The power of social influence will perhaps become a key influencer of driving speeds only when speeding is overwhelmingly considered to be very unacceptable, as is the case with driving with a Blood Alcohol Concentration (BAC) of 0.1%.

Notes
1 This package of measures included expansion of the covert speed camera program, a lowering of the cameras’ speed detection threshold, increased camera operating hours, the introduction of a 50 km/h general urban speed limit and a large public education campaign *Wipe off 5*. It has been evaluated [3] as having led to a statistically significant reduction in casualty crashes.

References

Methods for measuring motorcycle speeds and their implications for understanding ‘safe speeds’

by Darren Walton, Director - Research and Evaluation, Health Promotion Agency, Wellington, New Zealand; Senior Adjunct Fellow, University of Canterbury, NZ

Introduction
New Zealand traffic accident data show that motorcycles account for 13% of road crash fatalities [1] but that motorcyclists undertake only around 0.5% of travel time or trips [2]. From these statistics, it is determined that motorcyclists are around 16-23 times more likely to be involved in a fatal or injury crash than car drivers [1]. The high relative crash risk for motorcycles is replicated in every country; only the magnitude of the estimate varies, as motorcycles are always the most dangerous form of travel. One report estimates that motorcycles have a relative crash risk as high as 34 times that of cars [3].

Based on vehicle registrations, the number of motorcycles may seem insignificant: they constitute only 3.47% of the NZ vehicle fleet. However, motorcycle registrations have grown to over 100,000 in recent years, with the largest increase occurring between 2004 and 2008 [4]. The popularity of the motorcycle comes and goes but the recent rise in registrations coincides with increased rates of crashes resulting in death or injury [1]. Stephan et al [5] reviewed fatal motorcycle accident files from 115 Australian coroners’ cases and found the rider was travelling too fast for the conditions in over 70% of cases. This conclusion is made notwithstanding that forensic techniques used for estimating a motorcycle’s speed from crash scene evidence are far less accurate than those available for cars [6-7].

The main concern here is to consider the relative speeds of motorcycles and cars implied by reported statistics available from New Zealand, Australia, the United Kingdom and elsewhere. The argument developed in this paper is that our routine monitoring of vehicle speeds is not sophisticated enough to reveal the actual speed profile of motorcycles and is confounded by the classification of motorcycles in a group with scooters and mopeds. Recent work in New Zealand reveals how misleading our reported statistics are concerning motorcycle speeds.

The category that is referred to as ‘motorcycles’ formally includes motorcycles, motor scooters, mopeds, motor-powered bicycles and three-wheeled motorcycles [8]. The category can be referred to as ‘powered two-wheelers’ to avoid misclassification of the range of vehicle types, but this will simply mask the fact that scooters and motorcycles are used by different demographics for different trip purposes, implying different speed profiles and crash rates. To further complicate the issue, modern scooters can be more powerful than small motorcycles. The wide range in vehicle power associated with ‘motorcycles’ places the researcher in a position akin to classifying light trucks with family sedans and expecting speed monitoring to fit within a single distribution.

Annual speed surveys
In New Zealand, an annual vehicle speeds survey is conducted by the Ministry of Transport to provide key monitoring statistics on all vehicle speeds based on vehicle classifications [9]. The survey is central to all performance criteria established by other agencies (as it is in Australia, see for example [10]). It is usual practice to report mean speeds, ‘excessive speeds’ (defined as the percentage of vehicles travelling in excess of the speed limit) [11], and the 85% percentile of the distribution of observed speeds.
The methodology used in New Zealand relies on roadside observers and is sophisticated enough to accurately measure the speeds of different truck and trailer configurations. However, notably absent from what is otherwise best practice is the recorded speed of motorcycles, or ‘motorcycles, scooters and mopeds’.

New Zealand is not unique. Australian states report annual vehicle speed monitoring but do not attempt motorcycles [12-13]. Similarly, of the six states in America reporting annual speed survey results on the web (following OECD [11]), none provides estimates of the speeds for motorcycles. The US Department of Transport acknowledges the importance of particularly monitoring motorcycle behaviours because of their different behavioural patterns and the need to determine exposure rates from travel patterns to account for the fact that ‘motorcycles are the most dangerous motor vehicles for both operators and passengers of any age’ [8].

Relatively rare among jurisdictions is the United Kingdom (UK), which reports monitoring motorcycle speeds (see Table 1). In the UK, speed monitoring is conducted using a network of embedded automatic monitoring units (Figure 1). The UK statistics show motorcycles travelling around the speed of cars in all years from 2006 to 2011. Note that the percentage of motorcycles exceeding the speed limit is about 50%, but the percentage exceeding the speed limit by more than 5 mph is significantly more than that of cars (between 4-8% greater than that observed for cars).

Even when limiting their concern to simply count motorcycles, the US Federal Highway Authority (FHA) recognises five problems with automated systems [8]. Motorcycles (i) are lightweight, (ii) have low metal mass, (iii) have a narrow footprint, (iv) travel in parallel or in staggered formations, and (v) are easily confused with other vehicle types (especially truck and trailer units). The range of equipment marketed as automatic counters for motorcycles includes side looking radar, inductive loops, video capture, quadruple loops, road tubes, infrared beams and magnetometers. Recently emerging techniques include GPS monitoring and point-to-point speed data [15].

Table 1. Free flow vehicle speeds on built-up roads in 30 mph speed zones in the United Kingdom (Annual figures from 2006 to 2011, reported by the UK Department of Transport [14])

<table>
<thead>
<tr>
<th>30 mph limit (50 km/h)</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of sites</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Observations (thousands)</td>
<td>7346</td>
<td>7333</td>
<td>6649</td>
<td>6712</td>
<td>6447</td>
<td>6434</td>
</tr>
<tr>
<td>Average car speed (mph)</td>
<td>48.3</td>
<td>48.3</td>
<td>48.3</td>
<td>48.3</td>
<td>48.3</td>
<td>48.3</td>
</tr>
<tr>
<td>% exceeding limit</td>
<td>49</td>
<td>49</td>
<td>49</td>
<td>48</td>
<td>46</td>
<td>47</td>
</tr>
<tr>
<td>% exceeding limit by more than 5 mph</td>
<td>19</td>
<td>19</td>
<td>18</td>
<td>18</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Average motorcycle speed (mph)</td>
<td>48.3</td>
<td>49.9</td>
<td>49.9</td>
<td>49.9</td>
<td>46.7</td>
<td>48.3</td>
</tr>
<tr>
<td>% exceeding limit</td>
<td>51</td>
<td>51</td>
<td>53</td>
<td>50</td>
<td>45</td>
<td>50</td>
</tr>
<tr>
<td>% exceeding limit by more than 5 mph</td>
<td>25</td>
<td>26</td>
<td>26</td>
<td>24</td>
<td>29</td>
<td>23</td>
</tr>
</tbody>
</table>

Figure 1. The UK Department of Transport monitors vehicle counts and speeds using a network of around 180 sites with embedded sensors configured as Double D inductive loop arrays

There is a wide range of technical apparatus which, when claiming to monitor motorcycle speeds, purports to overcome five major technical hurdles:

- false positives – when other vehicle types are recorded as motorcycles, especially bicycles in urban areas or trailers on truck units on highways
- false negatives – failure to detect a motorcycle because they are masked by other traffic, missed in groups, travel too fast or too slow, miss the inductive loops, fail to trigger the magnetometer, or trigger the wrong mechanism
- classification problems – failure to distinguish the different distributions of speeds for mopeds, scooters and motorcycles; typical equipment for monitoring traffic speeds can fail to detect motorcycles or incorrectly classify bicycles as scooters or motorcycles but it is now recognised that scooters and mopeds travel at slower speeds than motorcycles [16], so combining them together distorts the value of the reported mean speeds and the variation
- accuracy of the speed estimate – the identification of the target vehicle can be successful but the measurement of speed is in error; road tube systems are notorious for coming loose, loop detectors need to be calibrated to a sensitivity that detects motorcycles but not a truck in the adjacent lane
- the error rate is not random across the range of speeds recorded (i.e. fast motorcycles are inaccurately measured). In summary, no system is perfectly suited to monitoring all traffic types, and none is especially good at detecting motorcycles.
Despite the significant technical challenges involved in attempting to accurately estimate the distribution of speeds of motorcycles, it is occasionally done within dedicated research. Reported methods for undertaking the more difficult task of monitoring motorcycle speeds include automated traffic monitoring [17], video camera surveillance [18-19] and equipment-supported roadside observation [16-17].

Comparing results from different surveys

Table 2 combines the available statistics from the UK [4], Australia [17] and NZ [3, 16] to report six sets of free speeds (headways of four seconds or more) for cars and motorcycles. Walton and Buchanan [16] had the aim of measuring motorcycle speeds using a portable TIRTL traffic monitoring system (a system developed, and used widely, in Australia) across five sites and two matched weeks of weekday observations. The system uses infrared beams to detect ‘wheel configurations’ based on algorithms that evaluate the size of the wheel base and the size of the wheels. Despite its technical sophistication, the system was found to confuse bicycles with motorcycles and could not distinguish between scooters and motorcycles (no current system can). Roadside observers were used to record ‘bicycle events’ and type of motorcycle (classifying scooters based on training). Results of this investigation are reported in Table 3. These results, among others, led to the conclusion that ‘motorcycle and scooter riders travel with an increased likelihood of exceeding the speed limit, around 3.4 times more likely than other traffic’ [16].

Baldock et al. [17] used ‘Metrocount’ hardware [20]. As Baldock et al. were examining highway speeds, they could be confident not to encounter the full range of difficulties concerning misclassifications (e.g. bicycles and mopeds). In addition, they used roadside observers to report other characteristics of the motorcyclist such as the use of high-visibility gear and to classify ‘motorcycle’ type, although they do not report separate estimates of mean speeds for motorcycles and scooters.

It is common to observe around 40-50% of traffic travelling at ‘excessive speeds’ with variation according to time of day [11]. So, at first sight, the UK results (50%) seem radically different to the results of Walton and Buchanan [16] (with only 20.6%) and also those in highway speeds in Australia (67%). It is clear in Table 2 that the mean speeds for motorcycles are significantly lower in the urban environments monitored in NZ, and also that a difference is observed when comparing the mean speeds across vehicle types, and this does not appear to be the case in the UK. Some of these differences are due to the site locations in NZ observations, resulting in lower mean scores and average speeds well below the speed limits. It is usual for annual speed surveys to record speeds at midblock sections of the road and maximise the opportunity for free speeds to

<table>
<thead>
<tr>
<th>Table 2. Reported mean free speeds for cars and motorcycles from samples drawn in the UK, NZ, Australia and France</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year</strong></td>
</tr>
<tr>
<td>Number of Vehicles (N)</td>
</tr>
<tr>
<td>Limit</td>
</tr>
<tr>
<td>Average car speed (km/h)</td>
</tr>
<tr>
<td>% exceeding limit</td>
</tr>
<tr>
<td>% exceeding limit by 5mph or 10 km/h</td>
</tr>
<tr>
<td>Average motorcycle speed</td>
</tr>
<tr>
<td>% exceeding limit</td>
</tr>
<tr>
<td>% exceeding limit by 5mph or 10 km/h</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Table 3. Average speed by vehicle type in five inner urban locations with 50 km/h limits in Wellington, NZ as reported by Walton and Buchanan [16]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Vehicles (n)</strong></td>
</tr>
<tr>
<td>Cars</td>
</tr>
<tr>
<td>Trucks</td>
</tr>
<tr>
<td>Motorcycles</td>
</tr>
<tr>
<td>Scooters</td>
</tr>
</tbody>
</table>

reduce error in the observations. Baldock et al. follow the pattern of NZ, showing significantly higher mean speeds for motorcycles compared to cars.

It is also important to consider the removal of bicycles and other sources of error in the research data of Walton and Buchanan, along with the division of motorcycles and scooters for separate considerations. Importantly, in NZ there are higher observed average speeds for motorcycles and scooters compared to cars, a finding that held consistent across each of five sites in inner city Wellington.

Despite appearances, the UK results and others are not radically different. The important consideration is not the mean speeds (which can been shown to vary between sites) but the variation in speed for motorcycles, and particularly the variation in motorcycle speeds compared to that observed for cars. This standard deviation of the samples can be calculated from the point estimates of the mean and the portion travelling above the speed limit. This backward estimation of the variation relies on the assumption that the speed distribution is approximately normal in both cases and the point estimates are determined with a sufficient sample. For example, the estimated standard deviation for the distributions in the UK (30 mph) samples for cars and motorcycles are 7.96 km/h for cars and 10.73 km/h for motorcycles. These calculated estimates of variation can be expressed as the proportion of motorcycles exceeding a notional limit (i.e a 50 km/h speed limit, 5 mph above the 30 mph limit in the UK or 10 km/h above the speed limits in France and Australia) relative to cars exceeding the same limit. These are then presented in Table 4 as the relative odds of motorcycles travelling faster than cars.
The implications of these considerations for safe speeds for motorcycles are clear. The safer motorcyclist would maintain the speed of the surrounding traffic and resist the temptation to use the capability of the machine and the opportunity given by road design to travel faster. That it is an everyday occurrence to observe motorcyclists doing otherwise should not be seen to normalise this behaviour and give it licence, but ought to prompt the question as to whether the ‘system’ design fails because it allows the opportunity to elevate the crash risk by design.

One rule that could be applied is a ‘one lane, one vehicle’ regulation to prevent the circumstances of under-passing and passing within the lane. Other opportunities exist within rider training and rider awareness, along with the idea of raising the awareness of all other vehicle drivers that motorcycles are currently more often travelling faster than surrounding traffic.

Limitations

At least one limitation to the current argument is that speed monitoring regimes are not intended to be as accurate as is implied. Rather, the intention of an annual free speed survey is to monitor vehicle speeds over time, and particularly changes in speeds over time. Any error in the speed measurement is consistent when efforts are made to choose the same sites, equipment, days and times of observation...
and so on. However, this argument is flawed when considering motorcycles for the reasons alluded to at the outset: motorcycle registrations are increasing, motorcycle power is increasing [11], and the purposes of the trips that are undertaken are altering along with the reasons for the waxing and waning of motorcycle popularity. As a consequence, the use of time as an independent variable is fraught with the difficulty that significant sources of error in the dependent measure (speed) are not evenly distributed across the independent variable (time).

Conclusions

Inadequate technology, poor quality data and poor assessment of the available data mean issues concerning the relationship between speed and crash risk for motorcycles are masked in the statistics we monitor and report, usually on an annual basis. It is exceptionally difficult to accurately determine true mean speeds for motorcycles; a dedicated sampling effort is probably necessary to remove sources of error that otherwise show that motorcycles are no more likely to travel faster than cars. Motorcycles do travel faster than surrounding traffic and this is rarely considered from the perspective of their elevated risk for crashes or from the perspective of examining the system that creates this opportunity.

Acknowledgements

The author wishes to acknowledge the support of the Accident Compensation Corporation for funding the series of investigations into motorcycle safety and especially Judy Buchanan who championed investigating motorcycle speeds. The author also thanks Steve Dennis, UK Department of Transport, for supplying the image of the Double D loop array used to assess vehicle speeds across their network.

References

Literature Review

**Recent reports reviewed by Andrew Scarce and Deborah Banks**

**Victorian study supports use of combined speed and red light cameras to reduce crashes at intersections**

A study conducted by researchers at Monash University Accident Research Centre (MUARC) has demonstrated the crash-reduction benefits of combining fixed digital speed and red light cameras. The study evaluated the crash effects of 87 fixed digital speed and red light (FDSRL) cameras and accompanying warning signs at 77 signalised intersections in Victoria over a ten-year period.

The combination of speed and red light fixed cameras is not common and had not been tested previously. Analysis of crash statistics at the 77 sites provided evidence that the use of FDSRL cameras and associated signage significantly reduced the number of casualty crashes. Results showed a 26% drop in all casualty crashes, and a 47% reduction when focusing only on vehicles travelling from the intersection leg where the camera was installed.

MUARC placed the equipment over a large population of signalised intersections in the Greater Melbourne area, with others in regional Victoria including three FDSRL cameras in Geelong, one in Echuca and another in Bendigo.

The study was conducted against a backdrop of entrenched research showing the association between red light running and speed and severe injury/fatalities. In Victoria, speeding has been identified as the main cause of 20% of fatalities and serious injury collisions, while another 20% of casualty crashes at major intersections in metropolitan Melbourne are caused by red light-running.

Currently more than 150 speed cameras and 83 red light cameras are used in Victoria, with an average 2.8 million vehicles speed-checked per month.

The study noted that the benefit of red light cameras ‘may be off-set by increases in rear-end crashes’. MUARC reported that while FDSRL cameras had their highest deterrence effect on the intersection leg where the camera was located, accompanying signage warning of the presence of cameras had a further deterrent effect on other lanes. ‘While the use of FDSRL cameras was associated with a reduction in overall casualty crash risk, there was no evidence of a reduction in relative crash severity’, MUARC said.

In contrast to public perceptions that cameras are installed as revenue-raising devices, the research found strong evidence that this automated technology has been associated with significant reductions in casualty crashes and associated costs to the community from road trauma. Across the 77 intersections studied, it was estimated that 17 crashes causing serious injuries or fatalities, and 39 minor injury crashes, would be prevented each year, representing cost savings to the community of over $8 million.


**Factors that influence driving speed**

Another MUARC study, published in June, looked at factors that influence driving speeds, including driver (or rider) characteristics, motivational and attitudinal