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THE IMPACT OF 20 MPH TRAFFIC SPEED ZONES ON INEQUALITIES IN ROAD CASUALTIES IN LONDON

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ABSTRACT

Background Road traffic casualties show some of the widest socio-economic differentials of any cause of morbidity or mortality, and as yet there is little evidence on what works to reduce them. This study quantified the current and potential future impact of the introduction of 20 mph zones on socio-economic inequalities in road casualties in London.

Methods Observational study based on analysis of geographically-coded police road casualties data, 1987-2006. Changes in counts of casualties from road collisions, those killed and seriously injured and pedestrian injuries by quintile of deprivation were calculated.

Results The effect of 20 mph zones was similar across quintiles of socio-economic deprivation, being associated with a 41.8% (95% CI 21.0-62.6%) decline in casualties in areas in the least-deprived quintile vs. 38.3% (31.5-45.0%) in the most-deprived quintile. Because of the greater number of road casualties in deprived areas and the targeting of zones to such areas, the number of casualties prevented by zones was substantially larger in areas of greater socio-economic deprivation. However, the underlying decline in road casualties on *all* roads was appreciably greater in *less* deprived areas ($p<0.001$ for trend) so that despite the targeting of 20 mph zones, socio-economic inequalities in road injuries in London have

widened over time. Extending 20 mph schemes has only limited potential to further reduce differentials.

Conclusions The implementation of 20 mph zones targeted at deprived areas has mitigated widening socio-economic differentials in road injury in London and to some degree narrowed them, but there is limited potential for further gain.

Keywords: socio-economic variations, road traffic crashes, traffic calming, 20 mile-an-hour zones

INTRODUCTION

Injuries and deaths from road collisions show some of the widest socio-economic differentials of any cause of morbidity or mortality.[1-2] For pedestrians in London, the risk of injury is over twice as high in the most deprived as in the least deprived areas.[3] But while such inequalities are well documented,[1, 4] there is little evidence on what works to reduce them.[5] Current policy approaches aim to reduce inequalities primarily through targeting interventions at those areas or populations known to be at highest risk.[6]

There is good evidence that reducing the speed and volume of traffic reduces casualty rates,[7] and therefore it is plausible that prioritising the implementation of traffic calming measures in areas of socio-economic deprivation might reduce not only overall casualty rates, but also inequalities in casualties.[8-9] However, few empirical studies have tested this. An ecological study found a narrowing of inequalities in one UK city that had traffic calming concentrated in more deprived areas, compared with another city, but the authors note the limitations of such 'natural experiments', which cannot control for all potential confounding factors, and the need for further research to replicate these findings.[10]

We have recently provided evidence that, in London, 20 mph zones have been associated with a 42% decline in road injury within the zones.[11] 20 mph zones are a form of area-wide traffic calming where physical engineering measures (such as speed humps and chicanes) are placed every one hundred metres to help reduce traffic speeds to 20 mph (for a more detailed description of the 20 mph zone intervention see Grundy et al 2009[11]). In this paper we assess the effect these zones have had on socio-economic inequalities in roads casualties in London as a

whole, and the potential for further reductions in inequalities from future expansion of the number of 20 mph zones.

METHODS

Analysis was based on Police Stats19 data, 1986 to 2006, which record the date, location and number and type of casualties for all injury-related road collisions (damage only collisions were excluded). In London, the commissioning of 20 mph zones occurs on a financial year calendar (April to March), therefore each casualty was first assigned an appropriate financial year.

Using a geographical information system (GIS), these data were then linked to a detailed road segment database (2005) which included the characteristics of all classified and unclassified roads in London. For each financial year, each segment of road between junctions was classified according to the type of road, and whether or not it was in a 20 mph zone or adjacent to a 20 mph zone. Each segment was further classified by quintile of deprivation (Q1-Q5) using the 2004 index of multiple deprivation (IMD)[12] for the lower super output area (LSOA) in which each road segment was located. Q1 indicates the least deprived areas of London, while Q5 represents the most deprived areas (Figure 1). LSOAs are geographic areas containing an average of 1,500 people, defined by the Office of National Statistics (ONS) using measures of population size, mutual proximity and homogeneity. For these analyses we applied LSOA boundaries defined in 2001 to our network of road segments. There are 4,765 LSOAs in London, within 33 boroughs. IMD 2004 was chosen because it is available at the level of LSOA, which has advantages over ward-based measures in densely populated urban areas where LSOAs are smaller than wards.[13]

Each road segment was further classified by the date engineering works started on the 20 mph zone (where relevant), and the date it commenced in operation, which may have been several years from the start of engineering works. Thus, using these dates, each road segment was classified as pre-intervention, under construction, or post-implementation. The implementation status was assumed to change only at the beginning of each financial year, so that a change from 'under construction' to 'post-implementation' status, for example, occurred on 1 April following the implementation date.

GIS was also used to generate adjacent areas around 20 mph zones. In this way, we defined three types of roads according to their intervention status: (i) those that were within or would become part of a 20 mph zone, (ii) those that were part of an area adjacent to a 20 mph zone, and (iii) all other roads. For more information on methods see Grundy et al 2009.[11]

From the combined data set, counts of casualties were generated for each road segment and year. The road segments enable stratification of the results by intervention status, deprivation quintile and by borough.

Statistical methods

We followed analytical methods described in more detail elsewhere.[11] In brief, our first focus was to characterize the influence of the 20 mph zones on casualties by quintile of socio-economic deprivation of the area where the collisions occurred after allowing for underlying trends over time. Analyses were based on the patterns of change in annual counts within each road segment where there had been one or more casualties over the period of analysis. We compared pre- post *change* in injury counts within 20 mph zones relative to the change seen on other roads within each deprivation quintile. To examine the effect of 20 mph zones by deprivation quintile, we fitted a model that included interaction terms for deprivation quintile and intervention status. Robust standard errors were obtained using jackknife procedures, clustering on borough (n=32).

The estimated number of casualties avoided as a result of 20 mph zones in 2006 by quintile of deprivation was calculated as:

$$E_i - O_i = (1/RR_i - 1) \times O_i,$$

where RR_i is the relative risk, and O_i and E_i the observed and expected number of casualties for quintile i. Similar calculations were used to estimate the numbers of casualties avoided in areas *adjacent* to 20 mph zones.

To estimate the potential for further change in injury inequalities from extending 20 mph zones, we confined analysis to minor residential road segments outside existing 20 mph zones where there had been >=0.7 casualty per km/year over 2004-06. (0.7 casualties per km/year is a 'benchmark' for cost-effectiveness of 20 mph zones[14]). The potential number of casualties preventable within each

deprivation quintile was then calculated using a similar approach to that described above using as a baseline the average number of casualties on each road segment for 2004-2006. For these calculations we used a more conservative estimate of the 20 mph zone effect based on analysis of data for 2000-2006 only, as there was evidence that the casualty reduction effects of 20 mph zones have been smaller in more recent years.[11]

RESULTS

Since 2001, the kilometres of road within 20 mph zones increased rapidly, particularly in the most deprived areas of London (Figure 2a). By 2006, 20 mph zones had been implemented on over a quarter of road kilometres in the most deprived areas of London, compared to less than 3% of road kilometres in the least deprived areas of London (Table 1).

While the number of casualties decreased in all deprivation quintiles between 1987 and 2006, casualties decreased at a greater rate in relative terms in areas of low socio-economic deprivation (Figure 2b), particularly in the 1987-2001 period. For instance, in Q1 there were 7,372 casualties in 1987 compared 5,577 casualties in 2001, an overall reduction of 24%. In Q5 there were 11,094 casualties in 1987 compared to 11,096 casualties in 2006, an overall reduction of 0%. In the 2001 to 2006 period there appears to be a modest narrowing of inequalities. In 2006, there were 4,154 casualties in Q1, corresponding to a 26% reduction in casualties in the 2001-2006 period in the least deprived areas of London. There were 7,253 casualties in Q5 in 2006, corresponding to a 35% reduction in casualties in the 2001-2006 period in the most deprived areas of London.

Effect of 20 mph zones

The effects of the 20 mph zones on casualties in each deprivation quintile are summarized in Table 2. The models used to derive these estimates allow for the (generally) downward trend over time in the annual number of casualties in London by deprivation quintile.

There was no clear evidence that the 20 mph zone effect varied with socio-economic deprivation in relation to all casualties, KSI or pedestrian casualties (Table 2), though the point estimate of effect was smallest in the most deprived areas for all outcomes. 20 mph zones were generally associated with reductions in casualties in adjacent areas, but there was again no evidence that the degree of protection varied with socio-economic status (Table 2).

However, there was evidence that the underlying annual rate of decline in casualties on *all* roads was appreciably faster on road segments in the *least* deprived areas for all casualties ($p<0.001$) and pedestrian casualties ($p=0.02$), but not for KSI casualties ($p=0.3$) (Table 2). Estimates on the effect of 20 mph zones on cyclist, powered 2-wheeler and car occupant casualties are available in a web appendix.

Estimate of casualties avoided

The estimated number of casualties prevented by 20 mph zones in 2006 is shown in Figure 3. We calculate that 510 casualties were prevented in 2006 within 20 mph zone boundaries (against 31,202 road casualties overall), the majority within the two most deprived quintiles (Figure 3). Per kilometre of road, 20 mph zones have prevented substantially more casualties in the most deprived areas of London compared to the least deprived areas (0.22 casualties per kilometre in the most deprived vs. 0.01 casualties per kilometre in the least deprived areas).

We estimate that without 20 mph zones the difference in the number of casualties between the most and least deprived quintile of socio-economic deprivation would have been 3,619, compared with the observed difference of 3,099, a relative reduction of 14.4%. Despite this socio-economic differentials overall have widened over time: in 1987 50% more casualties occurred on roads in the most deprived quintile compared to roads in the least deprived quintile; by 2001, that percentage had risen to 99%. 20 mph zones, the majority of which were introduced after 2001 appear to have mitigated the widening of socio-economic differentials; by 2006, the percentage difference in the number of casualties on roads in the most deprived quintile compared to the least deprived quintile had narrowed to 75%.

Potential benefit from extending zones in London

The potential additional benefit of extending 20 mph zones to all suitable roads in London which have not yet been included in 20 mph zones is shown in Table 3. We estimate that road casualties overall could be reduced by 699 a year. However, relatively few casualties occur on roads eligible for future 20 mph zones in the most deprived areas of London, and in consequence, future extension of 20 mph zones in appropriate areas would decrease the difference in the number of casualties in the most deprived quintile compared to the least deprived quintile by only 1%.

DISCUSSION

Reducing inequalities in health is an important policy goal. There is, however, limited evidence on how to do this, and the possibility that interventions can lead to overall health gain but exacerbate inequalities, often because their effectiveness is greater in more advantaged groups[15-16]. This study suggests that although there is an effective measure to reduce road injuries, namely 20 mph zones, [11] and that those zones have been effectively targeted at deprived areas of London, the effect of such targeting on socio-economic differentials has been more than offset by the underlying downward trend in road casualties which still favours less socio-economically deprived areas. Thus, remarkably, overall casualty numbers in less deprived areas have fallen faster over time, so that the impact of targeted 20 mph zones has been to mitigate the widening of differentials, rather than to reduce them.

The effect of 20 mph zones on socio-economic differentials has nonetheless been substantial, reducing the gap in the number of casualties between the most and least deprived quintiles of deprivation by around 14% compared with what it would otherwise have been. However, given that historical targeting has left fewer remaining suitable roads for 20 mph zone interventions in deprived areas, and the fact that the majority of collisions now occur on roads not currently considered eligible for 20 mph zones, we estimate that extending 20 mph zones to appropriate areas has the potential to further reduce the gap between the number of casualties in the most and least deprived quintiles of socio-economic deprivation by only 1%. Future efforts to reduce socio-economic inequalities in casualties may therefore have to address major roads, on which the majority of injuries occur.

It should be noted that, because this study was based on analysis of road injuries *by place of occurrence*, the results reflect changes in casualty *numbers* (by area type) rather than in casualty *rates* calculated by reference to a population denominator. (No such denominator exists for place of injury, as there are no readily obtainable data on population movements throughout the day.) However, much of the published evidence on inequalities in road injury also utilises collision location, and there is evidence that the majority of child pedestrian injuries occur close to home. This analysis could not take into account other changes to the road environment or the impact of other road safety measures such as road safety cameras. If, like 20 mph zones, they were introduced more frequently in deprived areas and were successful in reducing casualties, we have potentially underestimated the impact of 20 mph zones on inequality reduction.

A further uncertainty is the known under-reporting of road injuries in the Stats19 data which we used, and this might plausibly vary by deprivation. However, reporting in London is relatively good compared to the rest of the United Kingdom[17] and for such under-reporting to affect the results of our analysis one would have to invoke selective changes over time and deprivation quintile in recording of injuries in 20 mph zones compared with other road types. National evidence suggests that the rate of under-reporting overall has not substantially changed over time[17].

This analysis did not account for any changes in exposure over time. Road user behaviour is complex, and likely to change in response to engineering interventions. As 20 mph zones are introduced, pedestrian behaviour in particular is likely to change, as residents may feel safer and more confident in travelling around and playing in their local environment, thus increasing their exposure to road injury risk. There is no consensus as yet from the limited available evidence on the impact of traffic calming on pedestrian behaviour,[18-19] but potential changes in behaviour due to traffic calming might plausibly differ by area deprivation. We have identified evidence that 20 mph zones not only reduce the burden of injury, but have a role in reducing injury inequality. Challenges remain in identifying why background trends in injury decline have been faster in less deprived areas. Further research is needed to explore any potential changes in travel patterns by socio-economic status.

What is already known on this topic:

- There are steep socio-economic gradients in road injury.
- 20 mph zones are an effective way to reduce road injury risk.

What this study adds:

- Over the last twenty years, casualty rates have fallen fastest in less deprived areas.
- 20mph zones are equally effective at reducing injury in deprived and affluent areas.
- In London, the targeting of 20mph zones in more deprived areas has helped mitigate widening inequalities in road injury.

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CONFLICT OF INTEREST

All authors declare that the answer to the questions on your competing interest form are all No and therefore have nothing to declare.

CONTRIBUTORS

RS, CG, PE and PW all contributed to the design of the study, analysis of the data, and interpretation of results. JG contributed to the design of the study and interpretation of the results. All authors contributed to the writing of the manuscript.

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Table 1. Characteristics of 20 mph zones by deprivation group

	Quartile of socio-economic deprivation					All roads
	Q1 (least deprived)	Q2	Q3	Q4	Q5 (most deprived)	
Length of road kilometres in deprivation quintile: All road types	4,535	4,062	3,721	3,165	2,652	18,135
Length of road in kilometres within zones in 2006 (percentage)	115 (2.5%)	238 (5.9%)	362 (9.7%)	561 (17.7%)	731 (27.5%)	2006 (11.1%)

Table 2. Effect (percentage reduction) of introducing 20 mph zones on casualties in 20 mph zones and in adjacent areas, and the annual average decline in casualties on all roads, 1987-2006, by deprivation quintile

	Percent reduction (95% CI) following introduction of 20 mph zones		Annual average percent decline in casualties and collisions (underlying trend)
	In 20 mph zones	In areas adjacent to 20 mph zones	
Casualties			
Q1 (least deprived)	41.8 (21.0 to 62.6)	7.6 (-4.6 to 19.7)	2.5 (2.1 to 2.8)
Q2	42.9 (31.2 to 54.7)	3.1 (-5.9 to 12.1)	1.9 (1.6 to 2.3)
Q3	44.7 (27.5 to 61.8)	8.0 (1.8 to 14.3)	1.6 (1.3 to 2.0)
Q4	48.7 (41.0 to 56.4)	10.6 (5.6 to 15.5)	1.5 (1.2 to 1.8)
Q5 (most deprived)	38.3 (31.5 to 45.0)	12.1 (6.7 to 17.5)	1.2 (0.9 to 1.5)
p-value for trend across deprivation levels	p=0.624	p=0.105	p<0.001
KSI casualties			
Q1 (least deprived)	52.1 (30.7 to 73.6)	15.6 (5.7 to 25.5)	4.2 (3.7 to 4.8)
Q2	55.9 (37.4 to 74.5)	-0.5 (-18.3 to 17.3)	3.8 (3.2 to 4.3)
Q3	43.0 (24.2 to 61.8)	18.2 (7.3 to 29.1)	3.6 (3.1 to 4.1)
Q4	57.2 (44.5 to 69.9)	13.5 (4.0 to 23.0)	3.7 (3.2 to 4.2)
Q5 (most deprived)	35.8 (28.0 to 43.6)	1.7 (-8.9 to 12.3)	3.6 (2.9 to 4.4)
p-value for trend across deprivation levels	p=0.097	p=0.358	p=0.271
Pedestrian casualties			
Q1 (least deprived)	35.1 (5.8 to 64.5)	24.1 (18.5 to 29.7)	4.0 (3.6 to 4.4)
Q2	38.0 (7.4 to 68.5)	-2.3 (-10.2 to 5.5)	3.6 (3.3 to 3.9)
Q3	30.9 (9.3 to 52.4)	7.1 (-2.7 to 16.9)	3.2 (2.9 to 3.6)
Q4	34.9 (23.6 to 46.3)	3.0 (-3.7 to 9.7)	3.3 (2.9 to 3.8)
Q5 (most deprived)	30.9 (22.8 to 39.0)	4.4 (-8.1 to 12.3)	3.2 (2.9 to 3.5)
p-value for trend across deprivation levels	p=0.596	p=0.379	p=0.015

* – KSI = killed or seriously injured

Table 3 Potential further reduction in casualties following 20 mph zone implementation

Quartile of deprivation group	Annual average number of casualties 2004-2006 (A)	Number (%) of casualties in eligible areas (B)	Percent reduction (95% CI) following introduction of 20 mph zones (2000-2006) (C)	Number of avoided casualties following 20 mph zone implementation B(100/(100-C) – 1)
Q1 (least deprived)	4,440	567 (13%)	12.8 (-22.2 to 47.7)	73
Q2	6,992	730 (10%)	21.7 (-1.0 to 44.2)	158
Q3	7,180	665 (9%)	24.4 (9.7 to 39.2)	163
Q4	7,543	722 (10%)	27.2 (14.0 to 40.4)	196
Q5(most deprived)	8,020	533 (7%)	20.5 (8.6 to 32.5)	109

Figure 1 Characteristics of roads and casualty numbers 1987-2006, by quintile of socio-economic deprivation. Q1=least deprived quintile, Q5=most deprived quintile.

Figure 2. Trends in road casualty numbers and kilometres of road inside 20 mph zones, London, 1987-2006, by quintile of socio-economic deprivation. Q1=least deprived quintile, Q5=most deprived quintile.

Figure 3. Road casualties 2006 by quintile of the 2004 Index of Multiple Deprivation.