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Motor traffic on urban minor and major roads: impacts on pedestrian and cyclist injuries

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This paper compares per-mile risks posed by motor traffic to pedestrians and cyclists on urban major and minor roads. Carrying out new analysis of police injury data from 2005 to 2015, this study finds that per billion vehicle miles, motor vehicles on minor roads create more pedestrian casualties than motor vehicles on major roads. Specifically, for killed or seriously injured (KSI) casualties the rate per billion motor vehicle miles is 17% higher on minor roads (47 against 40 KSIs per billion vehicle miles), while for slight injuries it is 66% higher (188 against 123 slight injuries per billion vehicle miles). Examining the costs of injuries sustained, these are 7·4% higher for pedestrians per motor vehicle mile travelled on urban minor roads, compared with major roads. For cyclists, injuries per mile driven are similar on major and minor roads. These results suggest that re-routing motor traffic to major roads in urban areas may reduce pedestrian casualties. Cyclist safety on major roads should be improved to avoid unintended negative consequences and ensure positive outcomes for cycling.

1. Introduction

There is an extensive literature on pedestrian road injuries, covering a variety of behavioural and infrastructural risk factors, and potential solutions. However, two crucial determinants of pedestrian road injury risk are the volume and the speed of the motor traffic with which pedestrians interact (Elvik, 2013; Elvik and Bjørnskau, 2017). As Stoker *et al*. (2015: p. 384) state, '[r]esearch worldwide consistently finds that the higher the [motor] traffic volume, the greater the frequency of pedestrian injuries' while '[v]ehicle speeds are repeatedly associated with increased injury severity and death in motor vehicle collisions involving pedestrians'.

Hence, an 'upstream' approach to reducing pedestrian risk will focus on minimising pedestrian exposure to motor traffic, and reducing the harm imposed by such interactions, for example through reducing motor vehicle speeds. Stoker *et al*. (2015) comment that roadway treatment has been shown to be the single most consequential intervention in reducing pedestrian injury and fatality rates. Such treatments might include, for instance, providing separated footways for pedestrians, using traffic calming to deter motorists from certain routes and/or slow them down, and protecting pedestrians where they must cross motor vehicle streams.

An upstream approach shifts attention away from looking at what pedestrians might do to protect themselves, towards reducing the source of danger and/or its impact – that is motor vehicles (Davis, 1993). Recent research in London has indicated that such measures can succeed in reducing injury rates. Green *et al*. (2016) examined the impact of the London Congestion Charge and found two positive effects: first, a decline in motor traffic volumes (which itself reduced injuries, by cutting the numbers of potentially risky interactions) and second, that each remaining motor vehicle posed less risk (Green *et al*. (2016) attribute this to a reduction in congestion and hence smoother traffic flow, but this could potentially be due to other factors). Another recent study in London focusing on 20 mph zones confirmed these were successful in reducing casualties (Grundy *et al*., 2008). Population-based measures can further assist in reducing social gradients in road injury (Steinbach *et al*., 2011).

Like speed, road class may be important in shaping the risk posed by each motor vehicle. Many crashes occur on urban arterial roads, with vulnerable road users at particular risk (Turner *et al*., 2014). Given this, it is important to consider how injuries to vulnerable road users might change, if usage of the road network changes. The rapidly growing use of in-car GPS systems has the potential to radically change where drivers go, allowing them to bypass congestion and hence improving network efficiency, particularly with the use of dynamic routing systems (Hounsell *et al*., 2009: p. 7). The introduction of variable congestion charging could further encourage this, with drivers incentivised to avoid congested main roads at peak and use alternative streets.

However, concern has been expressed (Kojima *et al*., 2015) that the potential consequent increase in 'rat-running' through local neighbourhoods could have potentially negative consequences for residential streets. In some cities this has been a spur to introduce 'modal filtering' (Melia, 2016) closing residential streets to through motor traffic. Initial results from London (e.g. ES, 2016) suggest area-wide decreases in motor traffic, in line with the traffic evaporation thesis (Cairns *et al*., 1998). There are likely still to be some increases in motor traffic on local major roads, as not all displaced traffic evaporates. However, there has been little consideration of what the injury impacts might be of such redistribution of motor traffic.

In response to these social and policy changes, this paper explores the risk posed to pedestrians by drivers on urban major roads, compared with urban minor roads. It has incorporated risks posed to cyclists, as initial analysis suggested impacts on cyclists might differ from impacts on pedestrians, hence unintended consequences of policy should be considered. It was also considered important to cover cyclists because policy seeks to increase levels both of walking and cycling, and to reduce the risks associated with using both 'vulnerable' yet sustainable and healthy modes.

2. Methods

This paper uses police injury collision data (Stats19) to explore pedestrian and cyclist injury risk on major and minor urban roads. The analysis examines whether motor vehicles travelling on minor streets pose more, or less, risk to vulnerable users than motor vehicles travelling on major roads (For 2011–2016, similar analysis for pedestrians only has been done on an annual basis in DfT Table RAS30018. This paper has used original Stats19 data, enabling the inclusion of more years and of cyclists.). Under the British road classification system, A roads are designed as part of the Primary Route Network as being 'major roads intended to provide large-scale transport links within or between areas' (DfT, 2012: p. 6). By contrast, 'unclassified' roads ('C' or below) are 'local roads intended for local traffic' and 'B' roads are connectors allowing motor traffic to flow from A roads onto such local roads. Here the comparison is between those urban roads defined as A roads (designed to take large volumes of motor traffic) and other streets.

There are different ways to calculate and compare risk. Frequently, the user risk per mile travelled is compared for different modes. For this question, such a calculation is less helpful. Lower risks per pedestrian mile travelled on residential streets do not necessarily imply that pedestrian casualties would fall if motor vehicles moved from arterial to residential streets. The analysis here focuses on the level of risk attached to each motor vehicle mile travelled on the different classes of street. The analysis here is related to that conducted by Allan *et al*. (2014), who compare the injury risk posed by large goods vehicle (LGV) and heavy goods vehicle (HGV) kilometres driven in London, with implications for the merits of delivery consolidation or, conversely, replacing HGVs with LGVs.

To explore the association between road class and injury rates, Stats19 data for 2005–2015 was downloaded from data.gov.uk. Only urban injuries were selected, as it was considered that in rural areas, with sparser road networks, there might not always be an alternative (A road or non-A road) route – and more broadly road environments and risk characteristics of urban and rural roads differ substantially. Motorways and A(M) classified roads (the latter representing upgraded sections of A road) were excluded as there are relatively few within urban areas, and again might not be alternative routes (As relatively few pedestrian injuries occur on motorways, including them might bias the results making A roads appear safer. Only injuries involving motor vehicles were selected. Constituting the overwhelming majority (>95%) of pedestrian and cyclist injuries in Stats19 data, these were chosen as the focus is injuries as they vary in relation to motor vehicle distance. Some incidents involve more than one motor vehicle. For pedestrians, these represented 5·7% of collisions on relevant roads; with slightly higher rates on unclassified roads (6·4%); for cyclists these represented 2·8% of incidents with no statistical differences between road classes. Where more than one motor vehicle is involved, any casualty or casualties have been attributed to all motor vehicles.).

Data were obtained from DfT Road Traffic Statistics giving miles travelled per year along different road classes, for 2005–2015 (for 2006–2015, a breakdown by vehicle type is also available). This was used to calculate pedestrian and cyclist injuries rates per billion motor vehicle miles, for each road class. Department for Transport (DfT) Appraisal Guidance ('WebTAG') was used to establish costs (at 2015 prices) for different categories of injury. The resulting figures quantified and monetised risks to pedestrians and cyclists in urban areas for A roads against all minor roads, per billion motor vehicle kilometres. Finally, the risk differential between major and minor urban roads was explored specifically in relation to LGVs and HGVs.

This is a simple analysis with many limitations. For instance, while Stats19 data captures all or almost all deaths, coverage of serious and slight injuries is patchier, although generally coverage is much better for those incidents involving motor vehicles than those that do not (Ward *et al*., 2006). Comparisons with Hospital Episode Statistics data suggest a recent decline in the completeness of recording serious injuries in Stats19 (Gill *et al*., 2006). There may be further bias affecting results. For instance, while there is no evidence of this, it is possible that injuries on major roads are reported more completely than those on minor roads.

The use of DfT volume data also implies limitations and potential error. The data are based on manual and automatic counts at thousands of sites across Britain. Counts are not carried out every year on major roads, but rather up to every eight years and factored up based on calculated expansion factors and growth rates. A panel survey of 4000 sites surveyed annually is used to produce minor road estimates. While there is inevitably some error and natural variation, DfT (2015) considers that at a national level estimates are robust, although at per-site level variance is higher for minor road counts with lower motor traffic volumes. Within the set of urban minor roads there is substantial variation in motor traffic volume, although due to a lack of traffic counts on most minor roads the extent of this is frequently under-estimated (Morley and Gulliver, 2016). DfT suggests that pedal cycle counts are the least robust of all, however, such counts are not central to the analysis here.

The analysis does not consider other changes that might result from a shift in vehicle distribution across the network: for instance, factors such as potentially lowered speeds due to increased congestion, nor the potential for changes in overall demand where capacity changes within a network. Minor roads are more likely than major roads to have 20 mph limits, likely to contribute to different levels of road danger; but there is no national data in Britain on the extent of 20 mph limits. Finally, by calculating injuries per motor vehicle kilometre, the analysis provides an intuitive measure of risk per vehicle. However, motor vehicle volumes are likely to have a logarithmic relationship to injuries – that is it is relative rather than absolute changes that matter, and such relative changes (increase or decrease) will be larger on roads initially carrying smaller volumes of motor traffic (Aldred *et al.*, 2018).

3. Results

3.1 All motor vehicles

Table 1 illustrates the numbers of casualties for both pedestrians and cyclists where one or more motor vehicles were involved, for urban A roads and minor roads, recorded in Stats19 between 2005 and 2015. In terms of absolute numbers cyclist casualties are substantially lower than pedestrian casualties, linked to the much lower mode share of cycling compared to walking in Great Britain. For both pedestrians and cyclists, a higher number of fatal injuries took place on urban A roads than on minor urban roads. The typical injury for each however is a slight injury taking place on a minor urban road, particularly for pedestrians where this type of incident makes up 80% of injuries involving motor vehicles in urban areas.

Table 1. Pedestrian and cyclist casualties involving motor vehicles on urban roads, Britain 2005–2015

	Fatal	Serious	Slight	All
Pedestrian casualties, motor vehicles involved, urban roads				
A	1925	20 191	67 397	89 513
All minor	1814	32 183	135 281	169 278
Cyclist casualties, motor vehicles involved, urban roads				
A	336	9067	56 861	66 264
All minor	247	12 273	78 431	90 951

Traffic volume statistics from DfT were used to establish injury rates per billion motor vehicle miles. Between 2005 and 2015, in urban areas, 547 billion vehicle miles were travelled on A roads and 719 billion vehicle miles on urban minor roads. A roads make up around 8% of road distance in urban areas, and urban minor roads 92%. Hence, the average volume of motor vehicle traffic on urban A roads per mile of road is around nine times higher than the average volume of motor vehicle traffic on urban minor roads. Figure 1 illustrates the comparison between A and minor urban roads, for pedestrian injuries. This separates ‘KSIs’ (casualties killed or seriously injured (KSI)) from slight injuries. For KSI casualties the rate per billion motor vehicle miles is 17% higher on minor roads (47 against 40 KSIs per billion vehicle miles), while for slight injuries it is 66% higher (188 against 123 slight injuries per billion vehicle miles).

However, Figure 2 shows that the picture is not the same for cyclist injuries. Here rates per billion vehicle miles are similar for both types of road – almost identical for KSIs and only 3·8% higher for slight injuries. Therefore, while the number of pedestrians injured per motor vehicle mile is higher on urban minor roads than for urban A roads, the same is not true for cyclists.

Between 2005 and 2015, DfT traffic statistics estimate that 4·6 billion miles were cycled along urban A roads, compared with 19·4 billion miles along urban minor roads. As urban minor roads are 11·5 times longer in total than urban A roads, this equates to a cyclist flow per mile of urban A road around three times that for urban minor roads. Returning to the

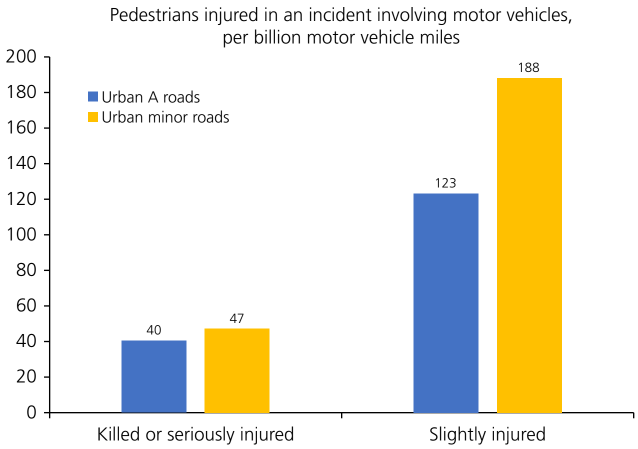

Figure 1. Pedestrian injuries, urban A roads against urban minor roads

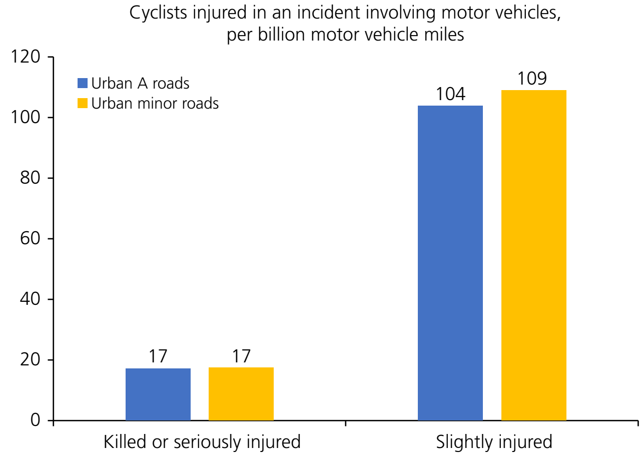

Figure 2. Cyclist injuries, urban A roads against urban minor roads

similar per-vehicle-mile KSI figures, this tells us that a driver is around three times more likely to kill or seriously injure each cyclist that they encounter on a minor road, compared with each cyclist they encounter on an A road. However, because motor traffic volumes are relatively high on A roads, this translates into substantially higher risks per cycled mile on A roads. Similar figures are not available to examine pedestrian volumes by road class, but one might expect most miles walked to similarly be along minor streets. For example a study by Ward *et al*. (1994) in Northampton found that only around 15% of pedestrian activity was along busy roads (primary and district distributors).

Now Figure 3 presents results for deaths. Here the picture is different: while deaths for both pedestrians and cyclists are relatively infrequent within the casualty statistics, they are more likely to occur on A roads. For pedestrians injured by motor vehicles, where the incident took place on an urban A road 2·2% led to fatality, compared with 1·1% for urban minor roads. For cyclists, rates were 0·5 and 0·3%, respectively. This higher risk of more severe injury may largely be due to higher free-flow speeds likely on A roads compared with more minor roads, particularly smaller residential streets.

> Struck by a vehicle traveling forty miles per hour, a pedestrian has an 85 percent chance of being killed. The fatality rate drops to 45 percent at thirty miles per hour and to 5 percent at twenty miles per hour or less (Ewing and Dumbaugh, 2009: p. 349)

Finally, this section uses the DfT WebTAG to compare the economic costs of injury collisions (2015). This gives a summary metric incorporating costs attributed to all injury severities. Injury costs per motor vehicle mile travelled on urban minor roads are 7·4% higher for pedestrians, compared with major roads. The figure for cyclists is reversed, with costs 4·2% higher per mile driven on A roads. Hence, diverting vehicle miles from minor to urban A roads would bring an overall economic benefit in reducing pedestrian and cyclist injuries (Figure 4).

3.2 LGVs and HGVs

Second, the paper compares risks posed by LGVs and HGVs on urban A or minor roads. This was chosen for further analysis due to (*a*) concern about risks that HGVs pose to cyclists and pedestrians in urban areas and (*b*) a substantial increase in LGV miles in some urban areas, such as London. Table 2 shows the distance travelled, in billion vehicle miles, by LGVs and HGVs between 2005 and 2015 (Tables from DfT broken down in this way only covered 2006–2015, so the distances

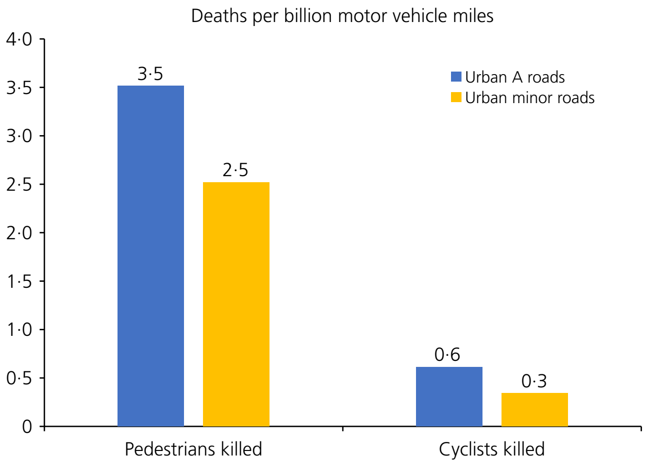

Figure 3. Pedestrian and cyclist deaths, urban A roads against urban minor roads

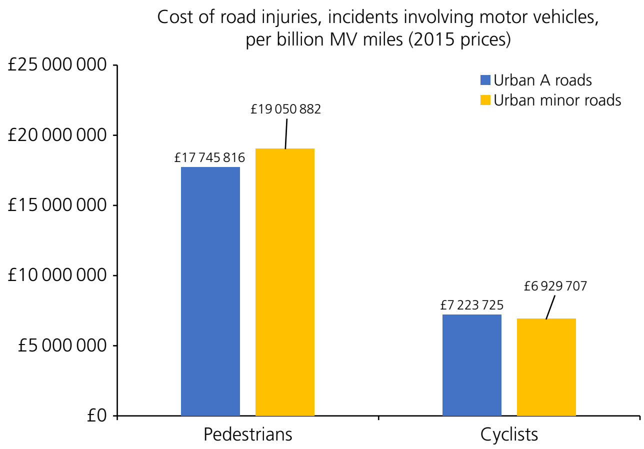

Figure 4. Economic costs of pedestrian and cyclist injuries, urban A roads against minor roads

were scaled up based on vehicle miles covered in 2005 by all vehicles.).

Table 3 illustrates pedestrian and cyclist injuries involving vans, in urban areas, while Table 4 presents pedestrian and cyclist injuries involving HGVs.

Figures 5 and 6 illustrates differences in casualty rates for cyclists and pedestrians, based on LGV mileage. Here the greater risk to pedestrians posed by LGVs on minor roads is countered by a greater risk posed to cyclists on A roads. Each van mile shifted from a minor to an urban A road would benefit pedestrians, but there is an increase in risk for cyclists, albeit smaller than the pedestrian benefit.

Figures 7 and 8 compare the risk posed to cyclists and pedestrians by HGVs on the different road types. HGVs pose substantially higher injury risk to pedestrians and cyclists than do smaller vehicles, with for instance 82·6 pedestrian KSIs casualties per billion HGV miles on urban minor roads, compared with 23·1 pedestrian casualties per billion LGV miles on urban minor roads.

For HGVs, the discrepancy between road types is much greater than for LGVs. A mile driven by an HGV along a minor urban road results in more than twice as many pedestrian casualties as does a mile driven by an HGV along an urban A road. For cyclists, there is a benefit from shifting HGV miles from minor to A roads, although the benefit is smaller than for pedestrians.

Table 2. Distance travelled 2005–2015, LGVs, HGVs and all motor vehicles

	LGVs	HGVs	All motor vehicles
All urban 'A' roads	62·1	15·6	547
Minor urban roads	88·3	8·6	719

Table 3. Pedestrian and cyclist injuries involving LGVs, urban areas

	Fatal	Serious	Slight
Pedestrians			
A road	112	1098	3625
Minor	157	1880	7633
Cyclists			
A road	18	713	4240
Minor	18	816	4210

Table 4. Pedestrian and cyclist injuries involving HGVs, urban areas

	Fatal	Serious	Slight
Pedestrians			
A road	263	585	1129
Minor	160	553	1852
Cyclists			
A road	120	413	1315
Minor	47	261	869

4. Discussion

The findings of this paper are relevant to considering the merits of likely or desired shifts in motor traffic between minor and major urban roads. Clearly the discussion must be tentative given the relatively simple analysis conducted here. More research, for example examining the actual impact on injuries of vehicular shifts between road categories, is needed. Still, the paper has generated some interesting findings with implications for policy and road design.

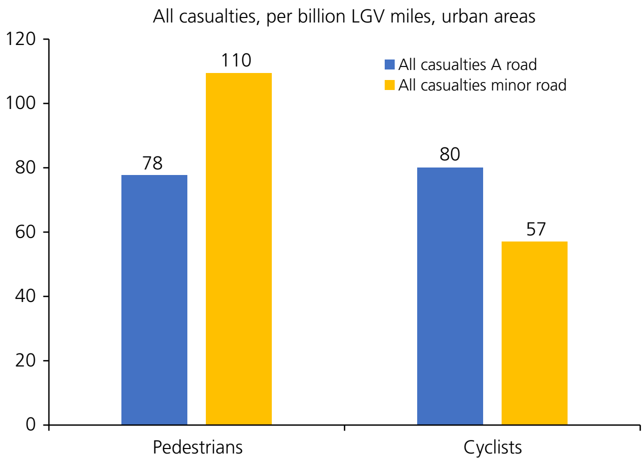

Figure 5. All casualties, LGVs involved

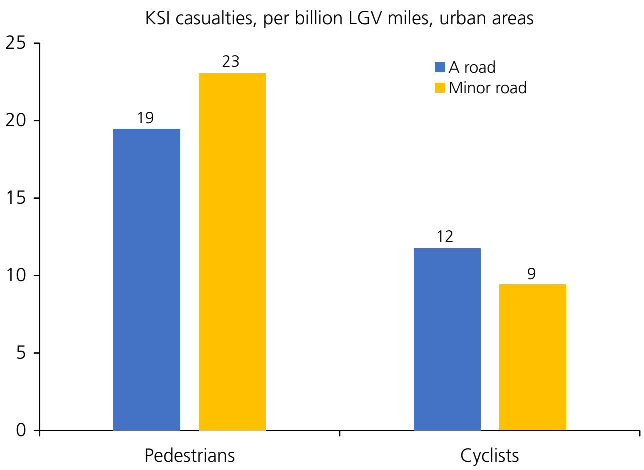

Figure 6. KSI casualties, LGVs involved

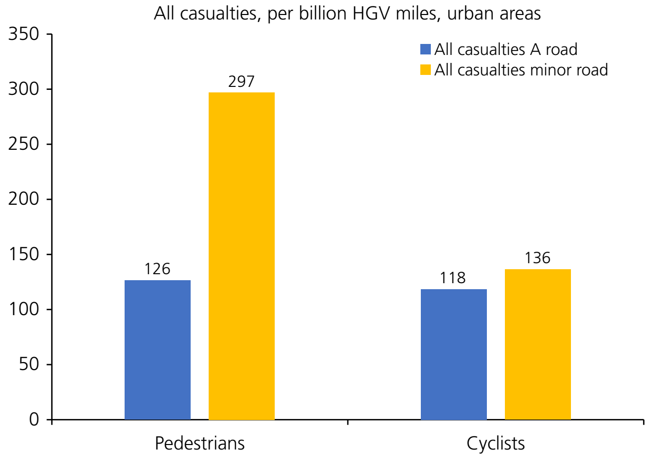

Figure 7. All casualties, HGVs involved

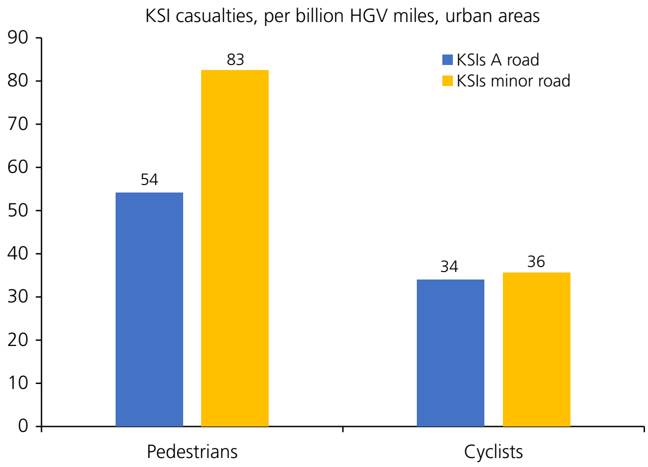

Figure 8. KSI casualties, HGVs involved

The growing use of in-car dynamic motor vehicle routing makes it likely that without policies to counter this, motorists may increasingly use minor urban streets in preference to congested urban major roads. Assuming overall distances travelled remain the same, with other factors remaining constant, this would likely result in increased pedestrian injuries, as risks posed to pedestrians per motor vehicle are higher on residential streets. One could plausibly argue that distances might decline, stay the same, or increase – the latter because ‘short cuts’ are often so due to (real or perceived) time savings, not shorter distances.

Conversely, policies to resist this shift and to encourage motor vehicles to use major rather than residential roads – for example, through ‘modal filtering’ or traffic calming residential streets – are likely to have a positive impact on pedestrian injury. Removing the largest vehicles from minor roads has a particularly noticeable impact, but in general the data suggest that motor vehicles pose lower injury risk to pedestrians on A roads. Policies to reduce motor dominance on residential streets may have co-benefits, creating more inclusive and sociable local streets, and encouraging modal shift with associated area-wide declines in motor traffic volumes (see e.g. Hartman and Prytherch, 2015).

Shifting motor traffic to A roads could have a positive effect overall on pedestrian injury. The data does not show why this is the case. It could for instance be related to differences in pedestrian and/or driver behaviour on such roads, or to infrastructural differences, such as the presence of controlled crossings or the absence of parked motor vehicles on some major roads. However, alongside this lower overall risk is the greater likelihood that collisions on A roads may lead to the deaths of vulnerable users. While in much of the United Kingdom 20 mph limits are only used in residential areas, in London they are increasingly used on main roads too (ES, 2015). This could be crucial in ensuring that higher volumes of traffic on A roads do not lead to an increase in pedestrian injury severity, as could redesign of HGVs to reduce the ‘blind spot’ problem, as HGVs can kill at very low speeds.

The impact of changing traffic patterns on cyclists should be considered. Cycling levels are very low in Britain, yet have been increasing particularly in some cities, and policy seeks to grow this. Data used for this study also show that during 2005–2015, British urban areas saw 73·8 cyclist deaths on A roads per billion miles cycled, compared with only 12·8 cyclist deaths on minor roads per billion miles cycled. This very high per-cyclist risk on A roads (due to a lack of exposure data one cannot calculate a similar comparison for pedestrians) may be affected by the approach taken to cycling provision on busy major roads. While pedestrians are largely separated from motor vehicles, through kerb-separated footways and protected crossings, cyclists for the most part must mix with motor vehicles on most British main roads. However, A roads tend to provide direct routes to key destinations, so it is unlikely that cyclists can be persuaded to eschew them, particularly as cyclist speeds are less affected by congestion than those of other users (TfL, 2009).

Bringing down the risk posed to cyclists by motor vehicles on major roads is likely to require building safer infrastructure that effectively separates them from motor traffic. A recent study (Teschke *et al.*, 2012) found roads with cycle tracks had one-ninth the per-km cycling injury odds of major roads with car parking and no cycle infrastructure. Without interventions to reduce risk for people cycling, moving motor vehicles onto A roads might reduce pedestrian injury, but have negative impacts on cycling injuries. However, creating very quiet residential streets while at the same time building cycle infrastructure on A roads might not just protect cyclists from injury but spur a substantial growth in cycling. This could help create a virtuous circle, given 'safety in numbers' impacts of this growth (Aldred *et al.*, 2018; Elvik and Bjørnskau, 2017) alongside growing evidence that building high-quality cycle infrastructure can increase levels of cycling (Panter *et al.*, 2016).

To summarise, the analysis presented here has suggested that one should be concerned about a growth in motor traffic on residential streets, particularly in relation to pedestrian injuries. Conversely, measures to shift motor traffic back onto A roads, and reduce motor traffic flows on minor urban roads, may reduce pedestrian injuries. This would ideally be accompanied by the reduction of free flow speed on urban arterials to reduce crash severity on those roads, as is now happening in London. Unintended consequences for cyclists need consideration, primarily making A roads safer through the introduction of best practice infrastructure.

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