclist fatality was often the impetus for the implementation of a minimum passing distance law. Public education campaigns, using various mediums (billboards, bumper stickers, cycling jerseys etc.), were conducted to inform the public of the law. The reviews also examined education provisions for police regarding details of the minimum passing law aimed to increase the prospect of enforcement. There were found to be few provisions for police education programs, with limited funding available. In states where training was provided, there was low attendance. In general, there was little enforcement of the minimum passing law, with very few infringements issued. States with minimum passing laws did not have access to accurate numbers of citations issued.

Strengths and limitations of the published research

Despite the research presented in this paper, there remains a need for a more complete understanding of what factors influence the safety of bicycles being overtaken by cars. There has been no clear assessment of whether, or under what circumstances, one metre is a safe passing distance. Is distance alone the most important factor, or is speed, or a combination of speed and distance, the better measure of the safety of the overtaking manoeuvre? If speed or a combination of speed and distance are better predictors of safety, can they be feasibly incorporated into legislation? There is a precedent for a speed limit of 20 km/h to overtake a school bus in some jurisdictions. While 20 km/h is probably too slow to overtake a cyclist, perhaps a 40 km/h limit for overtaking a cyclist would be easier for drivers to measure and for police to enforce?

The extent to which the observed pattern of drivers passing too close to cyclists reflects deliberate intimidation versus an inability to judge what is a safe passing distance is not clear. The limited research suggests that judgments of lateral distance can be overestimated, which is a concern if it also applies to judgments of passing distance. It also appears that safe passing distances nominated by cyclists may be lower than those by drivers, but these differences may not be evident in simulated behaviour. Thus we may need to exercise caution in interpreting self-reported measures of safe passing distances.

There has been no systematic evaluation of the road safety benefits of minimum passing distance laws. The limited international research suggests that minimum passing distance laws have received little police enforcement. It is unclear whether police enforcement is necessary for a minimum passing distance law to be effective.

Conclusions

The international studies show that while the average passing distance is more than one metre, significant proportions of passes occur at less than this distance. Average passing distances are greater with wider lanes, when bicycle lanes are present, for cars rather than vans or trucks, and (possibly) at higher speed limits. Perceived characteristics of the cyclist (other than gender) appear to have little effect on passing distances. The research questions the ability to judge lateral distance and whether nominated distances predict on-road behaviour. Cyclists have strong concerns about drivers passing too close but the extent to which this behaviour reflects deliberate intimidation versus an inability to judge what is a safe passing distance is not clear. Little is known about the potential effects of minimum passing distance laws on cyclist and motorist safety and the performance of the road system. The safety of bicycles being overtaken by cars is an important topic, and we still have much to learn.

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