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Speeding in urban environments: Are the time savings worth the risk?

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TITLE: **Speeding in urban environments: Are the time savings worth the risk?**

ABSTRACT: Perceived time savings by travelling faster is often cited as a motivation for drivers' speeding behaviour. These time savings, however, come at a cost of significant road injuries and fatalities. While it is known that drivers tend to overestimate the time savings attributable to speeding there is little empirical evidence on how much time drivers genuinely save during day-to-day urban driving and how this relates to speeding-related crashes. The current paper reports on a study to address the lack of empirical evidence on this issue using naturalistic driving data collected from 106 drivers over a period of five weeks. The results show that the average driver saves 26 seconds per day or two minutes per week by speeding. More importantly, the cost of these time savings is one fatality for every 18,947 hours saved by the population on 100 km/h roads and one injury for every 1,407 hours saved on the same roads. Full speed compliance – and consequently a dramatic reduction in the road toll – could be achieved through almost imperceptible increases in travel time by each driver.

KEY WORDS: ***Safety; Speeding; Crash Risk; Value of time***

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1. Introduction

Speeding is one of the most common driving behaviours despite being one of the largest contributors to road injuries and fatalities. Researchers have found that a common rationale for why drivers speed is the perceived time savings (Peer, 2011) and this frequently colours the debate on appropriate speed limits. For instance, proposed reductions to the speed limit on roads with high rates of speed-related crashes are sometimes rejected on this basis (Svenson and Salo, 2010) as are campaigns for increased enforcement of existing speed limits. Despite this there is little empirical evidence as to how much time is actually saved during day-to-day driving by drivers engaging in speeding behaviour which makes it difficult to counteract this argument. What is known is that improvements in compliance with speed limits would dramatically reduce injuries and fatalities. For instance, Elvik and Amundsen (2000) estimate that, in Sweden, if all drivers were to abide by the speed limit, road fatalities would be reduced by 38 percent and injuries by 21 percent. As a consequence, these 'speeding time savings', are paid for in greater injuries and fatalities.

The current paper reports on a study to address the lack of empirical evidence on this issue. Using naturalistic (Global Positioning System) driving data collected from 106 drivers over a period of five weeks in Sydney, Australia, the amount of time saved speeding during day-to-day driving was determined and subsequently this was related to speeding-related injuries and fatalities that occurred at the same time.

2. Literature review

It is known that perceived time savings forms part of the rationale for speeding behaviour. In a study about drivers' beliefs of speeding, agreement with the statement that speeding "makes me arrive quicker" was one of the strongest predictors of intention to speed and a significant contributor to an attitude of speeding. This was more so than statements about fun, fines, licence suspension and the risk of hitting a pedestrian (Warner, 2006). There is also some evidence that time-pressure as a reason for speeding may not necessarily need to be related to a specific event, such as a late appointment, but may relate more broadly to time pressures felt by drivers (McKenna, 2003). Several studies cited by Peer (2011) found that between 20 and 33 percent of drivers admitted to speeding to get somewhere quicker, some of whom thought the importance of arriving punctually for an appointment was of greater importance than breaking the speed limit. This is also stated by Tarko (2009) who proposed that minimising the time spent driving is a key reason for speed choice and is further influenced by the subjective value of time held by each driver.

It has also been well established in the literature that drivers overestimate the travel time savings that occur from higher speeds (Svenson, 2009; Fuller et al., 2009; Peer, 2010a; Peer and Solomon, 2012) which, in turn, is associated with higher risks of casualty crashes (Kloeden et al., 1997; Elvik, 2012). For instance, Richter et al. (2006) identified the time saved from (higher) speeds as a benefit to users and therefore a barrier to the acceptance of the role of speeding in road casualties. The authors also note that the practice of controlling for increases in VKT or population in analyses appears to create an artificial reduction in casualty rates as the small number of crashes are spread over a greater population. Peer (2010b, 2011; 2012) has conducted a number of studies on drivers' estimates of time savings from speeding. The results show that drivers significantly overestimate the time saved by speeding with greater differences the higher the change in speed. For example, participants were asked to estimate the time savings for a 50 km trip where the initial speed was 100 km/h and the increase in speed was 10, 20 or 30 km/h. With a speed increase of 30 km/h, the actual time saved is 6.92 minutes but the mean of the participants' estimates was 11.94 minutes.

Previous research has looked at the relationship between vehicle speed and casualties and how higher speeds are (in effect) paid for through higher casualty figures. Redelmeier and Bayoumi (2010) used data from the United States driving population to convert crashes into a time value and used this to adjust travel time as the speed increased (or decreased). They found that a reduction in average speed by 3 km/h (from 51 to 48 km/h) resulted in an increase in travel time of 3.6 minutes but once the resulting crashes were taken into account and converted to a time value of 16.6 minutes of crash time[1] there was a reduction of daily travel time. In contrast, an increase from 51 to 52 km/h resulted in 22.2 minutes of crash time and an overall increase of 1 minute once crash time was included despite a reduction in observed travel time of 4.6 minutes. These findings were however derived from average travel behaviour and did not take into account the variations between drivers. They do nonetheless reinforce the message that small reductions in travel time have significant impacts on road safety. This is related to the concept of marginal external costs (MEC) of crashes as studied by Hensher (2006) and Steimetz (2008) which attempt to quantify the crash and travel-delay costs associated with the relationship between speed and crash risk.

Svenson (2008) takes a different approach by taking risk out of the equation and instead surveys participants on perceived time savings which occur as a consequence of increases in mean speed due to changes to road infrastructure. The results show that people have a time saving bias in that they over optimistic about the time saved by driving faster. Given to alternatives where the first alternative

[1] Crash time was a measure of crashes as a unit of time.

has a lower initial speed and a lower increase in (absolute) speed and the second alternative has a higher initial speed and a higher increase in (absolute) speed, the majority of participants predicted the second alternative would result in greater time savings despite this not being the case for any of the sets presented.

What links all existing research on this topic is the lack of empirical evidence of the amount of time spent speeding and how this relates to the number of road casualties at a population level. If we accept that time savings generally provides positive utility to individuals, it must be established empirically to what extent time savings are accrued by speeding and if this is beneficial once speed-related casualties are taken into account.

3. Data sources and methodology

Two principal sources of data were employed for this research. The driving data used here is drawn from a broader study of driver behaviour (Greaves et al., 2010) from which second-by-second Global Positioning System (GPS) data were collected from 106 drivers over a period of five weeks in Sydney, Australia. Data on crash statistics are sourced from the New South Wales Traffic Accident Database System (TADS).

3.1 GPS driving data

While full details of the GPS data collection effort are provided in Greaves et al. (2010), for the benefit of the reader, a summary is provided here. The GPS device was installed in participants' own cars and, crucially, participants were not made aware that speeding was being monitored until after the five week period was over. This, together with excluding one week of data preceding the five-week period, reduced the likelihood of the mere presence of the device in the car influencing behaviour. Each second, Doppler speed, latitude, longitude, altitude, date and time were recorded. This information was then matched to a Geographic Information System (GIS) based database of speed limits so that observations where speeding was occurring could be identified. Trip ends were automatically identified using the car's engine status (off/on) and participants accessed a web-based prompted recall survey to provide additional information about each trip including the driver of the vehicle, number of passengers, trip purpose and the number of intermediate stops. For the purposes of this analysis, only trips driven by the primary driver (i.e. the participant in the study) were included, providing a total of 11 million observations or 3,049 hours of driving across all 106 drivers.

The travel times for the observed behaviour (including speeding) were determined from the GPS information itself and this formed the baseline case. To calculate the time *savings* occurring as a consequence of speeding any observations driven above the speed limit (i.e. driving 62 km/h in a 60 km/h zone) were re-coded to match the speed limit (to 60 km/h in this example). This was done by iterating through each observation in sequential order and verifying if the observed speed was at or below the speed limit. If this was the case, then the observation remained unchanged. In contrast, if the speed was greater than the speed limit then the observation was split into two or more observations each with a maximum duration of one second and a speed equivalent to the speed limit. The premise here was to keep each observation representing one second (or less) to ensure consistency with the original dataset.

Using the distance travelled at the actual speed, it is possible to calculate the amount of time necessary to cover the same distance at the speed limit. For example, if a driver is travelling at 72 km/h they will travel 20 metres in one second. If the speed limit is 60 km/h, then it would take 1.2 seconds to cover the same distance while travelling at the speed limit. As such, this is represented in the adjusted dataset as two observations. The first observation covers one second in duration and a distance of 16.67 metres with the second observation representing 0.2 seconds and 3.33 metres. By extension, that means that the speeding time savings in this example is 0.2 seconds. If the second observation had a duration of more than one second, then the same procedure would be applied. However, for this to be the case the observed speed must be more than double the speed limit and (fortunately) was not very common. Collectively across the 106 drivers, speeding resulted in a savings of 27 hours out of 3,049 hours (0.88 percent).

3.2 Crash data

In New South Wales, data on road crashes in the study area are stored in the Traffic Accident Database System (TADS). For the current analysis, data over a five year period (2002 – 2006) were used. The database comprises three main tables of relevance to this research: accident[2], casualties and traffic units respectively.

Each reported crash is represented by one row in the table and includes variables such as the speed limit of the road, weather conditions, location and the date on which the crash occurred. An accident number can be used to cross reference the casualties table for the details of each person injured or

[2] The term crash is preferred and used in this paper, however, the database itself uses accident.

killed. Similarly, details of the vehicle(s) involved in the crash (if any) can be cross-referenced to the accident and the casualties from each vehicle.

It should be acknowledged that these records only include crashes that are reported to the police. However, as the main interest here is in casualty crashes, this is not a big concern. Of particular interest here are speeding related crashes with at least one private car involved and at least one casualty regardless of if the casualties were inside or outside the vehicle.

3.3 Data Assessment and Interpretation

The analysis consisted of two phases. First, an analysis was conducted to compare the observed to the adjusted travel times for all driving, in free-flow conditions and when drivers were speeding. This was done in absolute terms and as a proportion of all driving activity for each driver individually. This provided an indication as to the extent to which drivers saved time by engaging in speeding behaviour and how this varied across the sample.

Second, these ‘speeding time savings’ were then computed in terms of the number of fatalities and injuries per minute saved using speed-related casualty crashes in the study area.

4. Time savings

As a precursor to the empirical-based analysis, it is worth considering how much time in theory might be gained by speeding. Consider a 40 km stretch of road with a 60 km/h speed limit with no traffic signals or congestion to cause delay. If the motorist was to drive at the speed limit, it would take 40 minutes to traverse. If they were to ‘speed’ by 2 km/h (i.e., 62 km/h) for the entire section, they would save around 77 seconds. If they were to speed by 6 km/h (i.e., 66 km/h), they would save around 218 seconds, while speeding by 10 km/h (70 km/h) would save them almost 343 seconds of time. If however, they only speed for one-third of that distance, they would only save 26 to 114 seconds depending on the magnitude of speeding. Consider now, the same stretch of road with a 100 km/h speed limit, taking 24 minutes to traverse at the speed limit. The savings from travelling at 102 km/h, 106 km/h and 110 km/h, would be 14, 67, and 117 seconds respectively. Evidently, there are more potential time-gains from speeding in low-speed environments than high-speed environments, which probably runs counter-intuitively to how motorists perceive the time-benefits of speeding

These theoretical examples suggest that the ‘gains’ from speeding are a function of the extent, magnitude and road type on which the speeding occurs. Given an *a priori* expectation that levels of speeding in urban areas are likely to be predominantly low-level and constrained by other factors (traffic, signals, crashes, breakdown, etc.), we might anticipate the levels of time-savings to potentially be small. For the empirical sample, overall levels of speeding (defined as 1 km/h) over the limit were 17% (distance) and 9% (time), while levels of speeding 10 km/h above the limit were 3% (distance) and 2% (distance), corroborating this expectation.

At an aggregate level, the results show these speeding statistics gave an average time savings of 26 seconds per day and a median of 18 seconds per day. This translates to an average time savings from speeding of three minutes per week and a median of two minutes per week. If this is extrapolated to an annual figure, this equates to less than two hours saved per year for the median driver. As illustrated by Figure 1, these time savings are skewed by the most frequent speeders (in terms of distance and magnitude). Nonetheless the most frequent speeders do not save much time. Even for the most prolific speeder, speeding for 44% of the 320 km travelled each week, speeding only saves two minutes per day or 14 minutes per week. Similarly, the driver who travelled the furthest distance (510 km per week) saved 1.5 minutes per day despite speeding for 34 percent of that distance. By way of context, two minutes is equivalent to waiting at a traffic light for an entire cycle and, therefore, the time savings from speeding are less than the variability in travel time introduced by factors such as traffic light timings. However, from the perspective of the driver the value and perception of time differs depending on the driving situation such as if they are stopped, moving slowly or moving quickly (Levinson et al., 2004). This may influence how likely drivers are to perceive increases in travel time.

There is some variation within each day reflecting the variability in where, when and how much people drive as well as the variability in their speeding behaviour. Figure 1 shows the average, minimum and maximum range and standard deviation of the time savings per travel day from speeding by each participant. As can be seen here, on occasion there are a small number of days in which more than four minutes is saved by an individual driver speeding. Nonetheless, over 75 percent of drivers never save more than three minutes in a single day supporting the evidence that drivers may be over-estimating the time they gain from speeding.

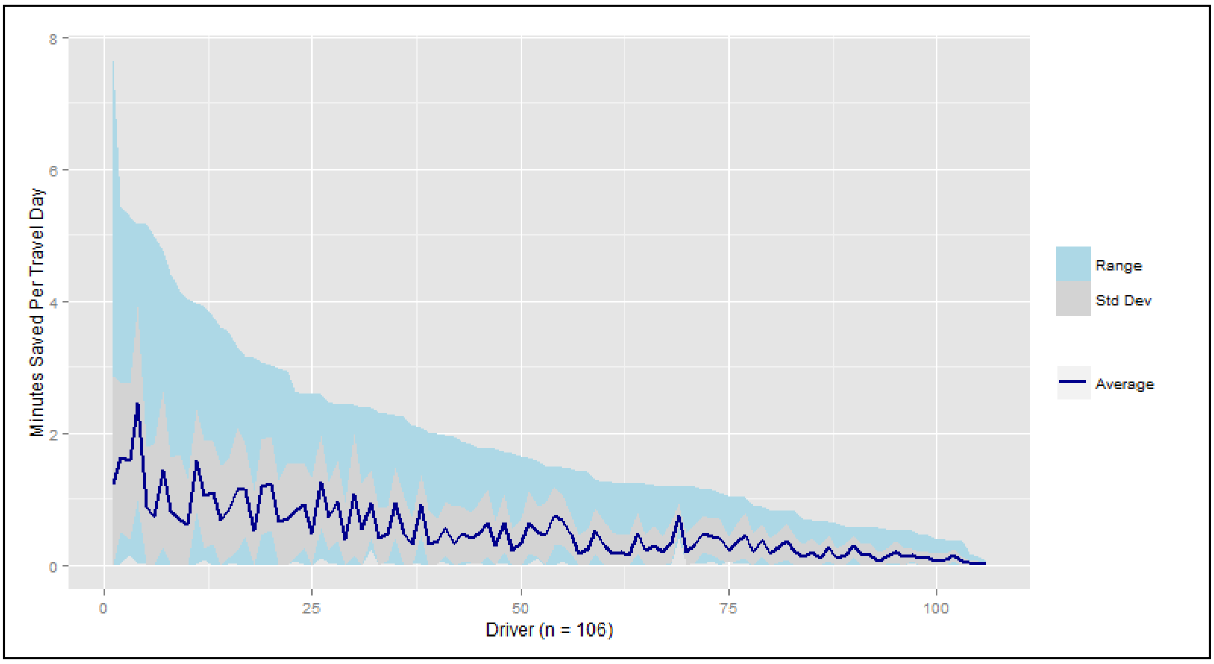

Figure 1: Average, range and std. dev. of minutes saved per travel day by speeding

The results are similar when analysed as a proportion of travel time; the average driver reduces their travel time by 0.9 percent of all driving and 2.4 percent of time spent in free-flow conditions. For the most frequent speeder, these are 3.1 and 7 percent respectively. If analysed on a daily basis (see Figure 2), drivers can on occasion save over 4 percent of travel time by speeding but this is rare, and on average, speeding time savings are no more than 1 to 2 percent of (all) travel time each day.

There is also some variation between speed zones consistent with the varying frequencies and magnitudes of speeding in each speed zone. As illustrated in Figure 3, the majority of time saved is in the 40, 50 and 60 km/h speed zones representing the high magnitude speeding in (primarily) school zones with 40 km/h speed limits (Ellison et al., 2013) and the proportion of time spent in 50 and 60 km/h zones which collectively account for 68 percent of all travel time. However, even in these cases the time saved in absolute terms, and as a proportion of travel time, is almost imperceptible at an average of less than one minute per week.

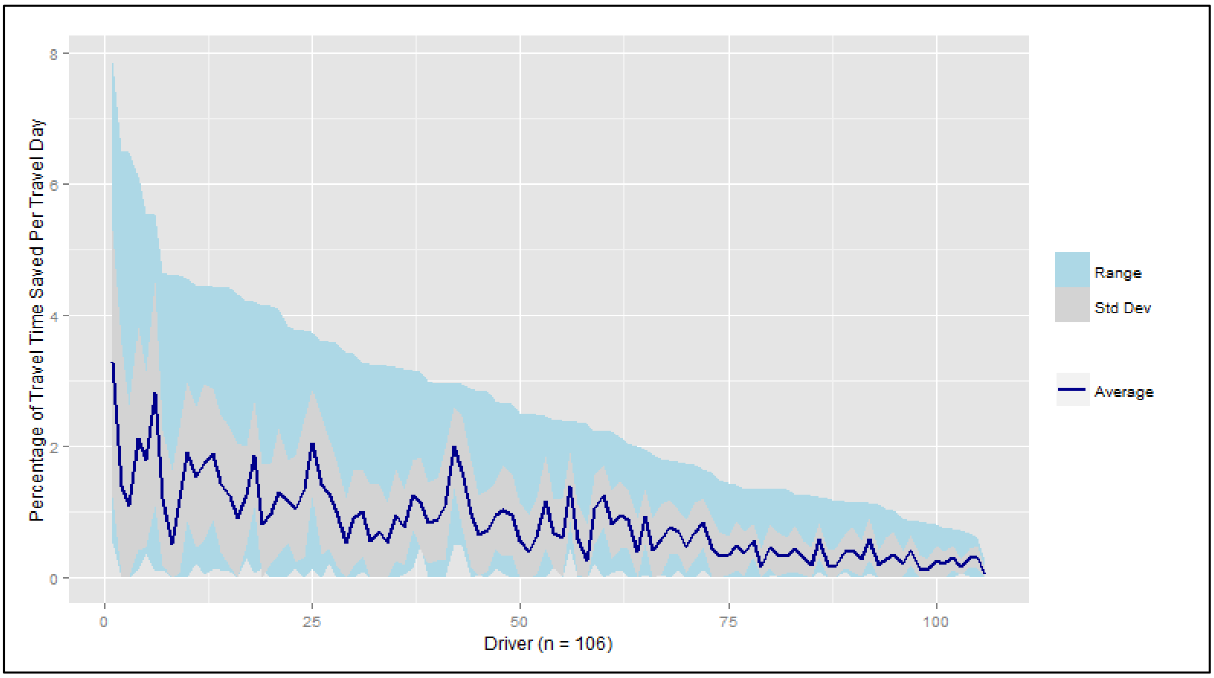

Figure 2: Average, range and std. dev of % of travel time saved per day by speeding

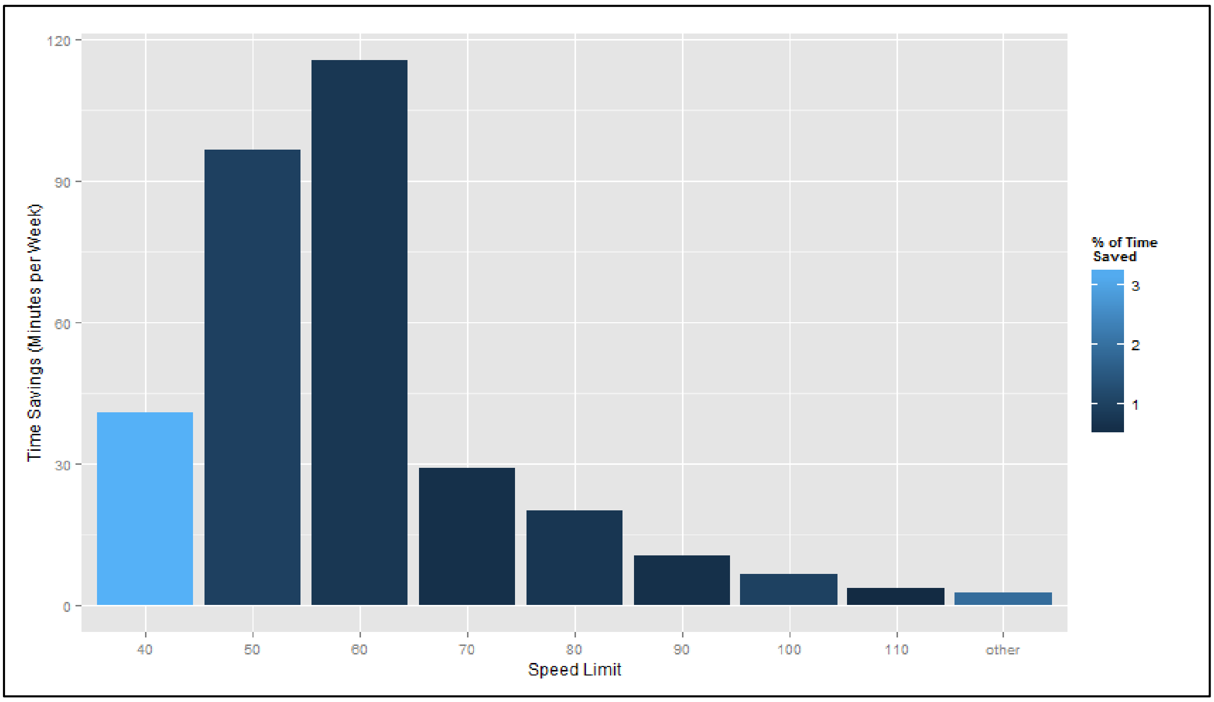

Figure 3: Time Savings per Week for Entire Study Sample (n = 106) in Minutes and Percentage of Observed Travel Time by Speed Limit

While at first glance these results seem low, in day-to-day city driving, very large proportions of the time are spent stopped, accelerating or decelerating. This can be seen by comparing the average distance speeding (17 percent) to the average time speeding (9 percent). Therefore, while the average driver drove for 5.75 hours per week, they were speeding for only 30 minutes per week despite speeding representing 17 percent of the distance travelled. Furthermore, the majority of the distance travelled in those 30 minutes spent speeding would still have been covered if driven at the speed limit. This is not to minimise the frequency with which speeding takes place but a reflection of the driving patterns commonly found within cities. Figure 4 illustrates the amount of time drivers in the study spent in various states, namely stopped, travelling at less than 10 km/h, travelling slower than 75 percent of the speed limit[3] and travelling at speeds greater than 75 percent of the speed limit (including speeding). Also shown is the additional time that would have been spent driving had the speed limit always been complied with (i.e., time savings from speeding). It is worth noting that time spent speeding is not saved in its entirety as only the marginal increase in speed results in time savings. Examined in this way, it is evident that the time savings from speeding represent an amount of time that is substantially smaller than the next smallest time category of driving less than 10 km/h and a very small proportion of all driving activity for even the most frequent speeders.

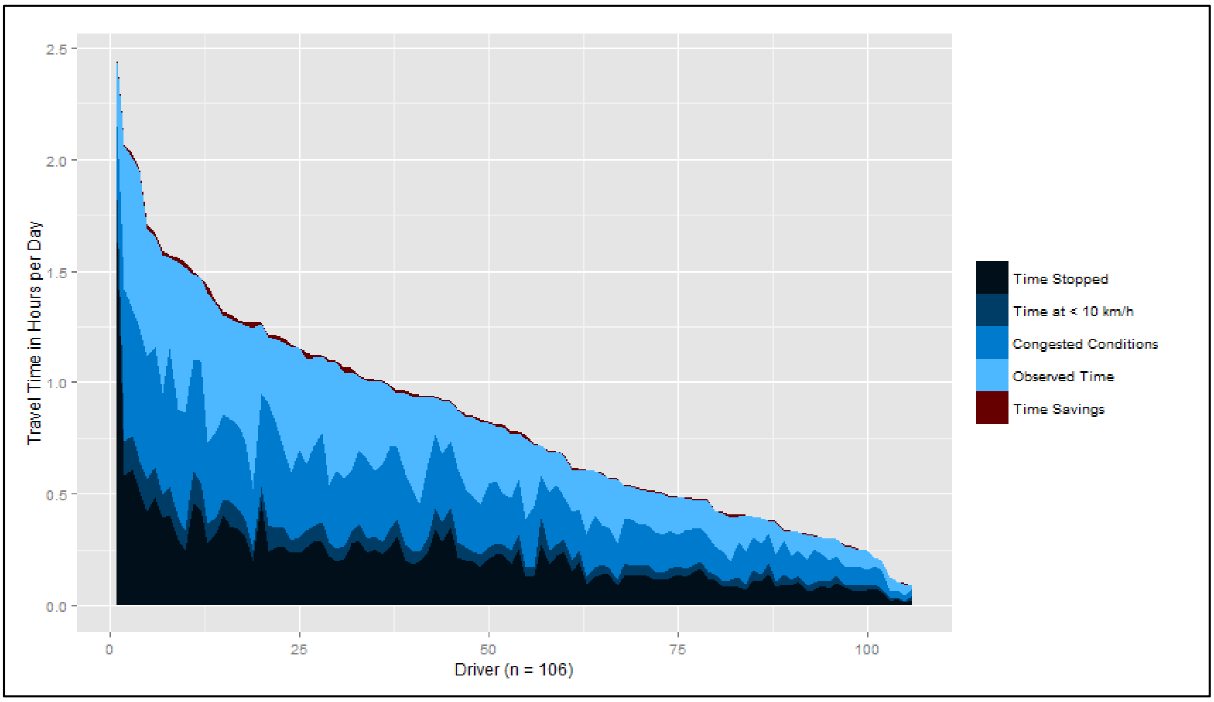

Figure 4: Travel time per driver by driving state

[3] Used as a proxy for congested conditions.

5. Injuries and fatalities

Having established the extent of time savings attributable to speeding, the question is how these time savings are traded off against road injuries and fatalities. To accomplish this it was necessary to extrapolate the behaviour of the drivers in this study to the population of the study area such that the time savings for the population could be compared against the number of fatalities and injuries in the population. For this purpose the Sydney Household Travel Survey (HTS) was used to find the total time and distance driven in one week in cars by the population. Although the speed profile of drivers in the population was not available, the ratio of (observed) travel time to distance was used as a proxy to ensure comparability of speed profiles between the drivers in the study and those in the population as a whole. The ratios were broadly similar with the study sample speed profile exhibiting slightly faster speeds, suggesting that the estimates of travel time savings may be overstating the amount of time saved relative to the population. The proportion of travel time from the study relative to the population was then used to extrapolate the time savings from the study data (5.4 hours per week) to the population (186,348 hours per week).

Since crash risk and casualty rates are not uniform across the road environment, the time savings and the corresponding casualty records were delineated by the speed limit of the road. Since the distribution of driving by speed limit was not available for the population, it was assumed that the distribution was the same as for the study sample, for which the distribution was available. Given that the ratio of travel time and distance discussed earlier is similar for the sample and the HTS (weighted to the population), this was deemed acceptable.

The crash data recorded in the Traffic Accident Database System (TADS) includes the number of fatalities and injuries for each crash, the speed limit of the road and if speeding was a contributor to the crash. Using this and information on the vehicles involved, crash data for crashes in which speeding was a factor and at least one passenger car involved. This subset of crashes was then used to compute the number of fatal, injury and casualty[4] crashes and the number of fatalities, injuries and casualties for each speed limit. This was used as input to determine the number of hours saved by the population before a crash or casualty occurred, with a higher number of hours representing a lower risk. Since the magnitude of speeding for each crash was not available, it had to be assumed that the increase in crash risk is correlated with the amount of time saved, which is itself a function of the speed of the vehicle. The results shown in Table 1 and illustrated in Figure 5 show that, for example, every 18,947 hours saved by speeding by the population in 100 km/h zones, one speeding-related

[4] Casualty crashes are crashes that result in an injury, fatality or both.

fatality occurs. Similarly, for every 1,407 hours saved by speeding across the population in 100 km/h zones, one injury occurs. In this case, lower numbers mean a greater number of crashes associated with each hour of speeding. Speeding in higher speed zones is therefore more 'costly' than the equivalent time period spent speeding in lower speed zones. This is partly a function of the greater likelihood of casualties at higher speeds (whether speeding or not) but also that the time savings achieved in higher speed zones are very small. In absolute terms, however, while the 'cost' of speeding on roads with lower speed limits is lower for a fixed unit of time (i.e. greater time savings are required before a casualty crash occurs) the number of casualties in lower speed roads are significantly higher due to the much greater proportion of distance and time spent on lower speed roads.

Table 1: Hours Saved by Speeding per Crash, Fatality, Injury and Casualty

Speed Limit	Fatal Crashes	Fatalities	Injury Crashes	Injuries	Casualty Crashes	Casualties
40	1,214,699 (1)	867,642 (1)	35,938 (34)	25,845 (47)	35,311 (34)	25,097 (48)
50	159,873 (18)	142,461 (20)	4,631 (621)	3,547 (811)	4,549 (633)	3,461 (831)
60	120,337 (29)	109,606 (31)	4,897 (703)	3,602 (956)	4,792 (718)	3,487 (987)
70	83,028 (10)	70,778 (12)	4,991 (173)	3,539 (244)	4,835 (179)	3,370 (256)
80	35,356 (17)	30,356 (20)	2,258 (266)	1,717 (350)	2,167 (277)	1,625 (370)
90	53,520 (6)	43,114 (7)	6,039 (51)	4,592 (68)	5,624 (55)	4,150 (75)
100	21,006 (9)	18,947 (10)	1,992 (97)	1,407 (137)	1,869 (103)	1,309 (148)
110	74,452 (1)	74,452 (1)	2,995 (35)	2,337 (45)	2,928 (36)	2,266 (46)
Other	-	-	9,719 (9)	1,692 (49)	9,719 (9)	8,707 (10)

Note: Average annual absolute number of crashes/fatalities/injuries/casualties shown in brackets

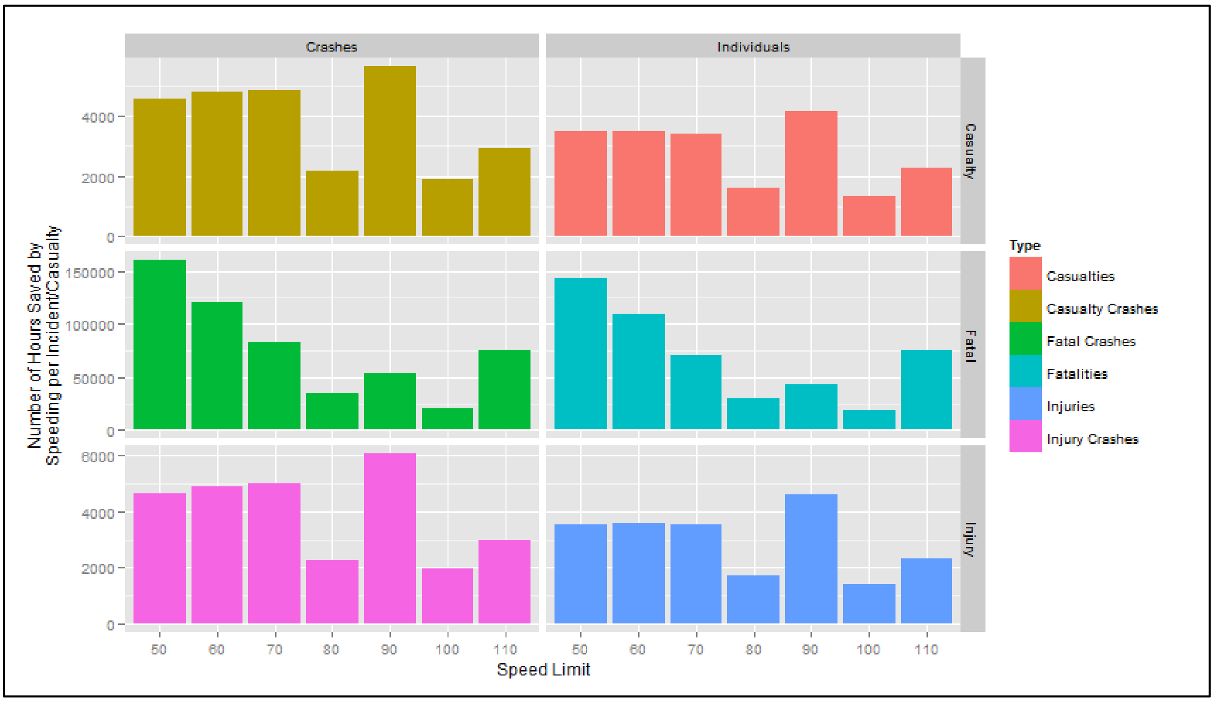

Figure 5: Hours saved by speeding per crash, fatality, injury or casualty5

While each individual's time savings is very small, and consequently their own contribution to casualty risk, collectively as a population speeding contributes to a large number of casualties. To put this in perspective, in 100 km/h zones, a speeding-related fatality involving a passenger car occurs once every five weeks and an injury occurs once every 2.5 days. These fatalities are 'paid' for through time savings of an average of six seconds per week per driver[6]. As a consequence, even if full speed compliance were to achieve only a 50 percent reduction in fatalities, increasing travel time in 100 km/h zones by only six seconds per week per driver would result in five fewer fatalities per year. Figure 6 shows the distribution of the increase in weekly travel time per driver as a result of full speed compliance for each speed limit. The most frequently used roads with 50 and 60 km/h zones have the highest values but the peaks are less than one minute per week.

[5] 40 km/h and other speed limits not shown, see Table 1 for values.
[6] Only includes drivers with at least some activity on 100 km/h zones.

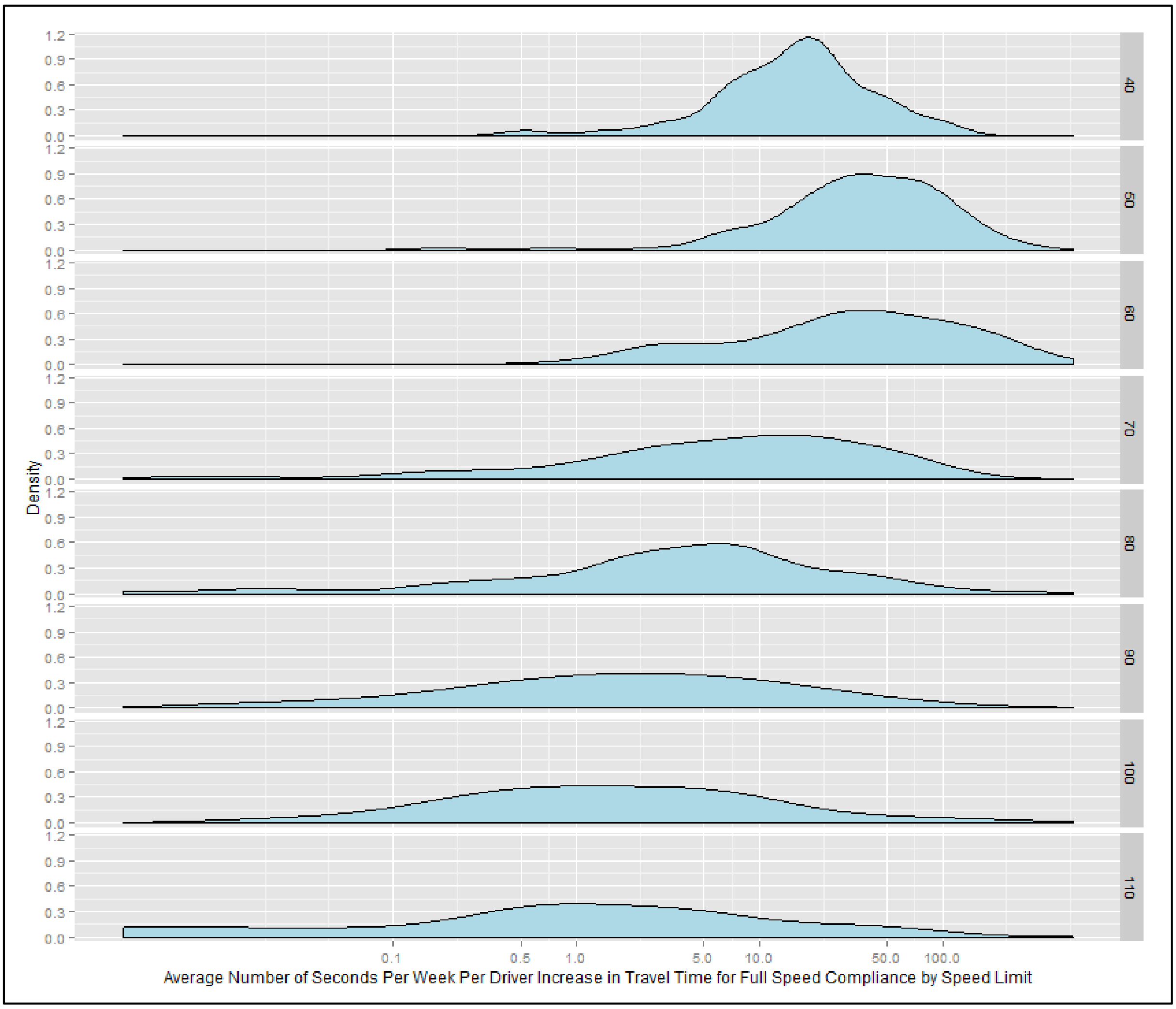

Figure 6: Increase in travel time by speed limit required for speed compliance

6. Discussion and conclusions

Ultimately, the concern here is the way in which drivers are effectively trading fatalities and injuries in exchange for minor time savings. Given that there are an average of 100 speeding-related fatalities and over 2,500 speeding-related injuries per year in Sydney, it would seem that full speed limit compliance could achieve dramatic reductions in road casualties (Elvik and Amundsen, 2000) in exchange for an imperceptible increase in travel time for even the most frequent speeders. However, the evidence suggests that drivers do not consider the trade-off between time savings and the value of a life. Estimates of the value of travel time savings (VOT) suggest that weekday travel time savings are valued at $6.81 per person hour (Ho and Mulley, 2013)[7]. If this were extrapolated using the

[7] Value of time estimates vary depending on method and trip purpose. Most estimates are from $6.30 to $9.56 per person hour (Hensher et al., 2011) but can be as high as $20.53 for work trips (Hensher and Rose, 2007)

number of hours per fatality (Table 1), this would mean that drivers value a life at $129,029.07 in 100 km/h zones and $970,159.41 in 50 km/h zones. Clearly this is not the case as studies on the value of a statistical life show the value of a fatality calculated using willingness to pay (WTP) of $6,369,655 (Hensher et al., 2009), a large discrepancy between these figures. It is acknowledged that estimates of VOT do not generally take into account the casualty risks associated with these time savings, nor are they calculated based on time savings from speeding specifically. As such, some of this discrepancy is likely attributable to the difference between the marginal value of risk reduction and the value of time across all speed levels. Nonetheless, given the role travel time savings play in debates on appropriate speed limits it would appear prudent to educate the public on the trade-off between speeding and casualties.

Regardless of whether or not time savings are a factor in speeding behaviour, among the methods of reducing road casualties, reducing speeding behaviour would appear to be one of the most equitable and cost-effective means of making a large impact on road casualties. The ‘cost’, whether in time or a monetary equivalent would be borne primarily by the most frequent and highest magnitude speeders who also pose the highest risk and even in the most extreme cases the additional travel time would appear almost inconsequential to most drivers. Road safety policy, therefore, should make drivers aware of how they can contribute to reducing the road toll by making a very small change to their daily travel behaviour – a change in duration that for any other activity would likely go unnoticed.

It must be acknowledged, that this analysis focused on day-to-day driving in urban environments, where (arguably) the opportunities to speed and the time-savings were constrained by congestion, intersection delay and (in the case of Sydney) considerable enforcement via fixed and mobile cameras in addition to traditional police radar. Nonetheless, it appears that time savings from speeding can be measured in seconds, not minutes or hours per day for the majority of drivers. Although the cost of speeding, in terms of casualties per hour saved is highest in 100 km/h zones if the end-goal is to reduce the number of casualties in absolute terms the focus should be on targeting speeding on the lower speed, but more frequently used roads. Even on these roads, the increase in travel time necessary to achieve substantial reductions would not substantially increase travel times.

While reducing speeding behaviour remains a considerable task these results challenge one of the popular perceptions of the ‘benefits’ of speeding and provide policy makers with another tool to encourage safer driving.

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