The effect of traffic lane widths on the safety of cyclists in urban areas

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Abstract

This literature review examines the relationship between traffic lane widths on the safety of road users. It focuses on the impacts of lane widths on motor vehicle behaviour and cyclists' safety. The review commenced with a search of available databases. Peer reviewed articles and road authority reports were reviewed, as well as current engineering guidelines. Research shows that traffic lane width influences drivers' perceived difficulty of the task, risk perception and possibly speed choices. Total roadway width, and the presence of on-road cycling facilities, influence cyclists' positioning on the road. Lateral displacement between bicycles and vehicles is smallest when a marked bicycle facility is present. Reduced motor vehicle speeds can significantly improve the safety of vulnerable road users, particularly pedestrians and cyclists. It has been shown that if road lane widths on urban roads were reduced, through various mechanisms, it could result in a safety environment for all road users.

Keywords

Urban, Geometric design, Cyclist

Introduction

This review will explore the relationship between lane width and the safety of cyclists on urban roads. Research into roadway design and cyclist safety has been limited. What research has been conducted in diverse fields of roadway design and safety has not been collated and summarised, and lacks substantive discussion of the various factors and principles that could be used to improve cyclists' safety on urban roads. Road design impacts on all road users, and it is therefore essential to investigate the effects of modifications in road design on each road user group.

Once the impact of road design on each road user group is understood, it is important to understand how the design factors influence the interactions between road user groups. The initial section of this paper will outline the methodology and scope of the review. The requirements of separate road user groups will be examined, and relevant road engineering guidelines will be highlighted. The review will then examine the effect of lane width on driver (motor vehicle) behaviour and then on cyclist behaviour and safety. The final section will summarise the findings of the available literature.

Methodology

A thorough search was conducted across available online databases. Multiple searches were undertaken using a variety of search strategies. Searches of individual journals *(Transportation research record, Accident analysis and prevention, Ergonomics, Safety science, Journal of transportation engineering, ITE journal), electronic databases* (Web of Science, Science Direct, and Australian Transport Index), and the internet were conducted. All papers identified through the search procedures (approximately 100 research papers, not including engineering and design guidelines) were scanned for relevancy.

Relevant papers were defined as those that evaluated the safety of road geometric designs for urban environments, excluding high-speed roads (freeways and motorways, where cyclists are usually prohibited from travelling). Through the review process, 71 of the papers were excluded. Papers exploring geometric design were excluded for the following reasons: research was conducted in rural locations, lane width was examined at roadwork locations, only a specific crash type was investigated, or research explored the effect of geometric design excluding lane width (landscaping, or median strip types). Research into cycling safety is limited, and as such, the exclusion criteria were less strict. No geographical restrictions were implement, however there was a preference for auto-centric locations (USA, UK, New Zealand, Canada or Australia). Only peer reviewed articles and reports by road authorities (local, state or national) were reviewed.

Research methodologies in the included papers were varied, which makes comparisons between findings difficult. Investigations into cycling safety included observational and modelling research methods. The majority of studies examining the effects of lane widths on driver behaviour were simulator based.

Selection of studies for inclusion

The scope of this review is purposely focused on general traffic lane widths on urban roads. Several other issues were perceived to be important enough to be investigated independently. These issues include:

- The effects of lane narrowing as a traffic calming measure
- Road shoulders, which were considered a separate issue in geometric design
- Lane width requirements at intersections (roundabouts, signalised intersections, uncontrolled intersections, turn lanes etc.)
- Other intersection measures, such as advanced stop lines and traffic signal sequences
- Other conflict points, such as lane merging and lane splitting.

As a result, these issues were not examined in this review. This review is limited to urban road segments without notable features (intersections, traffic calming and other features). Early research into geometric design parameters and their impact on safety has focussed on rural roads. Later research has moved the focus to urban roads. The majority of research has only examined the safety of these geometric design parameters on the safety of motor vehicle occupants. This paper investigates the implications of narrow lane widths for cyclists and for road users with whom cyclists have the greatest level of conflict. While research does show that the majority of crashes involving bicycles occur at intersections (54%), a large number occur on mid-block road segments devoid of road features (46%) [1]. Future research could examine the effect of lane widths on cyclist safety at intersections and other conflict points.

Vehicle requirements and engineering considerations

Vehicles, whether stationary or moving, occupy a defined space on the roadway. When vehicles are travelling, the space required by each vehicle is dependent on functional width and operational/dynamic width. The capabilities of all vehicles using a road should be considered when evaluating geometric design features, particularly with respect to lane width and road user safety. This review focuses on the requirements of three vehicle types – bicycles, as well as heavy vehicles and passenger vehicles – as these place the most pressure on cyclists' safety through size and likelihood of crash involvement.

Heavy vehicles

Heavy vehicles, due to their size and operating capabilities, have specific design requirements. One aspect that requires careful consideration, particularly when examining traffic lane widths, is the tracking ability of heavy vehicles. In the context of heavy vehicles, tracking ability refers to ability of the attached trailing unit to follow the same path as the lead unit. The lateral displacement the trailer undergoes when travelling at speed, in addition to the vehicle width, is the swept width. Swept width is dependent on the configuration of the vehicle, road factors and environment factors [2].

Comprehensive testing across various road surface environments (roughness and cross-slope measures) of various heavy vehicle configurations during straight path travel has been conducted on rural roads [3]. Swept width, or physical width requirements, of heavy vehicles increased as speed increased for all heavy vehicle combinations.

Modelling demonstrated that the majority of heavy vehicle configurations had a lane width requirement of 3.1m when travelling at 60km/h, increasing to 3.2m when travelling at 90km/h. Prime-movers and semi-trailer configurations were shown to have the smallest width requirements, estimated at 2.8m when travelling at 60km/h. At speeds of 60km/h, rigid +3 combinations (a rigid truck combined with a dog trailer) required 3.4m to avoid lane excursions. This increased to 3.85m when speed increased to 90km/h.

Passenger vehicles

Current road design standards are determined by the operational characteristics of passenger vehicles. The operating speeds of passenger vehicles are often the critical input used by engineers to determine the safety of a road [4]. It is assumed that passenger vehicles would be able to operate well within the boundaries discussed above for heavy vehicles.

Bicycles

There has been little research into the operating space requirements of bicycles. Almost all bicycles have a functional width of 0.65m, measured as the width of the handlebars [5]. Disturbing factors may impact on the ability of the cyclist to maintain a steady course. Common disturbing factors include removing a hand from the handlebar to signal a turn or looking over the shoulder to check for traffic when attempting a right turn. Cyclists' ability to hold a steady course was also impacted by road surface unevenness and side-wind disturbances, particularly at low speeds [6].

Allowing for slight movements in travel path due to operator control, associated with operating a single-track vehicle, a minimum operating space requirement of 0.75m is proposed [5]. However, research suggests that the space requirements of bicycles may be greater than this, and will be dependent on several factors. When cyclists can maintain sufficient speed on

	Netherlands[a]	Germany[a]	Sweden[a]	Norway[a]	USA[b]	UK[c]	NZ[d]	Australia[e]
Recommended bicycle lane width (m)	1.0	1.0	1.2	1.6	1.2 1.5*	1.5 2.0^	1.5† 1.9‡	1.5

[a] Allen et al, 1998 [5]
[b] American Association of State Highway Transportation Officials (AASHTO) Guide [7]
[c] Department of Transport [8]
[d] Transit New Zealand [9]
[e] Austroads [10]

* recommended minimum with an increase in bus and/or truck volume
^ recommended minimum with higher speeds (≥65km/h)
† desirable minimum when vehicle speed is ≤50km/h
‡ desirable minimum when vehicle speed is ≥70km/h

Table 1. Recommended bicycle lane widths: selected international locations

straight paths or gentle curves, they require at least 1m of lateral space. If interfering factors are present, or the cyclist has a lower travel speed, additional space may be required [6]. The skill of the bicycle operator may also impact on the lateral space requirement.

International road design standards do not provide consistent recommended widths for on-road bicycle lanes (see Table 1). This may reflect the range of attitudes towards bicycling by governments and/or other road users. It may also reflect the broad spectrum of motor vehicle travel speeds permitted in urban environments.

Current road engineering guidelines

In the current Australian guidelines, 3.5m traffic lane widths are considered standard [10]. This recommendation places Australian guidelines towards the upper end of lane width recommendations for arterial roads compared with international guidelines (see Table 2). In the Australian context, traffic lane width is measured from the kerb face to the centre of the marked line. This includes the gutter pan (from 500mm) and half of the lane marking (50mm of painted line, as general traffic markings are 100mm wide). This impacts on usable surface width for bicycles.

Country	Roadway classification		
	Freeway	Arterial	Minor/Local
Brazil	3.75	3.75	3.0
Canada		3.0	3.0 - 3.3
China	3.5 - 3.75	3.75	3.5
Denmark	3.5	3.0	3.0 - 3.25
France	3.5	3.5	3.5
Germany	3.5 - 3.75	3.25 - 3.5	2.75 - 3.25
Japan	3.5 - 3.75	3.25 - 3.5	3.0 - 3.25
Poland	3.5 - 3.75	3.0 - 3.5	2.5 - 3.0
UK	3.65	3.65	3.0 - 3.65
USA	3.6	3.3 - 3.6	2.7 - 3.6

Table 2. Urban road widths (in metres): Selected international locations [8]

There are provisions for considerations for wider traffic lanes, although this is limited to horizontal curves and is primarily for heavy vehicles. Several factors may allow for the provision of narrower traffic lanes of 3.3m. Situations where narrow traffic lanes may be permitted include a limited road reserve, low speed traffic environments, very low heavy vehicle traffic and satisfactory safety records [10].

Shoulder width is considered as part of the geometric design of roadways. Shoulders provide several functions, with one of them being ‘space for cyclists’ [10]. Drivers are required to drive completely in a marked lane, which does not include the road shoulder [12]. As bicycles are considered vehicles under the current road rules, this seems to suggest that bicycles should not be riding on road shoulders.

Bicycle amenity is considered in a separate section of the design guidelines. There are seven bicycle facilities outlined, and they are listed in order of safety and priority: off-road exclusive bicycle path within the road corridor; on-road segregated bicycle lane; on-road exclusive bicycle lane; on-road peak period exclusive bicycle lane; on-road bicycle/car parking lane; wide kerbside lane; and narrow kerbside lane. Facilities are considered unnecessary on local streets, due to lower traffic speeds, but are considered necessary on arterial roads and collector streets. These on-road facilities can be dedicated bicycle lanes, road shoulders, widened lanes for joint use by bicycles and moving/parked vehicles, and separated bicycle lanes.

Bicycles are given no special consideration for vertical and horizontal alignment. Consideration is given for vertical gradients; the guidelines state that ‘bicycle riders prefer to avoid hills wherever possible’ and will select the flattest alternative route [10]. This contradicts research conducted into cyclists’ route preferences, which has found that cyclists do not necessarily avoid hills, and prefer to select the most direct route [13].

Due to the specific considerations of bicycles as single-track vehicles with narrow tyres, it is important to consider the functional width rather than the measured width [14]. Design guidelines (see Table 3) suggest that consideration should be given to the kerb clearance of cyclists. On roadways with kerbs, cyclists allow 0.5m clearance from the kerb [14], although this decreases when the road is not kerbed. Cyclists will avoid surface hazards and temporary obstructions that may present stability issues.

Considering that 4.1% of all bicycle-motor vehicle crashes are a result of a car door being opened into the path of a cyclist [15], and almost 6% of mid-block crashes in Queensland [16] it may be necessary to consider whether additional space is required when parked cars are present. In shared bicycle/car parking lanes, the required space may include the parked vehicle, the width of the car door, as well as the cyclist envelope.

How lane widths affect motor vehicle driver behaviour

The following section will review research investigating how lane widths may influence driver behaviour. The focus of this section will be research into the effect lane widths have on speed choices, the difficulty of the driving task, and the perceived danger of narrower travel lanes.

The implications for narrow lane widths on self-selected driving speed have been examined in various situations. Low speed suburban environments have been investigated for curved sections of road. Results from this research have been dichotomous. Observed speed was found to decrease when lane widths were reduced, most noticeably at the mid-point of curves [17]. However, other results found no significant reduction in operating speed through horizontal curves [18].

	Desirable			Acceptable range		
	60km/h	80km/h	100km/h	60km/h	80km/h	100km/h
Exclusive bicycle lane	1.5m	2.0m	2.5m	1.2-2.5m	1.8-2.7m	2.0-3.0m
Bicycle/car parking lane	4.0m	4.5m		3.7-4.5m	4.0-4.7m	
Wide kerbside lane	4.2m	4.5m		3.7-4.5m	4.3-5.0m	

Table 3. Guidelines for bicycle facility widths for on-road facilities [7]

This research was conducted on low-speed urban roads and suburban streets. Further research would be required to determine what, if any, effects reduced lane widths had on roads with higher speeds.

The effect of lane widths has been invested on straight road sections. Research on low-speed urban roads suggests that lane width has a significant effect on self-selected speed on straight road sections. In real road situations, an increase in lane width by 1m was predicted to result in an increase in speed by 15km/h [18]. Simulator-based research supports these results. The influence of lane width on self-selected speed was found to be non-linear, but narrower lane widths did result in reduced travel speeds. Compared with 3.0m, 2.5m traffic lanes resulted in a 2.23km/h reduction in mean speed. However, there was no significant difference in mean speeds between 3.0m and 3.6m wide lanes.

Research is required to establish if a reduction in traffic lane widths increases the difficulty of the driving task or the perception of risk by drivers. Initial work in driving simulators found that especially narrow lanes (2.5m) were perceived to present a higher level of risk, although there was no significant difference in the ratings between lane widths (2.5-3.6m). Caution should be used when looking at these results. While the scale was designed specifically for the study, it has not been independently validated [19].

The same study also investigated the effect of lane width on the perceived difficulty of the driving task. Using the NASA Task Load Index, the mental, physical and temporal demand of the driving task was measured. Driver performance, effort and frustration level were also assessed for various roadway configurations. Subjective assessments by drivers found that difficulty ratings decreased when lane widths increased. Further research is required to establish the relationship between the subjective rating of task difficulty and safety.

It is important not just to consider the effect of single traffic lane widths on driver behaviour, but also the whole roadway environment. Research has shown that the total number of lanes (whole roadway width) also influences drivers' self-selected travel speed. As the road width or the number of traffic lanes increases, driver travel speed increases [20, 21]. This suggests that total roadway width can also be important in determining driver speed choices, independent of the width of the traffic lanes. Further research is required to determine if this relationship is true if the additional road space is dedicated to bicycle facilities.

The flow-on effects of lower speed choices by drivers increase the safety of all road users. Research has shown that a reduction in mean driving speed results in decreased speed variability [22]. Greater levels of speed variability have been shown to be associated with increased crash risk. As a result of these findings, it is hypothesised that a reduction in lane width that results in reduced self-selected speed would result in a reduced crash risk. The ability of a driver to control a vehicle is also affected by travel speed. Research in traffic safety has shown that increased travel speeds result in greater variability of vehicle positioning within lanes [23].

This review of the research has found that narrower lane widths result in reduced self-selected travel speed. Lower travel speeds are associated with an increase in perceived safety [20]. Research into the effects of reduced travel speed indicates that narrower lane widths would be beneficial to the safety of vehicle occupants and vulnerable road users. Narrow lane widths did not increase the perceived risk of the road environment, but were found to increase the perceived difficulty of the task. It is possible that the increase in task difficulty could have possible, as yet undetermined, implications for road safety. It is important to note that the research reviewed did not explicitly correlated speed with safety.

How lane widths affect cyclist behaviour and safety

The purpose of this section is to explore the implications on bicycle safety of roadway geometric design factors. Research has been conducted regarding the safety of traffic lane widths for vehicles. This has primarily focused on the safety of heavy vehicles and passenger cars. As far as we are aware, no such body of research exists in the area of safety of lane widths for bicycle safety.

Several factors have been found to influence a cyclist's route selection. Some of the findings may seem counter-intuitive to the non-cyclist. The primary body of evidence in this area is based in the United States, with the focus on commuter cyclists. Several facility and route factors have been identified as critical to cyclists, including shorter travel times, continuous facilities, smooth riding surface, flat to moderately hilly terrain, on-road bicycle facility in preference to a separate path, low traffic volumes and an absence of parked cars [14].

Despite experiencing collisions or falls while cycling, serious leisure cyclists were likely to rate traffic (including abuse, near misses or threats from aggressive motorists) and the ongoing risk of injury as low to moderate barriers to cycling [24]. It is important to remember that cyclists are not a homogenous group, and there a variety of trip purposes for cycling trips (recreation, leisure, commuting or training). Research suggests that off-road bicycle facilities should be considered recreational facilities rather than commuter facilities [25].

To account for the limited research between crashes and geometric design for bicycles, the concept of safety has been considered in three separate ways:

- Actual safety, typically measured through crash data
- Perceived safety, a subjective measure express by the road user
- Inferred safety, an indirect measure of safeness.

If a direct measure of safety is unavailable, it may be appropriate to evaluate safety of geometric designs by inferred measures. Measures that may be indicative of cyclists' safety may include vehicle speed when passing cyclists or the position of the motor vehicle in relation to the bicycle [26]. It could be hazardous to rely on cyclists' perceptions about safety when implementing safety interventions. Research has shown that cyclists are unable to accurately judge the speed of passing motor vehicles [27]. It is also possible that cyclists are unable to accurately assess the passing distance of motor vehicles.

It is important to also consider the road environment as a whole with regard to cyclist safety. Being single track vehicles, bicycles have inherently less stability than dual track vehicles (e.g., cars). Road surfaces and road markings have been found to present hazards to cyclists [28]. The only marking materials that did not cause significant hazards to cyclists were 2mm thermoplastic lines (no beads or calcite), waterborne paints lines (0.2mm and 0.5mm in height), and 0.2mm chlorinated rubber lines. There are several common road items that create hazards for cyclists, and these include rough ground, round utility access cover, loose gravel, domes, several thermoplastic lines (4.5mm dropon, 3.5mm, 3.5mm large beads, 7mm, 3mm dropon, and profiled thermoplastic), and RRPMs (reflective raised pavement markers) [28].

As a result of an increase in popularity of cycling in Australia (bicycle sales have increased by 140 % since 2001) [29], road authorities have considered design measures to improve cyclist safety. Initial research has found that the presence of bicycle lanes influences both driver and bicycle behaviour.

A cyclist's choice of travel path on a roadway is impacted by several roadway factors. The presence of an on-road bicycle lane results in cyclists' being less likely to demonstrate unpredictable behaviours and more likely to maintain a more consistent travel path [30]. On-road bicycle lanes also influence the positioning of bicyclists in relation to the kerb. When cycle lanes are present, there is an increase in the distance between the cyclists and road edge [29, 30].

The level of facility magnifies this trend. Lower level facilities, those marked with a single white line, result in less displacement between cyclist and kerb compared with higher level facilities (marked green bicycle lanes) [30]. Without the presence of a bicycle lane, total roadway width influences the bicycle's positioning on the road. The distance between kerb and bicycle increases as total roadway width increases [31]. The signed speed limit of the road, the number of traffic lanes and the presence of a motor vehicle also influences a bicycle's lateral positioning. Further information regarding the impact of these factors was not presented [31].

Initial research has found that the separation distance between bicycle and motor vehicle (an inferred measure of safety) during a passing manoeuvre depends primarily on the available travel space. In this context, travel space is the distance between the road marking (traffic lane demarcation, or the centreline) and the bicycle. The lateral displacement between bicycle and motor vehicle increases as travel space increases [32, 31].

The type of bicycle facility present on a roadway also impacts on the separation between bicycle and motor vehicle. Wide kerb lanes result in greater displacement between bicycle and passing motor vehicles compared with roadways where bicycle lanes are present [26, 30, 31, 33]. The presence of multiple motor vehicles during a passing manoeuvre reduces the lateral displacement between motor vehicle and bicycle [31].

As previously outlined, bicycle lanes result in bicycles behaving in a more predictable manner. Bicycle lanes also result in motor vehicles behaving in a more consistent manner, with fewer wide swerves or close passes [32]. Several other factors influence the position of vehicles in the relation to bicycles. These factors include urbanisation and the existence of a gutter pan [33].

Research has examined bicycle safety at roundabouts, bicycle crossings, intersections, road surfaces, sidewalks, street lighting, roads/paths design, and road design characteristics [31]. The primary focus of research has been the effectiveness of on-road bicycle facilities, with only one research paper investigating the effect of roadway width. There is little research identified that investigates the impact of on-road bicycle lanes on bicycle safety. Several early studies from the United States have examined the effect of bicycle lanes on cyclist safety. This research has shown that on-road bicycle lanes reduce injury rates, collision frequency or crash rates [34-37]. These papers were reviewed as part of a meta-analysis examining the effect of transportation infrastructure on bicyclist safety [39]. Research from New Zealand found that crash frequencies decreased over time in locations where bicycle facilities were not present [26]. This research was based on a single intervention site, where there was low exposure to bicycles. If bicycle facilities were implemented in nearby locations, it is possible that bicycle traffic itself decreased.

Initial research has been conducted into the effect of short-term road narrowings on cyclists. While not the primary stress of the cyclists interviewed, temporary narrowings were a source of concern. Cyclists implement various strategies to cope, including riding on footpaths and using alternative routes. Road narrowing had negative effects on driver behaviour, increasing risky behaviour. These included motorists passing closer to cyclists, and attempting to overtake the cyclists prior to the narrow point [39]. Further research is required to determine if these behaviours are observed on sections of narrower roads, rather than solely at 'squeeze points'.

The impact of various road design factors on bicycle crash severity has been examined through modelling. Two roadway design factors found to influence bicycle safety are total roadway width and road classification level (freeway, arterial or local) [40]. Other factors that influence bicycle safety include traffic volume, truck volume, population density, and commercial activity.

The results may seem counter-intuitive. Serious injury crashes were more likely to occur on wider roads, and with lower traffic volumes. Greater levels of injury severity with lower traffic volumes may be explained through possibly higher motor vehicle speeds. The relationship between roadway width and road classification level was not explored, although this may explain why wider roads resulted in serious injury crashes. A decrease in cyclists' safety when heavy vehicle density increases may be a result of the increased road width requirements of heavy vehicles.

Conclusions

It is difficult to come to definitive conclusions regarding the effect of a reduction in traffic lane widths on the safety of all road users. True experimental protocols are difficult to implement in the area of road geometry. The research in this area has employed diverse methods, making it difficult to integrate the research and make comparisons. There are differences in research design and statistical approaches, with variations in road types, traffic volume and other road factors.

It is also difficult to make conclusions about cycling safety research. Skill levels and confidence may impact on individuals' route choice, introducing bias when examining the safety of on-road facilities compared with unmarked roads. More research is required in the area of geometric design on cyclist safety. Additional research in the area of bicycle safety interventions such as bicycle lanes, especially in the Australian context, is also required, to establish their effectiveness in improving cyclist safety on urban roads.

A reduction in traffic lane width could reduce the financial and spatial burden of new roadways, and also allow for the retrofitting of marked bicycle lanes or wide kerbside lanes. The current body of research into the impact of reduced lane widths indicates that the resultant changes in driver behaviour could improve the safety of cyclists. Narrower lane widths result in drivers reducing self-selected travel speed in free flow traffic environments. A reduction in travel speed has a number of flow-on benefits, including a reduction in speed variability and improvements in vehicle handling ability. These benefits increase the safety not only of cyclists, but also pedestrians, vehicle occupants and other road users. Reduced vehicle speeds improve the outcome for cyclists and pedestrians in the event of a collision [33,41].

Preliminary research suggests that a reduction in lane width does result in an increase in the perceived difficulty of the driving task. As yet, the safety implications of the increased demand of the task have not been investigated. The increase in task difficulty may be offset by the decrease in travel speed, resulting in no effect on the safety of vehicle occupants. The perceived risk of driving has not been found to increase when lane widths are reduced. Lower travel speeds associated with reduced lane widths may explain the absence of significant difference in perceived risk.

It would be important to consider the typical vehicle types present on the roadway if reduced lane widths were to be implemented. Reducing lane widths on roadways with higher proportions of heavy vehicles may be impractical, and reduce safety, if heavy vehicles are subsequently unable to avoid lane incursions. As urban roads, with a speed limit of 70km/h and a low density of extreme heavy vehicles (A-Triples or Rigid +3), this may not be an important consideration. As an alternative for roads with high volumes of heavy traffic, it may be beneficial to create wider heavy vehicle lanes to accommodate larger vehicles to ensure the safety of all road users.

There is very little research into the effect of road geometric design factors and cycling safety. It is acknowledged that additional research is required to clearly define the implications of traffic lane widths on cyclist safety. Bicycle lanes are frequently implemented to improve the safety of cyclists travelling on roads. Further research is needed to clarify if on-road bicycle lanes have the desired effect on cycling safety.

Research suggests that narrowing traffic lane widths would result in safety improvements, such as reduced vehicle speed, but this may be lost if total roadway width is not reduced. Further research into this phenomenon is required with respect to the impact on cycling safety, particularly if marked bicycle lanes are introduced to the road environment through retro-fitting or more accommodating wider new roads. Australian guidelines still recommend traffic lane widths of 3.5m on urban roads (regardless of the provision of bicycle facilities).

While bicycle lanes have been shown to improve the interaction between bicycles and motor vehicles by making behaviour more consistent, several factors indicate they might not improve actual safety, with research being sparse and contradictory. Where a bicycle lane exists, the lateral clearance between bicycle and motor vehicles is reduced. This may suggest that recommendations of bicycle lane widths are insufficient, or a single white line is not sufficient to induce appropriate separation between bicycles and motor vehicles.

While bicycle lanes may improve perceived safety, research has shown that cyclists themselves are poor judges of the speed and position of vehicles during a passing manoeuvre. Bicycle lanes also reduce the freedom of the cyclist to assess the road and make context-appropriate judgements on position. It has been suggested that it is important for cyclists to have the 'freedom to manoeuvre', and bicycle lanes compel a cyclist to stay in the narrow bicycle lane (through traffic laws, or through motorist coercion). The absence of a bicycle lane allows the cyclists to choose how much lane to use based on the operational context, with the cyclist able to consider road conditions and other factors.

Early research has shown that marked bicycle lanes can improve cyclist safety; however, further research is required in this area to understand the mechanisms for reductions in crash rates and other measures. It is also pertinent to consider the appropriateness of shared bicycle/car parking lanes with respect to improving cyclists' safety. Further refinement of crash data is required for Queensland to evaluate the effectiveness of bicycle facilities, as the presence of marked facilities is not currently recorded in crash reports.

At present, the research suggests that reduced lane widths could improve the safety of all road users through various mechanisms. Further research is required in the area of geometric design to reach a definitive conclusion regarding the impact of narrow road lanes on cyclist safety in urban areas. Further research is required to understand the complex interactions between traffic lane width and total lane width impact on driver behaviour and cyclist behaviour, and ultimately on road user safety.

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Driver compliance with, and understanding of, level crossing controls

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Abstract

Since the early 1970s, in an effort to improve road safety, Australian railway authorities have made a concerted effort to reduce the number of level road-rail crossings, particularly those controlled by passive devices such as 'give way' or 'stop' signs. Despite this effort, approximately 1400 passive-controlled level crossings in Victoria remain in operation. To improve this situation, passive level crossings are often 'upgraded' with active traffic controls devices. Consequently, the question arises as to which of the available options represents the most effective active traffic control device at level crossings.

The main objective of the present study was to compare the efficacy, and drivers' subjective perception, of different traffic control devices at level crossings. Twenty-five fully-licensed drivers aged between 20 and 50 years participated in a high fidelity driving simulator study that compared three level crossing traffic control devices. A stop sign-controlled level crossing served as the passive referent, while two different active level crossing traffic control devices were also assessed: flashing lights and standard traffic lights.

Because traffic lights are believed to be more recognisable and to convey more salient information to drivers than flashing lights, it was hypothesised that drivers would report a preference for traffic lights over flashing lights at level crossings, and that this preference would correlate with safer driving behaviour. In fact, however, the majority (56%) of drivers reported preferring flashing lights to traffic lights, and were less likely to commit a crossing violation at one equipped with flashing lights than one with traffic lights.

Forty per cent of participants made violations at the stop sign-controlled level crossing. Collectively, results indicate that the installation of traffic lights at real-world level crossings may not offer safety benefits over and above those provided by flashing lights. Furthermore, the high rate of violations at passively controlled crossings strongly supports the continued practice of upgrading level crossings with active traffic control devices.

Keywords

Driving simulator, Driver behaviour, Subjective data, Road safety

Introduction

Road-rail level crossings exist within all road categories and can be either of two types: those controlled by active devices (i.e., that provide a signal to vehicle drivers of an approaching train), or those that are controlled by passive devices (referred to as 'passive' level crossings). The latter are characterised by signage only (usually a 'give-way' or 'stop' sign) and, as their name suggests, do not provide any active indication to drivers of the presence or absence of oncoming trains.

While the overall number of level crossings in Victoria has decreased by about 30% from the early 1970s to the year 2000, there has been, in the same period, a much larger reduction of 73% in the number of collisions and an even larger reduction of 85% in the number of deaths at railway level crossings [1]. This is likely due, at least in part, to the upgrading of many level