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Debnath, Ashim, Blackman, Ross and Haworth, Narelle (2015) A comparison of self-nominated and actual speeds in work zones. Transportation Research Part F: Traffic Psychology and Behaviour, 35. 213 - 222. ISSN 1369-8478

Cite this article as:
Debnath, A.K., Blackman, R., and Haworth, N. (2015) A comparison of self-nominated and actual speeds in work zones. Transportation Research Part F, Vol. 35, pp. 213-222.

A COMPARISON OF SELF-NOMINATED AND ACTUAL SPEEDS IN WORK ZONES

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ABSTRACT

Despite significant research on drivers' speeding behavior in work zones, little is known about how well drivers' judgments of appropriate speeds match their actual speeds and what factors influence their judgments. This study aims to fill these two important gaps in the literature by comparing observed speeds in two work zones with drivers' self-nominated speeds for the same work zones. In an online survey, drivers nominated speeds for the two work zones based on photographs in which the actual posted speed limits were not revealed. A simultaneous equation modelling approach was employed to examine the effects of driver characteristics on their self-nominated speeds. The results showed that survey participants nominated lower speeds (corresponding to higher compliance rates) than those which were observed. Higher speeds were nominated by males than females, young and middle aged drivers than older drivers, and drivers with truck driving experience than those who drive only cars. Larger differences between nominated and observed speeds were found among car drivers than truck drivers. These differences suggest that self-nominated speeds might not be valid indicators of the observed work zone speeds and therefore should not be used as an alternative to observed speed data.

Keywords: Speed perception, Work zone, Speeding, Seemingly Unrelated Regression, Roadworks**.**

1. INTRODUCTION

Poor compliance with speed limits is among the most serious and challenging safety issues in work zones (Finley, 2011; Schrock et al., 2004). Many studies (e.g., Benekohal et al., 1992; Benekohal et al., 2009; Brewer et al., 2006; Debnath et al., 2014a; Debnath et al., 2014b, 2015; Haworth et al., 2002; Wang et al., 2003) have found poor compliance, often with substantial proportions of drivers exceeding posted speed limits by large amounts. Speeding contributes to work zone crashes (Garber and Patel, 1995), which occur at higher rates compared with pre-work periods and at greater severity levels compared with crashes outside of work zones (Bai and Li, 2011; Khattak et al., 2002; Pigman and Agent, 1990; Whitmire II et al., 2011). Bai and Li (2006) reported that 25% of fatal work zone crashes were primarily caused by speeding or excessive speed for the conditions. Other research (Brewer et al., 2006) found that 42% of all work zone crashes had speed cited as a contributory factor.

Since speeding is common in work zones and contributes to crashes, it is important to not only collect robust measurements of on-road speeds (by direct observation) but also to gather information regarding what drivers judge to be appropriate speeds and the factors that underlie these judgments and behaviors (by self-report methods). While many studies (e.g., Benekohal et al., 1992; Benekohal et al., 2009; Brewer et al., 2006; Debnath et al., 2014a; Debnath et al., 2014b; Haworth et al., 2002; Wang et al., 2003) have observed speeds in work zones and provided useful insights into the circumstances influencing drivers' on-road speeding behavior, little is known about driver judgments of appropriate work zone speeds. Therefore, the relationship between such judgments and on-road behavior (i.e., observed speeds) has not been fully articulated. Consequently, it remains unknown if self-nominated speeds are a valid indicator of observed speeds and thus can be used, for example, in evaluations of work zone safety interventions as an alternative to observed speeds.

While no studies have comprehensively analyzed the relationships between drivers' self-nominated speeds and speeding behavior in work zones, several studies have done so for non-work zone road sections. In an early Australian study, Fildes et al. (1991) examined the relationships between observed speeds, self-reported speeds and attitudes to speeding. Speeds were observed at four sites, with selected vehicles identified by registration number and the drivers then requested to participate in a survey several kilometers downstream from the observation point. Participants were shown photographs of the road section where their speeds were observed and asked several questions regarding their speeds on that section. Driver-nominated speeds were generally close to the vehicle-matched observed speeds. The strength of this research is that the observed speeds could be linked to driver characteristics and survey responses (including nominated speeds) for each selected vehicle.

Similar studies have been conducted in Sweden (Åberg et al., 1997; Haglund and Åberg, 2000). In the study by Åberg et al. (1997), participants generally expressed positive attitudes toward compliance, but the observed speeds revealed that more than half of the sample exceeded the posted limits in a 50 km/h zone. Haglund and Åberg (2000) later replicated that study for 90 km/h zones, again finding that most drivers exceeded speed limits, with strong relationships between observed and self-reported speeds. It was also concluded that the perceived speeds of other vehicles influence individual driver behavior regarding speed limit compliance (Haglund and Åberg, 2000), as previously suggested (Åberg et al., 1997). One important limitation of these studies is that prior knowledge about the posted speed limits might have influenced drivers' answers to questions about safe and appropriate speeds. Such 'anchoring bias', in which respondents tend to anchor their perceptions around known values (which in this case is speed limit), is common in the survey literature (Debnath and Chin, 2009; Fischhoff et al., 1993; Weinstein, 1987).

In an Australian online survey (Lahausse et al., 2010), participants viewed images of different roadways and were asked what speed they would drive at in the scenarios, and then to estimate the actual posted limit, which was not visible in the images. With potential anchoring bias avoided, this study was useful for examining the relationship between anticipated behavior and estimated speed limits. However, as there was no observational measure of vehicle speeds at the sites depicted in the images, the relationship between estimated speeds and actual behavior could not be examined.

In the context of work zones, Bham and Mohammadi (2011) examined driver opinions about the appropriateness of posted speed limits, as well as their self-reported travel speeds. In their survey, 118 drivers who passed through a work zone upstream of the survey location were asked if they felt the posted limit in the work zone was safe. About 80% reported it as safe, however it was not clear from this question whether the posted speed limits were deemed appropriate (i.e., drivers might perceive a speed limit as safe, but consider it unnecessarily low). Drivers were also asked in separate questions to indicate what they thought was the appropriate speed limit and the speed they drove at through the upstream work zones. It was concluded that drivers generally nominated a speed limit based on their own travel speed. It should be noted that drivers were aware of the actual posted speed limit, which is likely to have influenced their travel speeds and may have produced anchoring bias in the overall responses, as noted earlier.

The above discussion identifies two important gaps in the work zone safety literature: (1) it is not well understood how well driver judgments of appropriate speeds match their observed speeds in work zones, and (2) no studies have examined the factors influencing drivers' work zone speed judgments. This paper aims to fill these important gaps by (1) examining the extent to which driver judgments of appropriate work zone speeds are consistent with real world work zone speed observations, and (2) examining how drivers' speed judgments are influenced by their demographic and licensing characteristics. Descriptive analyses were used to compare the self-nominated and real world speeds, while a simultaneous equation modeling approach was employed to model the self-nominated speeds as functions of driver characteristics.

2. DATA

Two types of speed data were collected in this study: (1) driver-nominated speeds for two work zone scenarios (depicted in photographic images), collected through an online survey, and (2) speeds observed at the depicted work zone sections. These two types of data and their collection methods are described in the subsequent sections.

2.1 Self-nominated Speed Data

Self-nominated speeds were collected using an online survey among drivers in Queensland, Australia. Still photographs and brief descriptions of two rural highway work zone scenarios (referred to hereafter as Sites 1 and 2) were shown to survey participants. Participants were asked to nominate the speed they thought they would drive at when traveling through the pictured work zones (see Figure 1). Importantly, the actual posted speed limits (Site 1: 40 km/h, Site 2: 60 km/h) were not visible in the photographs, thereby removing potential for anchoring bias (participants might anchor their nominated speed values close to the posted speed limits if they were aware of the limits). The pre-roadwork speed limit at both sites was 100 km/h. It is to be noted that the pre-roadwork and during-roadwork speed limits in Queensland are displayed using regulatory speed limit signs.

Site 1 was a long-term work zone on an undivided rural two lane highway (one lane each way) with one lane closed to traffic due to resurfacing works. Traffic control was in place to regulate traffic movements in the open lane. According to Queensland's MUTCD

(Queensland Government, 2010), a long-term work zone is one which requires a traffic guidance scheme to operate both day and night and may be left unattended. Site 2 was a long-term work zone on a four lane rural highway with two lanes each way divided by a 15 meter wide median. Work involved construction of a new slip lane which required a lane closure (separated by water filled barrier). There was no work on the other side of the road. These two sites represent the two major types of highways in Queensland: undivided one-lane each-way highways, and divided multi-lane highways.

Survey selection criteria required that participants were Queensland residents, held a current Queensland driver license, had driven at least weekly in the last 12 months and had never been employed in road construction, maintenance or traffic control.

Participants were recruited using a range of methods. Invitations were sent to 373 members of the Centre for Accident Research and Road Safety (CARRS-Q) InSPiRS Research Panel (Independent Survey Panel in Road Safety) who met the selection criteria for participation. Participants were also recruited through advertising on the CARRS-Q website, group email distribution by industry partners of the current research program to their staff, live-to-air radio interviews, newspaper coverage, and through snowballing techniques (word of mouth). Two media releases on the research project were prepared and disseminated by the university's media department.

A total of 410 participants completed or partially completed the survey, including 99 members of the InSPiRS panel and 311 members of the general public. Of the total responses, 405 had complete and valid responses for the variables of interest to the current paper and were included in the analysis.

Overall, the survey sample was representative of the Queensland licensed driver population (TMR, 2013) in terms of age and gender. Slightly more than half of all participants (53.8%) were male. Compared to Queensland driver license holders, younger drivers (17-24 years) were somewhat underrepresented in the survey sample (5.7% vs 13.1%), middle aged drivers (25-59 years) were slightly overrepresented (71.1% vs 64.2%) and older drivers (60 or over) were almost equally represented (23.2% vs 22.7%).

2.2 Observed Speed Data

Travel speeds were measured at the work zones depicted in the survey scenarios. The speed measurement locations were towards the start of activity areas (after the first speed reduction sign in the activity area) where the lowest speed limits are generally seen in work zones.

Standard signage following the Queensland Manual of Uniform Traffic Control Devices (MUTCD)[1] (Queensland Government, 2010) was used at the sites. Spot speeds were collected using pairs of pneumatic tubes installed 1 meter apart on the pavement and connected to a MetroCount Vehicle Classification System. Vehicles were classified using the ARX vehicle classification scheme into three aggregate classes: Light vehicles (e.g.,

[1] The typical components of a work zone in Queensland's MUTCD are termed differently from the FHWA's MUTCD. For example, the terms 'taper area', 'safety buffer', and 'work area' in Queensland correspond to the FHWA's terms 'transition area', 'buffer space', and 'work space' respectively. The terms 'advance warning area' and 'termination area' are similar in both versions of the MUTCD. The term 'activity area' is used in FHWA's MUTCD to represent the work space and buffer space together but a similar term is not used in Queensland's MUTCD.

motorcycle, sedan, utility, light van, caravan), Medium vehicles (two to four axle bus or truck), and Heavy vehicles (e.g., trailer with more than two axles, B-double, road train). Data were collected and analyzed in metric units. It should be noted that vehicles travel on the left in Australia.

Speeds of all vehicles that travelled over the pneumatic tubes were measured continuously for a seven day period. From the measured speed data, only those data that relate to the scenarios illustrated in the survey photographs (i.e., daytime, clear weather condition, and posted speed limits when the photographs were taken) were included in the analysis. The measured and self-nominated speeds did not come from the same drivers, but the driver samples in both speed datasets were large enough to be representative of the same driver population (i.e., Queensland drivers). Speeds of 9,800 and 44,949 vehicles at Site 1 and Site 2 respectively were included in the analysis.

3. ANALYSIS METHODS

3.1 Descriptive Comparison of Speeds

Both the self-nominated and observed speed data were analyzed descriptively to understand compliance rates. The observed speeds were classified into two groups: free flow speeds, and in-platoon speeds. Free flow speeds referred to conditions where drivers had the freedom to travel at their desired speeds, i.e., they were not closely following another vehicle. Vehicles traveling with more than four seconds headway were categorized as traveling in free flow condition, as defined in many studies (e.g., Debnath et al., 2014b; Maze et al., 2000; Sun and Benekohal, 2005). Descriptive statistics of different measures of safety (mean speed and compliance levels) were compared for the free flow and in-platoon speeds. Similar measures of safety were computed for the self-nominated speed data, allowing comparison of the measures among the observed and self-nominated speed data.

The presence of vehicles on the road, as illustrated in the pictures of Site 1 and Site 2, could have affected drivers' nominated speeds. To account for potential biases generated from this issue, the self-nominated speeds were compared with both the free flow and in-platoon speeds so that this comparative exercise truly reflected the differences between drivers' nominated speeds and the real world observations.

Speeds were compared both in aggregate for all vehicles as well as separately for light, medium and heavy vehicles. Identifying vehicle types in the observed speed data was straightforward as the MetroCount devices recorded the necessary information. In the case of self-nominated data, information regarding the vehicle types that participants drove regularly was used to classify the nominated speeds based on type of vehicle. For example, speeds nominated by survey participants who regularly drove cars (but not trucks) were compared with the observed speeds of light vehicles. On the other hand, speeds nominated by participants who regularly drove trucks were compared with the speeds of observed medium and heavy vehicles. A comparison of medium and heavy vehicle speeds was not possible as self-reported information on vehicle types used did not allow classifying between medium and heavy vehicles.

In addition to the descriptive analysis, the differences among the free flow, in-platoon, and self-nominated speeds (aggregately and separately for vehicle types) were tested by using two sample unpaired t-tests with considerations for equality/inequality of variances.

3.2 Regression Model

It is known that demographic and licensing characteristics can influence drivers' self-reported speeds (Mannering, 2007). For example, male drivers may choose higher speeds as safe compared to female drivers, or may actually drive at faster speeds than females in work zones and elsewhere (or vice-versa). To comprehensively understand the results obtained in the comparative analysis of the self-nominated and observed speeds, it is necessary to know how driver demographic and licensing characteristics might have influenced the speeds. A key challenge here is that such an analysis requires identification of driver characteristics in the observed speed datasets. Recording driver characteristics in the observed speed data is a difficult task as it requires stopping drivers after the data collection point to collect necessary information. It is possible to do this for selected drivers by stopping them at locations (e.g., service stations, cafes, traffic lights) downstream of work zones (as done in Fildes et al., 1991 and; Haglund and Åberg, 2000 for non-work zone sections), but it is impractical to stop all drivers who travel through work zones. Since the current study aimed to observe the speeds of all vehicles traveling through the work zones, driver characteristics could not be collected. On the other hand, it was possible to collect the driver characteristics in the survey and to link those characteristics with the nominated speeds. In the absence of driver characteristics for the observed speed data, this study focuses on understanding how driver-nominated speeds vary with survey participant characteristics.

A simultaneous equation modelling approach was employed to model the self-nominated speeds. Speeds at the two sites were nominated by each driver and are therefore likely to be correlated within individuals. In addition, unobserved driver characteristics might influence their self-nominated speeds in a similar way across the two speed variables. Modelling the data without appropriately treating this interrelated structure would result in erroneous model estimates (Washington et al., 2011). For modelling such interrelated data and endogeneity, the three-stage least squares (3SLS) and seemingly unrelated regression (SUR) approaches are appropriate choices. These two approaches differ in terms of the presence/absence of endogeneity in the model structures. In order to decide which approach suits the speed data, endogeneity was tested first using Durbin WU Hausman (DWH) test.

In the absence of significant endogeneity (as found later in the analysis), the SUR approach is an appropriate choice. The two outcome variables of self-nominated speeds at Site 1 (SRS_{s1}) and Site 2 (SRS_{s2}) can be written in the form of a system of simultaneous equations:

$$SRS_{s1} = \alpha_{s1} + \boldsymbol{\beta}_{s1}\boldsymbol{X} + \varepsilon_{s1} \quad (1)$$
$$SRS_{s2} = \alpha_{s2} + \boldsymbol{\beta}_{s2}\boldsymbol{X} + \varepsilon_{s2} \quad (2)$$

where $\boldsymbol{X}$ is the vector of driver demographic and licensing characteristics; α and $\boldsymbol{\beta}$ are the vectors of estimable parameters in the model, and ε's are the correlated disturbance terms within individual respondents. The two equations (eq. 1-2) are seemingly unrelated but there is contemporaneous correlation of disturbance terms.

4. RESULTS AND DISCUSSION

Results are presented and discussed in the subsequent sections in three groups: comparing mean speeds, comparing non-compliance rates, and examining the effects of driver demographic and license characteristics on self-nominated speeds.

4.1 Comparison of Mean Speeds

Comparison of observed free flow speeds and in-platoon speeds (Table 1) show that mean free flow speeds of all vehicles were higher than the mean in-platoon speeds in both Site 1 (44.7 km/h vs 43.4 km/h, Hedges's g = 0.16, p<0.001) and Site 2 (67.8 km/h vs 65.4 km/h, Hedges's g = 0.17, p<0.001). Similar results were obtained when speeds were compared separately for light (Site 1: 45.4 vs 43.6 km/h, Hedges's g = 0.22, p<0.001; Site 2: 69.1 vs 65.4 km/h, Hedges's g = 0.26, p<0.001) and medium vehicles (Site 1: 42.8 vs 41.8 km/h, Hedges's g = 0.11, p=0.034; Site 2: 64.8 vs 61.7 km/h, Hedges's g = 0.20, p<0.001). For heavy vehicles, Site 1 observed higher free flow speeds than in-platoon speeds (44.5 vs 43.2 km/h, Hedges's g = 0.18, p=0.001), but the difference at Site 2 (65.8 vs 65.4 km/h, Hedges's g =0.03) was not statistically significant (p=0.18).

Comparison of the self- nominated speeds and observed speeds (Table 1) showed that survey participants nominated lower speeds than those at which drivers were actually observed traveling at the two sites. For example, the mean self-nominated speeds for all vehicles were 42.1 km/h and 57.6 km/h at Sites 1 and 2 respectively, which were 2.6 km/h (Site 1) and 10.2 km/h (Site 2) lower than the corresponding observed mean free flow speeds. The differences (with Hedges's g of 0.29 and 0.62 for Site 1 and Site 2 respectively) were statistically significant (p<0.001). A similar pattern of results was also obtained when the self-nominated speeds were compared with observed in-platoon speeds.

Disaggregate comparisons of the mean speeds for different types of vehicles produced mixed findings. When the mean self-nominated speeds and mean observed free flow speeds were compared for light vehicles only, results similar to the aggregate analysis were obtained. The mean self-nominated speeds at both sites were significantly (p<0.001) lower (difference of 3.5 km/h at Site 1 and 11.5 km/h at Site 2 with corresponding values of Hedges's g as 0.36 and 0.73 respectively) than the corresponding mean observed free flow speeds. However, the differences for medium and heavy vehicle speeds were not statistically significant (Site 1: Hedges's g=-0.49, p=0.15, Site 2: Hedges's g=0.21, p=0.22). While a conclusive result was not obtained for the medium and heavy vehicles, it should be noted that the sample size for the medium and heavy vehicle drivers in the survey was relatively small (n=13) in comparison with the light vehicle drivers (n=390). When self-nominated speeds were compared with observed in-platoon speeds, results similar to those of the self-nominated versus free flow observed speeds were obtained.

The differences in the results among different types of vehicles indicate that the nature of self-nominated speeds might differ among driver groups, as well as vary by vehicle type in the real-world observations. Several studies (e.g., Bai et al., 2010; Benekohal et al., 2010; Debnath et al., 2014a; Debnath et al., 2014b) have shown that speeds of vehicles in work zones vary according to vehicle type. However, it is not yet known how driver characteristics influence their self-nominated speeds in the context of work zones.

Mean self-nominated speeds—both aggregated and disaggregated by type of vehicle—for Site 2 were higher than for Site 1. This was somewhat expected, because the posted speed limit (although not known by survey participants) at Site 2 was higher (60 km/h) than at Site 1 (40 km/h). Work zone characteristics and road surface conditions at the two sites were also different, which required the setting of different speed limits in accordance with work zone regulations. Site 1 had unsurfaced pavement on the closed lane (loose materials were visible to drivers) and bollards were used to separate the closed lane from the open one. On the other hand, the closed lane at Site 2 was surfaced (no loose materials visible) and was separated from the open lane using a continuous water filled barrier. These differences suggest that a lower speed limit is appropriate for Site 1 than for Site 2. However, it is interesting that while the difference between sites in posted speed limits was 20 km/h, the difference in mean self-nominated speeds was 15.5 km/h which indicates that the rate of compliance with posted speed limits might be different in the two sites. Non-compliance rates at the two sites are discussed in the next section.

4.2 Comparison of Compliance Rates

Comparison of non-compliance rates (% drivers above speed limit) in the self-nominated and observed speeds (Figure 2) showed that drivers of all types of vehicles were less compliant in real world observations than in the self-nominated speeds. For example, 73.8% of light vehicle drivers were observed speeding at Site 1, whereas only 26.4% were non-compliant according to their self-nominated speeds.

In the case of speeding by a margin of 5 km/h or more over the posted speed limit, the percentages of light vehicle drivers above this margin were smaller in the self-nominated speed data than in the observed speed data. The results related to the medium and heavy vehicle drivers were inconclusive among the two sites. Site 1 had higher non-compliance rate in the self-nominated speeds than in the observed speeds, whereas Site 2 had the opposite. In the case of the results related to speeding by a large margin (15 km/h or more) were also inconclusive among the two sites. The percentages of light vehicle drivers above this margin at Site 1 were almost equal in the self-nominated and observed speeds, but the percent values for observed speeds were higher at Site 2.

Non-compliance rates in the self-nominated speeds (Figure 3) showed that younger drivers were the least compliant group (Site 1: 43.5%; Site 2: 26.1%), followed by the middle aged (Site 1: 28.1%; Site 2: 24.0%) and older drivers (Site 1: 20.7%; Site 2: 12.0%). Male drivers were less compliant than female drivers (Site 1: 34.9% vs. 18.7%; Site 2: 25.7% vs. 17.1%). Among the drivers who regularly used cars, those who had truck licenses (but did not drive trucks regularly) were less compliant than those who had car licenses only (Site 1: 36.2% vs. 24.7%; Site 2: 41.4% vs. 18.4%). Among the truck-licensed drivers, non-compliance levels of those who regularly drove trucks and those who did not showed inconsistent results across the two sites. Overall, drivers were less compliant at Site 1 than at Site 2, which underlies the 15.5 km/h difference in the mean self-nominated speeds of the two sites when the difference in posted speed limits was 20 km/h.

The comparisons of the self-nominated speeds and observed speeds presented above clearly indicate that drivers nominated lower speeds (and therefore indicated higher compliance rates) than those observed in real-world work zones. The differences observed among the observed and self-nominated speeds indicate that these speeds might not be valid indicators of each other. Therefore, the self-nominated speeds should not be used as an alternative to the speed data obtained from real-world work zones. Use of self-nominated speeds should be restricted to understanding the influence of different driver factors on speed choice, as demonstrated in the next section.

4.3 Effects of Driver Characteristics on Self-nominated Speeds

Differences in mean speeds and compliance levels across different driver groups warranted examination of how driver characteristics affect the self-nominated speeds. Estimation results obtained from calibration of SUR models in software STATA 11.2 are presented in Table 2.

DWH test confirmed that endogeneity was not statistically significant in any of the models. Therefore, the SUR estimation approach was preferred over the 3SLS approach. Fitness statistics showed that the SUR models are superior to models with only a constant term. The Chi-square test results indicate that the test statistics were significant at 99% confidence level, suggesting that the outcome variables are functions of various explanatory variables.

The intercepts of the models were 38.2 and 51.9 for Site 1 and Site 2 respectively. Recall that Site 2 had a higher speed limit (60 km/h) than Site 1 (40 km/h) and drivers' self-nominated speeds were also higher at Site 2 (mean speeds of 57.6 km/h vs. 42.1 km/h at Site 1). Because of the higher speeds of Site 2, it was not surprising to see a larger intercept in the Site 2 model than in the Site 1 model. The regression coefficients of the Site 2 model were also of larger magnitudes than those of the Site 1 model, but were of consistent sign. Larger coefficients of the Site 2 model indicate that the rates of change in self-nominated speeds for the explanatory variables were higher in the case of Site 2 than in Site 1. It should be noted that this finding was obtained based on speeds from two sites with speed limits 40 and 60 km/h. Speed limits higher than these are quite common in work zones. Further research is necessary for work zones with higher speed limits in order to comprehensively understand the relative rates of change in self-nominated speeds for the explanatory variables.

Turning to specific estimation results, female drivers nominated lower speeds for both sites. On average, female participants nominated 1.9 km/h (Site 1, $p=0.084$) to 3.2 km/h (Site 2, $p=0.031$) lower speeds than males, suggesting that male drivers are less cautious than females regarding work zone speed choice. Existing literature (not related to work zone, but to other road sections) shows mixed results on influence of gender on speed choice. Mannering (2007) found that males drive faster than females according to self-report data, while females are reported to be more cautious (Hassan et al., 2012) and more supportive of lower speed limits (Debnath et al., 2013; Lahausse et al., 2010). Male drivers were also found to be less likely to believe that their safety is threatened when driving 10 mph (16.1 km/h) over posted speed limit (Mannering, 2009). However, other studies (Fildes et al., 1991; Haglund and Åberg, 2000) found no significant effects of gender on travel speed in normal road sections.

Both the younger (17-24 years) and middle aged drivers (25-59 years) nominated higher speeds than the older drivers (60 or more years). Examination of the regression coefficients for all age groups revealed an increasing trend with decrease in driver age, except for the 25-29 years group. This increasing trend implies that self- nominated speed values decrease with increase in their ages, possibly being associated with more driving experience and maturity. Among all driver groups, the younger drivers (17-24 years) nominated the highest speeds. They nominated 8.4 km/h (Site 1) to 13.0 km/h (Site 2) higher speeds than older drivers. These drivers are generally the novice drivers who have relatively little driving experience. The association of greater compliance with increasing age is supported by findings from other studies (not within the context of work zones though). For example, from analysis of speeds on normal road sections, Mannering (2007) found that increasing driver age had a negative effect on driver-reported speeds on interstate roads. Fildes et al. (1991) found drivers younger than 34 years of age are more likely to be excessive speeders and those older than 55 years are more likely to be excessively slow drivers. Debnath et al. (2013) found that middle aged drivers believe their safety can be improved by reducing speeds to a greater extent than younger drives do. In contrast, Lahausse et al. (2010) reported that older drivers held the most negative attitudes towards speed limits, although they note that this finding is contrary to those of most other studies.

Self-nominated speeds varied significantly by type of license held and type of vehicle commonly used. Compared to car-licensed drivers who regularly drove cars, the truck-licensed drivers who regularly drove cars nominated significantly higher speeds (3.7 km/h at Site 1 and 8.9 km/h at Site 2). Cross-tabulation of age and license status of the survey participants showed that about 43% (n=25) of the truck-licensed drivers who regularly drove cars were in the older group (aged 60+ years), 26% (n=15) were aged 50-59 years, 21% (n=12) were aged 40-49 years, and the remaining 10% (n=6) were aged 25-39 years. Since most of these drivers are in the older and high-middle aged groups, they were expected to nominate smaller speeds if the licensing variables were not present in the models. Recall that driver age was found to be negatively associated with increase in self-nominated speeds. Truck-licensed drivers who did not drive trucks regularly are different from the car-licensed drivers using cars regularly, in that the former likely have at least some previous experience driving trucks. Arguably, truck driving experience might have caused the truck-licensed drivers to nominate higher speeds than the car-licensed drivers. This argument is supported by another finding from the model estimates that truck-licensed drivers who drive trucks regularly nominated higher speeds than the car-licensed drivers who used cars regularly. This finding was found significant in the Site 1 model only (p=0.016), but not for the Site 2 model (p=0.197). While the inconsistency in statistical significance cannot be explained solely by the data used in this study, the low sample size (n=13) of the driver group (truck-licensed drivers who drive trucks regularly) could possibly be an explanation for the inconsistent result among the two sites.

While results show that truck-licensed drivers nominated higher speeds, analysis of the observed speeds produced different results (see Table 1). Observed speeds of medium and heavy vehicles (trucks) were lower than those of light vehicles (cars). These results indicate that car drivers have larger differences between their self-nominated and real-world speeds than truck drivers. This supports the findings obtained earlier by disaggregate comparison of the observed and the self- nominated speeds for different vehicle types (car drivers reported speeds significantly smaller than their measured speeds, but the results for truck drivers were inconclusive).

Particular strengths of the current study are that self-nominated speeds at specific work zone sections were compared with the actual observed speeds at the same work zone sections and drivers were unaware of posted speed limits when they provided the self-nominated speeds in the survey. This study is one of several that have asked participants to judge appropriate speeds from photographs of road sections in surveys (e.g., Lahausse et al., 2010). While the photographs of the work zone sections in the current survey might not accurately reflect some characteristics of roads and driving conditions (e.g., noise and tactile vibration felt by drivers from road surface while driving), the photographs clearly showed the important characteristics of the site (e.g., lane closure, lane width, traffic cones and bollards, roadside features, and loose materials on surface) that drivers usually keep in mind when judging appropriate speeds of travel. The photographs in the current study did not reveal the actual work zone speed limits to survey participants, thus removing the potential for anchoring bias present in other studies on speed choice. The nominated speeds were based on perceptions of the work zone characteristics and conditions without the influence of prior knowledge of the posted speed limit. This study design and its scope (i.e., work zone sections) sets the current research apart from other studies which have compared observed and self-reported speeds, both within work zones and on normal road sections.

5. CONCLUSIONS

Significant research efforts have been devoted in the past to understand speeding behavior in work zones, mostly by observing driver speeds in work zones. Relatively little research has aimed to understand driver judgments of appropriate work zone speeds and whether those judgments correspond with actual speeds observed in work zones. This paper therefore innovatively examined how consistent driver judgments of appropriate speeds are with their observed speeds and what driver characteristics influence their speed judgments.

Drivers self-nominated speeds were found to be lower than their observed speeds. Consequently, they were more compliant overall in their nominated speeds than in observed speeds. While this was found specifically for drivers of light vehicles, the results for medium and heavy vehicle drivers were either statistically non-significant or different among the two studied sites. Self-nominated speeds were also found to be significantly influenced by drivers' demographic and licensing characteristics. Higher speeds were nominated by males, young, and middle-aged drivers than the females and older drivers respectively. Drivers with truck licenses also nominated higher speeds than car licensed drivers. Car drivers had larger differences in their self-nominated and observed speeds than truck drivers. These differences suggest that driver-nominated speeds might not be valid indicators of their observed speeds. Therefore, self-nominated speeds should not be used as an alternative to observed speeds in evaluation of work zone safety treatments.

Future research should focus on examining the associations between the self-nominated and actual speeds by studying a larger number of work zones so that any potential effects of roadway geometric characteristics on the speeds can be accounted for in the analysis. Studying a larger number of sites may also allow further examining the inconsistent findings obtained in this study for medium and heavy vehicles.

ACKNOWLEDGEMENTS

The authors are grateful to Australian Research Council, GHD Pty Ltd, Leighton Contractors, and QLD Department of Transport and Main Roads for funding the research project titled "Integrating Technological and Organisational Approaches to Enhance the Safety of Roadworkers" (Grant No. LP100200038). The authors would also like to acknowledge the support of the Australian Workers Union. The comments expressed in this paper are those of the authors and do not necessarily represent the policies of these organizations.

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FIGURE 1 Photographs shown to drivers for obtaining self-nominated speeds (Top: Site 1, Bottom: Site 2).

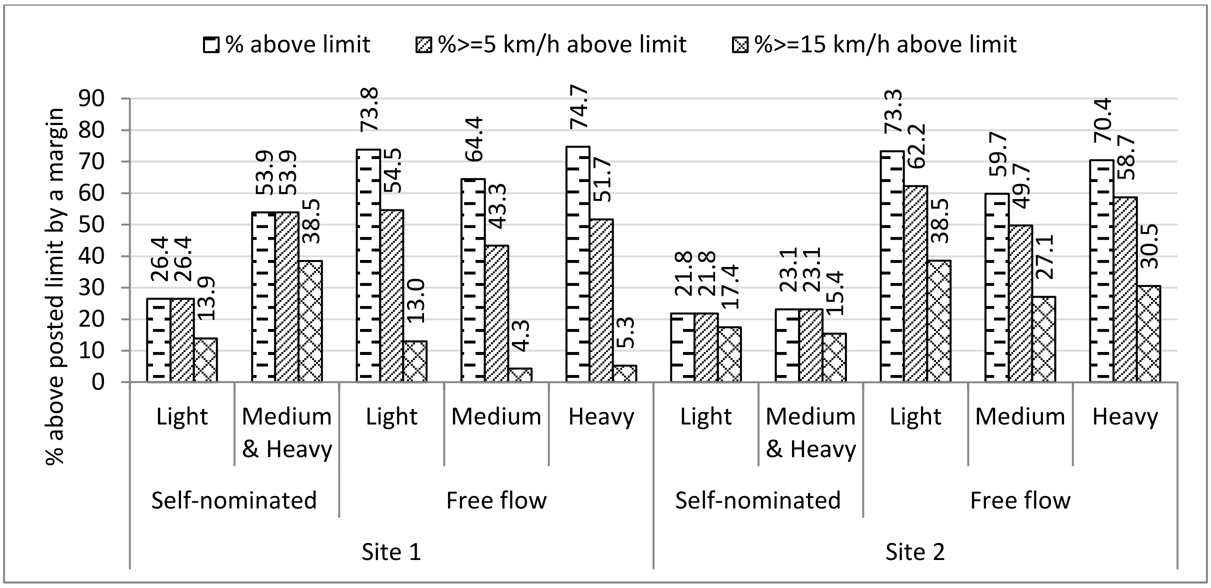

FIGURE 2 Non-compliance levels in self-nominated and observed speeds by types of vehicles.

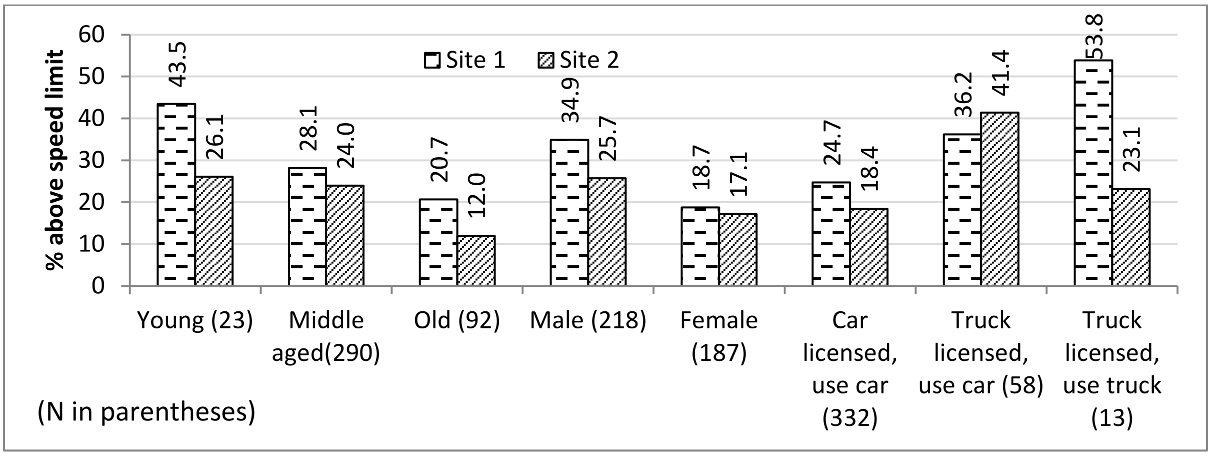

FIGURE 3 Non-compliance rates in self-nominated speeds by driver characteristics.

TABLE 1 Descriptive Statistics of Observed and Self-nominated Speeds

Site	Type of vehicle	In-platoon speed (Km/h)			Free flow speed (Km/h)			Hedges's g (Free flow vs. In-platoon)	Self-nominated speed (km/h)			Hedges's g (Free flow vs. Self-nominated)
		N	**Mean**	**S.D.**	**N**	**Mean**	**S.D.**		**N**	**Mean**	**S.D.**	
1	All	7116	43.39	8.09	2684	44.67	8.48	0.16	405	42.12	11.05	0.29
	Light	6086	43.57	8.05	1386	45.40	9.12	0.22	390*	41.95	10.91	0.36
	Medium	638	41.83	8.36	464	42.77	8.00	0.11	13^	47.69	12.35	-0.49
	Heavy	392	43.15	7.77	834	44.52	7.42	0.18				
2	All	29492	65.37	13.40	15457	67.78	16.37	0.17	405	57.64	14.99	0.62
	Light	24467	65.38	13.49	11808	69.05	15.87	0.26	390*	57.55	15.11	0.73
	Medium	2358	61.67	13.47	1659	64.80	18.25	0.20	13^	60.00	12.25	0.21
	Heavy	2667	65.39	12.48	1990	65.79	16.25	0.03				

* drivers who regularly drive car; ^ drivers who regularly drive truck

TABLE 2 Estimation Results of Seemingly Unrelated Regression Models

Variables	Beta	Z stat	p-value	95% CI	
Site 1 Model					
Female driver	-1.939	-1.73	0.084	-4.14	0.26
Age of driver					
17-24 years	8.429	3.34	0.001	3.49	13.37
25-29 years	3.550	1.83	0.068	-0.26	7.36
30-39 years	6.579	3.98	<0.001	3.34	9.82
40-49 years	6.248	3.73	<0.001	2.96	9.53
50-59 years	3.217	1.99	0.046	0.05	6.38
60 and more	Reference				
License-vehicle combination^					
Car licensed, use car	Reference				
Truck licensed, use car	3.712	2.28	0.022	0.52	6.90
Truck licensed, use truck	7.407	2.41	0.016	1.38	13.43
Other license-vehicle*	1.801	0.24	0.813	-13.10	16.70
Constant	38.199	28.57	<0.001	35.58	40.82
No of observations	405				
Chi-square	35.31		<0.001		
Site 2 Model					
Female driver	-3.239	-2.15	0.031	-6.19	-0.29
Age of driver					
17-24 years	13.038	3.86	<0.001	6.42	19.66
25-29 years	6.329	2.43	0.015	1.22	11.43
30-39 years	9.999	4.52	<0.001	5.66	14.34
40-49 years	6.355	2.83	0.005	1.95	10.75
50-59 years	5.023	2.32	0.020	0.78	9.26
60 and more	Reference				
License-vehicle combination^					
Car licensed, use car	Reference				
Truck licensed, use car	8.902	4.09	<0.001	4.63	13.17
Truck licensed, use truck	5.318	1.29	0.197	-2.75	13.39
Other license-vehicle*	8.075	0.79	0.428	-11.88	28.03
Constant	51.925	29.00	<0.001	48.42	55.43
No of observations	405				
Chi-square	46.40		<0.001		

* Licensed but don't drive any vehicles regularly (n=2, age group: 60 and more); ^ Combinations of 'type of license held' and 'type of vehicle regularly driven'—for example, 'Truck licensed, use car' refers to drivers who hold a Truck license and regularly drive a car.