

Bull Bar Prevalence Among Types of Vehicle in Metropolitan Adelaide

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Abstract

The purpose of this study was to estimate the prevalence of bull bars at typical pedestrian crash sites in metropolitan Adelaide, and to disaggregate the measured prevalence by type of vehicle. In 2007 a survey was conducted to examine the proportion of vehicles fitted with bull bars in Adelaide, South Australia, at sites where pedestrian crashes had occurred in the past. The sample was stratified to examine the prevalence in separate geographical regions of the metropolitan area of Adelaide. The survey results were combined using weights determined from the relative instances of pedestrian crashes in the three survey strata. The present study paper extends the results of the original survey by recording counts of different vehicle types using video footage of the original survey enabling the proportions of bull bar equipped vehicles within each vehicle type to be determined. It was found that 45.4% of four-wheel-drive vehicles (4WDs)/sports utility vehicles (SUVs), 49.8% of work utilities, 15.6% of vans, 1.5% of passenger cars and derivatives, 28% of trucks and 23.3% of buses were equipped with a bull bar. It was also found that alloy bull bars are the most common, more than twice as common as steel bull bars and over fifteen times as common as plastic bull bars. Alloy bull bars are particularly popular on 4WDs/SUVs and sedan and sedan derivatives where their fitment is three times more common than a steel bull bar. Vans were the only type of vehicle to be more commonly fitted with a steel bull bar than an alloy bull bar.

Keywords

Bull Bar, Pedestrian, Vehicle Safety, Vehicle Types.

Introduction

Casual observation will confirm that bull bars are a common addition to many passenger and other light vehicles in Australian cities. Previous research on the impact characteristics of current bull bar designs show that many bull bars pose a danger to pedestrians and vulnerable road users in a crash. In 2006 we published findings [1] that showed that metal bull bars, and steel bull bars in particular, are likely to cause serious injury in crashes with pedestrians, and that most of the bull bars tested were more hazardous than the fronts of vehicles to which the bull bars were attached. The purpose of this exploratory study was to estimate the prevalence of bull bars at typical pedestrian crash sites in metropolitan Adelaide, and to disaggregate the measured prevalence by type of vehicle.

The prevalence of bull bars in pedestrian crashes is difficult to establish from crash records. Crash reporting systems are not always suited to this task; for example, the crash reporting system in South Australia – the Traffic Accident Reporting System (TARS) – does not record whether or not a vehicle was fitted with a bull bar. The design of the present study provides a measure of the exposure of pedestrians in accidents involving light vehicles to the presence of bull bars.

In 1980 Chiam and Thomas [2] conducted bull bar counts in Melbourne and estimated a bull bar prevalence of between 0.7 and 0.92 percent of all traffic. In 1996, the Federal Office of Road Safety estimated that bull bars were involved in 12% of fatal pedestrian collisions but may have been involved in as many as 20% [3], although it is not clear how the latter estimate was arrived at. More recently Attewell and Glase [4] used Australian national fatality data to try and estimate the effect of bull bars on fatality statistics. They were not able to draw firm conclusions due to the incompleteness of the bull bar status of vehicles in their fatality database. Furthermore, there were (and are) few data on bull bar fitment rates, and that made it difficult to estimate risks associated with bull bar fitment.

Kloeden et al. [5] examined South Australian Coroner's records of pedestrian fatalities that occurred between 1991 and 1997, and found that bull bars were fitted to 8.8% of vehicles involved in fatal pedestrian crashes. In their report, they noted that in around half of the cases, while the bull bar was often

implicated in the specific injuries that the pedestrian received, the outcome of the crash (fatality) was probably not affected by the presence of the bull bar.

In 2007 we observed traffic at a representative sample of pedestrian crash locations, and estimated the prevalence of bull bars in the passing traffic [6]. The survey used a stratified sampling scheme to estimate bull bar prevalence in three geographical regions around Adelaide. The survey sites were the locations of a random selection of pedestrian crashes that occurred in metropolitan Adelaide in 2005. To combine survey results, weighting the results of each stratum was necessary to account for the relative incidence of pedestrian crashes in each stratum. The survey found that 6%, 8.8% and 10.4% of vehicles were equipped with a bull bar in the central business district (CBD), inner metropolitan and outer metropolitan strata. The weighted average for all sites was 8.6%. The survey also found that 7.9% of light vehicles and 28.2% of heavy vehicles were equipped with a bull bar and that 67.3% of bull bars were of alloy construction, 28.5% steel and 4.3% plastic. Data related to vehicle type were limited to the type of vehicle that each observed bull bar was fitted to, and therefore fitment rates by vehicle type could not be reported. Fitment rates by vehicle type require disaggregation of the total number of vehicles observed, both with and without bull bars.

This study sought to extend the results of the 2007 survey by reviewing video footage taken at the survey locations to count the number of different types of vehicles passing each survey site. These counts are used to determine the bull bars fitment rates of different types of vehicles.

Methods

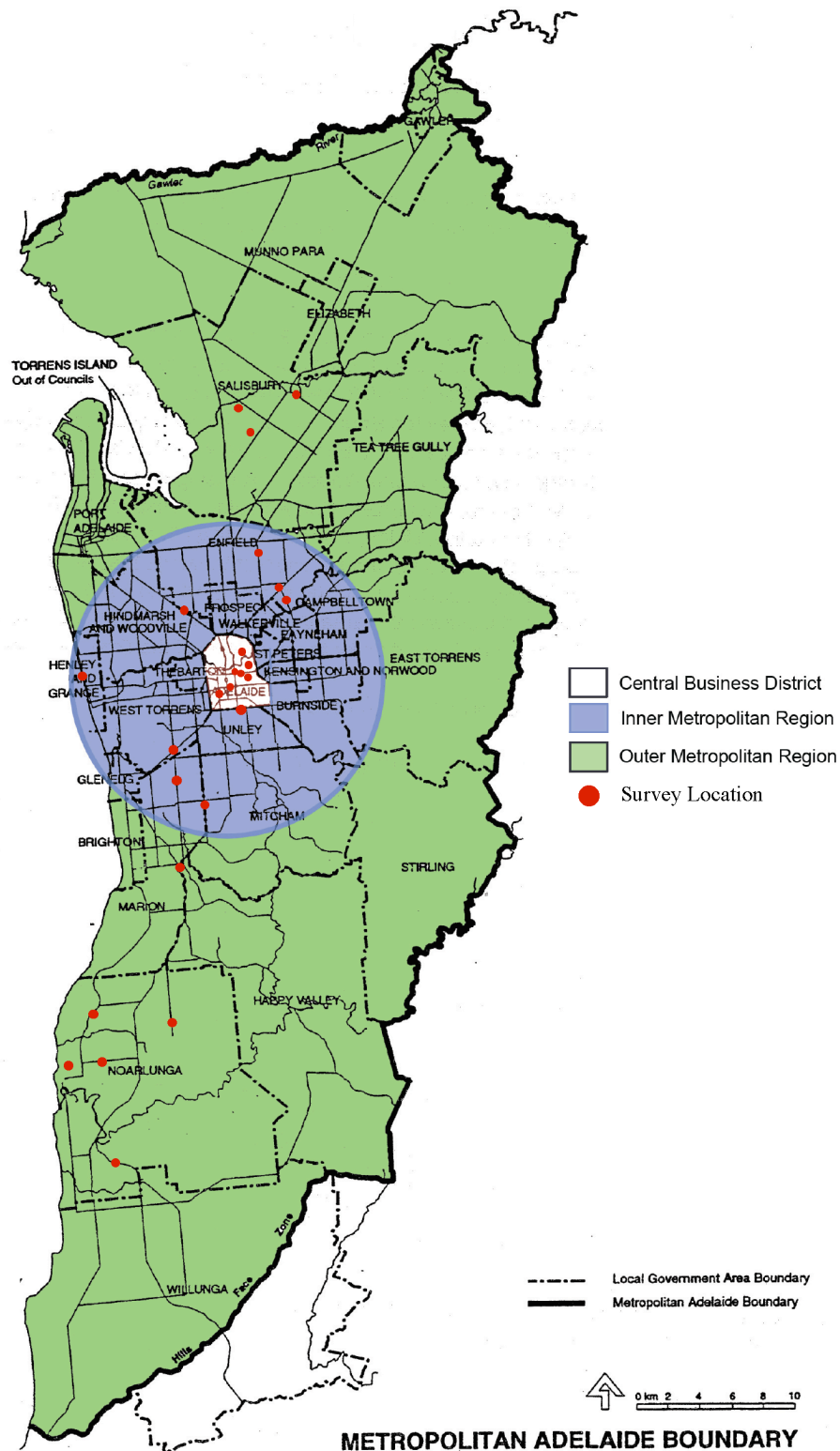
The aim of the sampling procedure was to identify a random sample of locations at which pedestrian crashes had occurred, and measure bull bar prevalence at those sites, thereby providing an estimate of the exposure of pedestrians struck by vehicles to bull bars. Measuring the prevalence of bull bars at crash sites, rather than any location on the road network, means that the prevalence measure is directly applicable to pedestrian crashes. Pedestrian crash sites are unevenly distributed across the Adelaide region and it was thought that their characteristics might vary with geographical region too. Therefore, a stratified sampling procedure was employed such that an equal number of locations were sampled from three geographical regions. The three regions were the CBD, an inner metropolitan region consisting of locations within 10 km of the Adelaide General Post Office (GPO), which is at the geographical centre of the city, and an outer metropolitan region consisting of locations more than 10 km from the Adelaide GPO, but within the Adelaide metropolitan area. These sampling strata are shown in Figure 1.

The relative proportions of pedestrian crashes that occur in the three strata were determined. These proportions provide weights that allowed the combination of the results from each stratum. Weighting the results allowed us to estimate the prevalence of bull bars in pedestrian crashes in Adelaide.

TARS was queried to determine the numbers of pedestrian crashes occurring in the three sampling strata in 2005. Crashes were included if a pedestrian required some medical treatment. Crashes were selected occurring on roads with speed limits greater than 20 km/h and not in car parks. Crashes of any type were included as long as the record included at least one pedestrian casualty. (Consequently, a few crashes were included where the crash was not coded as a pedestrian crash in TARS, but where a pedestrian was struck, usually after the primary collision.) The crashes were stratified according to the location criteria described above. The algorithm used the following logic:

- If a crash had a known location and was coded as occurring in the local government area of the Adelaide City Council, it was categorised as having occurred in the CBD (Stratum 1).
- If the crash had a known location, but was not within the CBD, but occurred within 10 km of the GPO, it was categorised as having occurred in the Inner Metropolitan Region (Stratum 2).
- If the crash had a known location but occurred 10 km or more from the GPO, and was coded as having occurred in a local government association within the Adelaide Statistical Division, it was coded as having occurred in the Outer Metropolitan Region (Stratum 3).

In 2005, 23.3% of pedestrian casualty crashes (with known locations) in the Adelaide Statistical Division occurred in the CBD, 48.8% in the Inner Metropolitan Region and 27.9% in the Outer Metropolitan Region. These proportions were used as weights when combining the results of the survey results of the three individual sampling strata. The period 2004-2006 was also examined, and crashes occurring in this period produced nearly identical weights.



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Figure 1: The three sampling strata chosen within the Adelaide Metropolitan Boundary.

(Source: Atlas of South Australia 2007 <http://www.atlas.sa.gov.au>)

As mentioned previously, survey locations and times were a stratified random sample of the location, day-of-week and time-of-day of pedestrian crashes in Adelaide. A randomly ordered but complete list of all crashes resulting in a pedestrian casualty was extracted from TARS for the year 2005 where the severity was coded either as 'Doctor Treated', 'Hospital Treated', 'Hospital Admitted' or 'Fatality'. This yielded a list of 465 individual pedestrian crash locations across South Australia. These individual crash locations were then categorised according to the stratum in which they fell, based on the criteria discussed above, and those falling outside the Adelaide statistical division were discarded.

The crashes considered for selecting survey sites were those where a passenger car, or passenger car derivative, was involved in a collision with a pedestrian. A total of 344 crashes resulting in at least one pedestrian casualty (with known locations) in 2005 fell within the three strata used in the survey (74% of all pedestrian casualty crashes in South Australia).

As the primary focus of the study was bull bar prevalence in the light vehicle fleet in the traffic stream, crashes involving buses, trucks, or motorcycles were excluded as were cases where vehicles were reversing out of car parks on main thoroughfares or where vehicles were moving from a parked position. Crashes that occurred on no-through roads or on roads that led to car parks were also excluded. Ten survey sites within each of the three survey strata were selected from the randomised list, starting at the top of the list and working down until ten locations in each stratum had been selected.

Observations of the traffic at each location were made for 40 minutes; 20 minutes before and after the time of the associated pedestrian crash. The survey included all vehicles in all traffic lanes in the same direction as the vehicle involved in the crash. Traffic at survey locations during daylight hours (and some night hours) was also recorded on video: recordings of twenty five of the thirty surveys were made and have been archived.

Two research officers collected all of the survey data. One person used two 'click' type counters with a range from 0 to 9999: one counter for recording the total number of light vehicles, and the other counter for recording the total number of heavy vehicles. Light vehicles included all vehicles that can be driven with a car licence but whose mass is no greater than that of a South Australian Ambulance (Mader Mercedes Benz, Type 2MB Ambulance) – 2680 kg. Small mini-busses such as the Toyota Hiace are included in the light vehicle category, but larger commercial mini-busses were included in the heavy vehicle category. Any vehicle requiring a Rigid Vehicle licence or Combination Vehicle licence was designated a heavy vehicle.

The second person used a survey sheet, and recorded all vehicles that had any sort of commercially produced 'vehicle frontal protection device' (typical bull bar, nudge bar or grille protection bar) and the type of vehicle it was attached to.

The observer recorded the predominant material that the bar had been manufactured from: steel, alloy or plastic. This task was difficult in some instances but a best assessment was made for each bull bar, based on prior physical examination of several bull bar types and the study of bull bar product brochures.

There were two main attributes that were used to characterise the type of metal bull bar. The first of these was colour. Generally if a bull bar had a metallic finish it was judged to be an alloy bar. If it was painted a colour other than silver (usually black), it was judged to be a steel bull bar. If the colour of the bull bar was not sufficient to judge the type, the bull bar's geometry was noted: if the observed bull bar had a large diameter top bar and no or only a small amount of metal plate, it was judged to be an alloy bull bar. If it had a smaller diameter top bar or significant use of plate metal it was judged as steel. Finally, manufacturing methods of bull bars could also help identify type: bumper sections of steel bar are generally pressed or folded sections compared with alloy bumper sections that tend to be extruded or stamped.

Plastic bull bars were identified from the colour, finish and geometry. Distinctively, many rotationally moulded plastic bull bars are moulded as a single part.

Passenger cars and derivatives included all vehicles having the frontal geometry of a typical car. This included taxi-cabs, as well as low-to-the-ground all-wheel-drive vehicles such as the Subaru Forester. Low-to-the-ground utility vehicles such as Holden 1-tonne utilities were also defined as a 'passenger car or derivative' for this purpose because of their frontal geometry (this classification may not apply for other purposes). Four-wheel-drive vehicles (4WDs)/sports utility vehicles (SUVs) included all high-off-the-ground wagon style vehicles (eg. Mitsubishi Pajero, Ford Territory). Work utilities included all commercial style cab-chassis vehicles with a tray, or tray and canopy and high ground clearance, typically 4x4 (e.g. Toyota Hilux 4x4 cab chassis). Vans included all forward control passenger vehicles and commercial vans (ambulances were the limiting case). Trucks included all rigid and articulated truck type vehicles, including light trucks and prime movers. Buses included all large passenger transport vehicles excluding public transport buses.

Traffic at survey locations during daylight hours (and some night hours) was also recorded on video: recordings of twenty five of the thirty surveys were made. An observer reviewed the video recordings using three 'click' type counters with a range from 0 to 9999 to count vehicle types, irrespective of bull bar fitment: one for recording the total number of 4WD/SUVs, one for recording the total number of work utilities and one for recording the total number of vans. The sum of these three counters could be subtracted from the total light vehicle count to determine the number of passenger cars and derivatives. The rare occurrence of a private bus was recorded on paper and this number was subtracted from the total heavy vehicle count to determine the total number of trucks. An assumption was that the omission of five sites from the survey would not materially affect the results, but note that the omissions are biased toward night time surveys.

Results

Table 1 shows the number of the different types of vehicle counted in each sampling strata, the numbers fitted with bull bars, and the weighted average percentage with bull bars (see Methods for the weights applied). The total vehicles and bull bars counted at the sites that could not be reviewed because a video had not been recorded are also included in Table 1.

It should be noted that the percentage of vehicles equipped with a bull bar in each stratum is the traffic-volume weighted average and as such is more strongly affected by sites that had greater traffic flow. The percentages can be thought of as the average prevalence of bull bars among vehicles of certain types passing the sites of pedestrian crashes in Adelaide.

10.4 % of all vehicles observed in the Outer Metropolitan Region had a bull bar. This region also had the lowest total traffic volume (28% of the total traffic volume in the survey). The central business district had the highest traffic volume recorded (38.5% of total traffic volume in the survey) and had the lowest prevalence of bull bars: 6%. The Inner Metropolitan Region had a bull bar prevalence of 8.8% and 33.5% of the total traffic volume. The weighted average proportion of vehicles observed with a bull bar fitted was 8.6%.

Work utilities had the highest bull bar fitment rate (weighted average 49.8%). Around 57% of work utilities in the outer metropolitan stratum were fitted with a bull bar.

Almost half of 4WD/SUVs were fitted with a bull bar (45.4% weighted average). It is interesting to note the proportion of 4WD/SUVs with bull bars rises sharply as one moves out from the CBD to the inner and outer metropolitan strata (increases of 8.9% and 19.5%). Similar rises between the CBD and the inner and outer metropolitan strata were observed for trucks and vans.

The 23.3% of buses that were fitted with a bull bar contributed very little to the total as they represented only 0.2% of the total traffic volume. Conversely the 1.5% of passenger cars and derivatives that were fitted with a bull bar contributed more to the total, as they represented 78.2% of the total traffic volume observed.

The prevalence of bull bars in the unreviewed sites was lower than that of the total traffic volume in all strata but these sites account for only 10.6% of the total traffic volume.

Table 1: The number of bull bars observed by vehicle type in each region, and the corresponding bull bar prevalence

Vehicle Category		CBD	Inner Metro. Region	Outer Metro. Region	Weighted Average
4WD/SUV	Number of vehicles	443	355	299	
	Number of bull bars	159	159	163	
	Percentage of vehicles with bull bars	35.9%	44.8%	54.5%	45.4%
Work Utility	Number of vehicles	116	170	173	
	Number of bull bars	59	77	98	
	Percentage of vehicles with bull bars	50.9%	45.3%	56.7%	49.8%
Van	Number of vehicles	264	315	217	
	Number of bull bars	25	53	40	
	Percentage of vehicles with bull bars	9.5%	16.8%	18.4%	15.6%
Passenger Car and Derivatives	Number of vehicles	3686	3477	2894	
	Number of bull bars	37	58	47	
	Percentage of vehicles with bull bars	1.00%	1.7%	1.6%	1.5%
Truck	Number of vehicles	104	190	122	
	Number of bull bars	20	54	42	
	Percentage of vehicles with bull bars	19.2%	28.4%	34.4%	28.0%
Bus	Number of vehicles	12	6	12	
	Number of bull bars	3	1	4	
	Percentage of vehicles with bull bars	25.0%	16.7%	33.3%	23.3%
Unreviewed Sites	Number of vehicles (all types)	918	302	306	
	Number of bull bars	30	21	26	
	Percentage of vehicles with bull bars	3.3%	7.0%	8.5%	6.6%
Total	Number of vehicles (all types)	5542	4815	4022	
	Number of bull bars	333	423	420	
	Percentage of vehicles with bull bars	6.0%	8.8%	10.4%	8.6%

Table 2 shows the proportions of each vehicle type fitted with a bull bar, split by bull bar material. Alloy bull bars were the most common type fitted to all types of vehicle except to vans. They were most common on 4WD/SUVs: 32.9% of 4WD/SUVs observed had an alloy bull bar. Work utilities had a high proportion of steel bull bars (20.5%) but note that the number of steel bull bars observed on 4WD/SUVs was greater (owing to the larger number of 4WD/SUVs in the sample). As a vehicle type, work utilities also had the highest proportion of plastic bull bars (2.2%) but numerically, work utilities with plastic bull bars were outnumbered by passenger cars and derivatives with bull bars (24).

Table 2: Percentages of vehicle types fitted with bull bars in all sampling strata. The number of observations is in parenthesis.

Vehicle type	Percentage of vehicle type equipped with an alloy bull bar (obs.)	Percentage of vehicle type equipped with a steel bull bar (obs.)	Percentage of vehicle type equipped with a plastic bull bar (obs.)	Total number of bull bars observed	Percentage of vehicle type observed with any bull bar type
4WD/SUV	32.9% (361)	10.4% (114)	0.5% (6)	481	43.8%
Bus	23.3% (7)	3.3% (1)	0.0% (0)	8	26.7%
Passenger Car	0.9% (86)	0.3% (32)	0.2% (24)	142	1.4%
Truck	24.8% (103)	1.7% (7)	1.4% (6)	116	27.9%
Van	6.8% (54)	7.9% (63)	0.1% (1)	118	14.8%
Work Utility	28.3% (130)	20.5% (94)	2.2% (10)	234	51.0%
All types	5.8% (741)	2.4% (311)	0.4% (47)	1099	8.6%

Discussion

Currently, TARS does not contain the information needed for a direct estimate of the prevalence of bull bars in pedestrian crashes. The presence of a bull bar is not coded and appears to be inconsistently recorded in the free text description of the crash. It also does not record unit type as 4WD, except for fatal cases since 2003, instead typically recording a 4WD/SUV as a station wagon.

This study has estimated the prevalence of bull bars at typical pedestrian crash sites in metropolitan Adelaide, and disaggregated the measured prevalence by type of vehicle, by building upon the results obtained in a survey conducted in 2007 that estimated the prevalence of bull bars in the vehicle fleet in Adelaide. A feature of the survey was that it was conducted at the locations, and at the time-of-day and day-of-week of pedestrian crashes in Adelaide, South Australia. Having done so, we estimate that around 1.5% of crashes involving a passenger car or derivative, 15.6% involving a van, 28% involving a truck, 45.4% involving a 4WD/SUV and 49.8% involving a work utility involve a vehicle equipped with a bull bar. The small number of buses observed does not allow us to draw any conclusions from the results regarding the prevalence of bull bars amongst privately operated buses involved in pedestrian crashes. (Note that we excluded public transport buses from our survey). The great majority of pedestrian crashes reported to police (around 99%) are casualty crashes (South Australian Traffic Accident Reporting System), and so we should consider that our sites might have been biased toward sites with high bull bar prevalence. However, because the measured total prevalence of bull bars is low, even a considerable increase in risk of injury is unlikely to have distorted our results in any significant way. The results might also have been biased by the exclusion of five of the original sites, which did have lower overall bull bar prevalence than the total sample. However, because these excluded sites contained only 10.6% of the total traffic counted and this study sought to determine the prevalence of bull bars among types of vehicle (not the overall prevalence) this is unlikely to have altered our results significantly.

In many pedestrian crashes, the presence of a bull bar is likely to make the severity of any injuries to the pedestrian worse. Previous testing has shown that a bull bar is generally more likely to cause severe injuries to a pedestrian in a crash than the front of a vehicle [1,7]. While this is not always the case for plastic bull bars, they appear to constitute only a small proportion of the bull bars fitted to vehicles in Adelaide – around 4% of all bull bars.

Theoretically, the results obtained in this study could be used to provide exposure data for the calculation of relative risks of serious injury associated with bull bar fitment in a series of crashes. However, such crash data would need to reliably code the presence of a bull bar, and potential confounders (such as any increase in the risk of crash involvement associated with bull bar fitment) would also need to be controlled before doing so.

Almost half of all work utilities and 4WD/SUVs were fitted with a bull bar. The volume of 4WD/SUVs observed was only second to passenger cars and derivatives. Thus 4WD/SUVs account for a large proportion of vehicles fitted with bull bars – greater than passenger cars and derivatives. Around a quarter

of all trucks and buses were fitted with bull bars but we do not know what difference the fitment of a bull bar makes to pedestrian casualties involving these types of vehicles, given that the outcome of crashes is often severe, with or without a bull bar.

4WD/SUVs were most common in the CBD stratum, representing 9.6% of the total traffic, 1.7% higher than in the inner metropolitan stratum and 1.6% higher than in the outer metropolitan stratum. Work utilities were most common in the outer metropolitan stratum, representing 4.7% of the total traffic volume, 0.9% higher than in the inner metropolitan stratum and 2.2% higher than in the CBD stratum.

Alloy bull bars were the most common type of bull bars observed, more than twice as common as steel bull bars and over fifteen times as common as plastic bull bars. Alloy bull bars were particularly prevalent on 4WD/SUVs, and passenger cars and derivatives, where their prevalence was three times that of steel bull bars. Alloy bull bars were more prevalent on work utilities than steel bull bars, but the difference in the prevalence was not as great as that observed amongst 4WD/SUVs. Vans were the only vehicle type that had a higher prevalence of steel bull bars than alloy bull bars. An explanation for these differences may lie in the different typical application of these types of vehicle, 4WD/SUVs and passenger cars and derivatives for commuting purposes rather than commercial use of vans and work utilities.

Higgins [8] presented a common notion when he suggested that the decision to fit a bull bar could be related to a conscious or subconscious desire to project a certain image of the driver, similar to a fashion statement. While this might explain the popularity of alloy bull bars on domestic 4WD/SUVs, such an explanation may be too simplistic overall when accounting for prevalence-weighted fitment patterns, where we observed differences in the fitment rates of types of bull bar to different vehicle types; these differences point to more functional motivations for fitting bull bars to some vehicle types.

If the differences in the patterns of fitment reflect differences in the motivation on the part of the vehicle owner, then strategies for reducing their prevalence might also reflect these motivations. If bull bars are fitted only for reasons of fashion, the high prevalence of bull bars may be dealt with, with a ban. However, if bull bars are fitted because they fulfil a perceived need (e.g. to protect commercial vehicles in work environments, or rural vehicles from animal strikes), manufacturers might consider ways in which adequate protection can be achieved without resorting to the fitment of steel or alloy bull bars, which present added dangers to vulnerable road users [1].

If occurrences of bull bars in urban areas are to be reduced without regulatory intervention a better understanding of the motivating factors behind their fitment will be needed. The authors suggest this as a focus of future research.

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