Motivations for Speeding

Volume II: Findings Report

U.S. Department of Transportation
National Highway Traffic Safety Administration

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Richard, C. M., Campbell, J. L., Lichty, M. G., Brown, J. L., Chrysler, S., Lee, J. D., Boyle, L., & Reagle, G. (2013, September) *Motivations for Speeding, Volume II: Findings Report.* (Report No. DOT HS 811 818). Washington, DC: National Highway Traffic Safety Administration.

This report is accompanied by:

Richard, C. M., Campbell, J. L., Lichty, M. G., Brown, J. L., Chrysler, S., Lee, J. D., Boyle, L., & Reagle, G. (2012, August). *Motivations for Speeding, Volume I: Summary Report.* (Report No. DOT HS 811 658). Washington, DC: National Highway Traffic Safety Administration. Available at www.nhtsa.gov/staticfiles/nti/pdf/811658.pdf

Richard, C. M., Campbell, J. L., Lichty, M. G., Brown, J. L., Chrysler, S., Lee, J. D., Boyle, L., & Reagle, G. (2013, August). *Motivations for Speeding, Volume III: Appendices*. (Report No. DOT HS 811 819). Washington, DC: National Highway Traffic Safety Administration.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS 811 818		
4. Title and Subtitle Motivations for Speeding, Volume II: Findings Report		5. Report Date September 2013
		6. Performing Organization Code
7. Author(s) Christian M. Richard, John L. Campbell, Monica G. Lichty, James L. Brown, Susan Chrysler (Texas Transportation Institute), John D. Lee (University of Wisconsin, Madison), Linda Boyle (University of Washington), George Reagle (George Reagle and Associates)		8. Performing Organization Report No.
9. Performing Organization Name and Address Battelle Memorial Institute 505 King Avenue Columbus, Ohio 43201-2696		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. DTNH22-06-D-00040, Task#2
12. Sponsoring Agency Name and Address National Highway Traffic Safety Administration Office of Behavioral Safety Research 1200 New Jersey Avenue SE. Washington, DC 20590		13. Type of Report and Period Covered FINAL REPORT August 2008 – December 2011
		14. Sponsoring Agency Code

15. Supplementary Notes

Geoffrey Collier (initial) and Randolph Atkins (final) were the Contracting Officer's Technical Representatives (COTRs).

16. Abstract

This is Volume II of a three-volume report. It contains the results of a study that examined the speeding behavior of drivers in their own vehicles over the course of three to four weeks of naturalistic driving in urban (Seattle, WA) and rural (College Station, TX) settings. The purpose of this research was to (1) identify the reasons why drivers speed, (2) model the relative roles of situational, demographic, and personality factors in predicting travel speeds, (3) classify speeders, and (4) identify interventions/countermeasures and strategies for reducing speeding behaviors. Data collected from 164 drivers included 1-Hz recordings of vehicle position and speed using GPS receivers, responses to a battery of a personal inventory questionnaires, and daily driving logs that captured trip-specific situational factors. Vehicle speed and position data were combined with road network data containing validated posted speed information to identify speeding episodes. The descriptive analysis of speeding data provided evidence for different types of speeding behaviors among individual drivers including: (1) infrequent or incidental speeding, which may be unintentional, (2) trip-specific situational speeding, (3) taking many trips with a small amount of speeding per trip (i.e., casual speeding), and (4) habitual or chronic speeding. Regression models were developed to identify predictors of "any" speeding (logistic regression) and amount of speeding (linear regressions). Significant predictors included demographic variables such as age and gender, situational factors such as time-of-day and day-of-week, and key personal inventory factors such as attitudes towards reckless driving. In addition, focus group discussions were conducted with a subset of study participants who were classified as "speeders" and "non-speeders" to identify key attitudes and beliefs towards speeding and the effectiveness of potential countermeasures.

17. Key Words	18. Distribution Statement
Speeding, Speed Selection, Free-flow Driving, Speeding Countermeasures, Unsafe Driving	Document is available to the public from the National Technical Information Service www.ntis.gov

19 Security Classif. (of this report)	20. Security Classif. (of this page)	21 No. of Pages	22. Price
Unclassified	Unclassified	204	

Form DOT F 1700.7 (8/72) Reproduction of completed page authorized

Acknowledgements

The *Motivations for Speeding* project involved a collaborative effort among numerous contributors, and only the key researchers are formally included as Final Report authors. We specifically acknowledge the efforts and contributions of Diane Williams, Mark Tianow, Ashley Loving, Elizabeth Jackson, Ta Liu, and Dale Rhoda of Battelle, and of the following researchers at Texas Transportation Institute, Katie Connell, Laura Higgins, and Marshall Ward.

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Abbreviations and Acronyms

BB-Safety .... Behavioral Beliefs related to Safety
BCB-Temptation .... Behavioral and Control beliefs related to Temptation to Speed
CB-Opportunity .... Control Beliefs related to Opportunity to Speed
CFCC .... Census Feature Class Code
DBQ .... Driver Behavior Questionnaire
DVRE .... Driver, Vehicle, Roadway, and Environment
FAA .... Federal Aviation Administration
FM .... Farm to Market
GB .... Gigabyte
GED .... General Education/Equivalency Diploma
GIS .... Geographic Information System
GPS .... Global Positioning System
HOV .... High Occupancy Vehicle
IRB .... Institutional Review Board
NCHRP .... National Cooperative Highway Research Program
NHTSA .... National Highway Traffic Safety Administration
NMEA .... National Marine Electronics Association
OR .... Odds Ratio
PS .... Posted Speed
RMC .... Recommended Minimum Communication
SD .... Secure Digital
SOFN .... Seattle Older Female Non-speeder
SOFS .... Seattle Older Female Speeder
SOMN .... Seattle Older Male Non-speeder
SOMS .... Seattle Older Male Speeder
SUV .... Sport Utility Vehicle
SYFN .... Seattle Younger Female Non-speeder
SYFS .... Seattle Younger Female Speeder
SYMN .... Seattle Younger Male Non-speeder
SYMS .... Seattle Younger Male Speeder
ToD .... Time of Day
TOFN .... Texas Older Female Non-speeder

TOFS .... Texas Older Female Speeder
TOMN .... Texas Older Male Non-speeder
TOMS .... Texas Older Male Speeder
TPB .... Theory of Planned Behavior
TXDOT .... Texas Department of Transportation
TYFN .... Texas Younger Female Non-speeder
TYFS .... Texas Younger Female Speeder
TYMN .... Texas Younger Male Non-speeder
TYMS .... Texas Younger Male Speeder
UTC .... Coordinated Universal Time
WAAS .... Wide Area Augmentation System
WSDOT .... Washington State Department of Transportation
ZKPQ .... Zuckerman-Kuhlman Personality Questionnaire

Chapter 1: Background and Introduction

Although speeding is one of the most significant contributors to crash severity and traffic fatalities, attempts to address this problem through a variety of approaches have not led to a significant reduction in speed-related fatalities (National Highway Traffic Safety Administration (NHTSA), 2005). NHTSA's (2007) report, *Countermeasures That Work*, provides a list of speeding countermeasures that have been demonstrated to be effective; most of which focus on enforcement or punishment to reduce speeding. A limitation with these types of countermeasures is that they may not be as effective with some driver groups, such as risk-taking young males, who rarely consider the potential consequences of their behaviors (McKenna & Horswill, 2006). Similarly, National Cooperative Highway Research Program (NCHRP) Report 500 provides several engineering-based countermeasures to address speeding (NCHRP, 2005). These countermeasures can be effective in reducing speeding at specific locations, but they can be expensive and only cover small parts of the transportation network, and other non-speeding drivers are also impacted by these countermeasures. Thus, there is a strong interest in new countermeasures to better target identifiable groups of speeders using approaches that specifically and effectively address the reasons for their speeding.

A substantial amount of research has been conducted on the causes of speeding. Table 1 shows the multitude of factors that have been found to be associated with speeding or speed-related crashes. Despite all this research, there is still uncertainty regarding the relative importance of these factors, and how this information can be used to develop countermeasures that effectively target specific types of drivers. This project provides an opportunity to look at several of these factors in a single study and, importantly, to match findings about specific factors to on-road speeding behavior.

Table 1. Factors found to be associated with speeding in previous research.

Factor	Example Variables	Example References
Demographic	Age, Gender, Socio-economic & Education Level	DePelsmacker & Janssens, 2006; Harré et al., 1996; Hemenway & Solnick, 1993; Stradling et al., 2002
Personality	Attitudes, Habits, Personal & Social Norms, Thrill-seeking, Beliefs	Arnett et al., 1997; Clément & Jonah, 1984; DePelsmacker & Janssens, 2006; Ekos Research Associates, 2007; Gabany et al., 1997; McKenna & Horswill, 2006; Stradling et al., 2002
Roadway	Posted Speed	Book & Smigielski, 1999; Giles, 2004
Environment	Urban/Rural	Giles, 2004; Rakauskas et al., 2007
Vehicle	Engine Size; Vehicle Age	Hirsh, 1986; Stradling et al., 2002
Risky Behaviors	Drinking & Driving, Seatbelt Use, Red-light Running	Arnett et al., 1997; Cooper, 1997; Gabany et al., 1997; Harré et al., 1996; Hemenway & Solnick, 1993; Rajalin, 1994
Situational	Trip time, Mood, Inattention, Fatigue	Arnett et al., 1997; Ekos Research Associates, 2007; Gabany et al., 1997; Hirsh, 1986; McKenna, 2005, McKenna & Horswill, 2006

Objectives

The purposes of this research effort are to:

Identify the reasons why drivers speed,

Model the relative roles of situational, demographic, and personality factors in predicting travel speeds,

Classify speeders, and

Identify interventions/countermeasures and strategies for reducing speeding behaviors.

Specific questions that the project sought to address include:

1. What is the relative importance of situational factors, demographics, and personality in predicting episodes of speeding?
2. What are the subtypes of drivers with respect to speeding? Can we replicate (or fail to replicate) and refine the classification of speeders into two groups: pragmatic speeders and rebels?
3. To what extent are these classes of speeders defined by demographics? To what extent are speeders, in general, defined by demographics? Specifically, are the subtypes of speeding drivers the same across demographic groups?
4. For the sample studied, to what extent is the predilection to speed correlated with the tendency towards other unsafe driving acts?
5. What attitudes, habits, and behaviors are directly or indirectly related to possible countermeasures (points systems, points reduction classes, checkpoints, automated enforcement, crackdowns, traffic calming measures, etc.), so that subgroups can be compared on these measures?

In short, this effort focused on identifying "who" is speeding, "what" contributes to their decisions to speed, and it attempted to identify "which" countermeasures can be most effectively focused at those drivers who account for a significant proportion of the speeding problem. The research consisted of two phases. In Phase 1, the Battelle Team has examined individual drivers' travel speeds in an on-road study; in Phase 2, we conducted focus groups of select speeder subgroups.

Overview of Technical Approach

The research involved a comprehensive approach for studying speeding in drivers and identifying appropriate countermeasures (see Figure 1 below). The field data collection portion drew upon existing research to identify driver and situational factors associated with speeding, and used this information to develop data collection tools, including a personal inventory questionnaire, a Global Positioning System (GPS)-based, on-road speed recorder, and daily driving-logs that capture situational factors. The information provided by these tools was used to address the objectives listed above, including questions related to: (1) the relative importance of situational, demographic and personality factors; (2) the classification of speeder subtypes; (3) the predictiveness of demographics for speeder subtypes; and (4) correlations between speeding and unsafe driving acts. Following Phase 1 (the field data collection), information about speeder subtypes was used to conduct focus group studies on a subset of participants that match speeder subtypes. This qualitative information addresses the broader project goal of obtaining driver attitudes and behaviors related to countermeasures.

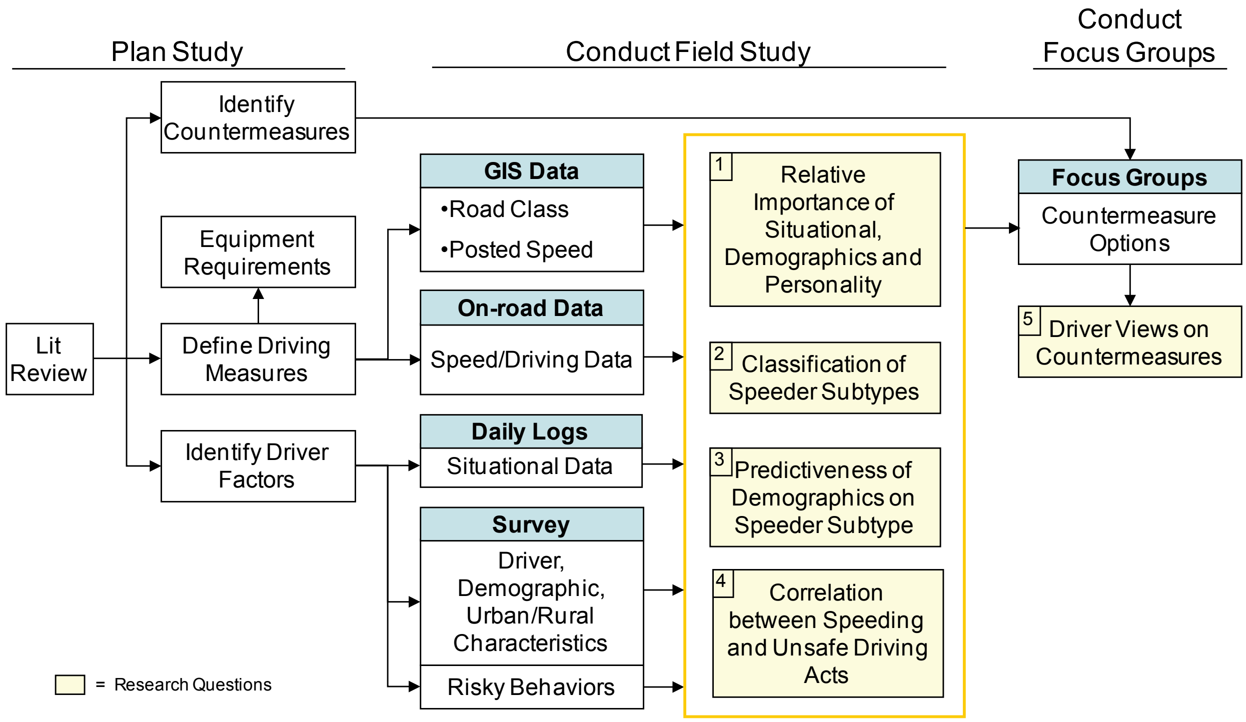

Figure 1. Overview of proposed approach for studying speeding in drivers and identifying countermeasures.

This report provides the methods, results, and conclusions associated with the field data and focus group data collection. Specifically, this report describes a naturalistic field study in which 164 volunteer drivers from Seattle, Washington, and College Station, Texas, agreed to have GPS units installed in their vehicles for 3 to 4 weeks. The GPS data obtained in the study was used to compare the drivers' speeds to the posted speed limits, referred to in this report as posted speeds (PSs), associated with the roads that they were driving on at any given point in time. These comparisons between actual speeds and posted speeds formed the basis for the analyses and findings described in this report.

This report consists of a number of chapters and appendices, as described below:

Chapter 2 describes the methods associated with the on-road data collection effort, including descriptions of the experimental design, study participants, recruiting procedures, driver questionnaires, GPS devices used in the study, detailed data collection procedures, and procedures for processing, validating, and filtering the resulting on-road data.

Chapter 3 describes the initial results from the field study, including the findings from a series of analyses providing basic descriptive information about the data, as well as the results of inferential analyses focused on identifying predictors of speeding.

Chapter 4 provides the methods and results of the focus groups.

Chapter 5 provides our conclusions from this study.

Chapter 6 provides a brief discussion of some methodological considerations relevant to our results and conclusions regarding the data collection and analyses.

Seven appendices are provided in Volume III of this report. They are:

- Appendix A: Description of Data Processing Activities;
- Appendix B: Description of Data Validation Activities;
- Appendix C: Regression Analyses with Socioeconomic Control Variables;
- Appendix D: Factor Analysis;
- Appendix E: Personal Inventory Questions;
- Appendix F: Personal Inventory Responses; and
- Appendix G: Draft Moderator Guide and Handouts for the Phase 2 Focus Groups.

Chapter 2: Methods

Introduction

This study employed an on-road, naturalistic approach to investigating drivers' speed choices and speeding behavior in both Seattle, Washington (urban driving), and College Station, Texas (rural driving). GPS units were installed in the 164 participants' vehicles for three to four weeks and participants were asked simply to engage in their normal driving activities. Location and vehicle speed were derived from the GPS data and the posted speed limits, referred to in this report as the posted speeds (PSs), on travelled roadways were obtained from State and county databases. These data were merged into a final data set to compare driving speeds to posted speeds. Below, we discuss the research methods used in this study, including:

Experimental Design;

Dependent Variables and Covariates;

Participants;

Apparatus and Test Instruments;

Data Collection Procedures;

Data Processing Activities;

Definition of Speeding; and

Selection of Speed Type/Threshold.

Experimental Design

The goal of this research project is to quantify the factors that influence drivers' propensity to speed and to use this information to determine effective speeding countermeasures. The experimental design had to balance carefully the need to sample a representative population with the need to control variance by defining homogeneous populations. It was important to maintain as representative a sample as possible in the current study. In particular, this research represents a new, more detailed look at real-world high-speed driving observed on the road with the potential to provide more nuanced information about who is speeding, when they are speeding, and what the different types of speeding look like. For this reason, it was important to cast as wide a net as possible in order to catch as much of this new information as possible, even if it meant that we were left with higher variance as a result.

The experimental design was also tailored towards capturing segments of the population that are likely to engage in speeding behavior, and for which we hope to develop countermeasures. Previous studies have shown that age, gender, and geographical area influence the propensity to speed (De Waard et al., 1995; Rienstra & Rietveld, 1996; Yagil, 1998). The experimental design in the proposal reflected these influences, combined them in a study consisting of a 2^3 full factorial design with age, gender, and geographical area as between-subjects factors with 164 drivers, and with data from each driver collected over at least three weeks.

Based on a power analysis conducted during the planning phase of this study, a small range of driver ages was excluded from the experimental design. This was done because overall statistical power was determined to be low and restricting the age variable to certain ranges was a simple way to reduce within-group variability. Table 2 shows the age ranges used in the study: 18 to 25 years old for the younger group and 35 to 55 for the older group. This change provided more homogeneous groups, which should have correspondingly reduced the variance and increased the statistical power. This change also provided a clearer separation of the groups so that the young drivers (i.e., younger than 25)—if they have a greater propensity to speed—are not mixed with those 25 to 30 years old, a transition point in the age range to generally safer drivers. From our power analysis, differences between drivers "younger than 30" and "older than 30" would require a greater number of drivers to be discernible. As a result, we chose to focus our sampling on drivers 18 to 25 and 35 to 55.

Table 2. Study design and allocation of participants.

Geography	Urban (Seattle, WA)				Rural (College Station, Texas)			
Gender	**Male**		**Female**		**Male**		**Female**	
Age	18-25	35-55	18-25	35-55	18-25	35-55	18-25	35-55
Subjects	*Ss 1-20*	*Ss 21-40*	*Ss 41-60*	*Ss 61-80*	*Ss 81-100*	*Ss 101-120*	*Ss 121-140*	*Ss 141-160*

Dependent Variables and Covariates

In order to accommodate the range of research questions in this study, several different types of data were collected from participants. A summary of the types of dependent variables is presented in Table 3 below. Note that each of the data categories listed in the left-most column was comprised of multiple, more specific variables. More detailed information about each is provided in the relevant sections below or as separate appendices (i.e., for the personal inventory data).

Table 3. Data used in the analyses.

Data	Data Type		Data Collection Method
Demographic	Between Ss	Categorical	Participant Screener & Pre-Drive Questionnaire
Vehicle variables	Between Ss	Categorical	
Personality/risk taking/attitude	Between Ss	Qualitative	Pre-Drive Questionnaire
Driving behavior (speed-related measures)	Within Ss	Continuous	On-Road GPS
Driving situational factors (roadway class, time, day, trip length, etc.)	Within Ss	Categorical	
Trip situational factors (purpose, passengers, weather, stress, congestion, lateness, etc.)	Within Ss	Categorical	Driving Logs
Attitudes, beliefs, and intentions related to speeding	Between Ss	Qualitative	Post-Drive Questionnaire

The primary dependent measures involve variables that quantified the participants' travel speed relative to the posted speed. The travel speed was taken from the GPS device, while the posted speed information was extracted from county and State GIS data sets (and validated with Google StreetView™ and on-road driving; See Appendix A for a detailed discussion of data processing activities and Appendix B for a detailed discussion of validation activities). Several other speed-related measures were also recorded and/or computed, such as median speed, and maximum acceleration/deceleration rates (see Table 4 below). In addition to speeding-related variables, other information about the driving situation (road type, trip duration, cumulative heading change, etc. and data-verification variables) were recorded during each driver trip.

Table 4. Driving-related variables recorded for each 30-second driving epoch/record.

Type of Variable	Elements of Variable
Driving	Average and median travel speed, cumulative heading change, posted speed, percentage of epoch spent in various speed bands.
Speed Variability	Standard deviation, minimum, maximum, standard deviation relative to exponentially weighted moving average.
Descriptive	Road name, road type, county, ZIP, trip ID, trip duration, spatial position.
Variables and Flags for Checking Validity	GPS signal, spatial-join error, missing GIS data, change tracking, etc.

Participants

A total of 164 participants fully completed the study requirements at both locations. Table 5 below shows the participant breakout by location, age group, and gender. Note that some participants have fewer days of driving data for a variety of reasons, including partial equipment failure, or personal activities limiting the number of their driving days during the study (e.g., vacation). Another noteworthy aspect is that the number of completed older male drivers in Texas (16 drivers) is lower than the objective for that condition (20 drivers). Although the data collection period was extended and participant compensation increased to recruit more of these drivers, interest among this group was so low that it was not possible to reach the data collection objectives. In order to compensate for this shortcoming to a limited extent, additional older male drivers were recruited in Seattle.

Table 5. Distribution of participant demographics.

Urban – Seattle, WA					
Gender	**Male**		**Female**		**Total**
Age	*18-25*	*35-55*	*18-25*	*35-55*	
Objective	20	20	20	20	80
Total Scheduled	35	35	27	30	127
Total Enrolled	22	25	22	22	91
Withdrew/Hardware Failure	1	0	1	1	3
Total Complete	21	25	21	21	88
Rural – College Station, Texas					
Gender	**Male**		**Female**		**Total**
Age	*18-25*	*35-55*	*18-25*	*35-55*	
Objective	20	20	20	20	80
Total Scheduled	25	17	24	25	91
Total Enrolled	22	17	22	22	83
Withdrew/Hardware Failure	0	1	1	2	4
Total Complete	20	16	21	19	76
Grand Total Complete	**41**	**41**	**42**	**40**	**164**

Participant Recruitment

Participants were recruited using multiple approaches, and the specific approaches used varied based on location because of the greater difficulty of obtaining eligible participants in Texas than in Seattle. Both locations used newspaper and internet classified advertisements, in addition to posting flyers at local colleges, community centers, and libraries. These approaches were sufficient to reach urban/suburban drivers in Seattle who did most of their driving in built up areas. However, obtaining rural drivers in Texas was a more difficult task, and additional measures had to be taken at that location, such as setting up information tables at locations frequented by rural drivers, distributing post cards, placing ads on local radio stations, handing out business cards at hardware stores, and sending emails to clubs. These approaches were supplemented by an informational Web site. The Web site was advertised in all recruiting materials that contained detailed information about the overall study, participant eligibility requirements, and what participants could expect to do during the study. Potential participants were given a screening interview over the phone.

Participant Incentive Structure

Participant financial compensation contained two components:

1. Fifty dollars ($50) for the primary participation stipend (completion of questionnaires, most log entries, on-road data collection); and

2. Fifty dollars ($50) for the logbook completion incentive (which required approximately 80 to 90% or greater completion rates for logbook entries).

At the end of the study, it became increasingly difficult to recruit participants. This was particularly the case for older male drivers in Texas; on multiple occasions during recruiting interviews, these drivers indicated that total compensation levels were too low. In order to meet recruiting objectives, compensation was increased to $200 for each participant.

Apparatus and Test Instruments

This section describes three devices that were used to characterize personality and related factors, situational factors while driving, and driving behavior. These devices include:

1. Pre-drive and post-drive personal inventories;

2. Trip logs; and

3. GPS-based driving data.

Each of these devices is described below. The GPS-related information includes device selection, a description of the chosen device, and device preparation and installation.

Pre-Drive and Post-Drive Personal Inventory

A personal inventory was developed to measure demographic, personality, attitudinal, and other individual factors associated with speeding behavior. The set of questions covered topics identified as having the greatest potential to account for variance in on-road speeding data. These included elements such as demographic factors, sensation seeking attitudes, risk-taking behaviors, and attitudes and beliefs about speeding. To the extent possible, we incorporated existing measurement scales that had already been validated (Sensation Seeking Scale, Driver Behavior Questionnaire (DBQ), etc.). Table 6 below shows the types of questions included in the personal inventory.

One of the key issues that was necessary to address in question set development was to minimize the potential for "contaminating" driver behavior if participants became aware that the primary objective of the study was to investigate speeding. In particular, because the questions covered several different aspects of speeding behavior, there was a real possibility that drivers might be alerted to the study objective of recording speeding behavior. The concern was that this could cause some drivers to change their actual speeding behavior to avoid being "caught breaking the law." The simplest solution to this problem was to exclude most speeding-related questions from the pre-drive inventory, and instead move them to the post-drive inventory (see below). In this case, it would not matter to the on-road portions of this study if drivers guessed the study objective at that time, since the driving data already would have been collected by that point.

Table 6. Questions included in the personal inventory.

Start-Up Inventory (15-20 min)	Scope	Number of Questions	Comment
Demographic Questions	Age, income, education, vehicle, etc.	10	Questions were modeled from the 2000 U.S. Census questions.
Travel Behavior	Trip planning, route selection, etc.	5	Questions developed for this study.
Driver Behavior Questionnaire (DBQ)	Driving behavior (inattention/"slips," errors, and violations).	28	Modified from Reason et al., 1990.
CARDS and DeJoy Risk Perception Questionnaires Combined	Risky driving behaviors.	18	Redundant questions with DBQ and across both risk question sets were removed.
Zuckerman's ZKPQ Imp-SS scale	Sensation seeking and impulsivity.	9 sensation seeking, 10 impulsivity questions	Shortened and updated version of Sensation Seeking Scale.[1]
Close-out Inventory (15-20 min)	**Scope**	**Number of Questions**	**Comment**
Theory of Planned Behavior (TPB)	Attitudes, beliefs, social norms.	39	Questions from Elliott et al., 2005.
Self-Reported Driving Speeds	Typical comfortable driving speeds on different types of roads.	4-Seattle 7-Texas	Part of the post-drive questionnaire.

Trip Log

In order to capture additional information on situational factors during trips, participants were asked to complete daily trip logs as a component of their participation. The logs consisted of easy-to-complete checklists, designed to capture the situational factors that may influence speed choice, including trip time and purpose, number of passengers, weather conditions, distraction, fatigue, alcohol use, and if someone other than the participant drove the vehicle during an outing. An example of the trip log form for a single trip is shown below in Figure 2.

[1] Information about the Zuckerman-Kuhlman Personality Questionnaire (ZKPQ) is available from www.zkpq.com/principaling.htm.

Trip Date: __________ *Time of Day:* ________*AM / PM* *No. of Passengers:* _______

Who Drove: ☐ Self ☐ Other

Purpose of Trip (check all that apply):
☐ Weekday Commute ☐ Appointment ☐ Recreational ☐ Errands ☐ Other

Road / Weather Conditions (check all that apply):
☐ Dry/Sunny ☐ Fog ☐ Light Rain/Drizzle ☐ Heavy Rain/Hail ☐ Snow/Ice

Ongoing Conditions/Factors During your Trip (check all that apply):
☐ You were late ☐ Traffic was heavy ☐ You were stressed out ☐ You were fatigued ☐ You were generally distracted ☐ Consumed alcohol in last hour

Figure 2. Daily trip log data fields for a single trip.

Although the trip logs were simple to complete, doing so consistently required a relatively high degree of participant involvement. Accordingly, several steps were taken to encourage trip log completion, including:

- *Communicating the trip log activities as a study priority to participants*. This was effective because the study was described to participants as a "travel" study that involved collecting data about their route selection and factors that affect this, which made the trip logs highly relevant. Also, several of the logbook data fields were consistent with this explanation (trip purpose, congestion, levels, etc.). Accordingly, logbook completion was described as a primary objective of the study, with the understanding that they were expected to devote effort to this task as part of the participation requirements.

- *Making log completion easy*. Participants were provided with three different ways to complete the daily log information, including: (1) small booklets that participants could keep with them in their vehicles, (2) phoning in their entries, and (3) online completion. Also, a trip entry consisted of only a limited number of easy-to-complete check-box fields, with a few requiring written entries (e.g., time, date). In addition to these written logs, each participant was e-mailed a daily reminder with a link to the online version of the logbook.

- *Providing financial incentive for consistently completing the trip logs*. Participants were informed that they could receive a significant monetary bonus if they completed all or most of the trip log entries ($50, the same amount as the value for study participation).

Note that the trip log information was not used in the current analyses, although it is available for future analyses. The primary reasons why these data were not used are listed below.

Despite our effort to maximize completion rates, there were a relatively high number of missing trip log entries for most participants (i.e., approximately 50% of trips identified from the GPS data did not have corresponding trip logs).

Similarly, a few drivers that had usable driving data had no trip log data at all, so we would have had to eliminate these drivers from any analyses. We decided that this cost was too high.

Trip log entries were often the same across most trips, and the key situational factors (being late, stressed, fatigued, etc.) were rarely indicated. Part of this had to do with the unusually dry weather conditions in Seattle during the data collection period.

Given the high level of effort to include trip log data in the data set compared to the limited use we had for those data in the current analyses, we decided to focus on other data analysis activities instead.

Device Selection and Pilot Testing

This section provides an overview of the process used to select and test the GPS device. See the project work plan (Richard et al., 2008) for a detailed description of this process.

GPS device selection involved careful consideration of trade-offs between device capabilities, device cost, staff labor for installing/removing the devices, costs associated with any required modifications to the GPS unit packaging, and labor for turning raw GPS outputs into data that is appropriate for statistical analysis. To facilitate device selection, a set of selection criteria was developed that included GPS performance requirements, data content and storage requirements, and operations-related requirements (required packaging modifications, installation options, power management, etc.). Table 12 in the work plan provides a complete list of these criteria. An assessment of over a dozen current devices was performed, and two units were identified as candidate systems. The two units were evaluated in a series of rigorous, side-by-side tests to determine which device offered the best overall performance and addressed the evaluation criteria in the most workable fashion.

GPS Device

The GeoChron GPS data logger, manufactured by SparkFun, was chosen as the GPS device to be used in the project. This data logger continuously records GPS data to a removable Secure Digital (SD) flash memory card with a maximum storage capacity of 2 GB. The data are recorded to the SD card in human-readable form using standard National Marine Electronics Association (NMEA)[2] sentences at a rate of one sample per second. The on-board GPS module is based on the SiRFIII chipset and is specified to exhibit positional accuracy of 5 m or better with Wide Area Augmentation System (WAAS)[3] enabled and speed accuracy of 0.1 m/s (0.22 mph). The GPS module includes a built-in antenna as well as a connector for attaching an optional external antenna. The unit operates on a range of voltages (6 V to 14 V), and is designed

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[2] The GeoChron GPS module outputs the location, speed, heading, and other data using a standardized format published by the NMEA. The GeoChron supports a small subset (SiRF, 2005) of the sentences available in the NMEA 0183 standard; in our implementation, we recorded only the Recommended Minimum Communication (RMC) sentences specified in the standard.

[3] WAAS (FAA, 2009), is a GPS error correction system that uses a network of satellites that transmit messages to precisely surveyed ground stations. These messages contain information that GPS receivers use to correct errors in the GPS signal and improve location accuracy and reliability.

to record a new data file each time power is applied to the power connector. Finally, the unit is packaged in an enclosure that was easy to modify and made it possible to develop multiple methods of mounting the unit in the vehicle. Figure 3 shows the GeoChron as it was received from the manufacturer.

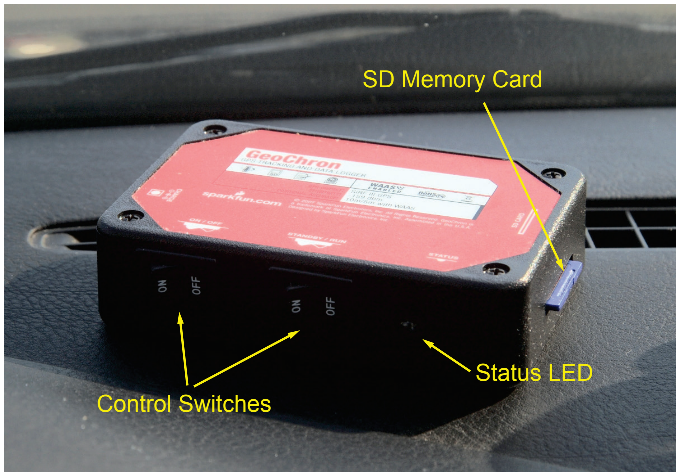

Figure 3. GeoChron GPS data logger prior to modification.

A 2-GB SD flash memory card was used to capture the GPS data. This high level of memory capacity ensured that ample memory was available to capture all of the data for a participant, particularly for those vehicles in which the unit was continually powered for the duration of his/her trial.

Device Preparation and Installation

Although the GeoChron data logger was well suited for our application, some modifications to the unit were required in order to prevent participants from tampering with the unit, to manage power, and to affix the mounting hardware to the data logger. This section describes the modifications that were made to the GeoChron to accommodate these requirements.

Tamper Proofing

The GPS installation was designed to be completely self-contained and require no participant interaction or intervention. We also wanted to prevent participants from inadvertently turning off the unit or removing the SD memory card from the side of the unit. In order to achieve these goals, the GeoChron's power and standby switches were removed from the unit and a custom mounting adapter bracket was fabricated from ABS plastic with tabs that covered the switch mounting holes and prevented access to the SD memory card.

Power Management

The GeoChron includes an internal rechargeable battery for use without an external power source. The duration of a participant trial, however, was expected to far exceed the life of a single battery. Therefore, it was necessary to power the unit using an external power source. To simplify installation and minimize installation time, a 7.5 V regulated DC power adapter that plugs into the vehicle's cigarette lighter power receptacle was chosen to provide power to the GPS. The power adapter cable was replaced with a 10-foot cable in order to accommodate installations in larger vehicles, such as pickup trucks and sport utility vehicles (SUVs).

The GeoChron charges the battery whenever power is applied to its power receptacle. However, it was discovered during testing that if the battery is drained completely, the charging circuit limits current to the battery in order to optimize the charging current and prevent over-charging the battery. In consequence, the unit does not supply sufficient current to power the GPS module while charging a completely drained battery. Because the unit is constantly active, the battery will drain once the ignition is turned off and power is not available at the vehicle's power receptacle, resulting in significant data loss while the battery recharges.

The data logger charging circuit was modified to overcome this challenge. The GeoChron's internal battery was not needed because the unit was powered by the vehicle's battery, so the internal battery was disconnected from the circuit board, and the charging circuit and power switch were bypassed using a jumper wire to the data logger's voltage regulator circuit. The effect of this modification was that the GeoChron was always active and logging GPS data whenever power was applied at the vehicle's cigarette-lighter power receptacle.

Mounting Hardware

One of the requirements for the GPS unit was that it require minimal time to install in a variety of vehicles. To accomplish this goal, mounting hardware was developed to accommodate two methods for mounting the GPS in the vehicle: (1) windshield mount and (2) dash mount. In order to allow a GPS unit to use either type of mount, a custom adapter bracket was fabricated from ABS plastic that allowed rapid installation and removal of a windshield-mounting bracket. The windshield mount had three large suction cups for gripping the windshield and was adjustable to allow the experimenters to level the GPS unit after mounting it on the windshield. The suction cups were easily replaceable in the event that repeated use should reduce effectiveness of grip. Figure 4 shows the GPS installation using the windshield mount.

Figure 4. GPS installation using the windshield mount option.

The GPS could also be installed by placing it directly on the dashboard (see Figure 5 below). A non-skid rubber pad was affixed to the bottom of each GPS unit to prevent the unit from sliding during hard braking, sharp turns, or other sudden maneuvers. To provide additional mechanical security, a tether was inserted into a slot that was milled in the enclosure and attached to the vehicle either with a suction cup affixed to the windshield or else by tying it through one of the heater vent louvers. Also, a black felt cover was attached to the top of the unit to minimize glare of reflections from the GPS and to reduce conspicuity of the device on the dashboard.

Figure 5. GPS installation using the dash mount option.

The GPS units were not as robust as expected in the summer heat, particularly in Texas where temperatures as high as 187.5 degrees F. were measured on the dashboard. Although the GPS electronics were not damaged, the plastic enclosures became severely deformed under these conditions. In order to solve this challenge, a third, antenna-based approach was developed. In Texas, an external antenna was mounted on the roof of the vehicle using a magnetic mount, and the cable was routed through the doorframe to the GPS logger. In Seattle, the antenna was mounted inside the vehicle, in either the front or the rear windshield. In both locations, the GPS logger was placed under the front passenger seat or under the dashboard to protect it from direct sunlight. Figure 6 illustrates the antenna installations on the roof and inside the vehicle.

Figure 6. GPS installations using exterior and interior antenna mount options.

In order to allow this type of installation, the GPS enclosure was modified by drilling a hole in the body and mounting a pass-through connector for an external antenna. In addition, the batteries inside the GPS unit were removed as a precaution to prevent them from swelling and leaking due to overheating. All units in Texas were modified, and the antenna mount option was the only installation used at that location. In Seattle, only eight units were modified, and the antenna mount option was installed only if the participant indicated that he or she parked in the sun all day or had no air conditioning. In addition, the antenna mount option was used for a few participants who were concerned about thieves breaking into the vehicle and wanted the installation to be as inconspicuous as possible. The small size and inconspicuous placement of the antenna in the windshield was an acceptable alternative for those participants.

Device Installation and Removal Procedures

GPS installation required either five or six steps, depending on whether the antenna mount option was chosen for installing the GPS. These steps are described as follows:

Step 1. **Determine the appropriate GPS mounting option.** This step was performed in collaboration with the participant. The experimenter described the various mounting options and gave the participant an opportunity to express any preferences or concerns about where to place the GPS or how to mount it in the vehicle. The GPS was mounted after agreement on an appropriate mounting strategy.

Step 2. **Mount the GPS antenna (antenna mount installation only).** The antenna typically was placed on the dashboard near the right A-pillar or in the center of the dashboard near the windshield. In a few vehicles, the antenna was placed in the rear window. The antenna cable was routed by tucking it in the seam where the windshield met the dash and then through the gap between the dash and the right A-pillar. If necessary, the antenna was secured to the dash with a cable tie through the heater vent louver.

Step 3. **Secure the data logger to the vehicle.** Windshield-mounted units were attached to the windshield near the right A-pillar using three large suction cups on a swiveling mounting bracket. The windshield was cleaned with a damp cloth and the GPS data logger was mounted on the windshield. The GPS was then leveled laterally and longitudinally using a spirit level to ensure maximum signal strength.

In the dash-mounted installation, the GPS loggers were placed on the dashboard either near the right A-pillar or in the center of the dash over the center stack. The placement of the GPS logger depended on the flatness of the dashboard's surface, location and orientation of appointments (clocks, coin wells, etc.), and participant preferences. The tether was then attached to the windshield with a suction cup or, alternatively, was tied to one of the heater vent louvers in order to prevent dislocation of the unit in the event of a sudden maneuver.

In the antenna-mounted installation, the GPS data loggers were placed under the front passenger seat to conceal them and to protect them from radiant heat from the sun. In one participant's vehicle, the data logger was mounted under the dashboard and secured with cable ties to existing hardware.

Step 4. **Mount the power adapter.** The 7.5 V regulated DC power adapter was installed in the vehicle's cigarette lighter receptacle to power the GPS data logger. Participants who regularly used their receptacle to power another device were given the option to install a "Y" adapter that provided an additional power outlet.

Part way through data collection, it was determined that the power to most participants' GPS was being intermittently interrupted because of loose connections between the power adapter and the power receptacle. In order to reduce these interruptions, a small cardboard shim was wedged into the socket between the power adapter and the socket wall. This shim ensured a tight fit of the power adapter in the socket and greatly reduced transient power interruptions.

Step 5. **Route and dress the cables.** The cables from the power adapter and the antenna (for antenna mount installations) were routed through seams in the dashboard trim, under the passenger-side floor carpet, or under the dashboard in order to make the installation as inconspicuous as possible and to prevent passengers from tangling in the wires. Care was taken to make sure the power adapter and cables would not interfere with normal operation of the vehicle or use of cup holders or other features in the vehicle.

Step 6. **Inspect the installation.** After installation, the vehicle was inspected to make sure that the GPS was properly installed, the cables were hidden, and the power to the GPS was functioning.

Removal of the GPS data logger was accomplished by performing steps 2 through 5 in reverse order. After removal, the vehicle was inspected to make sure that all items related to the installation were removed from the vehicle and that the vehicle had sustained no damage. The memory card was then removed from the data logger, and the data were uploaded to a data repository for processing and warehousing.

Data Collection Procedures

There were three basic steps involved in collecting data from participants. These included participant enrollment and start-up activities, on-road data collection, and close-out and debriefing activities.

Figure 7 below describes the sequence of events encountered by each participant.

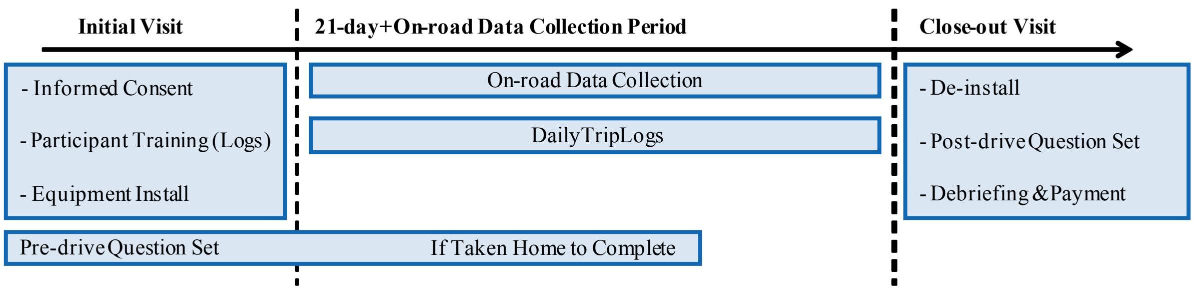

Figure 7. Overview of participant activities.

Enrollment and Start-up Activities

All participants enrolled in the study by visiting the research facility at their location. Participants were guided through a comprehensive consent process, which included discussion of potential risks and how the GPS device would be installed in their vehicle (only one prospective participant declined during the consent process). Following the consent process, the GPS device was installed in their vehicle. While this work was being conducted, participants were given detailed instructions on how to properly complete the trip logs in the log books and online. Finally, participants were given an opportunity to complete the pre-drive questionnaire while they waited for the installation to be completed. Apart from scheduling a close-out visit, answering any questions during the study, or providing reminders if participants were not completing online log entries, there was no other contact with them until the close-out visit.

Another important aspect of the study was to avoid presenting it to participants as a study focused primarily on speeding behavior. There were two important reasons for this. The first was so that participants who often drive at high speeds were not discouraged from signing up for the study under the belief that they would be penalized if they were recorded speeding. The second important reason was to avoid a situation in which participants who normally drive at high speeds curtail their normal speeding behavior out of concern for getting caught speeding. Our overall strategy for dealing with this issue was to frame the study as more of a general travel behavior study, emphasizing our interest in learning about where, when, and on what types of roads participants travel on, in addition to the speed at which they travel. More specifically, the study's speeding aspect was not withheld from participants, but rather it was presented as one of several factors we were interested in measuring. Necessary disclosures and protection of driver confidentiality were incorporated into the consent and debriefing process, and the overall data collection and analysis protocols. Moreover, drivers were informed fully about the precise objectives of the study during the debriefing process. Although all participants were given an opportunity to withdraw from the study during debriefing, none chose to do so, and no participants expressed concern about the speeding nature of the study to either the researchers or the study's Institutional Review Board (IRB) representatives.

On-Road Data Collection

Participants were asked to drive as they normally would for the duration of the data collection. While data collection was targeted to last at least 21 days per participant, it extended longer for some participants due to their individual schedules; the average length of data collection was about 25 days per participant. During this time, participants' primary responsibility was to complete trip logs after each trip and enter them online within one day. Trip log completion rates were tracked daily, and participants that fell behind by a few days were contacted to remind them about the importance of completing the trip logs, or to find out if there was any systematic reason for the lack of entries (e.g., vehicle in the repair shop or short vacation).

Data collection was conducted from May to December 2009 in Seattle, and from July to December 2009 in Texas.

Close-out and Debriefing Activities

Once the data collection period was complete, participants returned to the research facility to have the GPS equipment removed. During this visit, participants completed the final close-out personal inventory with speeding-related questions. After this, they were debriefed about the full study objectives and any questions that they had were answered. Finally, drivers were paid for their participation based on their trip log completion rate. Since it was only possible to estimate their completion rate at that time, only participants that clearly neglected this task (e.g., no trip logs for more than one continuous week) did not receive full compensation for this activity.

We also took this opportunity to inform participants about the focus groups to be conducted in Phase 2 and inquired about their interest in participating in those as well. Those who agreed (which was almost everyone who expected to be in the same area during the focus groups) were asked to provide consent for us to retain their contact information until recruiting for the focus groups could begin.

Data Processing Activities

The purpose of data processing was to clean and prepare the raw data into a final data set that was ready for analysis. These raw data came from four sources:

1. Personal Inventories,
2. Trip Log Data,
3. GPS Data, and
4. GIS Data.

These raw data required varying degrees of processing in order to clean and massage them into a form that was conducive to analysis.

Figure 8 is a flowchart that describes the flow of the data during processing and the relationships between various stages as the data were processed into the final data set.

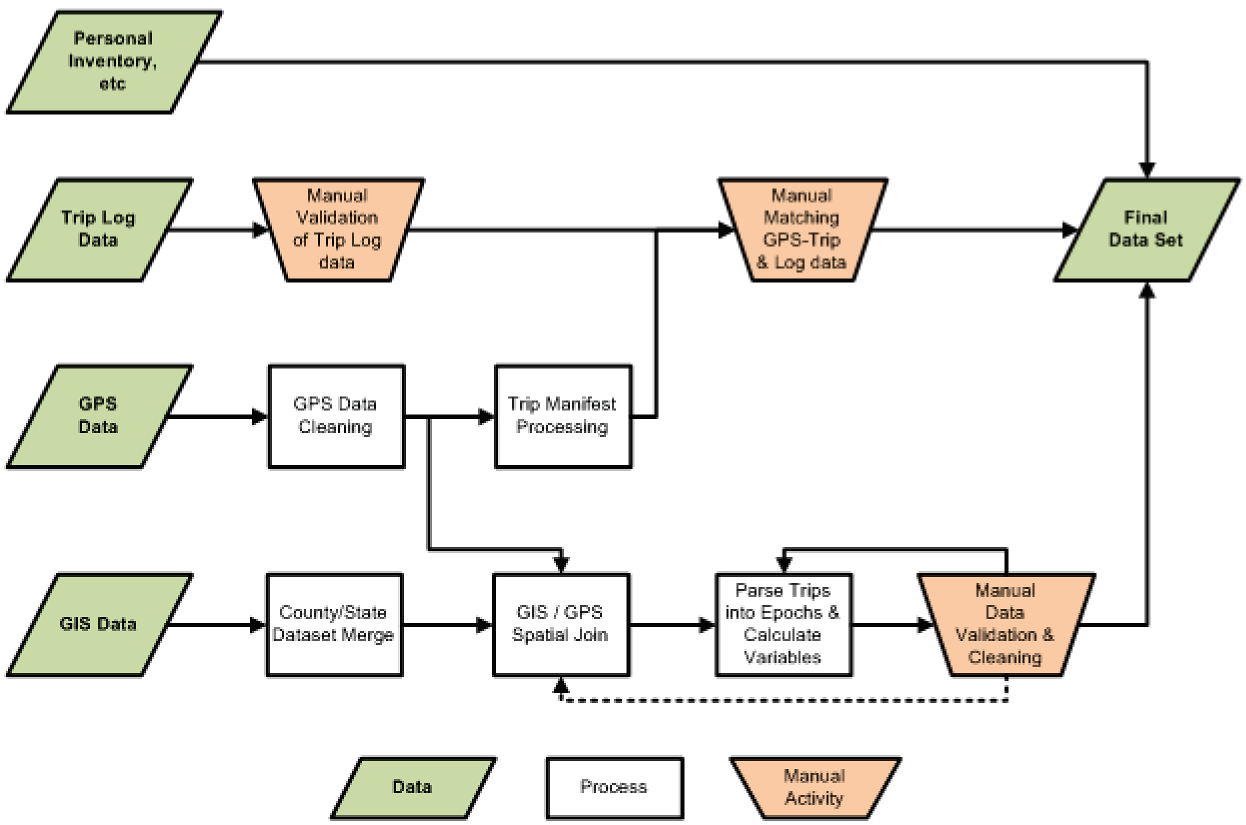

Figure 8. Data processing flowchart.

The raw GPS data were cleaned and joined with the GIS maps, which were composited from a variety of sources, in order to match the driving data with the underlying roadways. The integrated GPS/GIS data were then partitioned into 30-second epochs, and a set of 135 variables were calculated that characterized each epoch. Variables included: road characteristics; trip duration; time on road; posted speed; heading range; difference between travel speed and posted speed; minimum, maximum, average, and median speed and acceleration/deceleration; variability of speed and acceleration; and time below numerous speed thresholds associated with an individual epoch. Several flags also were included that were used to assess the validity of the data within the epoch.

In a separate process, the trip log data were manually matched with the GPS/GIS data in order to link the data with the trip logs. At various stages in the process, the data were validated to ensure the results were of high quality and reliable. The final data set included three databases:

1. An epoch database.
2. A trip log database.
3. An Excel spreadsheet with the personal inventory data.

The epoch database deserves some additional explanation. In short, the real-time, on-road driving data obtained from 164 participants resulted in a very large data set of driving speeds and geographical locations that were—at least within trips—essentially continuous. The only practical way to analyze this type of data set is to condense the driving data in a manner that captures the underlying behaviors of interest and ignores irrelevant driving situations. In addition to the sheer number of data points representing speed choice/behaviors, different drivers under various driving conditions will employ different strategies for selecting and maintaining a desired speed. In order to address the effects of these different strategies and to remove time periods when drivers had no opportunity to speed (i.e., time periods when the driver is accelerating from a stop or decelerating, or when drivers are consistently driving at a speed that is below a threshold that represents "free-flowing" traffic conditions), we parsed the trips into 30-second epochs.

The three databases (epoch database, trip log database, and a database for the personal inventory data) were linked by a common participant identification code. The final output of the post-processor was an Access database for each participant that contained the 135 fields of data for each epoch. All of the individual participant databases were merged into one large database for final analysis.

Appendix A provides details related to each step performed during data processing.

Data Validation Activities

A key requirement throughout all aspects of the project was that the data used in the data analyses must be of the highest possible quality in order to obtain reliable results and maintain high confidence in our conclusions. There were a number of data integrity challenges and checks used throughout our post-processing activities associated with: the GIS data, the GPS data, spatial joins, the development of epoch data sets, and validating the trip logs. Appendix B provides a detailed description of the data validation activities.

Final Data Filtering

While the primary activity in data validation was to fix as much "problematic" data as possible, the final stage of this process involved filtering out any "problematic" data that remained. During the final filtering process, driving epochs were successively filtered to remove (1) missing information, (2) inaccurate information, and (3) driving epochs in which participants had no chance to speed. Further details about these filtering stages are provided in Table 7 and Table 8.

Note that prior to conducting the filtering stages listed above, all epochs containing data points in which the vehicle was not in motion (i.e., vehicle speed <= 3 mph) were removed from the data set. There were two primary reasons for excluding these epochs from the actual data set. The first was that the GPS device did not function accurately when stopped or at very low speeds (i.e. the position information and heading had an unusually high degree of error). Second, the number of these epochs was somewhat arbitrary. In particular, most of these epochs represented time when the vehicle was stopped (perhaps even parked and with no occupant) but the GPS device was still recording, which occurred in any vehicle that supplied continuous power to the device. For this reason, the elimination of these was not considered part of formal filtering (hence the "step 0" label).

The tables on the following pages show the filtering results for the Seattle and Texas data. The filtering steps followed the same basic approach at both locations, with the following exception: With the Seattle data, all epochs containing posted speed changes had to be removed because of problems with overlaid roads/ramps. This specific problem did not occur with the Texas data. In fact, because of how the GIS data set was built from different sources, it was necessary to permit some degree of "flipping" (i.e., accommodating a flip or change to the wrong road and back). Permitting some flipping does not compromise the data since the modal posted speed during an epoch is used as the posted speed value, and the modal speed is largely unaffected by short-duration flipping.

The filtering described above resulted in what we labeled the "free-flow" epochs, since epochs in which drivers were traveling at least 5 mph below the posted speed likely represent times when they are stuck in traffic, slowing to turn, or responding to a traffic control device. Although epochs are not used in the primary analyses, they were used to obtain an overall picture of the amount of free-flow and speeding driving data available for analysis, and to generate maps showing where free-flow driving occurred. Accordingly, filter stage 4 in Table 7 and Table 8 shows the filtering step used to extract "free-flow epochs." In particular, epochs that had more than 15% of the driving time at speeds below the free-flow threshold (posted speed minus 5 mph) were removed. It should be noted that the data set used to conduct the descriptive and inferential analyses did not use this filtering stage. Specifically, all one-second records with free-flow and speeding time were extracted from the validated data set (post Stage 3) regardless of how much free-flow time was present in an epoch (i.e., these points were pulled from both free-flow and non-free-flow epochs). Essentially, epochs were used to eliminate "non-driving" or "invalid" data, but beyond that, we returned to one-second records for data analysis.

There was another stage of filtering conducted with the free-flow data set to isolate the epochs that were defined as speeding events. This filtering is described in the Results section as part of the discussion about the definition of speeding events.

Table 7. Seattle data filtering results.

Filter Stage	Filter Step (Criteria for *Removing* Epochs)	Epochs at Start of Step	Epochs at End of Step
Stage 0: Remove non-driving data (vehicle not moving).	Vehicle is stopped or traveling less than 3mph for the duration of the epoch.*	255885	*163842*
Stage 1: Remove missing or incomplete data.	Posted speeds less than 15 mph.	163842	*149809*
	More than 5 missing GPS points.	149809	*149005*
	Epoch length less than 25 sec (out of 30).	149005	*143539*
Stage 2: Remove invalid or incorrect data.	Posted speed changes during the epoch.	143539	*120709*
	Max acceleration > 5 m/s^2.	120709	*120534*
	Max deceleration > 5 m/s^2.	120534	*120435*
	Absolute value of heading range > 180.	120435	*120033*
Stage 3: Remove data on unvalidated roadways.	FlagRoadValRatio ≠ 1.	120033	*76539*
Stage 4: Remove data where there is no chance to speed.	Traveling slower than posted speed minus 5 mph, more than 15% of the epoch.	76539	*43363*
Stage 5: Remove data that are not speeding events.	Traveling <10 mph above the posted speed (defines Type 3 speeding events).**	43363	*4164*
	Traveling <20 mph above the posted speed (defines Type 4 speeding events).	43363	*111*

* This row is included to account for all of the data collected (e.g., when the GPS device had power), but these epochs are not considered to be analyzable data because the vehicle is stopped or almost stopped.

** Type 3 speeding events do not include Type 4 speeding events.

Table 8. Texas data filtering results.

Filter Stage	Filter Step (Criteria for *Removing* Epochs)	Epochs at Start of Step	Epochs at End of Step
Stage 0: Remove non-driving data (vehicle not moving).	Vehicle is stopped or traveling less than 3mph for the duration of the epoch.*	180565	*114894*
Stage 1: Remove missing or incomplete data.	Posted speeds less than 15 mph.	114894	*85332*
	More than 5 missing GPS points.	85332	*85188*
	Epoch length less than 25 sec (out of 30).	85188	*81554*
Stage 2: Remove invalid or incorrect data.	Posted speed changes more than once during the epoch.	81554	*76616*
	Max acceleration > 5 m/s^2.	76616	*76568*
	Max deceleration > 5 m/s^2.	76568	*76546*
	Absolute value of heading range > 180.	76546	*76450*
Stage 3: Remove data on unvalidated roadways.	FlagRoadValRatio ≠ 1.	76450	*59138*
Stage 4: Remove data where there is no chance to speed.	Traveling slower than posted speed minus 5 mph, more than 15% of the epoch.	59138	*28822*
Stage 5: Remove data that are not speeding events.	Traveling <10 mph above the posted speed (defines Type 3 speeding events).**	28822	*1114*
	Traveling <20 mph above the posted speed (defines Type 4 speeding events).	28822	*34*

* This row is included to account for all of the data collected (e.g., when the GPS device had power), but these epochs are not considered to be analyzable data because the vehicle is stopped or almost stopped.

** Type 3 speeding events do not include Type 4 speeding events.

Definition of Speeding

One of the key challenges in a study focused on understanding drivers' motivations for speeding is defining what actually constitutes speeding. There are differences between the legal definition and other aspects, such as safety and what drivers commonly view as acceptable speeds. Moreover, the inferential analysis conducted in this effort required that speeding be categorized into time in which drivers are considered to be "speeding" versus "not speeding." In order to address these issues, it was first necessary to define these States based on the travel speeds recorded in this study.

A review of the research literature indicates that there is no single accepted definition of speeding, and a variety of approaches have been used (see Table 9 below). For example, many questionnaires that cover speeding ask about driving 10-20 mph above or greater than 20 mph above the posted speed (e.g., DeJoy, 1992), whereas others ask about driving faster than other drivers (e.g., passing most drivers). Other approaches have included defining speeding relative to law enforcement practices, which captures the psychological effects that avoiding a speeding ticket likely play in determining driving behavior (Book & Smigielski, 1999). Another common approach is to use posted speed plus a fixed amount (Warner & Aberg, 2006). This is a reasonable approach, since other studies suggest that posted speed is the most significant predictor of aggregate travel speed, although other factors, such as road design, are also important in many circumstances (Fitzpatrick, Carlson, Brewer & Wooldridge, 2000; Giles, 2004).

The reality is that there are multiple ways to define speeding, and each lends itself to particular research objectives, such as understanding why drivers do not comply with posted speed, or why they are willing to drive at "risky" speeds, etc. Drivers' willingness to comply with posted speeds provides important information for developing countermeasures that rely on changing driver motivations and attitudes. Similarly, defining speeding relative to crash risk is also useful in that it helps identify the driver and environmental factors that are most likely related to safety, and which could be potentially addressed by a different set of countermeasures. Consequently, it is important to be mindful of the overall research objectives when selecting a definition of speeding.

One problem that most definitions of speeding encounter is how to set the specific threshold that divides driving into "speeding" and "not-speeding." There are two key issues:

1. Whether or not driving constitutes speeding depends greatly on the particular driver and situation, and

2. Even if these driver and situational variables are known, there is not enough other empirical evidence to claim with any certainty that driving below a certain speed is safe/acceptable whereas driving above that speed is not.

Consequently, there is an unavoidable degree of arbitrariness in whatever approach is selected for defining speeding. However, in spite of this, it is still important to try to minimize this arbitrariness by avoiding certain approaches that rely solely on data-driven, post-hoc definitions of speeding (e.g., to define speeding as the fastest 15% of driving). Although this approach can be used to ensure that there are a sufficient number of speeding episodes available for analysis, it loses the connection to the underlying driver behaviors and decisions because the threshold is arbitrary (i.e., wherever the 15% mark is).

Table 9 provides an overview of relevant approaches for defining speeding, as well as the relative advantages and disadvantages of each approach.

Table 9. Different definitions of speeding.

Speed Definition	Rationale	Value/Definition	Advantages	Disadvantages
Analytical	Uses a fixed criterion relative to the posted speed.	Posted speed + X%, or Posted speed + X mph	Simple to implement.	Overly simplistic and misses factors related to road type and overall speed level.
Risk/ Kinematic	Reflects "driving too fast for conditions." Ideally takes into account what speed is acceptably safe based on the immediate roadway/driving environment, weather, time-of-day, driver, and vehicle factors.	Specific thresholds that depend on data about driving conditions (road class, posted speed, time of day, weather, etc.).	Connects speed behavior to primary safety objectives.	Insufficient GIS data scope and quality to support reliable "risk" classification.
Enforcement	Some drivers may view this as the practical definition of speeding—how fast can they drive without getting a ticket.	Posted speed + 11 mph, etc.	– Some drivers implicitly take into account likelihood of a ticket in speed decisions. – Should be simple to implement if we can obtain typical enforcement values.	– Need information from local law enforcement to determine nominal values. – Is probably an incomplete basis for understanding speeding behavior.
Psychological	Is directly based on what drivers consider to be speeding. It can reflect factors that are specific to individuals or groups, such as what seems to be safe or comfortable, which speeds will avoid enforcement, etc.	Posted speed + 5 or 10 mph (the psychological space for speed likely consists of 5 mph increments).	– Provides general insight into which speeds drivers consider to be speeding under certain conditions. – Can be used to provide driver-specific speeding benchmarks.	Requires additional information about speeding beliefs and attitudes from participants or sample drivers that we did not collect.
Behavioral	Separate travel-speed bands that represent underlying behavioral intentions, including: 1) Intentionally trying to stay at or below the posted speed, but exceeding due to normal variation (control condition). 2) Deliberately exceeding the posted speed, but unlikely traveling fast enough to be unsafe or get a speeding ticket. 3) Traveling fast enough to increase safety risk and chances of getting a ticket, but not recklessly so. 4) Clearly reckless or excessive speeding.	See Table 10 below.	– Ranges are tied to plausible driver behaviors and to safety risk. – Incorporates most useful aspects of other speeding definitions.	– "Clearly reckless" criterion is somewhat arbitrary and may not generalize consistently across different driving conditions. – Complicates the analysis by adding additional dependent variables.

For the analysis in the current project, we used a behavior-based approach to defining speeding. The basic rationale is that if drivers have control over their travel speed (not locked to traffic, etc.), then there is likely to be an underlying motivation or behavioral frame that is explicitly or implicitly governing their speed selection. There are perhaps several different types of speeding behaviors, different ways to conceptualize similar behaviors, and overlap between their corresponding ranges (both by definition and from natural speed variation). Note that there are other ways to define speed-related behaviors (inattentive speeding, versus deliberate speeding, etc.); however, the approach we selected appeared to provide the best way to differentiate categories based on travel speed with minimal overlap in expected speed ranges.

For the purpose of the analysis, we developed a framework and rationale for defining *speeding*, and then developed a way to implement the definition using the current data set. As a starting point, we focused on developing a behavioral framework that could segment driving into different categories reflecting different attitudes about speeding. In particular, four different behavior types were identified that correspond to different speed bands relative to the posted speed. These include:

- **Type 1**: Driver is intentionally trying to stay below posted speed, which forms the control condition (ranges up to posted speed + natural speed variability).
- **Type 2**: Driver is not concerned with or constrained by posted speed, but is trying to avoid getting a speeding ticket (ranges from posted speed to enforcement speed).
- **Type 3**: Driver is unconcerned with posted speed or consciously willing to accept some risk (safety and speeding ticket) to drive faster (ranges from enforcement speed to what is clearly unsafe).
- **Type 4**: Driver is traveling at a speed that most other drivers would clearly identify as "reckless" or too fast for conditions with a clear disregard for the posted speed.

These four types, translated into actual speed ranges (for a 60 mph posted speed), are shown in Figure 2 below (blue arrow bars), with hypothetical distributions showing speed variability around those ranges.

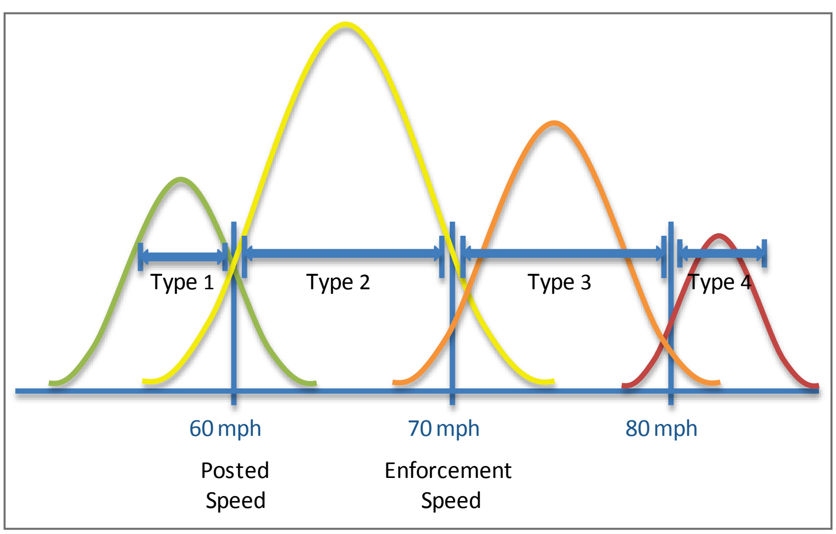

Figure 9. Theoretical speed ranges.

Table 10 below provides further details about what these behavior types represent and how they would be used in the analyses.

Table 10. Speed behavior types.

	Speed Behavior			
	Type 1	**Type 2**	**Type 3**	**Type 4**
Behavioral Intention	Driver is intentionally trying to stay below posted speed.	Driver is not concerned with or constrained by posted speed, but is trying to avoid a speeding ticket.	Driver is unconcerned with posted speed or willing to accept some risk to drive faster.	Driver is traveling at a speed that most other drivers would clearly identify as reckless or too fast for conditions.
Numeric Range	Upper bound is mostly below posted speed+5 mph.	Upper bound depends on perception of Enforcement speed.	Range is less certain than lower groups because boundaries are more situation-dependent.	Range is ultimately artificial because it is defined by external criteria rather than specific driver behavioral intentions.*
Driver Perception of Risk	No extra risk.	Driver likely feels that they are driving at a safe speed.	Complicated relationship to risk: drivers may feel safe even though they are not, or they may be accepting some risk.	Safety risk is probably disregarded, or driver is seeking out the "thrill" associated with risk.
Relationship to Safety	Should not involve elevated risk (based on roadway design).	Unlikely to be elevated risk under most driving conditions.	Possibly elevated risk depending on conditions.	Clearly elevated risk.
How It Could Be Used in the Data Analysis	Non-speeder control condition/exposure.	Can be analyzed separately or combined with non-speeder control condition since it likely does not involve "speeding of concern."	Speeding-related independent variable.	Speeding-related independent variable.

* A kinematic/risk-based approach would provide a more objective measure of this range.

A key practical problem we faced during the analysis was that the distributions around each band were unlikely to be as narrow or "tidy" as those shown in Figure 9, and that the initial data set looked more like a single undifferentiated normal distribution. Consequently, the true boundaries between behavior types were nearly impossible to discern with any degree of certainty. Nevertheless, this overall approach allowed us to maintain some degree of a priori constraints on how speeding events were defined and minimize opportunistic and arbitrary setting of the speeding criteria.

Selection of Speed Type/Threshold

Once the basic rationale for defining speeding was outlined, the next step was to develop a workable implementation using the current data set. As a starting point, we defined Type-3 speeding to be driving 10 to 20 mph above the posted speed and Type-4 speeding to be driving over 20 mph above the posted speed. These values were chosen primarily to provide round numbers to define the speeding categories, and give reasonable cutoffs for the underlying attitudes and motives that we are trying to capture. However, after examining the set of Type-4 speeding events, it was clear that there were too few events to be statistically analyzed (particularly on the 70 mph roadways in Texas). Therefore, although they represent different behaviors, Type-3 and Type-4 speeding events were combined and are referred to simply as "speeding events" or "speeding time" hereafter. Accordingly, the threshold for categorizing driving as "speeding" in this report is 10 mph above the posted speed. [4]

In both Seattle and Texas, a subset of the roadways with frequently traveled posted speeds were chosen for speeding analysis. Driving on roadways with different posted speeds was pooled to a general speed band. Driving on roadways with 30, 35, 55, and 60 mph posted speeds was combined to form two speed bands: 30-35 mph roadways and 55-60 mph roadways at both locations. (An additional 70 mph speed band was included in Texas, since this band contained the greatest amount of driving at that location.) This approach essentially involved pooling the data from roads with similar roadway environments, which allowed us to capture and examine more driving data. In general, the selection of two speed bands was important to examine certain posted speeds in isolation of others because of situation-specific factors systematically associated with posted speeds that likely affect driver behavior (e.g., 60 mph roads are more likely to be limited access highways). The drawback, however, is that it significantly increases the number of these separate analyses that have to be conducted.

Table 11 below shows the final thresholds used to define speeding-event epochs for posted speeds in each speed band. This table also provides a high-level view of the amount of free-flow and speeding driving available for analyses. Specifically, the numbers of driving epochs that qualify for each driving speed category are shown. This table also lists, in parenthesis, the free-flow and speeding time in terms of the number of seconds of driving in each of these categories (these one-second records ultimately comprised the data set used in the descriptive and inferential analyses). These individual seconds were taken from all validated epochs, not just the ones that met the free-flow epoch criterion (i.e., 85% of driving at free-flow speeds). More specifically, while many of the seconds represent the same driving as represented by the epochs, other seconds of driving were captured from non-free-flow epochs. For example, the Texas 70 mph speed band shows three eligible epochs (90 seconds worth); however, 121 seconds of driving were included in this speed band.

Defining "speeding" was a necessary first step of the data analyses. However, it still lacks a way to reflect exposure and begs the question, "*amount of speeding relative to what?*" Without a way to estimate overall exposure, directly comparing the amount of speeding across drivers, roadway types, geographic locations, etc., becomes problematic. To address this problem, a new variable was constructed from the data set—"*free-flow time*"—that could serve as the denominator to the "*speeding time*" numerator in our subsequent analyses. The free-flow time variable was carefully defined and constructed, with the objective of making sure that the measure reflected a driver's <u>opportunity</u> to speed. For example, time spent warming up a vehicle was not included, nor was time spent idling at a stoplight. A less obvious consideration is that a drivers' decisions about speed selection include many instances in which the vehicle's speeds are constrained by traffic control devices or traffic congestion—instances in which drivers clearly have no opportunity to speed. If not accounted for, travel time that represents stopped time or slower driving could end up being overrepresented in terms of chronological time

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[4] Note that actual thresholds may have been even more conservative than our calculated thresholds. More specifically, during pilot testing, we found that test vehicle speedometers routinely displayed speeds as being around 2 mph *faster* than those actually recorded by the GPS. This is similar to results from other independent field tests (Markus, 2002), which showed a consistent 1-2 mph overestimation of travel speed by speedometers across 230 different vehicle makes. This suggests that a driver whose speed choice was based on the displayed speedometer speed may actually have been comfortable driving 1 or 2 mph faster than the speed recorded on the GPS.

relative to episodes in which drivers are able to select their desired speed, since drivers take longer to travel the same distance in the former case. Consequently, comparing the time that drivers spent speeding to the total amount of time they drove likely underestimates their speeding exposure by a substantial amount because their trip data is "diluted" by a large amount of inconsequential time when they were stopped or had no chance to speed.

The approach used to address this dilution of data was to remove from the data set all of the recorded time in which drivers clearly had no opportunity to speed. To generate the free-flow driving time variable, all driving that was 5 mph or more *below* the posted speed was removed (e.g., on a roadway with a posted speed of 35 mph, only driving time in which the vehicle was traveling at 30 mph or greater was retained). Relative to the complete data set, driving time was also filtered to remove driving that occurred on unvalidated (i.e., uncertain posted speed) roads, and due to other data-integrity issues, such as missing GPS data points.

Table 11. Final filtering thresholds used to define speeding-event epochs. The right side of the figure shows the number of 30-second epochs and seconds (in parentheses) retained. The Type 3 and Type 4 combined data were used in the analyses to represent speeding.

Speed Band	Posted Speed Condition	Speeding Threshold (mph)	Data Retained: Epochs (Seconds)			
			Free-flow	***Type 3***	***Type 4***	***Types 3 & 4 Combined***
Seattle						
30-35 mph Speed Band	30 mph	40 mph	3052 (122672)	366 (4673)	2 (13)	*368 (4686)*
	35 mph	45 mph	4429 (172353)	414 (6130)	10 (156)	*424 (6286)*
55-60 mph Speed Band	55 mph	65 mph	922 (29834)	57 (888)	1 (12)	*58 (900)*
	60 mph	70 mph	28586 (990439)	3327 (50329)	98 (1350)	*3425 (51679)*
Texas						
30-35 mph Speed Band	30 mph	40 mph	1257 (62456)	105 (1759)	18 (324)	*123 (2083)*
	35 mph	45 mph	1864 (90601)	78 (914)	0 (0)	*78 (914)*
55-60 mph Speed Band	55 mph	65 mph	1993 (75860)	319 (6101)	3 (101)	*322 (6202)*
	60 mph	70 mph	2588 (99919)	451 (11681)	10 (136)	*461 (11817)*
70 mph Speed Band	70 mph	80 mph	15226 (525075)	161 (3840)	3 (121)	*164 (3961)*

Chapter 3: On-Road Data Collection Results

Introduction

The following sections provide the initial results of the statistical analyses conducted in this study. The first section is the descriptive analyses, which provide a detailed description of the basic results. In an exploratory study such as this one, an in-depth understanding of the data is a critical first step for determining the most suitable approaches for answering questions about speeding behavior. The second section describes the inferential statistics conducted to examine, in more detail, the factors associated with speeding.

Descriptive Statistics

Overview

The descriptive statistics presented in the following sections provide results that cover a wide range of variables associated with speeding behavior. The scope is broad to the point that there is a risk that interesting findings are overwhelmed by the volume of information provided. This is somewhat unavoidable because of the complexity of the study, which involves separate locations, demographic groups, roadway factors (e.g., posted speed), and different types of measures (e.g., driving data and personal inventory data). To facilitate navigating the descriptive statistics, the rationale for our approach and an overview of the topics covered is provided below.

This more detailed examination of the data was a deliberate approach reflecting the nature of this study. In particular, this study represents a new way of looking at speeding behavior, and it has an exploratory nature to it. Essentially, going into the analyses, there were no established and proven approaches for investigating the type of speeding data obtained in this study. Also, in the absence of detailed hypotheses that we can use to focus the analyses, we think it is useful to describe the data on hand at a detailed level. This will make it easier to identify emerging patterns and trends that can be examined more closely in subsequent analyses.

A key challenge for presenting the descriptive statistics is that this study examined driving in a naturalistic context. More specifically, participants provided data at the time and location of their choosing, which means that we had no control over the driving conditions or other factors that influenced their opportunity to speed, and importantly, whether or not they chose to do so. This lack of control over driving conditions made the analyses vulnerable to systematic differences between groups and individuals in terms of key uncontrolled variables that affect speeding, which can lead to misleading patterns of results. For example, the older females recruited in Texas drove almost twice as many miles on 55 and 70 mph posted speed roads than the next closest demographic group. This driving pattern has repercussions for comparisons involving demographic groups, since the driving data used to make between-group comparisons is based on systematically different driving conditions.

Although driving epochs were used for filtering the data, the primary dependent measures were based on the free-flow driving that occurred at least 10 mph above the posted speed (i.e., Type 3 or Type 4 speeding). Two different dependent measures were used in the descriptive and inferential analyses.

These included (1) the percentage of trips that had any speeding, and (2) the proportion of free-flow driving that was speeding. These measures were computed using "free-flow time" and "speeding time" values calculated from the data. Driving data were grouped in speed bands (i.e., 30-35, 55-60, and 70 mph), and analyzed separately since these bands represent qualitatively different driving conditions. The key data elements are described in Table 12.

Table 12. Definitions of key terms used to calculate speeding measures.

Term	Definition/Usage
Speed Band	Identifies the posted speeds associated with a measure. The speed bands included in the analyses are: 30-35 mph (Seattle & Texas), 55-60 mph (Seattle & Texas), and 70 mph (Texas only).
Free-Flow Time (FF Time)	Number of seconds (typically in a *single* trip), for which a driver is traveling at speeds above the free-flow speed threshold (posted speed minus 5 mph). Free-flow time is a proxy for "opportunity to speed." Free-flow time is separated out based on the speed band in which it occurred.
Speeding Time	Number of seconds (typically in a *single* trip) that the driver is traveling at 10 mph above the posted speed or faster (Type 3 and 4 speeding combined). Speeding time is separated out based on the speed band in which it occurred.

The descriptive results for Seattle and Texas are discussed separately, but sub-sections for each location share a common structure and cover the same basic data. The discussion of the analyses follows a specific progression that examines the basic elements of naturalistic driving and provides the initial understanding necessary for planning and conducting valid and applicable inferential analyses about the factors associated with speeding behavior. In particular, the descriptive analyses covered the following questions:

What do we know about the drivers in the sample? (Personal Inventory Questions section)

What can we say about their driving patterns overall? (All Driving Data section)

What can we say about their opportunities to speed? (Free-Flow Time section)

What can we say about their actual speeding behavior? (Speeding Time section)

The descriptive statistical sections that cover each type of data subset are described in more detail below.

Personal Inventory Questions

The first section of the descriptive statistics for each location provides a summary of participant responses to the personal inventory questions. The questions covering basic socio-demographic characteristics are detailed in separate charts, while the answers to other personal inventory questions are provided in a series of charts and tables that break down average participant responses by demographic category. The personal inventory was comprised of a series of question sets based on existing measurement instruments.

General Driving Patterns

This section covers the full, unfiltered driving data set. It is not the ideal data set for investigating specific aspects of driving behavior (and it is not used this way) because it contains episodes when vehicles were stopped and episodes with missing data (e.g., no posted speed information). However, it is the only data set that can provide information about driving patterns as a whole, in addition to basic trip characteristics (duration, time of day, types of roads, etc.). For this type of high-level analysis, the imperfections in the data do not meaningfully affect the results, and the benefits gained by filtering out missing data, etc. do not offset losing useful information, such as trip start time or duration, that can only be computed with the full, unfiltered data set. If there was an option, however, we used dependent measures that were more robust regarding data issues when presenting findings (e.g., miles driven instead of time driven because it was unaffected by time when the vehicle was stopped).

Free-flow Time

This data subset represents the "cleaned" driving data that eliminates missing, inaccurate, or un-verified driving data (i.e., missing posted speed information) and, importantly, removes driving time in which participants clearly had no opportunity to speed. Free-flow time is used as the driving exposure measure (as opposed to epochs or miles driven). The summary of free-flow driving data provides basic information about driver speed choice patterns and information about some driving conditions, such as overall congestion levels.

Speeding Time

The speeding-time data subset comprised the key data for examining speeding behavior. This data subset contains all of the driving time (in seconds) that meets the criteria for speeding on each posted speed road (e.g., each second recorded above 70 mph on a 60 mph posted speed road). Two primary measures were used to quantify speeding behavior. The first was the proportion of a driver's trips that had any speeding. This allowed us to examine the questions related to *who is speeding*. The second measure was the proportion of free-flow time on an individual trip during which the driver was speeding. This allowed us to examine the question related to *who speeds the most*. More details about how these measures are calculated and used are provided in the analysis of speeding time presented in later sections.

Seattle Data

This section discusses the descriptive statistics for the Seattle data set, including analyses of all personal inventory responses, general driving patterns, free-flow data, and speeding events.

Seattle – Demographic and Personal Inventory Data

This section provides more detailed information about who the drivers are in the study, and importantly, how the demographic groups generally differ in terms of their broader demographic characteristics, attitudes, behaviors, and beliefs, regarding driving. Drivers completed several personal inventories at the beginning and end of their participation in the study. These inventories were comprised of demographic and personality questions, generally organized by topic as follows:

Demographic questions (based on US Census questions);

General travel questions;

Driver Behavior Questionnaire (DBQ);

A combination of the DeJoy/Cards Risky Driving scales;

The Sensation Seeking and Impulsivity scales from Zuckerman's ZKPQ personality inventory; and

Questions about attitudes, beliefs, and social norms regarding speeding based on the Theory of Planned Behavior (TPB).

The complete text of the personal inventories completed by participants is presented in Appendix C, which also includes the full set of response options for each question.

The following histograms describe the responses to the demographic questions. Note that the range of the Y-axis varies between figures in order to better show the differences between demographic groups.

Figure 10 below shows the distribution of household income levels for the Seattle area drivers. In general, older drivers have higher income levels than younger drivers.

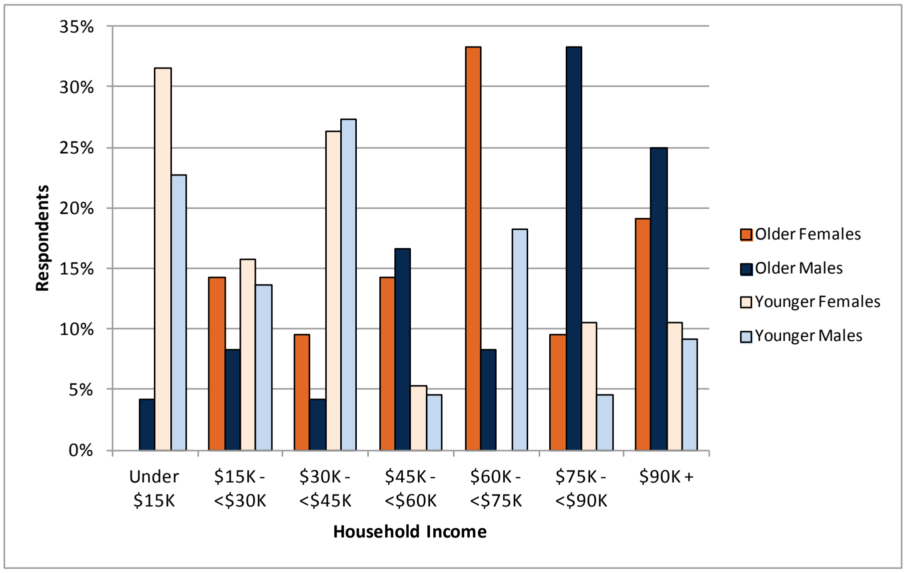


Figure 10. Histogram showing household income for Seattle drivers.

Figure 11 below shows the highest level of education obtained by drivers in each demographic group. All drivers obtained either a high school diploma or General Education/Equivalency Diploma (GED) and most drivers had at least an additional associate or bachelor's degree.

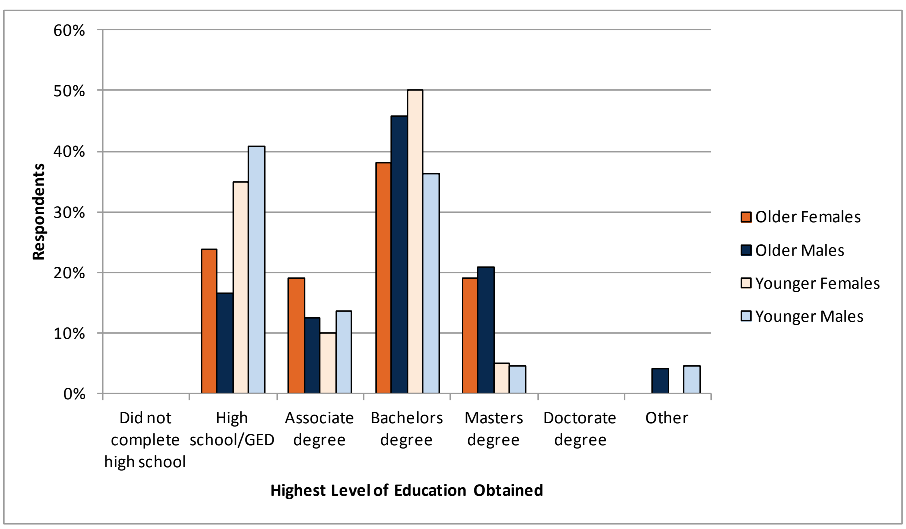


Figure 11. Histogram showing highest level of education obtained for Seattle drivers.

Figure 12 below shows the marital status of the drivers in each demographic group. The younger drivers were mostly single, never married, while the older drivers were more distributed among categories. Most of the older drivers were married or had a partner.

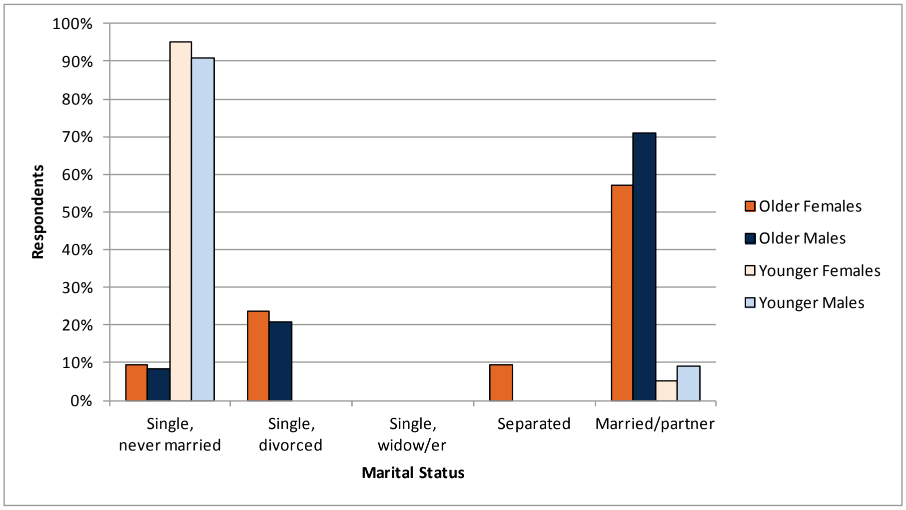


Figure 12. Histogram showing marital status for Seattle drivers.

Figure 13 shows the number of children that the Seattle area drivers had living with them. All of the younger drivers had no children. The older drivers were split among groups; most did not have children or had one or more children living with them most of the time.

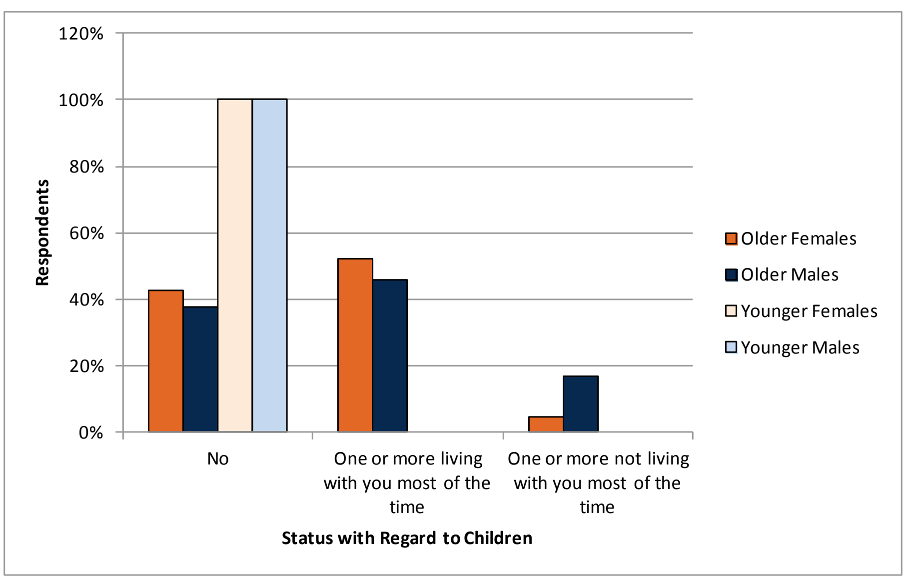


Figure 13. Histogram showing status with regard to children for Seattle drivers.

Figure 14 shows the distribution of self-reported weekly mileages for Seattle area drivers. Older Females tended to report higher mileages than the other groups.

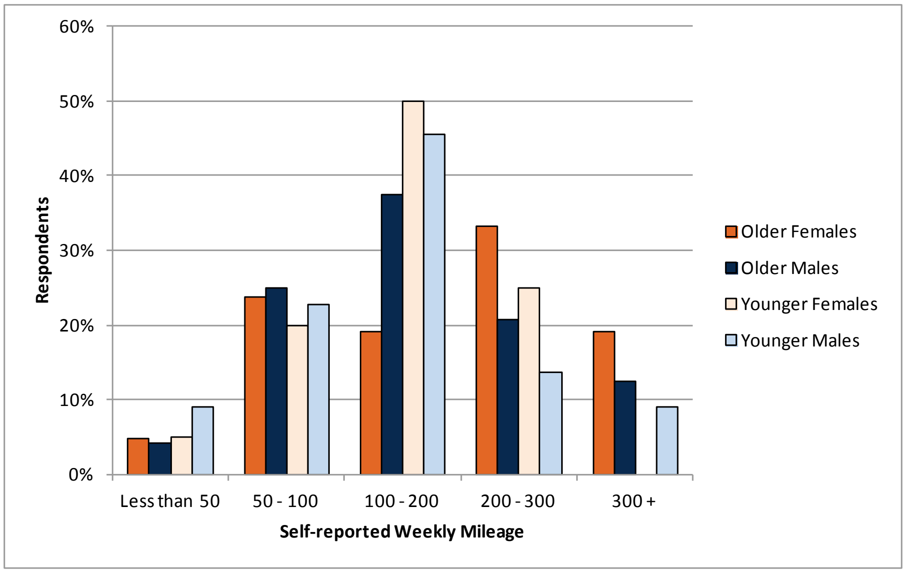
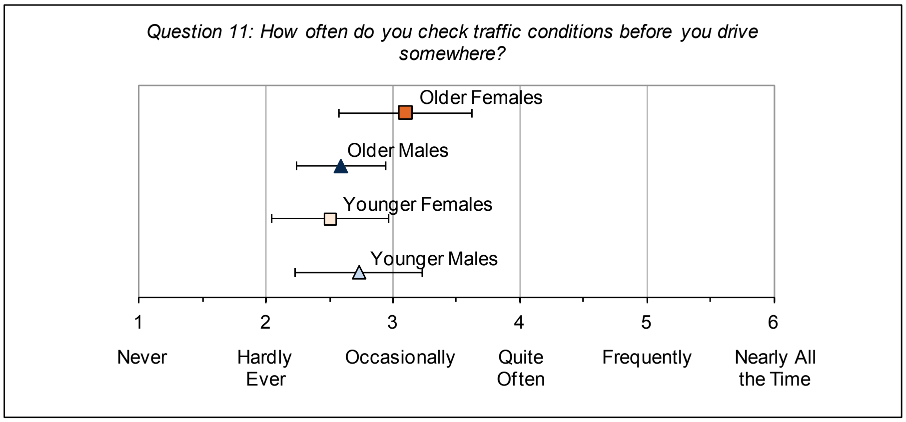
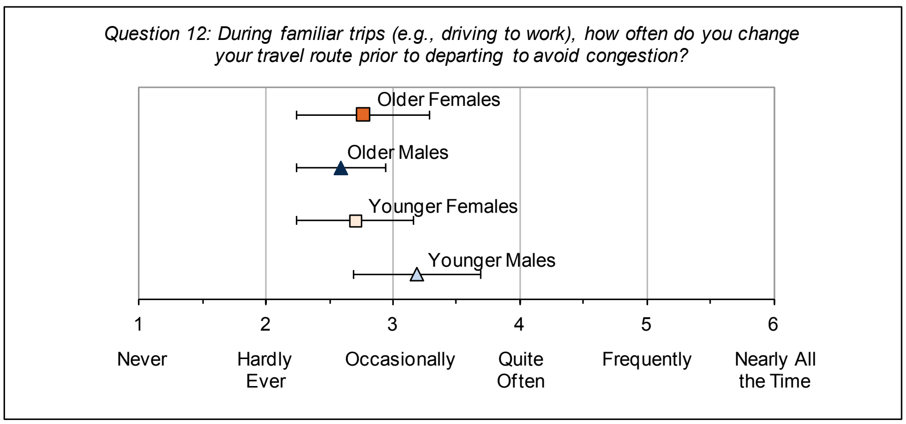


Figure 14. Histogram showing self-reported weekly mileage for Seattle drivers.

The personal inventory data from Seattle drivers is presented in a series of figures (Figure 15, Figure 16, Figure 17, and Figure 18) below. Given the large number of questions included in the personal inventory, only the three questions in each question set with the greatest range in responses (across all demographic groups) are shown. Accordingly, this subset provides an indication of the ways in which the demographic groups differ the most for a particular question set. Appendix D provides the average responses by demographic group for the full set of personal inventory questions. Each figure below shows the average response of each demographic group, with bars representing the 95% confidence interval.

Seattle – General Travel Questions





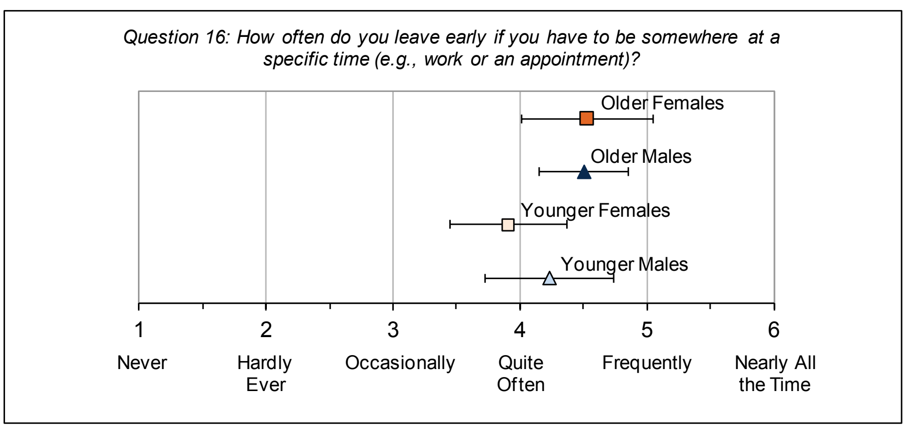


Figure 15. Results of general travel questions for Seattle drivers.

Seattle – Driver Behavior Questions

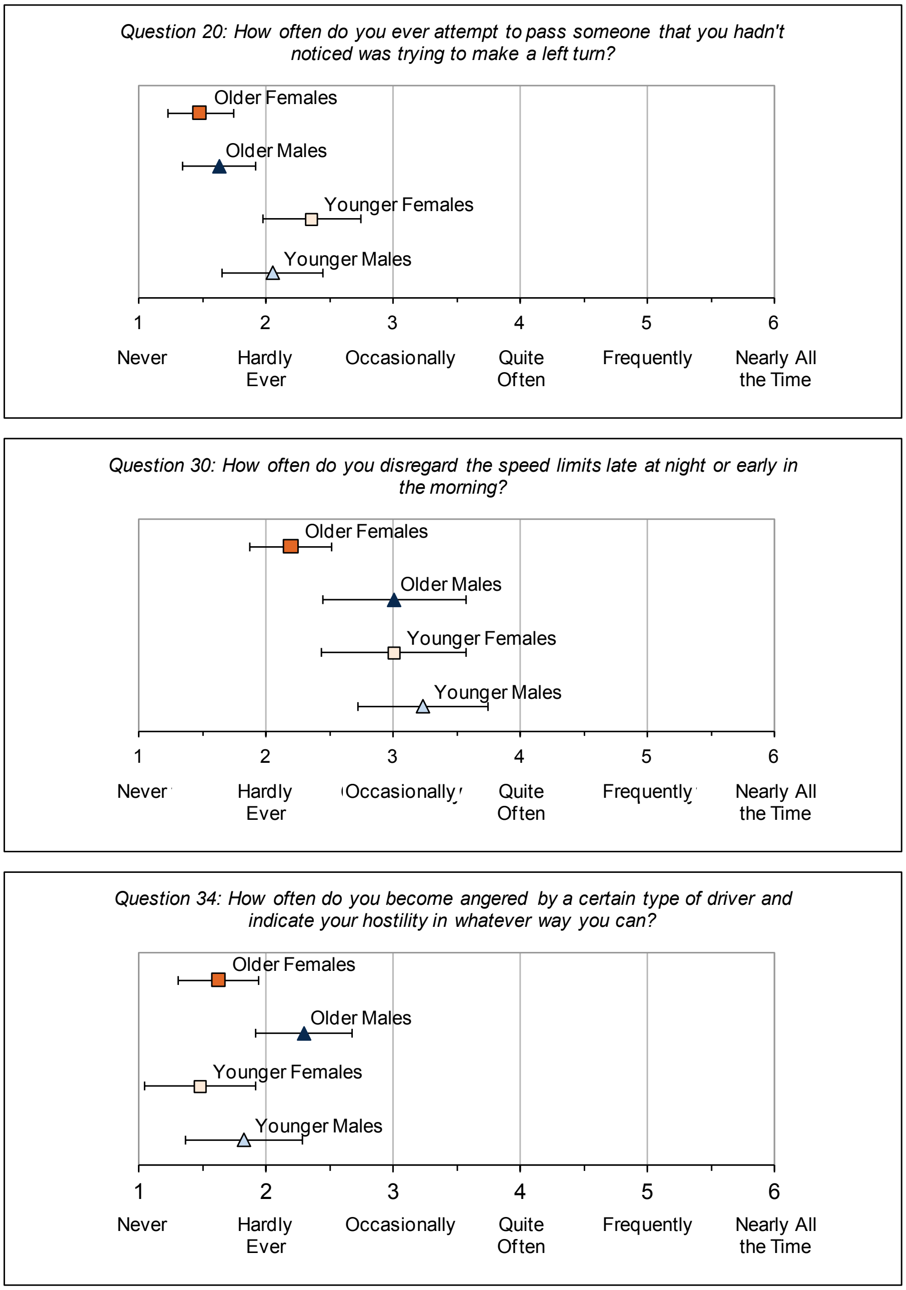
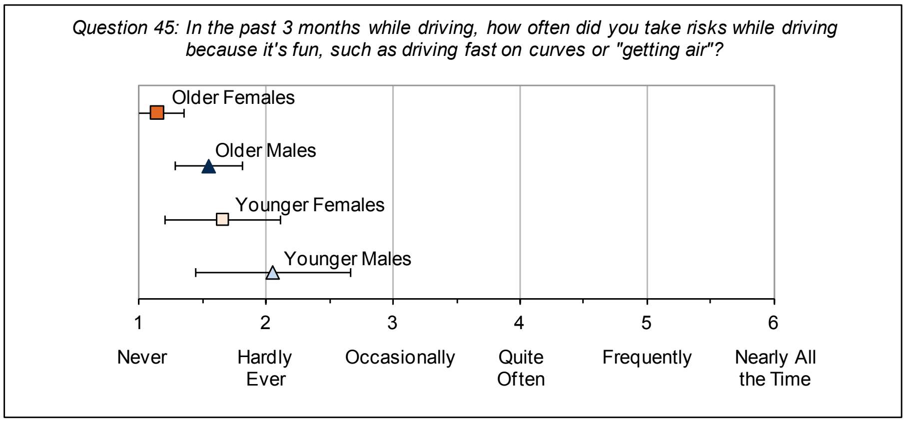
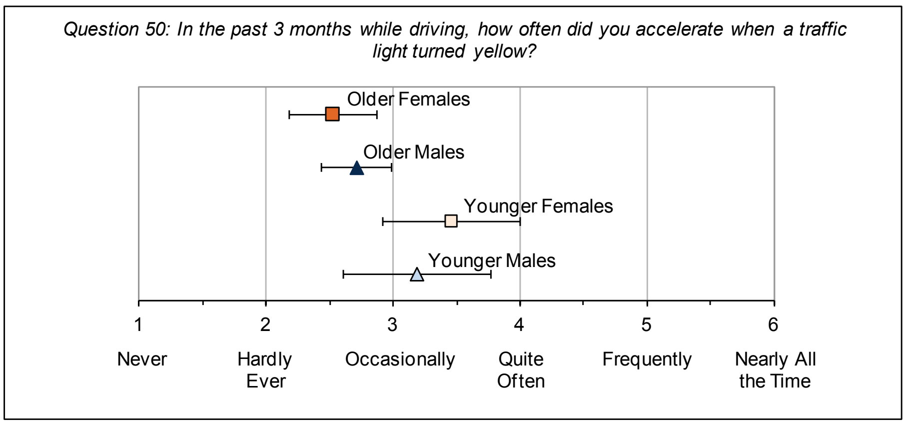


Figure 16. Results of driver behavior questions for Seattle drivers.

Seattle – Risk Questions





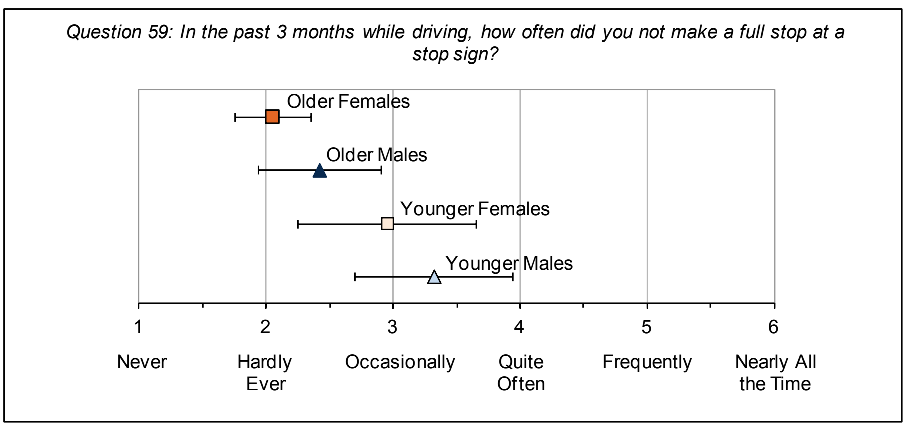


Figure 17. Results of risk questions for Seattle drivers.

Seattle – Speeding Beliefs, Attitudes, and Social Norms

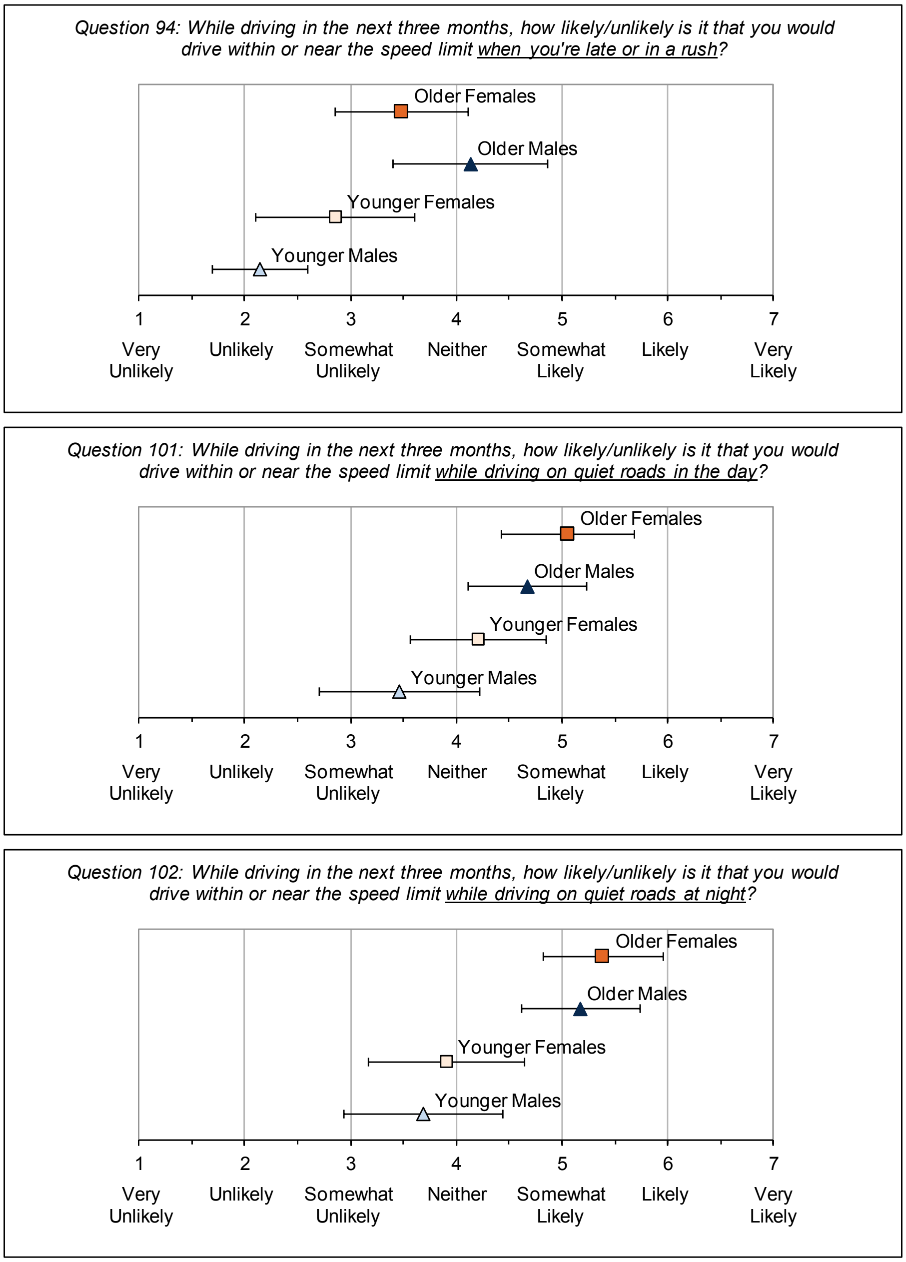


Figure 18. Results of speeding beliefs, attitudes, and social norms questions for Seattle drivers.

Seattle – Sensation Seeking and Impulsivity Subscale Scores

The 19 questions that were based on Zuckerman's ZKPQ personal inventory can be summarized using two subscales: the Sensation Seeking subscale and the Impulsivity subscale. The Sensation Seeking subscale "describes the seeking of excitement, novel experiences, and the willingness to take risks for the sake of these types of experiences." The Impulsivity subscale shows "a lack of planning and the tendency to act impulsively without thinking" (ZKPQ, n.d.). Figure 19 below shows the summary scores for each subscale by demographic group. Younger drivers scored higher on the Sensation Seeking subscale, but all drivers scored comparably on the Impulsivity subscale. Higher scores correspond to higher Sensation Seeking and greater Impulsivity.

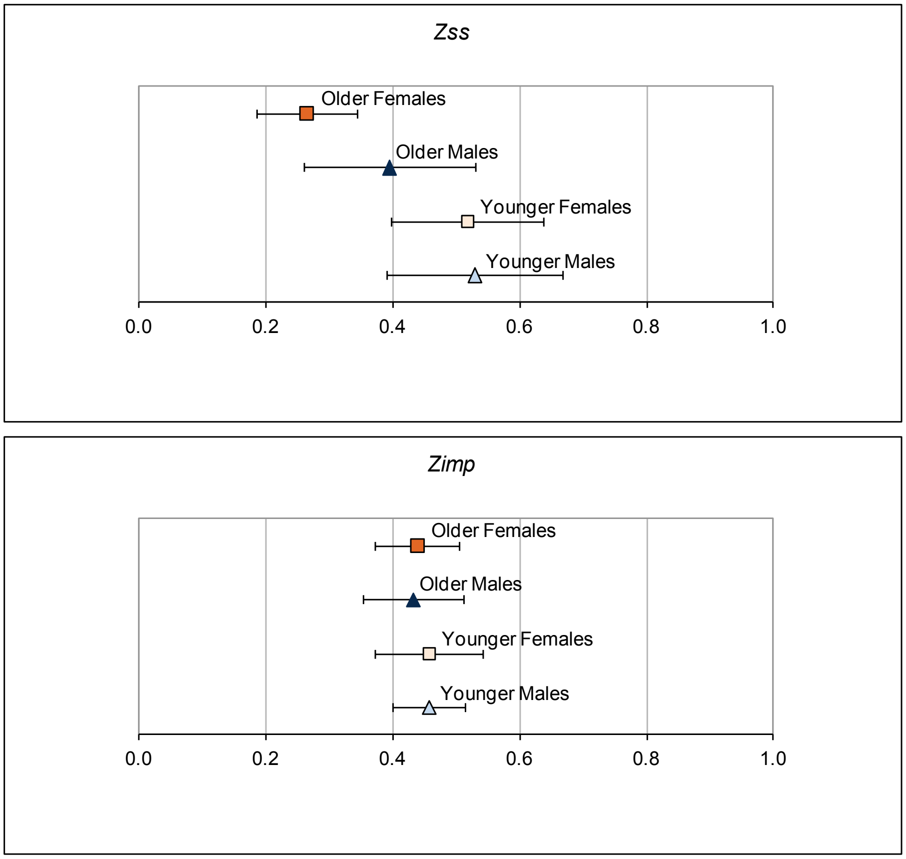


Figure 19. Seattle – Sensation Seeking (Z_{ss}) and Impulsivity (Z_{imp}) subscale scores by demographic group.

Seattle Data – All Driving

This section provides information about the overall driving patterns of study participants by demographic group. This includes information about when participants drove, for how long, and on what types of roads/speed bands. This information helps identify important trip-related factors that can be controlled for in the inferential analyses.

Seattle – Geographic extent of all driving

Figure 20 below provides a map of the lateral and longitudinal coordinates of the middle time point in each driving epoch (dots). The data points represent the location of each driver in 30-second increments. Driving epochs are presented here rather than time (i.e., one-second records) to reduce the number of points for a simpler and clearer map. Overall, these points indicate where the participants drove in the Seattle area. Most of the points are concentrated along the Seattle-Tacoma corridor, especially near the downtown core of Seattle, as indicated by the near-solid concentration of points in this area.

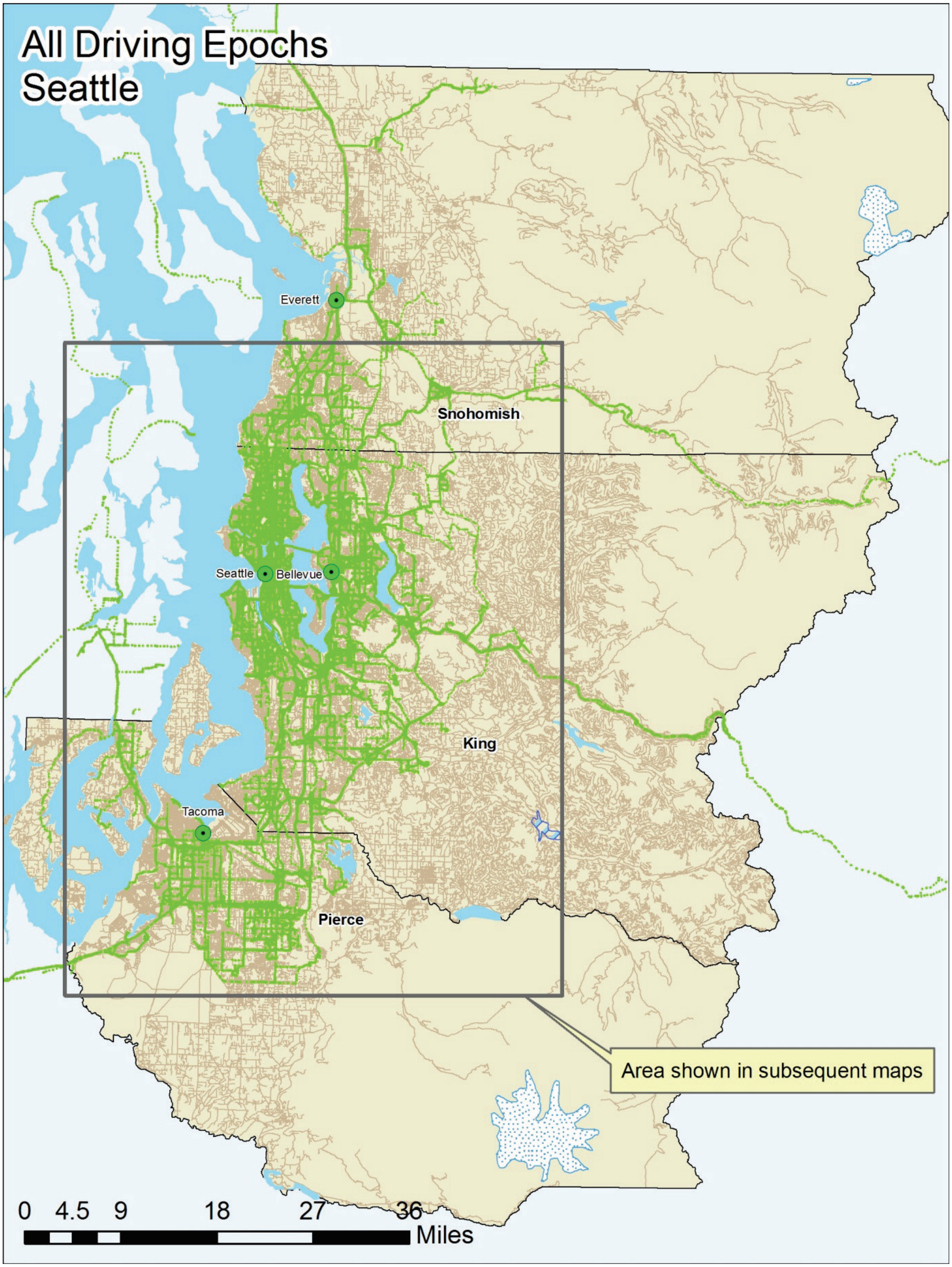


Figure 20. Map showing the geographic extent of all driving epochs in Seattle.

Seattle – Number of trips by duration and start time for all drivers combined

Table 13 below shows the number of trips that participants made as a function of the trip start time and the overall duration of the trip. Note that because the first and last half mile or first and last 90 seconds of travel (whichever was longer) was removed from each trip to protect participant privacy, 3 minutes was added back in to the trip duration to account for this deleted time. The table below shows that the majority of trips were between 5 and 30 minutes in duration and undertaken between the hours of 9 a.m. and 3 p.m.

Table 13. Number of trips by duration and start time for Seattle drivers.

	Time of Day					
Trip Duration (min)	**12 a.m.-5 a.m.**	**5 a.m.-9 a.m.**	**9 a.m.-3 p.m.**	**3 p.m.-7 p.m.**	**7 p.m.-12 a.m.**	
<5	12	82	319	194	162	10.7%
5-10	46	112	589	403	317	20.4%
10-20	55	243	867	639	463	31.6%
20-30	23	169	479	381	212	17.6%
30-40	13	138	194	242	99	9.6%
40-50	7	61	117	130	26	4.7%
50-60	5	18	54	58	20	2.2%
>60	2	25	82	100	22	3.2%
	2.3%	11.8%	37.6%	29.9%	18.4%	

Seattle – Number of trips by duration and start time for each demographic group

Table 14 below shows the number of trips that participants in each demographic category made based on the trip start time and the overall duration of the trip. Again, 3 minutes were added to the duration of each trip to account for the time removed for participant privacy. The distributions of trips are similar across demographic categories. The most notable difference is that Older Females had a greater concentration of trips in the 9 a.m. to 3 p.m. time band than other groups. Additionally, younger drivers recorded more nighttime trips, between 7 p.m. and 12 a.m., than the older drivers.

Table 14. Average number of trips by duration and start time for each demographic group in Seattle.

Older Females			**Time of Day**			
Trip Duration (min)	**12 a.m.-5 a.m.**	**5 a.m.-9 a.m.**	**9 a.m.-3 p.m.**	**3 p.m.-7 p.m.**	**7 p.m.-12 a.m.**	
<5	1	11	76	49	26	9.4%
5-10	10	44	175	95	51	21.6%
10-20	4	47	268	183	59	32.3%
20-30	1	25	150	91	35	17.4%
30-40	1	40	66	45	23	10.1%
40-50	0	20	37	18	3	4.5%
50-60	0	5	17	11	2	2.0%
>60	1	2	24	20	3	2.9%
	1.0%	11.2%	46.8%	29.4%	11.6%	
Older Males			**Time of Day**			
Trip Duration (min)	**12 a.m.-5 a.m.**	**5 a.m.-9 a.m.**	**9 a.m.-3 p.m.**	**3 p.m.-7 p.m.**	**7 p.m.-12 a.m.**	
<5	1	16	82	37	34	9.2%
5-10	4	29	140	104	66	18.6%
10-20	6	98	195	149	98	29.7%
20-30	2	78	113	104	37	18.2%
30-40	4	45	54	75	26	11.1%
40-50	1	25	42	52	12	7.2%
50-60	0	4	16	18	5	2.3%
>60	0	16	15	36	1	3.7%
	1.0%	16.9%	35.7%	31.3%	15.2%	
Younger Females			**Time of Day**			
Trip Duration (min)	**12 a.m.-5 a.m.**	**5 a.m.-9 a.m.**	**9 a.m.-3 p.m.**	**3 p.m.-7 p.m.**	**7 p.m.-12 a.m.**	
<5	4	47	83	43	47	12.2%
5-10	16	22	146	103	82	20.1%
10-20	24	63	186	144	164	31.7%
20-30	11	39	112	120	72	19.3%
30-40	5	40	43	72	29	10.3%
40-50	2	9	16	30	4	3.3%
50-60	1	3	8	8	3	1.3%
>60	1	2	14	12	3	1.7%
	3.5%	12.3%	33.2%	29.0%	22.0%	
Younger Males			**Time of Day**			
Trip Duration (min)	**12 a.m.-5 a.m.**	**5 a.m.-9 a.m.**	**9 a.m.-3 p.m.**	**3 p.m.-7 p.m.**	**7 p.m.-12 a.m.**	
<5	6	8	78	65	55	12.0%
5-10	16	17	128	101	118	21.5%
10-20	21	35	218	163	142	32.7%
20-30	9	27	104	66	68	15.5%
30-40	3	13	31	50	21	6.7%
40-50	4	7	22	30	7	4.0%
50-60	4	6	13	21	10	3.1%
>60	0	5	29	32	15	4.6%
	3.6%	6.7%	35.2%	29.9%	24.7%	

Seattle – Number of trips by day of week for all drivers combined

Figure 21 below shows the total number of trips taken on each day of the week by all Seattle drivers combined. The day of the week is based on the trip start time. The number of trips taken is generally similar across weekdays, with many fewer trips taken on weekends. The number of weekend trips is likely smaller because participants tend to drive less on these days. However, another contributing factor is that most drivers were enrolled in the study for fewer weekend days than individual weekdays overall. Participant enrollments were not performed on the weekends, which reduced the opportunity to drive on one Saturday and one Sunday during the enrollment period for each participant.

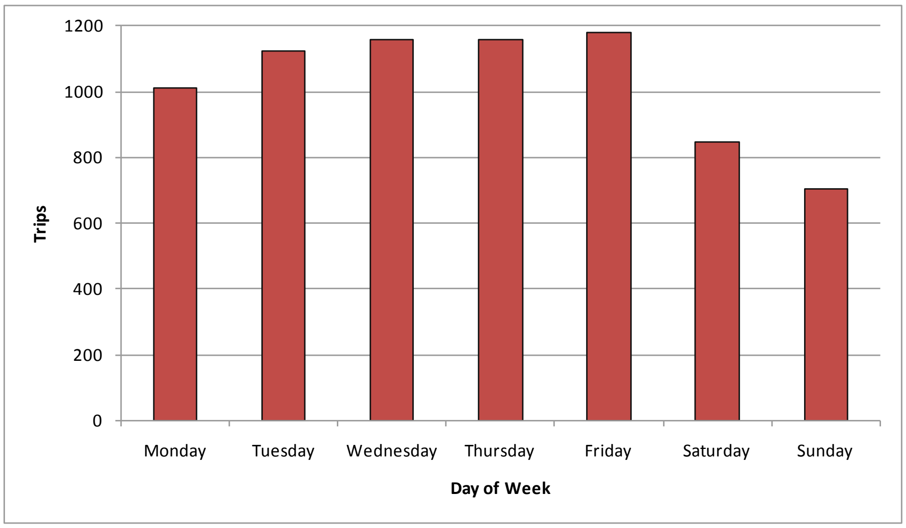


Figure 21. Histogram showing the total number of trips taken on each day of the week for all Seattle drivers combined.

Seattle – Average of trips by day of week for each demographic group

Figure 22 below shows the average number of trips taken on each day of the week (based on trip start time) for each demographic group. For most drivers, this represents two to three instances of each day of the week (e.g., 2-3 Mondays) depending on which days the start-up and close-out visits occurred and on the total duration of enrollment. Note that the average value is used in this table to compensate for the different number of participants in each demographic group. The differences across demographic groups appear to be minor, with the possible exception of Younger Males who drove more on Saturdays than the other groups.

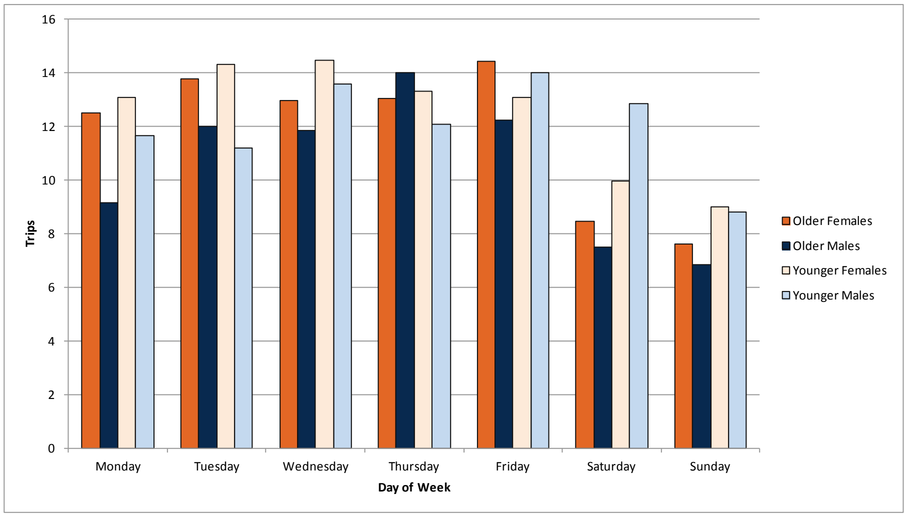


Figure 22. Histogram showing the average number of trips taken on each day of the week for each demographic group in Seattle.

Seattle – Total miles driven by posted speed

Figure 23 below shows the total number of miles driven by all participants on roadways with the indicated posted speeds. The largest proportion of driving occurred on roads with either 35 or 60 mph posted speeds. This distribution of driving across posted speeds served as the basis for selecting these two posted speeds as the focus of our analyses. For the analyses, these speed bands were each combined with a neighboring posted speed, as denoted by similarly colored triangles in the graph below. The reasons for combining posted speeds were: (1) to increase the number of seconds of data in each speed band (particularly in Texas), (2) to enable the examination of the same posted speeds in both locations, and (3) because the road environments/driving conditions represented by the road types that were combined are similar.

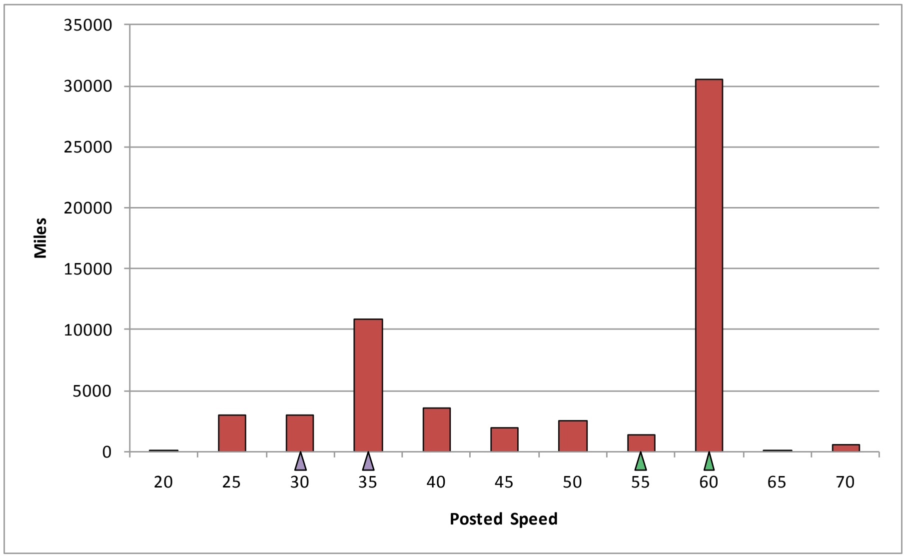


Figure 23. Histogram showing the total number of miles driven by all participants on Seattle-area roads with different posted speeds (in mph). The colored triangles denote the posted speeds selected for analysis in the 30-35 mph speed band (purple) and the 55-60 mph speed band (green).

Seattle – Average miles driven on 30-35 and 55-60 mph posted speed roads for each demographic group

Figure 24 below shows the average number of miles driven on 30-35 and 55-60 mph posted speed roads by drivers in each demographic group. Note that the average value is used in this table to compensate for the different number of participants in each demographic group. Overall, there appear to be no systematic differences across demographic groups.

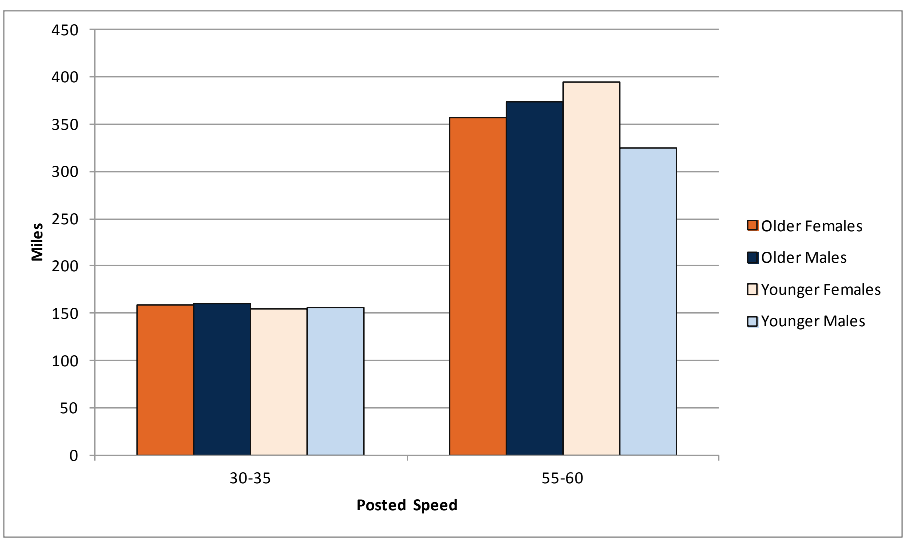


Figure 24. Histogram showing the average number of miles driven on 30-35 and 55-60 mph roads in Seattle by demographic group.

Seattle – Summary of trip-level data by demographic group

Table 15 describes some of the basic measures used to depict driving patterns per demographic group. This table shows that the trip-level characteristics were relatively consistent across drivers as measured by the average number of trips per day, average trip duration, and average trip distance. However, when looking at driving time, it appears that older participants drive more than younger participants do during weekdays, while Younger Males drive the most on weeknights and weekends.

Table 15. Key trip-level characteristics for drivers in Seattle.

	Older Females	Older Males	Younger Females	Younger Males	*All*
Number of Participants (N)	21	25	21	21	*88*
Avg Days of Driving (unique days with trips)	21.2	20.3	22.4	20.4	*21.0*
Avg Trips per day	3.9	3.6	3.9	4.2	*3.9*
Avg Trip Duration (minutes)	20.6	21.9	19.1	22.0	*21.0*
Avg Trip Distance (miles)	9.1	10.0	8.6	9.4	*9.3*
Avg Driving Time Weekdays (hrs) 5 a.m.-7 p.m.	16.8	16.1	14.1	13.9	*15.4*
Avg Driving Time Weeknights (hrs) 7 p.m.-5 a.m.	2.1	2.4	3.8	5.0	*3.3*
Avg Driving Time Weekend (hrs) 12 a.m.-12 p.m.	4.7	4.3	4.7	6.6	*5.0*

In summary, there are some differences between groups with regard to the variables examined in this section, though the differences are small. However, if these differences systematically affect the opportunity to speed or a driver's propensity to speed, they could potentially influence the overall findings. Some of these variables, therefore, were used as control variables in the inferential analyses.

Seattle Data – Free-Flow Driving

Seattle – "Free-flow" driving epochs

The data described in the previous sections were based on the full data set. One limitation of this data set with regard to examining driver speeding is that it includes many instances in which drivers' speeds are constrained by traffic control devices or traffic congestion—instances in which they clearly have no opportunity to speed. Moreover, travel that represents slower driving or stopped time ends up being overrepresented in terms of chronological time relative to episodes in which drivers are able to select their desired speed, since drivers take longer to travel the same distance in the former case. Consequently, comparing the time that drivers spent speeding to the total amount of time they drove likely underestimates their speeding exposure by a substantial amount because their trip data is "diluted" by a large amount of inconsequential time when they were stopped or had no chance to speed.

One approach for addressing this dilution of data is to remove all of the recorded time (seconds) in which drivers clearly had no opportunity to speed. We did this in two different ways. For most of the descriptive and inferential analyses, we filtered individual one-second records of driving based on whether or not the vehicle speed was above the free-flow speed criterion. The other way we did this was to filter by epochs (this was necessary for making the GIS maps of free-flow driving). However, since epochs contained up to 30 one-second records--not all of which may have been at free-flow speeds--we added a time-criterion for the epoch filtering. In particular, we only retained epochs for which driving was done within 5 mph of posted speed at least 85% of the time (e.g., traveling at 30 mph or greater on a 35 mph road for at least 85% of the time in an epoch). Table 16 below shows how many epochs were retained on 30-35 and 55-60 mph roads for each demographic category after this filtering step. Note that relative to the complete data set, free-flow epochs were also filtered to remove driving that occurred on unvalidated roads and due to other data-integrity issues, such as missing data points.

There is an important caveat with regard to using free-flow time as a measure of opportunity to speed. The key problem is that it can be a highly imprecise measure under certain conditions (i.e., light traffic). In particular, because we could not collect data about a driver's immediate traffic environment, it is impossible to tell if a driver traveling at the posted speed (which we count as free-flow driving) is doing so deliberately or if they would rather be speeding but are (for example) trapped behind another vehicle that they cannot pass. A detailed description of how free-flow time was calculated for this study is provided on pages 58-59, below.

Table 16 shows how much of the validated driving data was done under free-flow driving conditions. In particular, just over half of the epochs on both 30-35 mph and 55-60 mph roads represented free-flow driving. Overall, there appeared to be little difference in these proportions across demographic groups.

Table 16. Comparison of the number of Seattle driving epochs in each demographic category before and after filtering to retain only free-flow driving epochs on 30-35 and 55-60 mph roads.

Demographic Group	30-35 mph Posted Speed			55-60 mph Posted Speed		
	Driving Epochs*	***Free-flow***	***Percent Retained***	***Driving Epochs****	***Free-flow***	***Percent Retained***
Older Females	2776	1661	59.8%	11568	6347	54.9%
Older Males	3448	2068	60.0%	15864	8630	54.4%
Younger Females	3231	1975	61.1%	14325	7998	55.8%
Younger Males	3006	1777	59.1%	11278	6533	57.9%
Overall	**12461**	**7481**	**60.0%**	**53035**	**29508**	**55.6%**

*Driving epochs include filtering to remove stationary vehicle data, missing/incomplete data, invalid or incorrect data, and data from unvalidated roadways (through Stage 3 of filtering as described in the Methods section).

Note that the percentage values in the table above are slightly higher than those found in Table 7 (on page 23) for the overall Seattle Stage 4 data filtering results. This is because the data obtained for driving on roads with 30-35 mph and 55-60 mph posted speeds was more reliable than the data obtained for driving on roads with other posted speeds. In other words, the amount of unreliable data from roads with posted speeds that were not selected was disproportionately high (due to missing data, invalid data, no chance to speed, or unverified posted speeds).

Seattle – Geographic extent of filtered free-flow epochs

Epochs can also show where in the road network the free-flow driving occurred. Figure 25 below provides a map showing two different types of epochs. The first represents all driving epochs (green dots), which are also the same set of data points as shown in the map in Figure 20 (page 44) above. The second set (blue dots) shows all of the epochs that remained after filtering for data quality/validity and for "opportunity to speed," as described in the Methods section on epoch filtering. Essentially, the blue dots indicate which of the total driving epochs (green dots) were included in the speeding analyses. Note that the green dots include all of the posted speeds, whereas the free-flow epochs shown (blue dots) represent only driving from 30-35 and 55-60 mph posted-speed roads.

As seen in Figure 25, the free-flow driving spans most of the overall driving area and it covers all of the major types of driving in the Seattle area (urban, suburban, freeway, and outlying areas with more open roads, or hillier terrain). Another notable pattern in the results is that on several roads the blue dots appear intermittently with green dots. This indicates instances of free-flow driving interspersed with slow driving, which raises questions about whether drivers actually had an opportunity to speed in these cases, even though they were traveling at free-flow speeds.

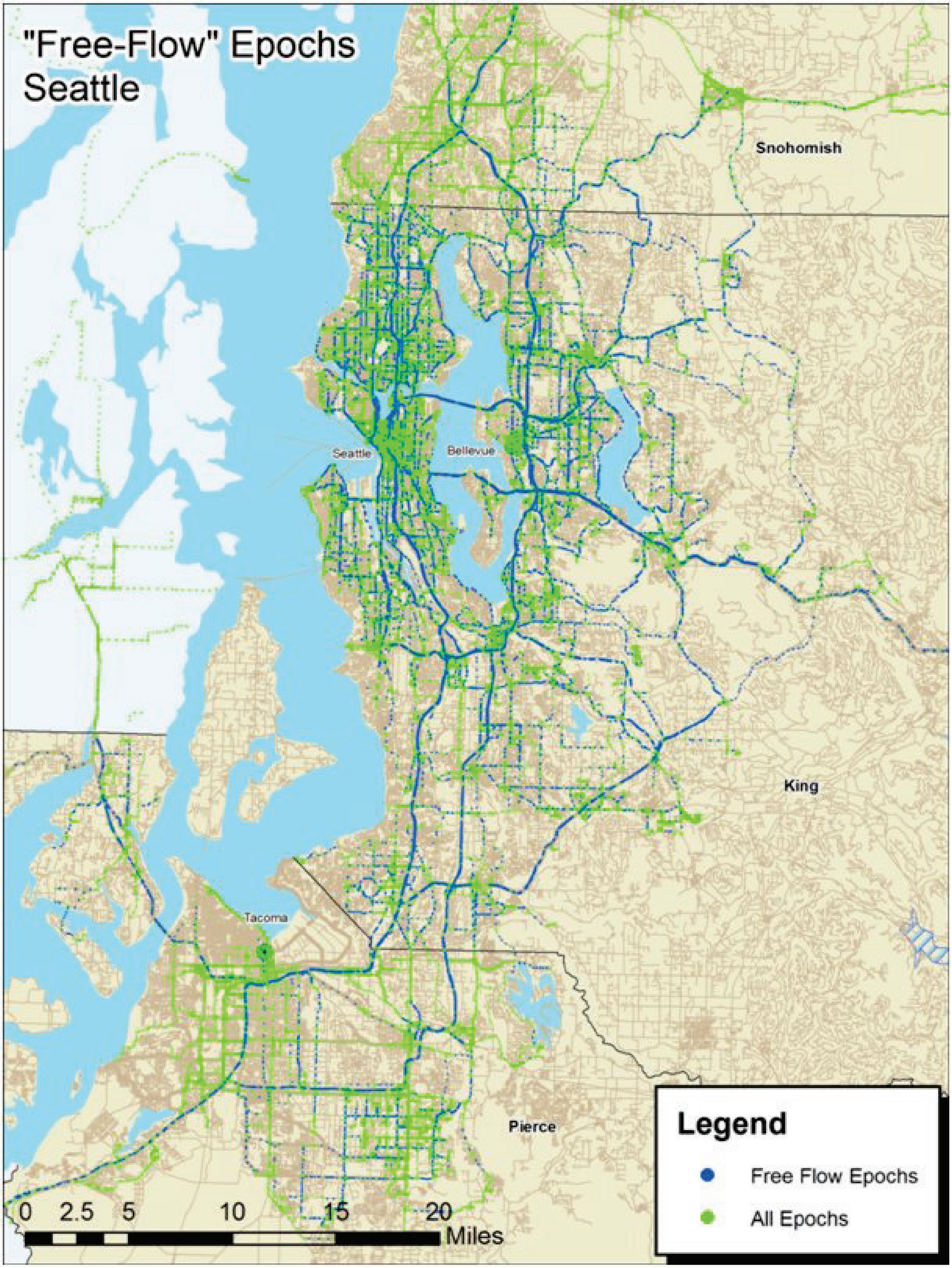


Figure 25. Map showing the geographic extent of the Seattle free-flow epochs.

Seattle – Percentage of free-flow driving time spent in different speed bands relative to the posted speed.

Free-flow driving time can provide a comprehensive view of driver speed choice across all of the driving in the study. In particular, Table 17 shows the distribution of speeds relative to the posted speed across all of the Seattle drivers in a demographic group--shown in five-mile-per-hour bands (e.g., "PS+5" represents driving at speeds between 40-44.99 mph on a 35 mph road). The bold line between the "PS-5" (mph) and "PS" categories indicates the posted speed.

Table 17 indicates that the majority of driving occurred within ±5 mph of the posted speed. Speeding in the current report was defined as driving that was 10 mph or more above the posted speed (categories shown in red text in the table below). In this case, the speeding that did occur was predominately between 10 and 15 mph above the posted speed. Almost no speeding occurred at speeds faster than 20 mph above the posted speed. In terms of this overall characterization of driving speed, there are some differences between demographic groups, but these differences are small.

Table 17. Percentage of free-flow driving time in Seattle spent in different speed bands relative to the posted speed (PS) for each demographic group on 30-35 and 55-60 mph roads.

30-35 mph Roads	Travel Speed (mph)						
	PS-5	PS	PS+5	PS+10	PS+15	PS+20	PS+25
Older Females	38.8%	43.7%	14.8%	2.5%	0.2%	0.0%	0.0%
Older Males	34.0%	43.5%	17.8%	3.7%	0.8%	0.1%	0.0%
Younger Females	33.2%	42.3%	20.7%	3.5%	0.2%	0.0%	0.0%
Younger Males	31.9%	44.9%	19.6%	3.1%	0.4%	0.0%	0.0%
Overall	34.4%	43.6%	18.3%	3.2%	0.4%	0.0%	0.0%
55-60 mph Roads							
	PS-5	PS	PS+5	PS+10	PS+15	PS+20	PS+25
Older Females	34.8%	42.4%	19.9%	2.6%	0.3%	0.0%	0.0%
Older Males	31.6%	46.2%	17.6%	3.6%	0.7%	0.1%	0.0%
Younger Females	25.1%	39.9%	28.2%	5.9%	0.7%	0.1%	0.0%
Younger Males	24.1%	42.4%	27.3%	5.1%	0.8%	0.2%	0.0%
Overall	28.9%	42.8%	23.1%	4.4%	0.7%	0.1%	0.0%

Seattle Data – Speeding Time

A detailed analysis of the speeding time on each trip was used to examine patterns in driver speeding behavior. In particular, we focused on two primary measures to quantify speeding behavior. The first was the proportion of a driver's trips that had any speeding. This allowed us to examine the questions related to *who is speeding*. The second measure was the proportion of free-flow time on an individual trip that was speeding. This allowed us to examine the question related to *who speeds the most*. More detailed discussion of each measure and how each was calculated is provided below.

Seattle – Percent of free-flow trips with speeding time by demographic group

This measure represents the percentage of trips during which the driver took advantage of the opportunity to speed, or the likelihood that speeding occurred on any particular trip for a driver. The percentage of trips with speeding time provides a high-level measure of the propensity to speed on a given trip, in addition to providing a way to identify which drivers engage in any speeding. Note that this measure only counts trips that contain free-flow driving in the specified speed band, and the speeding time is also specific to that speed band. The following definition shows how the percentage was calculated:

$$\textbf{Percentage of Trips with Speeding}_{(\textbf{speedband})} = \frac{\textit{number of trips with Speeding Time}_{(\textbf{speedband})}}{\textit{number of trips with Freeflow time}_{(\textbf{speedband})}}$$

Figure 26 below shows the percentage of trips with free-flow time that also have any speeding time, averaged within each demographic group. The likelihood of any speeding is generally greater on 55-60 mph roads than on 30-35 mph roads. This may be due to drivers having more chances to speed (at least briefly) on longer trips or on more open roads. Figure 26 also shows that younger drivers were more likely to have any speeding on 55-60 mph roads and, to a lesser extent, on 30-35 mph roads. This may reflect demographic differences in speeding behavior or driving patterns.

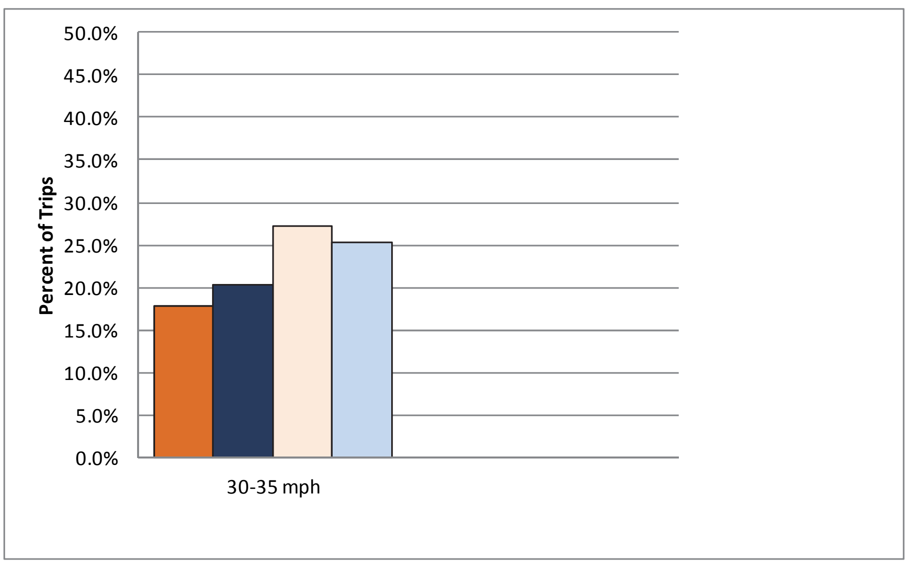


Figure 26. Percentage of trips with free-flow time that have speeding time in Seattle, by demographic group.

Table 18 below shows the numeric values associated with the bars in the figure above as well as a measure of the number of trips with free-flow driving in a given speed band. In general, Younger Females had a higher percentage of trips with any speeding, in both speed bands; however, they also had a higher average number of trips per driver than other groups.

Table 18. Number of trips with free-flow driving and the percentage of the trip that was speeding by demographic group in Seattle.

Group	30-35 mph Roadways		55-60 mph Roadways	
	Avg Number of Trips with Free-Flow Driving	*Average % Speeding Trips*	*Avg Number of Trips with Free-Flow Driving*	*Average % Speeding Trips*
Older Females	33.4	17.9%	27.5	24.3%
Older Males	33.4	20.3%	31.2	29.9%
Younger Females	38.1	27.2%	38.1	45.8%
Younger Males	29.3	25.3%	29.9	43.1%
Mean	33.6	22.7%	31.6	35.5%

One relevant question regarding speeding behavior is whether drivers that speed consistently in one speed band are more likely to do so in another speed band. More broadly, this question addresses the extent to which this speeding measure can identify speeding that is a persistent "behavioral trait" whereby some individuals try to speed at every opportunity (i.e., a "habitual" speeder). Figure 27 below shows the percentage of trips with any speeding for individual drivers in each demographic group. The 30-35 mph and 55-60 mph speed bands are plotted on each axis.

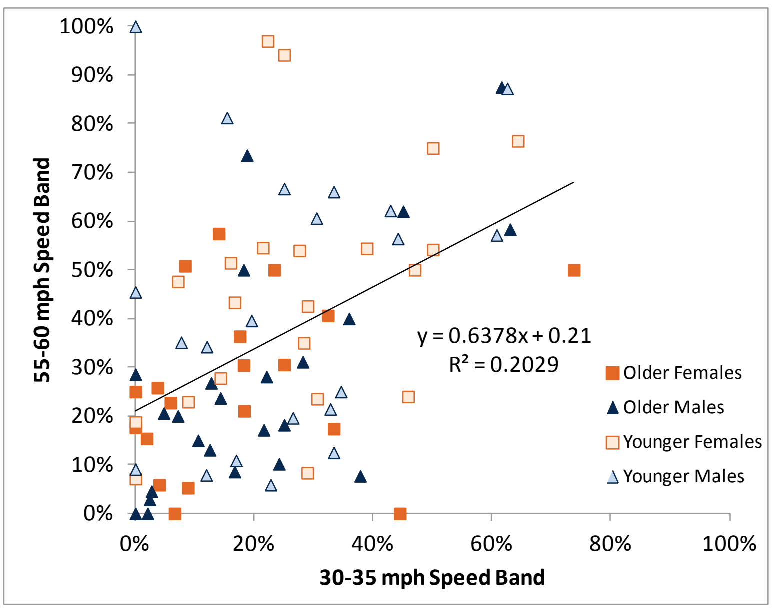


Figure 27. Scatter plot of percentage trips in Seattle with any speeding in each speed band for individual drivers. The trend line is based on drivers from all demographic groups.

A couple of trends are apparent in the scatter plot above. The first is that individuals are generally more likely to have any speeding in the 55-60 mph than in the 30-35 mph speed band, which is consistent with the averages reported in the table above. Moreover, several individuals in all groups (but less so Older Females) have some speeding on more than half of their trips in the 55-60 mph speed band. This indicates that driving above 10 mph above the speed limit—at least for a short period—is relatively common for most drivers on higher-speed roads in Seattle. Another finding from Figure 27 is that across all drivers in Seattle, there is a generally positive relationship between having some speeding in one speed band versus having speeding in the other. There is also a cluster of drivers that have speeding on more than half of their trips in both speed bands. Taken together, these results suggest that some Seattle drivers may be inherently more likely to speed than others whenever they drive.

Seattle – Average Speeding Time

An additional measure of speeding behavior is the average speeding time. This measure is the proportion of free-flow time within a single trip that a driver spends speeding. For example, 1 minute of speeding in 10 minutes of free-flow driving on a trip would be counted as 10% speeding. While the measure described in the previous section (percentage of trips with speeding) provides an indication of whether speeding is occurring, speeding provides an indication of how much speeding occurs on a trip.

Definition of Speeding

Figure 28 below provides an illustration of how driving data are extracted from a trip and categorized into free-flow and speeding time. The topmost bar shows a hypothetical trip, with the purple shaded regions representing free-flow driving on 30-35 mph roads, and the green shaded regions representing free-flow driving on 55-60 mph roads. The dark purple and green show the time during which drivers are speeding. The unshaded portions of the trip bar represent driving that is excluded from the data for a variety of reasons (e.g., driving too slow, driving on roads with unvalidated posted speeds, or roads with ineligible posted speeds). The middle set of bars shows the driving periods that are counted as free-flow time. Free-flow driving that occurred on different parts of the trip is combined into a single value (i.e., part A in the figure). Note that speeding time is also counted as free-flow driving. The bottom set of bars represents the speeding time during a trip. All speeding, even if it occurred at different times, is combined into a single value (i.e., part B in the figure).

Speeding on a single trip was specifically defined as:

$$\text{Speeding}_{(\text{speedband})} = \left(\frac{\boldsymbol{Speeding\ Time}_{(\textbf{speedband})}}{\boldsymbol{Freeflow\ time}_{(\textbf{speedband})}}\right)\ \boldsymbol{for\ each\ trip}$$

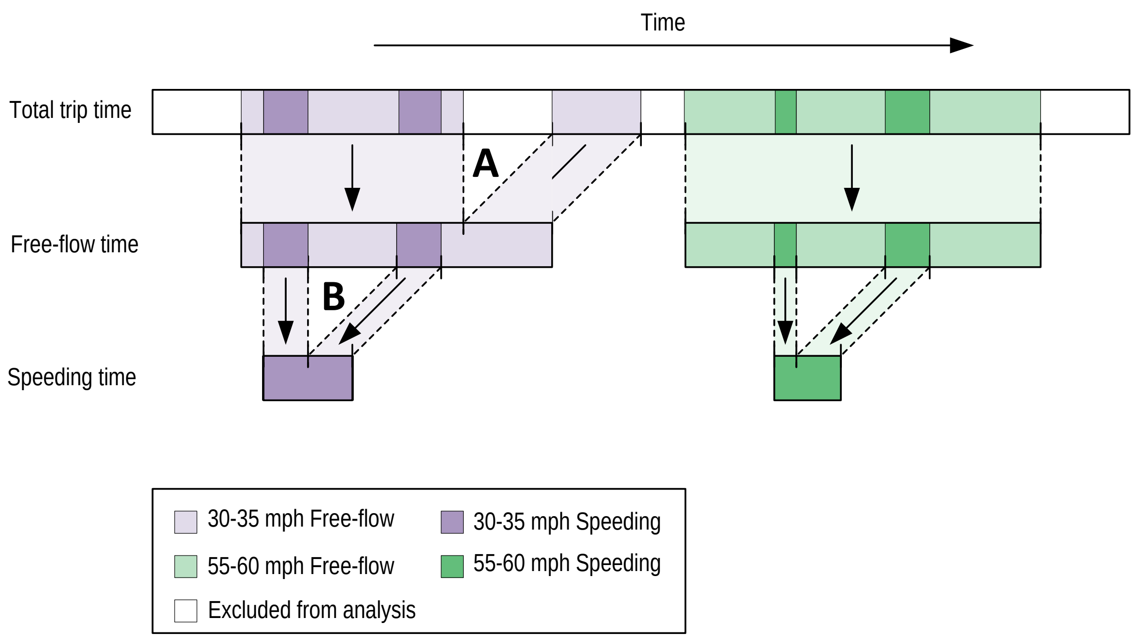


Figure 28. Illustration of how driving data are extracted from a trip and categorized into free-flow and speeding time.

The speeding measure was used to calculate average speeding for individual drivers. The specific definition of this measure is shown below:

$$\text{Average Speeding}_{(\text{speedband})} = \boldsymbol{Average}\left(\frac{\boldsymbol{Speeding\ Time}_{(\textbf{speedband})}}{\boldsymbol{Freeflow\ time}_{(\textbf{speedband})}}\right)\ \boldsymbol{for\ all\ trips}$$

Average speeding across all of an individual's trips provides a global measure of the amount of speeding those drivers did in a speed band for the entire data collection period. In some ways, it is an incomplete measure because it does not count every second of driving in the same way (i.e., it gives short and long trips the same weight in the calculation of overall time speeding in contrast to how this was done in Table 17, page 54). However, we found that this aspect actually leads to a better representation of regular driving patterns relative to pooling speeding and free-flow time across all trips (i.e., weighting each second across trips the same). The reason for this is that very long trips that reflect atypical driving patterns (i.e., like recreational travel) can skew the results by contributing as many seconds of driving as potentially dozens of short, more-typical trips.

Table 19 below shows average speeding across members in each demographic group. This represents an average of averages, since speeding is averaged within each driver then averaged again across all drivers in a demographic group. Note that two versions of this measure are shown. The first averages across all trips that drivers made (left column in each speed band). This measure provides an overall estimate of the speeding that members of a demographic group do under free-flow driving conditions. The clearest pattern indicated by this measure in Table 19 is that Older Females have the lowest amount of average speeding, while the Younger Females have the highest. Also, the averages for both younger groups are higher than for both older groups, although not by much in the case of male drivers. In general, the overall amount of speeding is low for all demographic groups. Given the previous results (Figure 26 on page 55 and Table 18 on page 56 showing that having any speeding on a trip was relatively common for most drivers, the results in Table 19 suggest that—on the whole—speeding is more of a situational, "in-the-moment" behavior than a persistent/habitual behavior. In other words, although a relatively high proportion of trips include some speeding, the amount of speeding in a trip is still quite low relative to the amount of free-flow driving, which suggests that even when they have a chance to speed, most drivers do so only sparingly.

The second way to measure average speeding is to only consider trips that have any speeding in the calculation, which is also shown in Table 19 (right column in each speed band). This approach should be more robust with regard to representing the more situational elements of speeding (if they are late, where they are driving, roadway characteristics, etc.) since this measure is less likely to be diluted if drivers have a high number of trips or particularly long trips with no speeding. An important point is that this is not a better measure of average speeding, but rather it is a different measure that provides a sharper focus on the magnitude of speeding when drivers are doing speeding at all. As seen in Table 19, the average proportions are higher when only trips with speeding are considered (which should be true by definition); however, this difference is much smaller on 55-60 mph roadways than on 30-35 mph roadways. Also, with the exception of Older Females, who again have the least speeding, the demographic differences are less clear compared to the averages for all trips.

Table 19. Average speeding for all trips with free-flow time and only trips with speeding by speed band in Seattle.

	30-35 mph Roadways		55-60 mph Roadways	
Group	*All Trips with Free-Flow Time*	*Only Trips with Speeding*	*All Trips with Free-Flow Time*	*Only Trips with Speeding*
Older Females	2.7%	14.0%	2.0%	6.6%
Older Males	4.0%	20.9%	3.8%	7.8%
Younger Females	5.9%	19.3%	5.9%	10.1%
Younger Males	5.1%	17.6%	4.8%	8.8%
Mean	4.4%	18.2%	4.1%	8.4%

As was the case with the "percentage of speeding trips with speeding" measure described in the previous section, it is also possible to use average speeding to investigate whether drivers that speed consistently in one speed band are more likely to do so in another speed band. Figure 29 below shows average speeding (only trips with any speeding) for individual drivers in each demographic group. The 30-35 mph and 55-60 mph speed bands are plotted on each axis.

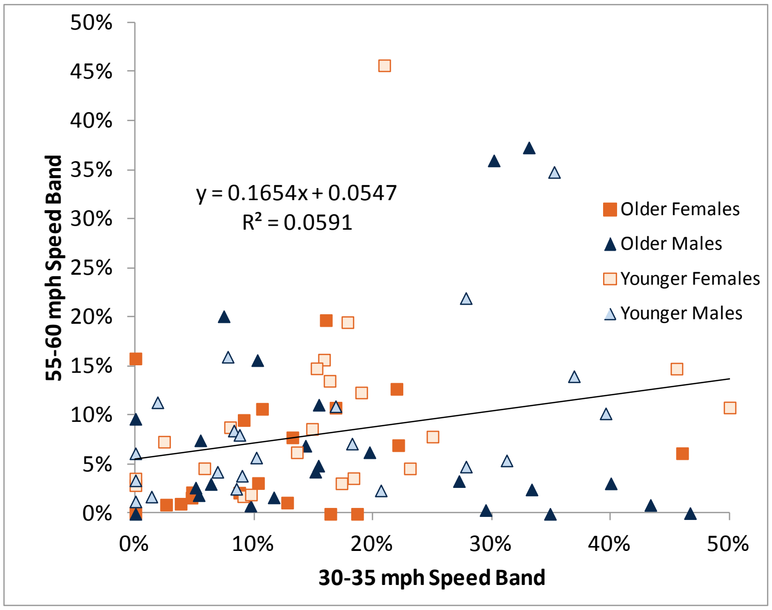


Figure 29. Scatter plot of average speeding in Seattle (only for trips with any speeding) in each speed band for individual drivers. The trend line is based on drivers from all demographic groups.

A few trends are apparent in the scatter plot shown in Figure 29 above. The first is that individuals are generally more likely to have higher proportions of average speeding in the 30-35 mph speed band than in the 55-60 mph speed band. This is the opposite pattern to what was found using the measure based on percentage of trips with any speeding (note that the range of the axis is reduced compared to Figure 27, on page 56, to better show the distribution of points). However, this pattern makes sense if trips taken on 55-60 mph roads are generally longer, making it easier to have any speeding by chance, though these types of spurious events would generally constitute a small proportion of time travelled.

Another finding from Figure 29 is that there is a small cluster of high speeders in both speed bands, which could represent the habitual speeders. In general, however, the relationship between speeding on one speed band versus the other is weaker than in the earlier version of this scatter plot. Also, at the higher values of speeding on 30-35 mph roads, male drivers outnumber female drivers.

It should be noted that this scatter plot is sensitive to the number of trips that drivers make. For example, it is easier to maintain a high average speeding percentage with a smaller number of trips. A later section that covers types of speeding behavior presents charts that explicitly take into account the number of trips that underlie each data point.

Texas Data

Included in this section are the descriptive statistics for the Texas data set. This includes analyses of all personal inventory responses, driving epochs, free-flow data, and speeding events.

Our presentation of the Texas data mirrors the previous presentation of Seattle data. Since the rationale behind certain descriptive analyses is already discussed in detail in the Seattle section, a more streamlined approach is taken with the Texas descriptive statistics results, with a focus on explaining the findings.

Texas – Demographic and Personal Inventory Data

In addition to providing on-road driving data, all of the participants in Texas also completed two inventories: a start-up personal inventory and a close-out personal inventory. These inventories were comprised of demographic and personality questions, generally organized by topic as follows:

Demographic questions (based on US Census questions);

General travel questions;

Driver Behavior Questionnaire (DBQ);

A combination of the DeJoy/Cards Risky Driving scales;

The Sensation Seeking and Impulsivity scales from Zuckerman's ZKPQ personality inventory; and

Questions about attitudes, beliefs, and social norms regarding speeding based on the Theory of Planned Behavior (TPB).

The complete text of the personal inventories completed by participants is presented in Appendix C, which also includes the full set of response options for each question.

The following histograms describe the responses to the demographic questions. Note that the range of the Y-axis varies between figures in order to better show the differences between demographic groups.

Figure 30 below shows the distribution of household income levels for the Texas drivers. In general, older drivers had higher income levels than younger drivers.

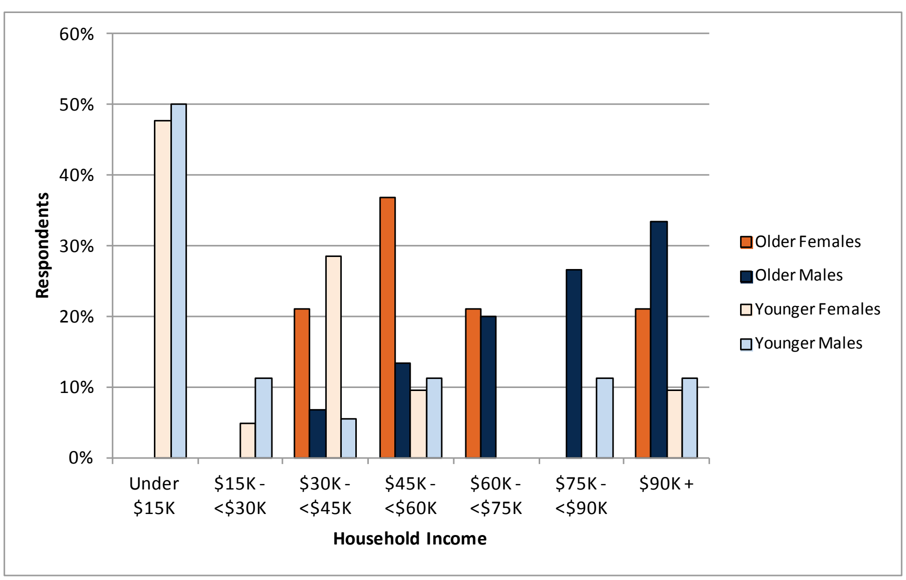


Figure 30. Histogram showing household income for Texas drivers.

Figure 31 below shows the highest level of education obtained by drivers in each demographic group. All drivers obtained either a high school diploma or GED and most drivers had at least an additional associate or bachelor's degree.

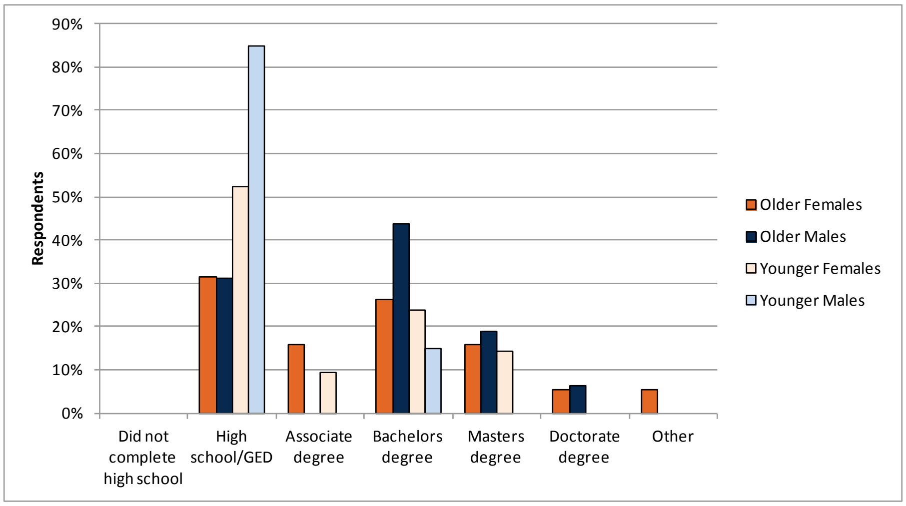


Figure 31. Histogram showing highest level of education obtained for Texas drivers.

Figure 32 below shows the marital status of the drivers in each demographic group. The younger drivers were mostly single, never married. Most of the older drivers were married or had a partner.

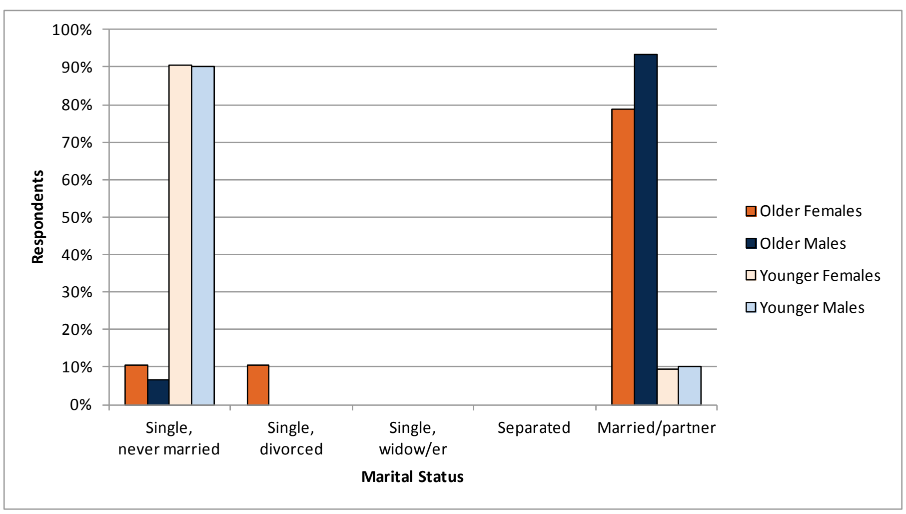


Figure 32. Histogram showing marital status for Texas drivers.

Figure 33 shows the number of children that the Texas drivers had living with them. Most of the younger drivers had no children. The older drivers were split among groups; most did not have children or had one or more children living with them most of the time.

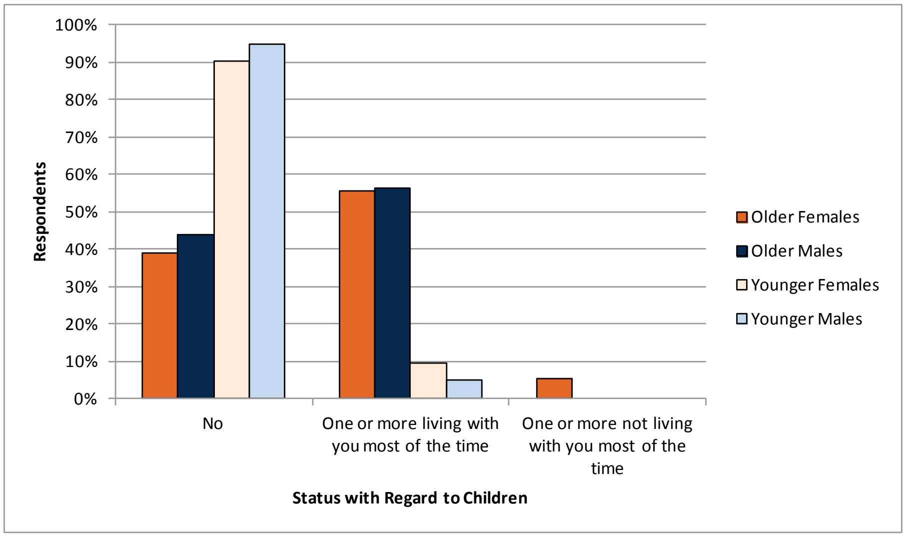


Figure 33. Histogram showing status with regard to children for Texas drivers.

Figure 34 shows the distribution of self-reported weekly mileages for Texas drivers. Older Females tended to report higher mileages than the other groups.

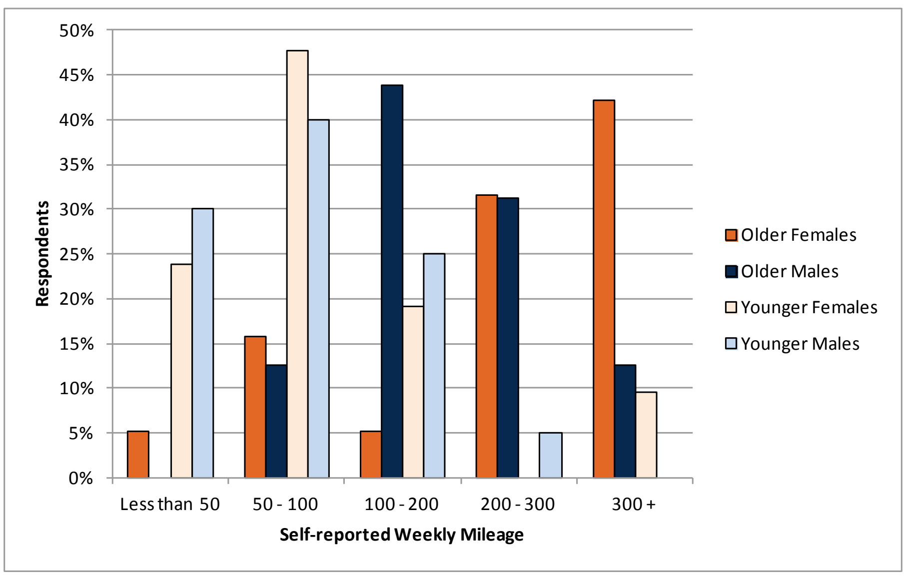


Figure 34. Histogram showing self-reported weekly mileage for Texas drivers.

The personal inventory data from the Texas drivers is presented in a series of figures (Figure 35, Figure 36, Figure 37, and Figure 38) below. Given the large number of questions included in the personal inventory, only the three questions in each section with the greatest range in responses (across all demographic groups) are shown. Accordingly, this subset provides an indication of the ways in which the demographic groups differ the most for a particular question set. Appendix D provides the average responses by demographic group for the full set of personal inventory questions. Each figure below shows the average response of each demographic group, with bars representing the 95% confidence interval.

Texas – General Travel Questions

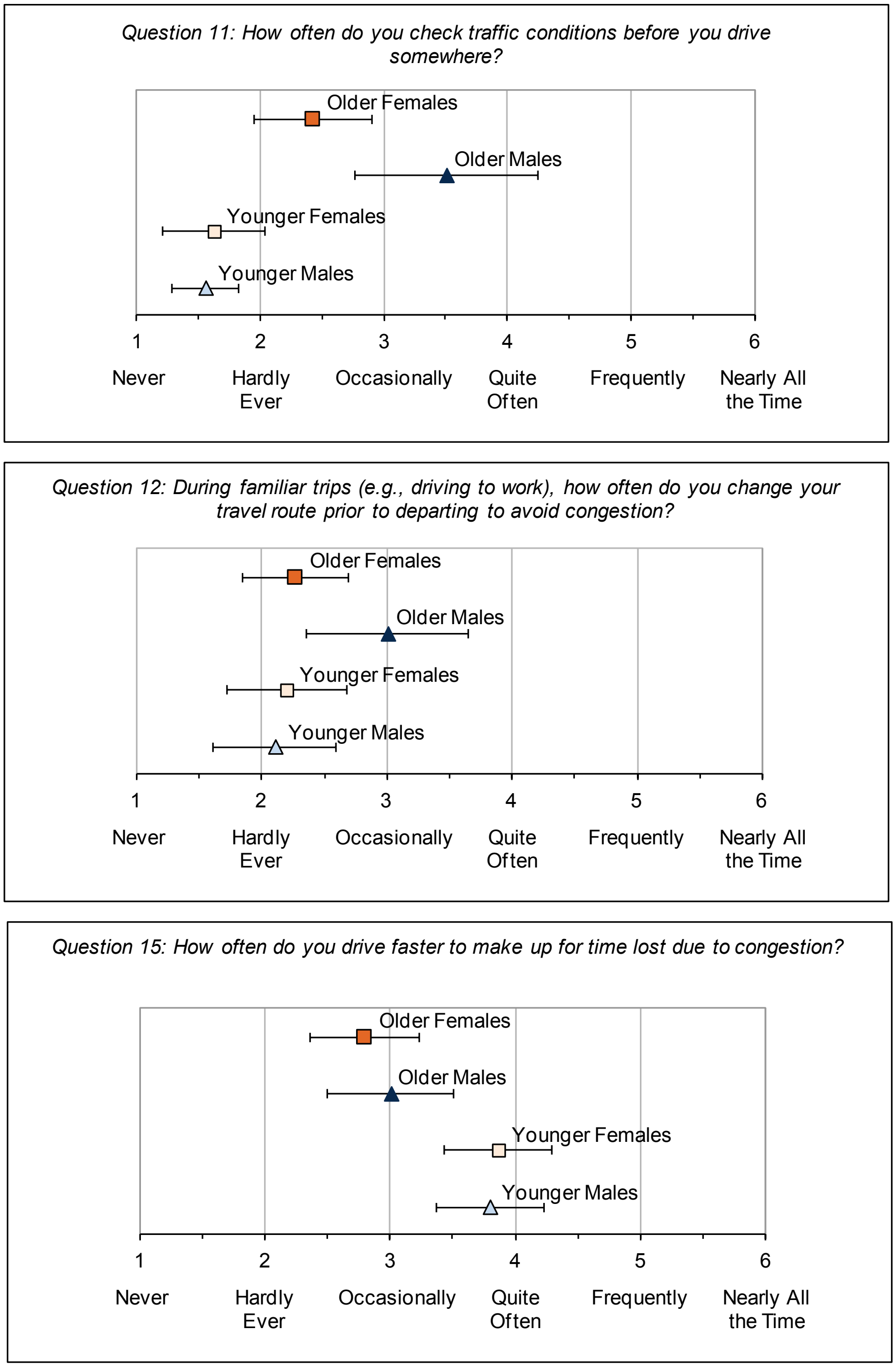


Figure 35. Results of general travel questions for Texas drivers.

Texas – Driver Behavior Questions

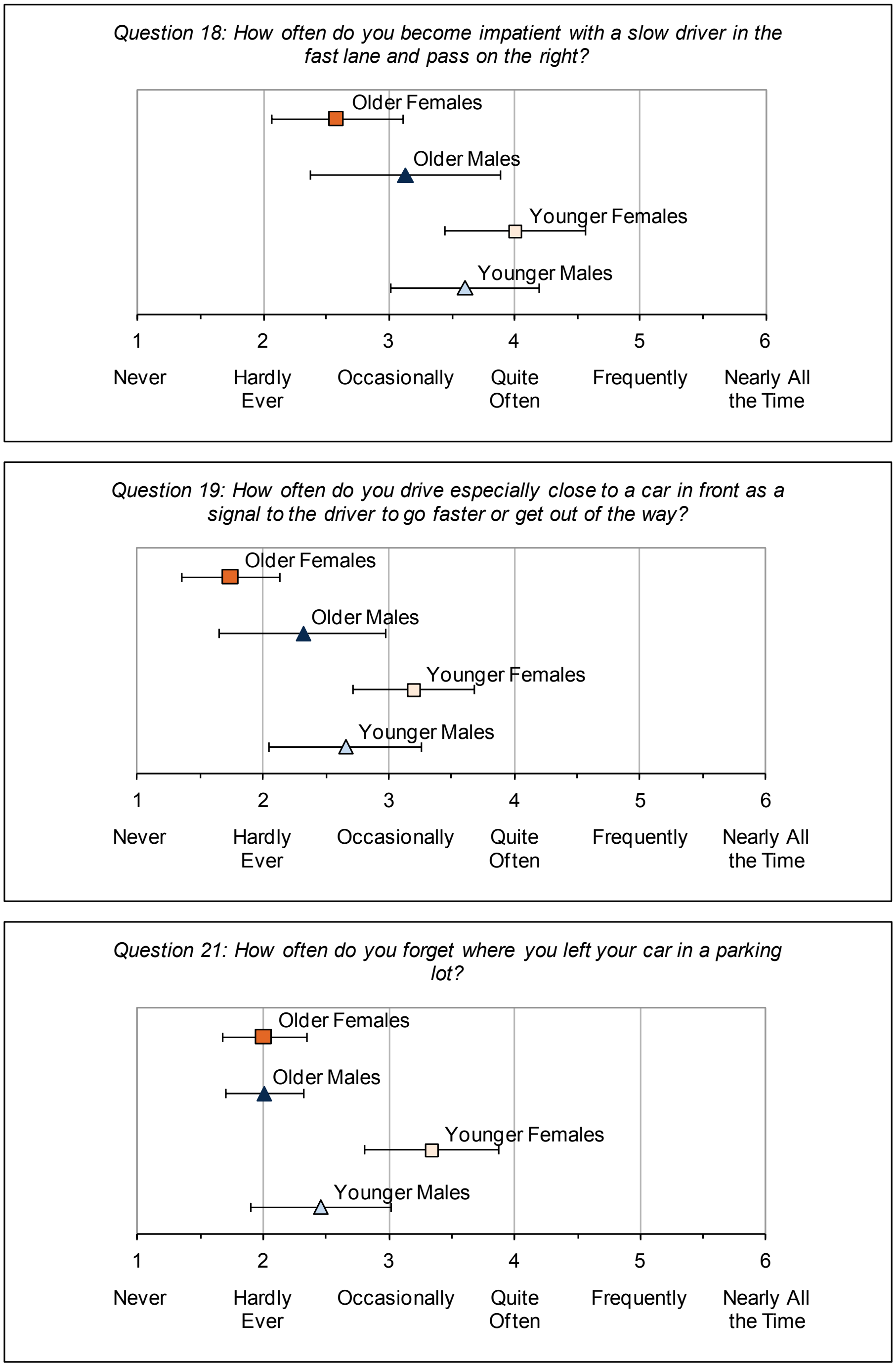


Figure 36. Results of driver behavior questions for Texas drivers.

Texas – Risk Questions

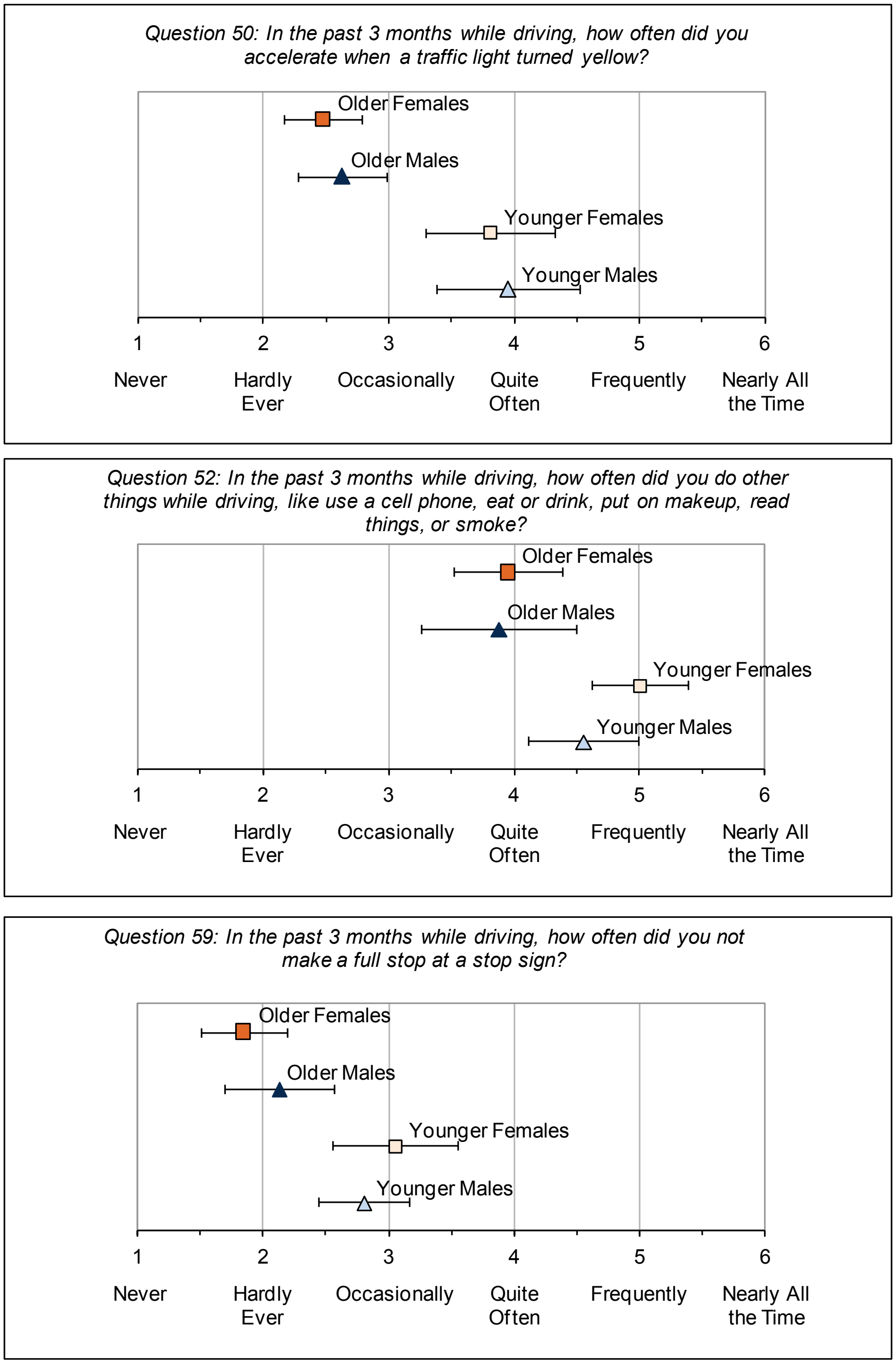


Figure 37. Results of risk questions for Texas drivers.

Texas – Speeding Beliefs, Attitudes, and Social Norms

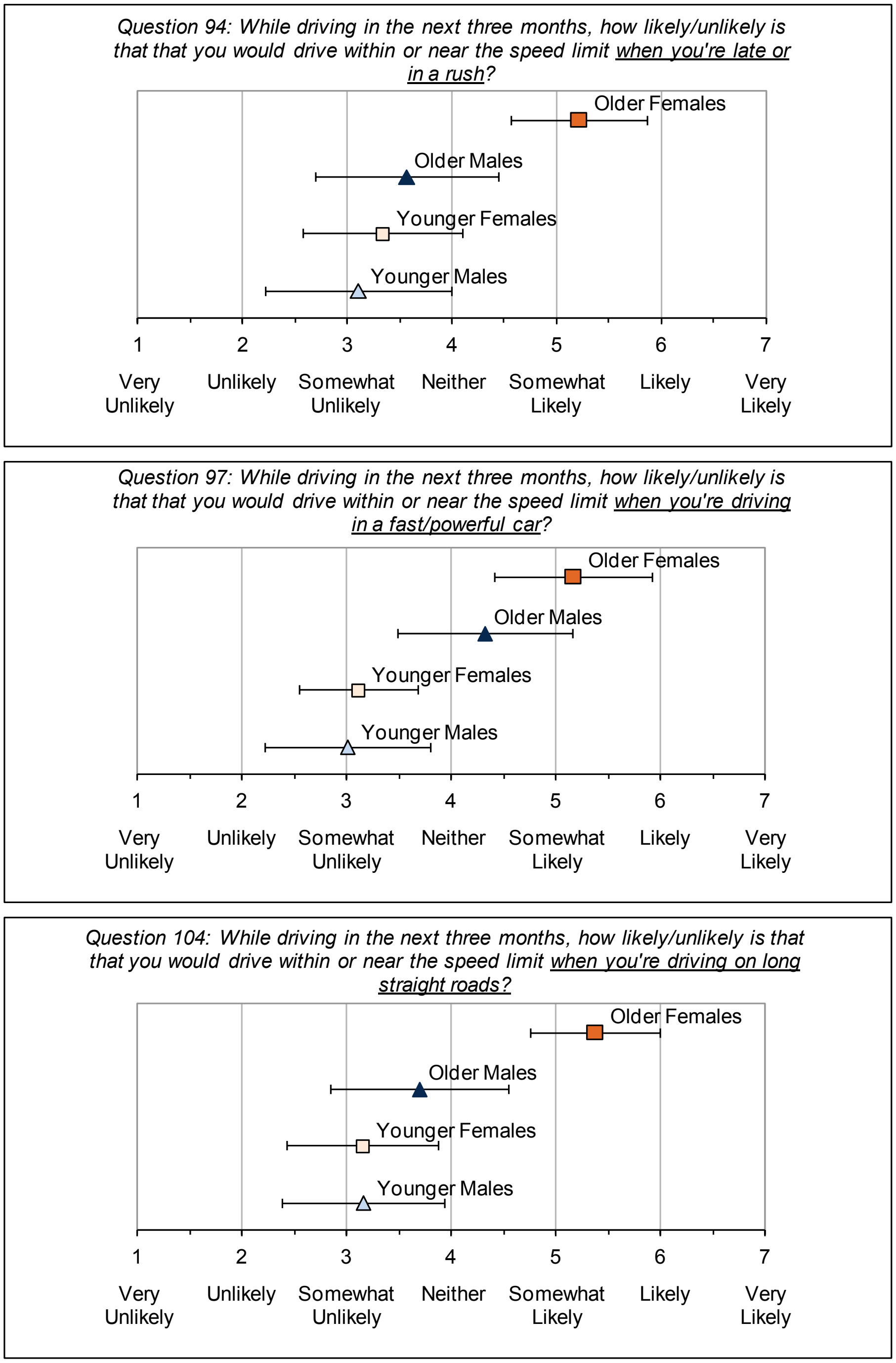


Figure 38. Results of speeding beliefs, attitudes, and social norms questions for Texas drivers.

Texas – Sensation Seeking and Impulsivity Subscale Scores

The 19 questions that were based on Zuckerman's ZKPQ personality inventory can be summarized using two subscales: the Sensation Seeking subscale and the Impulsivity subscale. The Sensation Seeking subscale "describes the seeking of excitement, novel experiences, and the willingness to take risks for the sake of these types of experiences." The Impulsivity subscale shows "a lack of planning and the tendency to act impulsively without thinking" (ZKPQ, n.d.). Figure 39 below shows the summary scores for each subscale by demographic group. Younger drivers scored higher on the Sensation Seeking subscale, but all drivers scored comparably on the Impulsivity subscale.

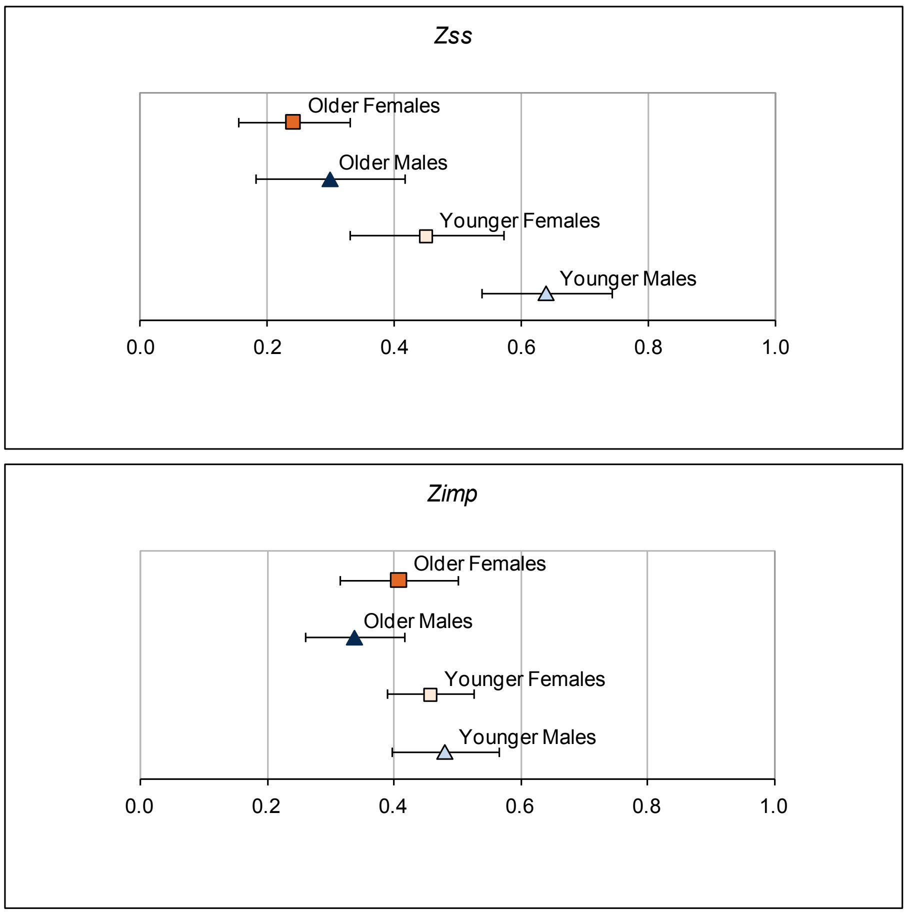


Figure 39. Texas – Sensation Seeking (Zss) and/Impulsivity (Zimp) subscale scores by demographic group.

Comparing Texas and Seattle Using Beliefs, Attitudes, and Social Norms Regarding Speeding

One of the reasons for conducting data collection in two locations was to identify potential differences in driver motivations, beliefs, and attitudes between drivers in urban and rural driving cultures. The personal inventory questions based on TPB (Eliot, Armitage, & Baughan, 2005) provide the most suitable measures of these types of differences. Table 20 below shows the average responses to the full set of personal inventory questions related to driver beliefs, attitudes, and social norms about speeding.

Average responses are shown separately for each demographic group, in addition to the average response across all participants at a location.

In order to compare responses between Seattle and Texas, t-tests were run on the average responses for each site (pooled across demographic groups). The questions that show significant differences across sites (using an alpha level of 0.05), are shown in bold in Table 20 below. However, these differences followed specific themes regarding beliefs and attitudes towards speeding at each location. In particular, Seattle drivers had significantly stronger beliefs and attitudes for questions related to traffic and interactions with other vehicles. Specifically, Seattle drivers were more likely to report that driving within the posted speed: annoys other drivers (Q85), holds up traffic (86), takes them longer to reach their destination (Q87), and makes them feel annoyed (Q88). In contrast, the beliefs and attitudes that were significantly stronger for Texas drivers were related to vehicle control and safety. Specifically, Texas drivers were more likely to report that driving within the posted speed: makes them feel relaxed (Q89), makes them feel safer (Q91), and makes them feel more in control of their vehicle (Q93). Texas drivers were also more likely to report that they would stay within the posted speed when late/in a rush (Q94).

There was another set of questions that asked drivers about the extent to which they were likely to be influenced to drive within the speed limit by various groups of people. An interesting finding here is that there is a remarkable degree of consistency in the average responses between location, even though the averages across "source of influence" vary substantially (i.e., ≈2.6 for friends to ≈6.0 for police). However, this consistency is not as apparent when the responses across demographic groups are considered for each site.

**Table 20. Speeding beliefs, attitudes, and social norms in Texas and Seattle.
Questions that were significantly higher are marked in red for Seattle, and blue for Texas.**

Q#	Survey Question	Seattle Data Set					Texas Data Set				
		Older Females	Older Males	Younger Females	Younger Males	Avg.	Older Females	Older Males	Younger Females	Younger Males	Avg.
Driving within or near the speed limit… (1-7 scale: higher number means greater agreement with the statement)											
Q81	Puts pedestrians at less risk	5.71	5.21	5.50	5.41	5.4	5.37	5.31	5.15	5.40	5.3
Q82	Reduces my chances of an accident	5.90	5.48	5.45	5.50	5.6	5.74	5.56	5.38	5.90	5.6
Q83	Makes it difficult to keep up with traffic	5.10	4.92	4.60	5.36	5.0	4.11	5.00	4.29	5.05	4.6
Q84	Uses less fuel	5.86	5.38	4.89	5.18	5.3	5.11	5.13	4.43	5.55	5.0
Q85	**Annoys other drivers**	**5.25**	**4.46**	**5.00**	**5.68**	**5.1**	**4.21**	**5.25**	**4.19**	**4.85**	**4.6**
Q86	**Holds up traffic**	**4.43**	**4.42**	**4.50**	**4.86**	**4.6**	**3.11**	**4.25**	**3.75**	**3.95**	**3.7**
Q87	**Takes me longer to reach my destination**	**4.57**	**4.46**	**5.42**	**5.55**	**5.0**	**3.21**	**4.13**	**4.71**	**4.75**	**4.2**
Q88	**Makes me feel annoyed**	**4.00**	**3.25**	**4.65**	**4.50**	**4.1**	**2.42**	**3.56**	**4.14**	**3.95**	**3.5**
Q89	**Makes me feel relaxed**	**4.15**	**4.00**	**3.58**	**3.64**	**3.8**	**5.42**	**4.25**	**4.05**	**4.58**	**4.6**
Q90	Makes me feel bored	3.57	3.21	4.16	4.55	3.8	2.53	3.63	4.05	4.63	3.7
Q91	**Makes me feel safer**	**5.00**	**5.08**	**4.75**	**4.00**	**4.7**	**5.47**	**4.75**	**5.33**	**5.05**	**5.2**
Q92	Makes it easier to detect hazards	5.81	5.58	4.95	5.00	5.3	5.63	5.25	5.63	5.55	5.5
Q93	**Makes me feel more in control of my vehicle**	**5.05**	**4.79**	**4.90**	**4.36**	**4.8**	**6.00**	**5.31**	**5.24**	**5.35**	**5.5**
While driving in the next three months, how *unlikely/likely* is it that you would drive within or near the speed limit under the following circumstances? (1-7 scale: higher number means more likely to drive within posted speed)											
Q94	**Driving when late/in a rush**	**3.48**	**4.13**	**2.85**	**2.14**	**3.2**	**5.21**	**3.56**	**3.33**	**3.10**	**3.8**
Q95	Driving when others are exceeding the speed limit	3.29	3.92	3.00	3.09	3.3	4.89	3.81	3.21	3.00	3.7
Q96	Driving in traffic calmed areas (with small roundabouts, speed bumps, special warning signs, etc.)	6.38	5.83	5.63	5.41	5.8	6.16	6.13	5.38	5.30	5.7
Q97	Driving in a fast/powerful car	4.29	3.96	3.80	3.32	3.8	5.16	4.31	3.10	3.00	3.9
Q98	Driving when carrying passengers who want you to drive fast	4.16	4.00	3.35	3.55	3.8	5.00	4.40	3.43	4.35	4.3
Q99	Driving when carrying passengers who want you to drive slow	5.10	5.17	4.90	5.23	5.1	5.33	5.00	5.60	5.10	5.3
Q100	Driving when many pedestrians are around	6.52	5.87	5.79	6.00	6.0	6.32	5.88	6.10	5.60	6.0
Q101	Driving on quiet roads in the day	5.05	4.67	4.20	3.45	4.3	5.63	4.19	4.00	4.21	4.5
Q102	Driving on quiet roads at night	5.38	5.17	3.90	3.68	4.6	6.16	4.69	4.62	4.50	5.0
Q103	Driving when the speed limit is clearly signed	5.16	5.30	4.55	4.05	4.8	6.05	4.63	4.48	4.70	5.0
Q104	Driving on long straight roads	4.29	3.92	3.30	3.05	3.6	5.37	3.69	3.14	3.15	3.8
Q105	Driving in areas where there are speed cameras	6.52	5.88	6.15	6.27	6.2	6.58	6.13	6.33	5.68	6.2
How much do you think that the following groups of people will influence whether or not you drive within or near the posted speed limit in the next three months? (1-7 scale: higher number means driver is more influenced)											
Q109	Friends of the same sex	2.38	2.58	2.85	2.14	2.5	2.26	2.44	2.52	3.15	2.6
Q110	Friends of the opposite sex	2.10	2.88	2.70	3.00	2.7	2.32	2.38	2.86	3.25	2.7
Q111	Parents/children	4.29	4.33	4.55	4.55	4.4	4.63	4.31	4.62	4.50	4.5
Q112	Spouse/partner	3.57	4.33	3.33	4.23	3.9	3.63	4.56	3.86	4.10	4.0
Q113	The police	5.76	5.25	6.00	6.23	5.8	6.16	5.69	6.29	6.00	6.1
Q114	Most other drivers on the road	3.76	3.38	3.55	3.73	3.6	2.74	3.19	4.24	3.80	3.5

Texas Data – All Driving

This section provides information about the overall driving patterns of study participants by demographic group. This includes information about when participants drove, for how long, and on what types of roads/speed bands. This information helps identify important trip-related factors that can be controlled for in the inferential analyses.

Texas – Geographic extent of all driving

Figure 40 below provides a map of the lateral and longitudinal coordinates of the middle time point in each driving epoch (dots). The data points represent the location of each driver in 30-second increments. Driving epochs are presented here rather than time (i.e., 1-second records) to reduce the number of points for a simpler and clearer map. Overall, these points indicate where the participants drove in the Texas data-collection area. Most of the points are concentrated in the Bryan – College Station area, as indicated by the dense concentration of points in that region. The map shows that less than half of driving occurred on rural roads outside of the Bryan – College Station area, with epoch trails that connect the more populated areas via rural driving. It should be noted that although the raw epoch data set shown on the map includes driving outside the seven-county site, these data were not included in the analyses.

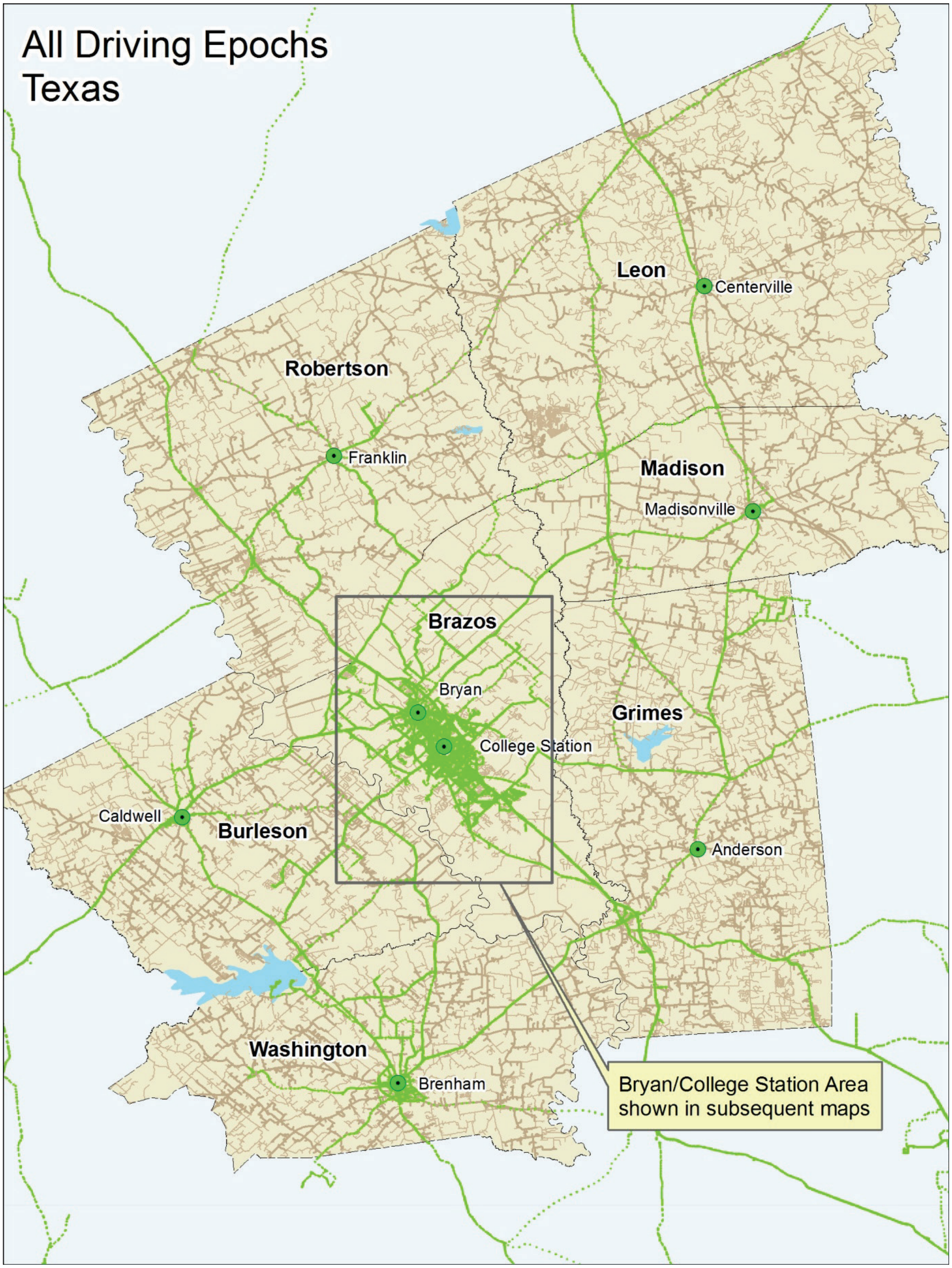


Figure 40. Map showing the geographic extent of all driving epochs in the Texas data-collection area.

Texas – Number of trips by duration and start time for all drivers combined

Table 21 below shows the number of trips that participants made as a function of trip start time and the overall duration of the trip. Note that because the first and last half mile or first and last 90 seconds of travel (whichever was longer) was removed from each trip to protect participant privacy, 3 minutes was added back in to the trip duration to account for this deleted time. The table below shows that the majority of trips were between 5 and 20 minutes in duration and undertaken between the hours of 9 a.m. and 7 p.m.

Table 21. Number of trips by duration and start time for Texas drivers.

	Time of Day					
Trip Duration (min)	**12 a.m.-5 a.m.**	**5 a.m.-9 a.m.**	**9 a.m.-3 p.m.**	**3 p.m.-7 p.m.**	**7 p.m.-12 a.m.**	
<5	42	43	281	226	142	12.8%
5-10	87	130	601	463	351	28.4%
10-20	28	241	574	585	341	30.8%
20-30	9	133	204	270	103	12.5%
30-40	6	98	99	125	51	6.6%
40-50	3	60	55	75	16	3.6%
50-60	5	26	39	36	6	2.0%
>60	4	36	62	62	20	3.2%
	3.2%	13.4%	33.4%	32.1%	18.0%	

Texas – Number of trips by duration and start time for each demographic group

Table 22 below shows the number of trips that participants in each demographic category made based on the trip start time and the overall duration of the trip. Again, three minutes were added to the duration of each trip to account for data removed to protect participant privacy. The distributions of trips are similar across demographic categories, with a few notable exceptions. Younger drivers made more trips in the 7 p.m. to 12 p.m. time band and fewer trips in the 5 a.m. to 9 a.m. time band. Older Females had a greater concentration of trips in the 3 p.m. to 7 p.m. time band than the other groups. Older drivers generally took longer trips than younger drivers did, and Older Females took longer trips than Older Males.

Table 22. Average number of trips by duration and start time for each demographic group in Texas.

Older Females

Trip Duration (min)	12 a.m.-5 a.m.	5 a.m.-9 a.m.	9 a.m.-3 p.m.	3 p.m.-7 p.m.	7 p.m.-12 a.m.	
<5	2	15	78	46	14	13.0%
5-10	3	9	87	74	25	16.6%
10-20	2	37	93	116	42	24.3%
20-30	0	44	45	69	21	15.0%
30-40	3	58	38	64	22	15.5%
40-50	0	33	12	37	4	7.2%
50-60	4	16	13	17	0	4.2%
>60	2	7	16	22	4	4.3%
	1.3%	18.3%	32.0%	37.3%	11.1%	

Older Males

Trip Duration (min)	12 a.m.-5 a.m.	5 a.m.-9 a.m.	9 a.m.-3 p.m.	3 p.m.-7 p.m.	7 p.m.-12 a.m.	
<5	2	12	59	40	18	10.4%
5-10	26	32	157	84	54	28.1%
10-20	1	72	120	156	51	31.9%
20-30	0	54	54	55	12	13.9%
30-40	0	20	19	15	4	4.6%
40-50	1	21	18	19	3	4.9%
50-60	0	9	10	7	0	2.1%
>60	0	15	20	12	3	4.0%
	2.4%	18.7%	36.4%	30.9%	11.6%	

Younger Females

Trip Duration (min)	12 a.m.-5 a.m.	5 a.m.-9 a.m.	9 a.m.-3 p.m.	3 p.m.-7 p.m.	7 p.m.-12 a.m.	
<5	5	4	65	56	36	10.2%
5-10	17	39	171	133	131	30.3%
10-20	7	82	201	167	117	35.4%
20-30	0	17	55	83	38	11.9%
30-40	2	15	26	31	16	5.5%
40-50	1	5	16	11	7	2.5%
50-60	1	1	9	7	3	1.3%
>60	1	8	13	16	9	2.9%
	2.1%	10.5%	34.3%	31.1%	22.0%	

Younger Males

Trip Duration (min)	12 a.m.-5 a.m.	5 a.m.-9 a.m.	9 a.m.-3 p.m.	3 p.m.-7 p.m.	7 p.m.-12 a.m.	
<5	33	12	79	84	74	16.9%
5-10	41	50	186	172	141	35.4%
10-20	18	50	160	146	131	30.3%
20-30	9	18	50	63	32	10.3%
30-40	1	5	16	15	9	2.8%
40-50	1	1	9	8	2	1.3%
50-60	0	0	7	5	3	0.9%
>60	1	6	13	12	4	2.2%
	6.2%	8.5%	31.2%	30.3%	23.8%	

Texas – Number of trips by day of week for all drivers combined

Figure 41 below shows the total number of trips taken on each day of the week by all Texas drivers combined. The day of the week is based on the trip start time. The number of trips taken is generally similar across weekdays, with many fewer trips taken on weekends. A factor contributing to this trend is that most drivers were enrolled in the study for fewer weekend days than individual weekdays overall. As in Seattle, participant enrollments were not performed on the weekends, which reduced the opportunity to drive on one Saturday and one Sunday during the enrollment period for each participant.

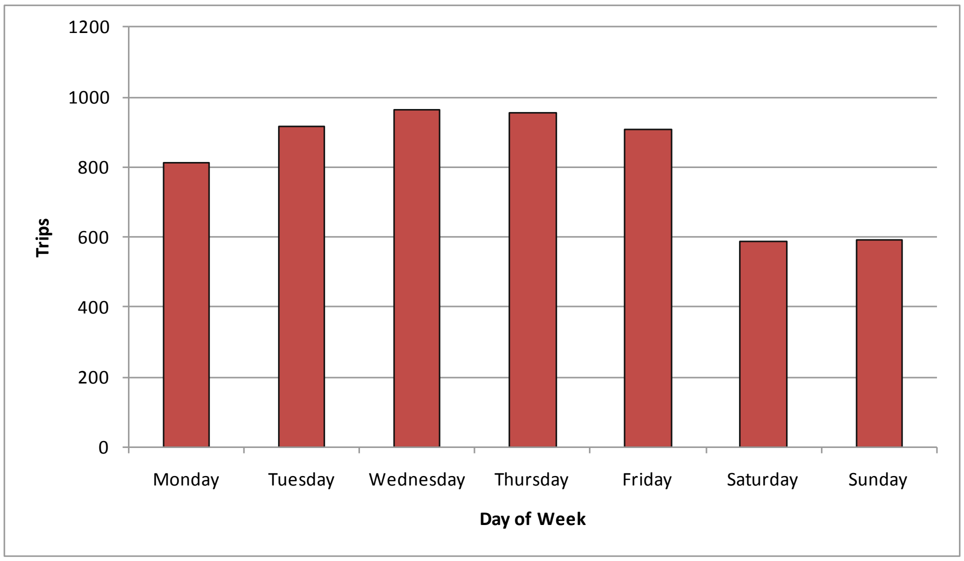


Figure 41. Histogram showing the total number of trips taken on each day of the week for all Texas drivers combined.

Texas – Average of trips by day of week for each demographic group

Figure 42 below shows the average number of trips taken on each day of the week (based on trip start time) for each demographic group. For most drivers, this represents two to three instances of each day of the week (e.g., 2-3 Mondays) depending on which days the start-up and close-out visits occurred and on the total duration of enrollment. Note that the average value is used in this table to compensate for the different number of participants in each demographic group. The only systematic difference across demographic groups appears to be that, in general, Older Females made fewer overall trips than the other groups.

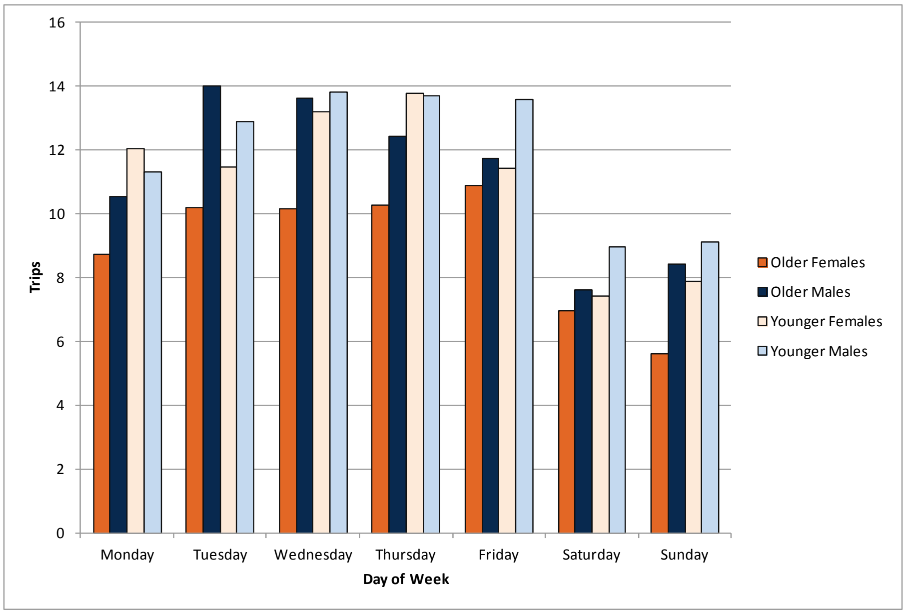


Figure 42. Histogram showing the average number of trips taken on each day of the week for each demographic group in Texas.

Texas – Total miles driven by posted speed

Figure 43 below shows the total number of miles driven by all participants on roadways with the indicated posted speed. The distribution of driving across posted speed served as the basis for the decision to focus subsequent descriptive and inferential analyses on only three posted speed bands. In particular, it was important to examine certain posted speeds in isolation of others because of situation-specific factors systematically associated with posted speeds that likely affect driver behavior. The drawback, however, is that this decision significantly increases the number of these separate analyses that have to be conducted. It should be noted that although more total miles in Texas were driven on roads with posted speeds of 40 and 45 mph than those driven on 30 mph roads, the 30 and 35 mph roads at the Texas site were more similar to those with 30 or 35 mph posted speed at the Seattle site. Therefore, the Texas analysis included driving on roads with posted speeds of 30 and 35 mph in order to make reasonable comparisons between rural Texas driving and urban Seattle driving at those posted speeds.

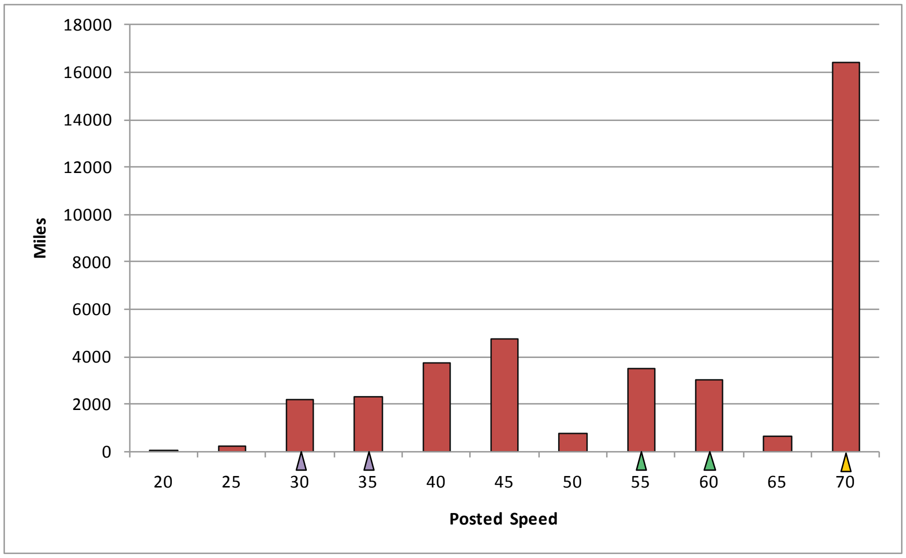


Figure 43. Histogram showing the total number of miles driven by all participants on Texas roads with different posted speeds (in mph). The colored triangles denote the posted speeds selected for analysis in the 30-35 mph speed band (purple), the 55-60 mph speed band (green), and the 70 mph speed band (yellow).

Texas – Average miles driven on 30-35, 55-60, and 70 mph posted speed roads for each demographic group

Figure 44 below shows the average number of miles driven on 30-35, 55-60, and 70 mph posted speed roads by drivers in each demographic group. Note that the average value is used in this table to compensate for the different number of participants in each demographic group. Overall, Older Females drove more miles on 55-60 and 70 mph roads and fewer miles on 30-35 mph roads than the other groups did. Males drove slightly more miles on 30-35 mph roads than females did. Younger Males drove the fewest average miles overall.

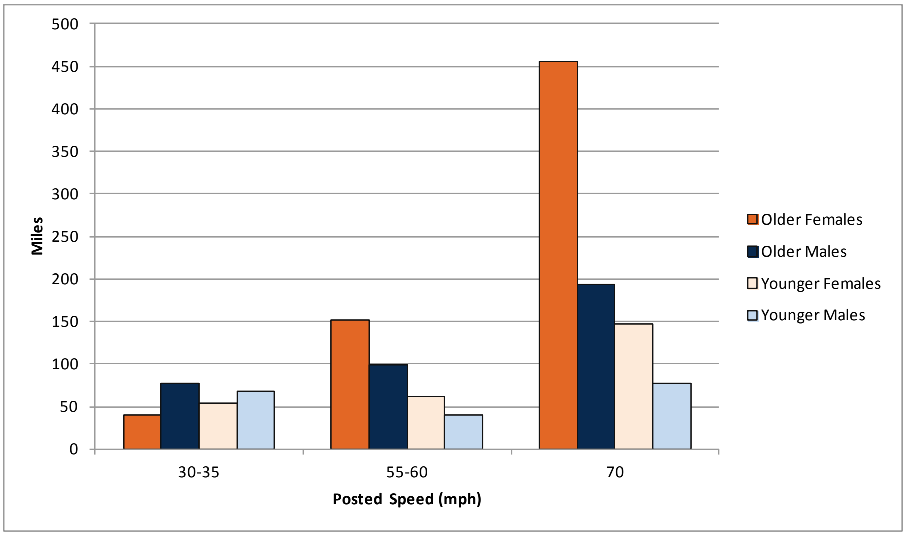


Figure 44. Histogram showing the average number of miles driven on 30-35, 55-60, and 70 mph roads in Texas by demographic group.

Texas – Summary of trip-level data by demographic group

Table 23 describes some of the basic measures used to depict driving patterns per demographic group. This table shows that the trip-level characteristics were relatively consistent across drivers as measured by the average number of trips per day. However, when looking at average trip duration and average trip distance, differences emerge. Older participants, particularly Older Females, tend to take longer trips than younger participants, particularly Younger Males. A similar trend is seen for average trip distance. When looking at driving time, older participants appear to drive more than younger participants do on weekdays, while younger participants drive slightly more on weeknights. Driving time on weekends is very similar across all demographic groups.

Table 23. Key trip-level characteristics for drivers in Texas.

	Older Females	Older Males	Younger Females	Younger Males	*All*
Number of Participants (N)	19	16	21	20	*76*
Avg Days of Driving (unique days with trips)	18.1	19.8	19.4	21.5	*19.7*
Avg Trips per Day	3.2	3.9	3.9	3.9	*3.7*
Avg Trip Duration (minutes)	24.0	20.3	17.1	15.0	*19.0*
Avg Trip Distance (miles)	15.5	10.4	7.8	5.7	*9.7*
Avg Driving Time Weekdays (hrs) 5 a.m.-7 p.m.	16.2	15.8	11.1	8.9	*12.8*
Avg Driving Time Weeknights (hrs) 7 p.m.-5 a.m.	2.1	1.4	3.3	3.1	*2.5*
Avg Driving Time Weekend (hrs) 12 a.m.-12 p.m.	4.1	4.3	3.9	4.2	*4.1*

In summary, there are differences between groups in the variables examined in this section; some of the differences are small. However, if these differences systematically affect the opportunity to speed or a driver's propensity to speed, they could potentially influence the overall findings. Some of these variables, therefore, were used as control variables in the inferential analyses.

Texas Data – Free-Flow Driving

Texas – Free-flow driving epochs

Following the same approach as with the Seattle data, an initial step in developing the Texas data set was to filter the data based on driving epochs. In particular, we removed from the data set all epochs that did not have at least 85% of the data points within 5 mph of posted speed or greater (e.g., traveling at 25 mph or greater on a 30 mph road at least 85% of the time in an epoch). Table 24 below shows how many epochs were retained on 30-35, 55-60, and 70 mph roads for each demographic category after this filtering step. Note that relative to the complete data set, free-flow epochs were also filtered to remove driving that occurred on unvalidated roads and to address other data-integrity issues, such as missing data points.

Table 24 shows how much of the validated driving data was done under free-flow driving conditions. In particular, around 40% of the epochs from 30-35 mph roadways and just under half of the epochs from 55-60 mph roadways represented free-flow driving. On 70 mph roads, around 62% of the driving epochs represented free-flow driving. In contrast to the Seattle data, there is greater variation in the percentage of free-flow epochs retained across demographic groups. Moreover, these differences vary by speed band, which likely reflects differences in driving patterns and driving routes across the groups.

Table 24. Comparison of the number of Texas driving epochs in each demographic category before and after filtering to retain only free-flow driving epochs on 30-35, 55-60, and 70 mph roads.

Group	30-35 mph Posted Speed			55-60 mph Posted Speed			70 mph Posted Speed		
	*Driving Epochs**	*Free-flow*	*Percent Retained*	*Driving Epochs**	*Free-flow*	*Percent Retained*	*Driving Epochs**	*Free-flow*	*Percent Retained*
Older Females	1540	685	44.5%	4039	2273	56.3%	13317	8294	62.3%
Older Males	2002	901	45.0%	2503	1084	43.3%	4664	3050	65.4%
Younger Females	2089	841	40.3%	1620	593	36.6%	4448	2612	58.7%
Younger Males	2036	694	34.1%	1350	631	46.7%	2333	1270	54.4%
Overall	**7667**	**3121**	**40.7%**	**9512**	**4581**	**48.2%**	**24762**	**15226**	**61.5%**

*Includes filtering through Stage 3 (stationary vehicle data, missing/incomplete data, invalid or incorrect data, and data on unvalidated roadways removed).

Another difference relative to the Seattle data is that the percentages of free-flow epochs retained for each demographic category and road type are smaller than in Seattle. The most likely explanation of this is that more data were lost due to driving on unvalidated roads in Texas, as opposed to the data lost due to traffic congestion in Seattle. The percentage of epochs retained on 70 mph roads is similar (and even slightly higher) than on the higher speed roads in Seattle, which is expected because these roads have an elevated opportunity for free-flow conditions on the more rural roads between towns.

Texas– Geographic extent of filtered free-flow epochs

Epochs can also show where in the road network free-flow driving occurred. Figure 45 below provides a map showing two different types of epochs. The first represents all driving epochs (green dots), which are also the same set of data points as shown in the map in Figure 40 (page 72) above. The second set (blue dots) shows all the epochs that remained after filtering for data quality/validity and for “opportunity to speed,” as described in the Methods section. Essentially, the blue dots indicate which of the total driving epochs (green dots) were included in the speeding analyses. Note that the green dots include all of the posted speeds, whereas the free-flow epochs shown (blue dots) represent only driving from 30-35, 55-60, and 70 mph posted-speed roads. Despite this, visual inspection of Figure 45 indicates that most of the key driving routes across the data collection area ended up being included in the Texas data set.

The pattern of green and blue dots in Figure 45 below is consistent with the notion that removed epochs in Texas were more likely to be due to driving on roads with unvalidated posted speeds. In particular, the corresponding Seattle map shows a greater degree of alternation between green and blue dots (representing intermittent periods of free-flow and slow driving on the same roads). However, in Texas, the pattern is better described as separate areas of continuous green or blue lines. This suggests that most driving occurred under free-flow conditions, but a sizable portion of it occurred on roads that could not be validated.

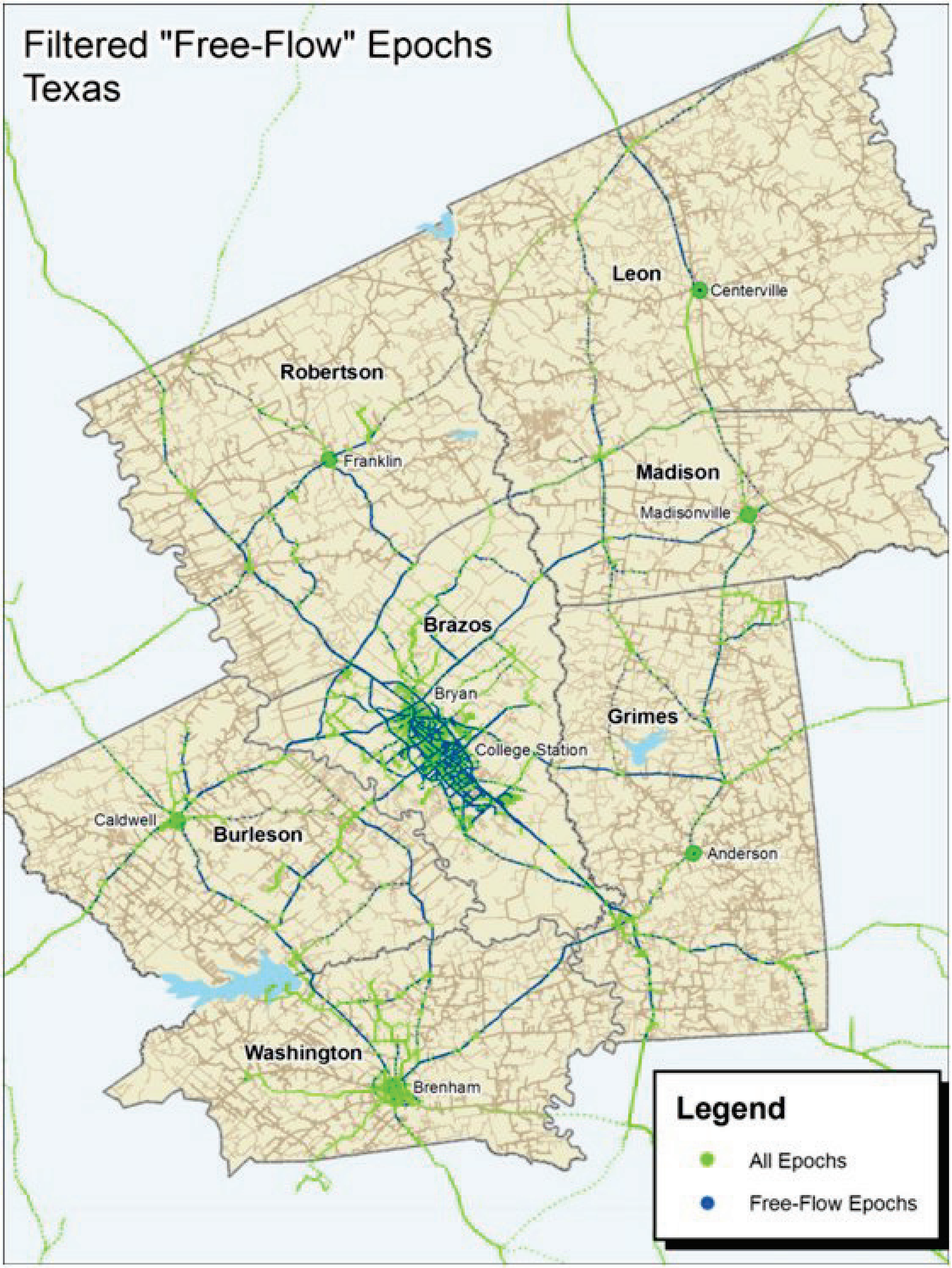


Figure 45. Map showing the geographic extent of the Texas free-flow epochs.

Texas – Percentage of free-flow driving time spent in different speed bands relative to the posted speed

Free-flow driving time can provide a comprehensive view of driver speed choice across all driving in the study. In particular, Table 25 shows the distribution of speeds relative to the posted speed across all drivers in a demographic group—shown in five-mile-per-hour bands (e.g., "PS+5" represents driving at speeds between 40-44.99 mph on a 35 mph road). The bold line between the "PS-5" (mph) and "PS" categories indicates the posted speed.

Table 25 indicates that the majority of driving occurred within ±5 mph of the posted speed. Speeding in the current report was defined as driving that was 10 mph or more above the posted speed (categories shown in red text in the table below). In this case, the speeding that did occur was predominately between 10 and 15 mph above the posted speed. Almost no speeding occurred at speeds faster than 20 mph above the posted speed in the 30-35 and 70 mph speed bands. Although the differences were still small, it does appear that the 55-60 mph speed band had higher amounts of speeding at 15-20 and 20-25 mph above the posted speed. One aspect of the driving environment that may have contributed to the faster driving on 55-60 mph roads is that many of these roads are physically similar to 70 mph roads in terms of road geometry and design, but they just have a lower posted speed (e.g., because many are in rural-urban transition areas). Thus, based on roadway characteristics and cues, drivers may feel like they can travel at faster speeds on those roads.

Table 25. Percentage of free-flow driving time in Texas spent in different speed bands relative to the posted speed for each demographic group on 30-35, 55-60, and 70 mph roads.

Travel Speed (mph)

30-35 mph Roads	PS-5	PS	PS+5	PS+10	PS+15	PS+20	PS+25
Older Females	42.7%	45.1%	10.3%	1.7%	0.1%	0.1%	0.0%
Older Males	37.4%	42.8%	16.9%	2.5%	0.3%	0.0%	0.0%
Younger Females	44.7%	43.5%	10.9%	0.9%	0.1%	0.0%	0.0%
Younger Males	51.4%	39.3%	7.2%	0.8%	0.6%	0.3%	0.3%
Overall	44.0%	42.6%	11.5%	1.5%	0.3%	0.1%	0.1%

55-60 mph Roads	PS-5	PS	PS+5	PS+10	PS+15	PS+20	PS+25
Older Females	27.9%	44.8%	13.6%	10.0%	3.5%	0.2%	0.0%
Older Males	31.9%	40.6%	19.3%	6.5%	1.7%	0.1%	0.0%
Younger Females	38.8%	39.2%	16.5%	4.5%	1.0%	0.0%	0.0%
Younger Males	31.6%	40.8%	20.9%	5.5%	1.0%	0.1%	0.1%
Overall	30.9%	42.5%	16.4%	7.8%	2.4%	0.1%	0.0%

70 mph Roads	PS-5	PS	PS+5	PS+10	PS+15	PS+20	PS+25
Older Females	47.4%	47.0%	4.8%	0.6%	0.1%	0.0%	0.0%
Older Males	48.0%	41.6%	9.7%	0.6%	0.1%	0.0%	0.0%
Younger Females	49.1%	42.1%	8.1%	0.5%	0.1%	0.0%	0.0%
Younger Males	41.2%	42.3%	15.1%	1.2%	0.2%	0.1%	0.0%
Overall	47.3%	44.7%	7.2%	0.6%	0.1%	0.0%	0.0%

Note: The bold line represents the posted speed limit.

Texas Data – Speeding Time

A detailed analysis of the speeding time on each trip was used to examine patterns in driver speeding behavior. In particular, we focused on two primary measures to quantify speeding behavior. The first was the proportion of a driver's trips that had any speeding. This allowed us to examine the questions related to *who is speeding*. The second measure was the proportion of free-flow time on an individual trip that was speeding. This allowed us to examine the question related to *who speeds the most*.

Texas – Percent of free-flow trips with speeding time by demographic group

This measure represents the percentage of trips during which the driver took advantage of the opportunity to speed, or the likelihood that speeding occurred on any particular trip for a driver. The percentage of trips with speeding time provides a high-level measure of the propensity to speed on a given trip, in addition to providing a way to identify which drivers engage in any speeding. Figure 46 below shows the percentage of trips with free-flow time that also have speeding time, averaged within demographic groups. The likelihood of any speeding is generally greater on 55-60 and 70 mph roads than on 30-35 mph roads. This may be due to drivers having more chances to speed (at least briefly) on longer trips or on more open roads. Figure 46 also shows that Younger Males have a higher percentage of their trips with any speeding in the 70 mph speed band.

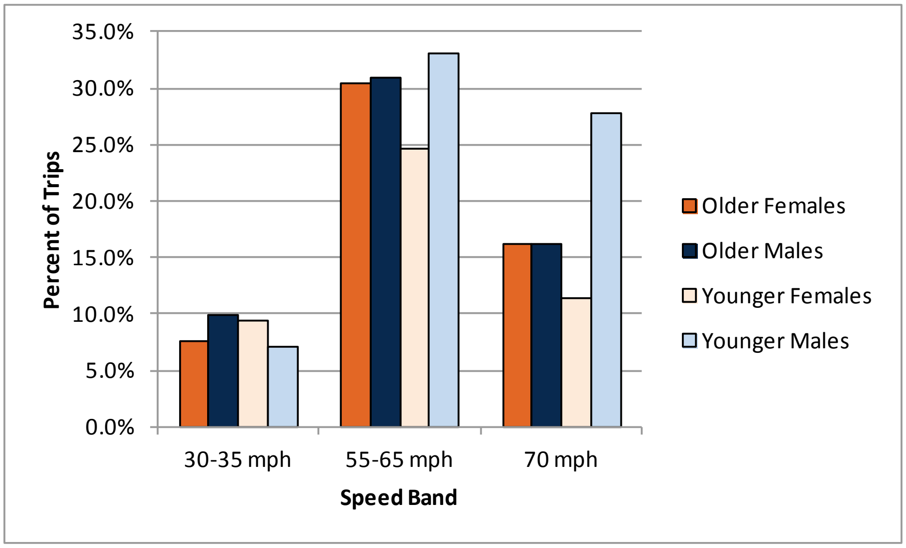


Figure 46. Percentage of trips with free-flow time that have speeding time in Texas, by demographic group.

Table 26 below shows the numeric values associated with the bars in the figure above as well as a measure of the number of trips with free-flow driving in a given speed band. In contrast to Seattle, demographic differences are much less pronounced. The most apparent trends are that Younger Females appear to have a smaller proportion of trips with any speeding in the 55-60 and 70 mph speed bands, and Younger Males have a higher proportion in the 70 mph speed band.

Table 26. Number of trips with free-flow driving and the percentage of the trip that was speeding by demographic group in Texas.

Group	30-35 mph Roadways		55-60 mph Roadways		70 mph Roadways	
	Avg Number of Trips with Free-Flow Driving	*Average % Speeding Trips*	*Avg Number of Trips with Free-Flow Driving*	*Average % Speeding Trips*	*Avg Number of Trips with Free-Flow Driving*	*Average % Speeding Trips*
Older Females	22.3	7.5%	25.8	30.4%	33.4	16.1%
Older Males	31.9	10.0%	22.3	30.9%	21.9	16.2%
Younger Females	33.2	9.4%	17.2	24.6%	13.7	11.3%
Younger Males	37.4	7.1%	13.8	33.1%	9.3	27.7%
Mean	**31.3**	**8.4%**	**19.5**	**29.7%**	**19.2**	**18.1%**

One relevant question regarding speeding behavior is whether drivers who speed consistently in one speed band are more likely to do so in another speed band. More broadly, this question addresses the extent to which this speeding measure can identify speeding that is a persistent "behavioral trait" whereby some individuals try to speed at every opportunity (i.e., a "habitual" speeder). Figure 47 below shows the percentage of trips with any speeding for individual drivers in each demographic group. The 30-35 mph and 55-60 mph speed bands are plotted on each axis.

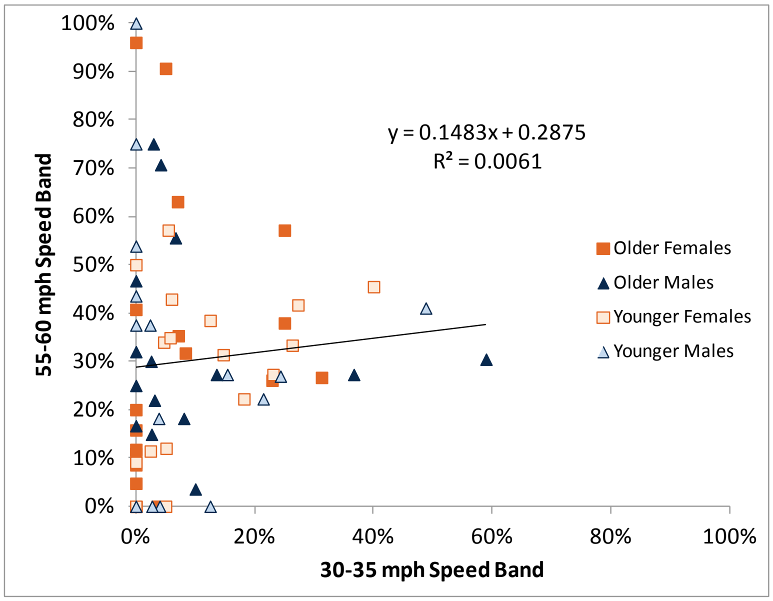


Figure 47. Scatter plot of percentage trips in Texas with any speeding in the 30-35 mph and 55-60 mph speed bands for individual drivers. The trend line is based on drivers from all demographic groups.

The scatter plot above includes only the 30-35 and 55-60 mph speed bands to be comparable to the Seattle scatter plot. The 70 mph speed band in Texas is less interesting because so few drivers have any speeding on those roadways. Similar to the Seattle data, a larger proportion of drivers have any speeding on 55-60 mph roads on a regular basis than on 30-35 mph roads. Overall, there is a much weaker relationship of the percentage of trips with any speeding between the speed bands than was found in Seattle. There is a cluster of drivers who show moderate amounts of any speeding on both types of roads, and drivers from all demographic groups are represented in this cluster.

Texas – Average Speeding Time

An additional measure of speeding is the average speeding time. This time measure is the proportion of free-flow time within a single trip that a driver spends speeding, which provides an indication of how much speeding occurs on a trip. Table 27 below shows average speeding averaged across members in each demographic group. This represents an average of averages, since speeding is also averaged within each driver. Note that two versions of this measure are shown. The first averages across all trips made by each driver (left column in each speed band). This measure provides an overall estimate of the speeding that members of a demographic group do under free-flow driving conditions. The clearest pattern indicated by this measure in Table 27 is that all groups have the highest proportion of speeding on 55-

60 mph roads, and the lowest proportion on 70 mph roads. In terms of demographic differences, Younger Males and Older Females seem to have slightly higher levels of speeding on 30-35 and 55-60 mph roads, while males in general have the highest levels on 70 mph roads.

The second way to measure average speeding is to only consider trips that have any speeding in the calculation, which is also shown in Table 27 (right column in each speed band). As indicated by this table, average proportions are higher (which should be true by definition), and the basic trends identified in the previous paragraph are similar, except that Younger Females now show a higher relative proportion of speeding in the 55-60 mph speed band than in the previous calculation of speeding (i.e., all trips).

Table 27. Average speeding for all trips with free-flow time and only trips with speeding by speed band in Texas.

Group	30-35 mph Roadways		55-60 mph Roadways		70 mph Roadways	
	All Trips with Free-Flow Time	*Only Trips with Speeding*	*All Trips with Free-Flow Time*	*Only Trips with Speeding*	*All Trips with Free-Flow Time*	*Only Trips with Speeding*
Older Females	2.2%	18.4%	8.1%	20.4%	0.5%	4.2%
Older Males	1.9%	14.9%	4.7%	13.2%	1.6%	10.2%
Younger Females	1.2%	11.7%	5.4%	21.0%	0.3%	2.4%
Younger Males	2.9%	23.9%	8.8%	26.2%	1.2%	6.9%
Mean	**2.0%**	**16.8%**	**6.8%**	**20.1%**	**0.9%**	**6.0%**

As was the case with the percentage of trips with speeding measure described in the previous section, it is also possible to use average speeding to investigate whether drivers that speed consistently in one speed band are more likely to do so in another speed band. Figure 48 below shows average speeding (only trips with any speeding) for individual drivers in each demographic group. The 30-35 mph and 55-60 mph speed bands are plotted on each axis. The 70 mph speed band was excluded since it contained very low levels of speeding.

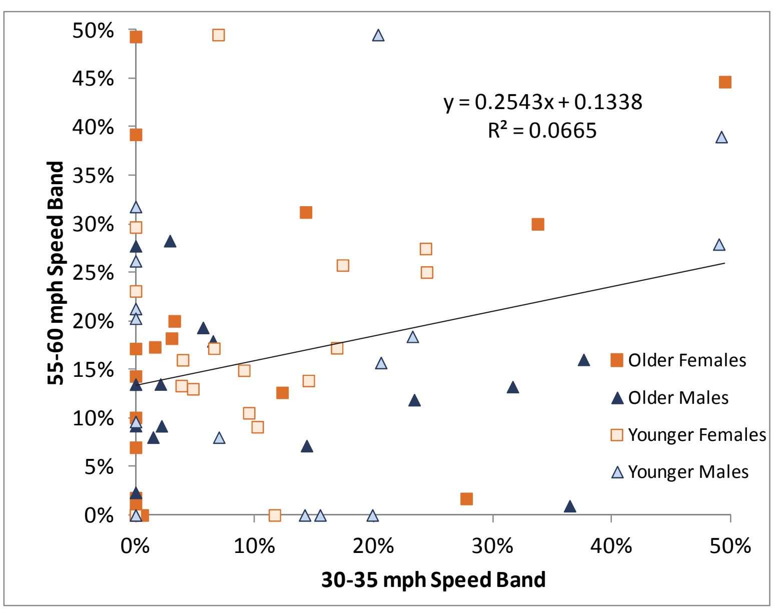


Figure 48. Scatter plot of average speeding in Texas (only for trips with any speeding) in each speed band for individual drivers. The trend line is based on drivers from all demographic groups.

A few trends are apparent in the scatter plot shown in Figure 48 above. The first is that individuals are generally more likely to have higher proportions of average speeding in the 55-60 mph speed band than in the 30-35 mph speed band (as indicated by the higher proportion of points on the Y-axis). This is the opposite pattern than what was found in Seattle, but it is similar to the previous scatter plot using percentage of trips with any speeding in Texas. Another finding from Figure 48 is that there is a diffuse cluster of relatively high speeders in both speed bands, which could represent the habitual speeders. It is evident from the scatter plot that this cluster includes drivers from all demographic groups.

It should be noted that this scatter plot is sensitive to the number of trips that drivers made. For example, it is easier to maintain a high average speeding percentage with a smaller number of trips. The following section that covers types of speeding behavior presents charts that better accommodate for this effect.

Types of Speeding – Seattle and Texas

In the descriptive analyses described above, we obtained information about driver speeding patterns using two different speeding measures, including (1) the percentage of trips with any speeding, and (2) the average speeding per trip. These measures provide complementary information about driver speeding since they differently reflect persistent and situational elements of speeding behavior. Accordingly, we used the two measures to characterize different types of speeding at the level of individual drivers. This was done by plotting individual driver values for each of the two measures in a scatter plot (for each speed band separately).

A generic example of this approach is provided in Figure 49. In particular, the scatter plot can be divided up into different zones that reflect different types of speeding behavior. Zone boundaries are set at 20% but these are somewhat arbitrary at this point, and they are only included to illustrate potential differences between groups of drivers. These boundaries divide the drivers into four groups, described below:

Zone A: Speeding occurs on a small number of trips and for only a small portion of those trips if at all. Speeding here could be unintentional or incidental.

Zone B: A high level of speeding per trip exists but it only occurs on a small proportion of trips taken. These drivers usually do not speed, but have a few trips with a lot of speeding. This could reflect situational speeding (i.e., being late).

Zone C: Speeding happens on a larger proportion of trips. However, speeding generally occurs for just a small part of the trip. This may reflect more regular behaviors or tendencies.

Zone D: In this zone, drivers speed regularly and for relatively large portions of their trips. These drivers may be characterized as habitual speeders.

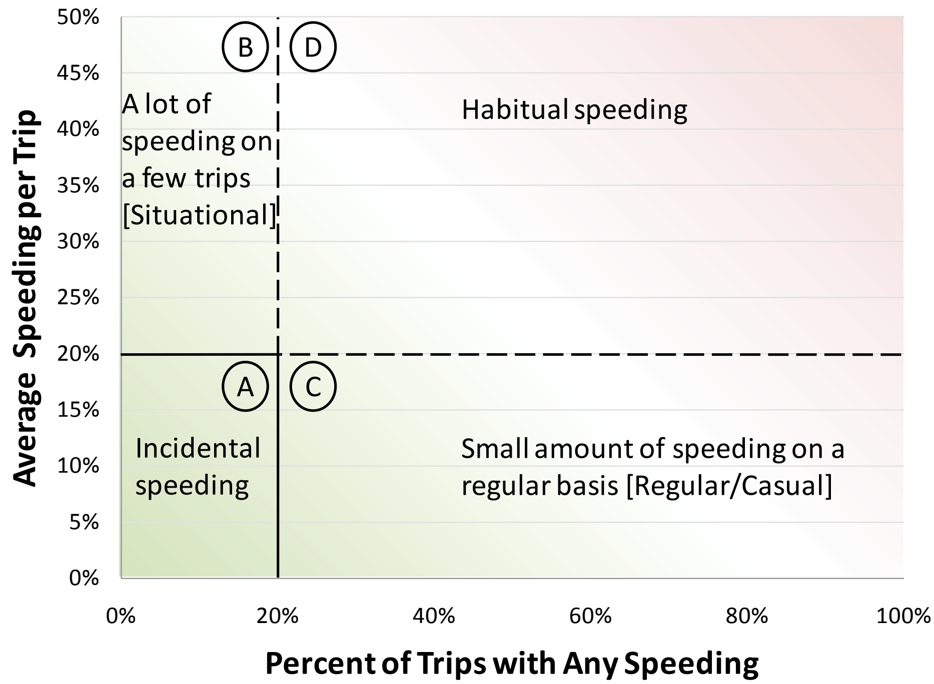


Figure 49. Types of speeding based on the scatter plot of the primary dependent measures.

Using this approach, the corresponding scatter plots for the two Seattle speed bands are shown in Figure 50 below. Individual drivers are plotted as separate circles on the graphs. An important element in these graphs is that the size of each data point corresponds to the number of trips with driving in the relevant speed band for that driver. This makes it easier to discount "spurious" data points that may not reflect true behavioral patterns because they represent just a small number of observations. Another informative element of the scatter plots is the text that indicates the number of points at the origin (i.e., "N=9" for the 30-35 mph roads and "N=5" for the 55-60 mph roads), which represents the number of drivers that had no speeding on any trips in that speed band. In Seattle, there were nine drivers with no speeding on 30-35 mph roads and five drivers that had no speeding on 55-60 mph roads.

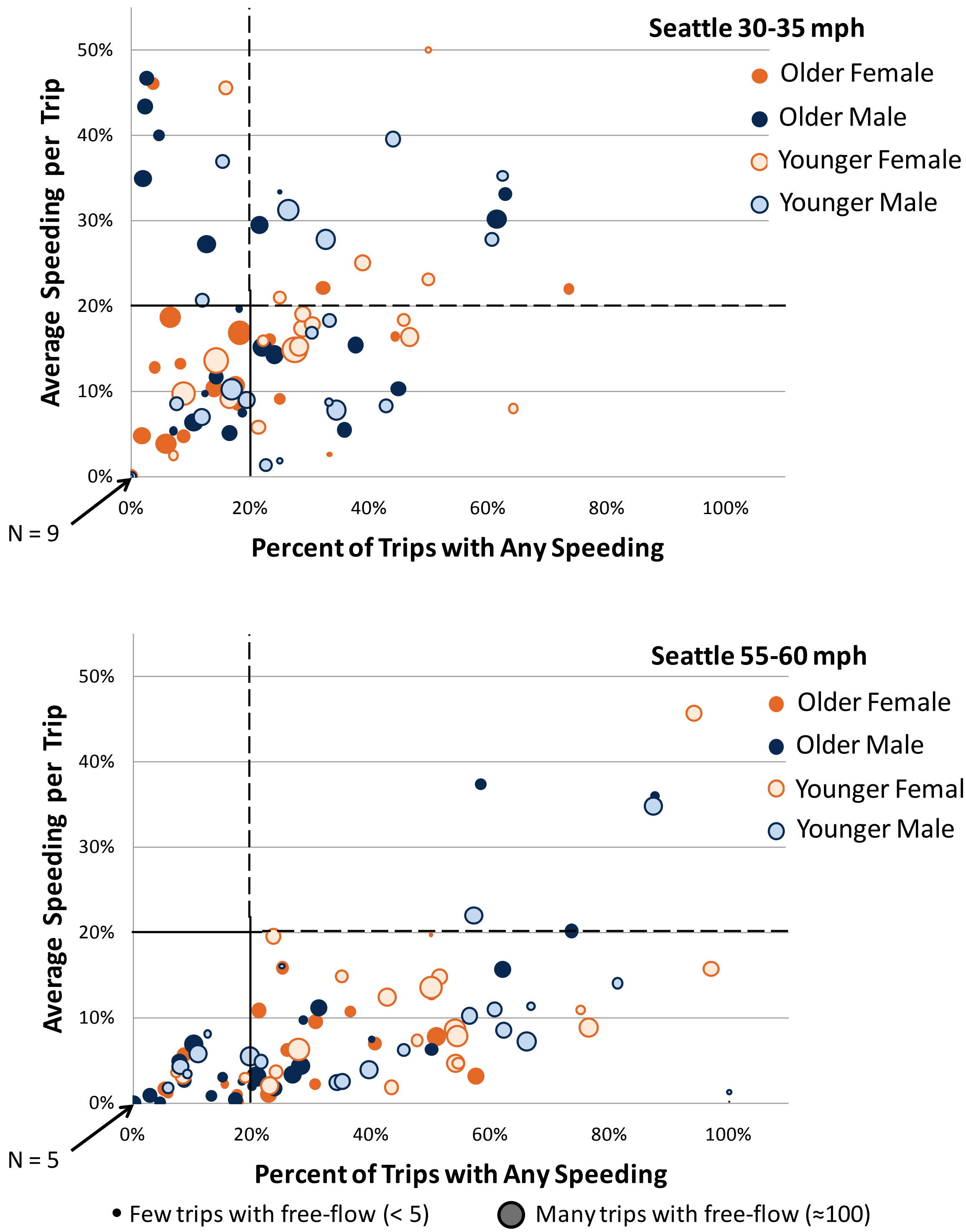
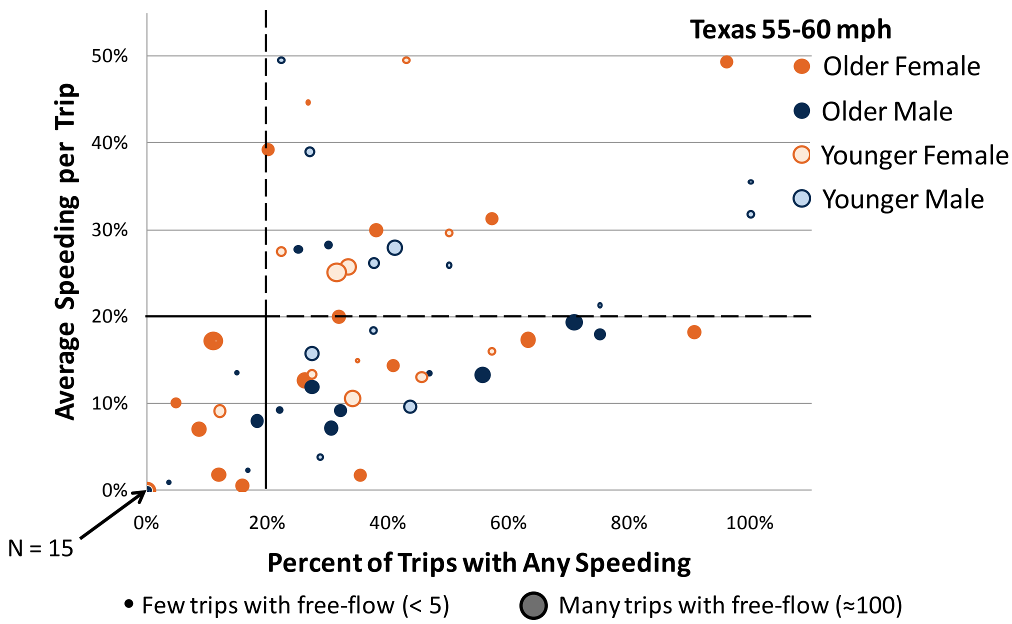
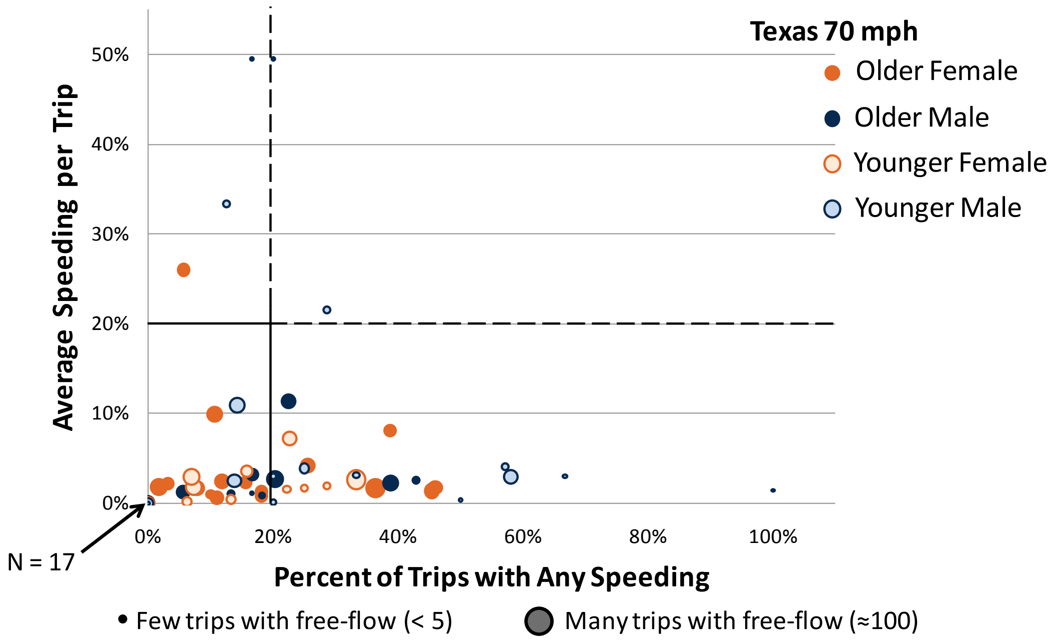


Figure 50. Seattle – Scatter plots of types of speeders in each zone.

A distinguishing pattern of the 30-35 mph scatter plot is that there are multiple drivers in each zone. Another finding is that the counts of males are higher in both the "Situational" (Zone B) and "Habitual" (Zone D) speeder zones, females are higher in "Incidental" – (Zone A), and males and females are fairly equally distributed in the "Regular/Casual" zone – (Zone C).

The pattern on 55-60 mph roadways is clearly different than on the lower speed roads. In particular, most drivers have many trips with a little speeding on those trips. Longer trips in this speed band can increase the likelihood of a driver having any speeding, which may account for the higher concentration of drivers in Zone C. Nevertheless, engaging in some speeding on a trip is a regular occurrence for many drivers. There is also no evidence of "Situational" speeding among the group of drivers that speed infrequently (i.e., Zone B is empty), but there is a small group of "Habitual" speeders.



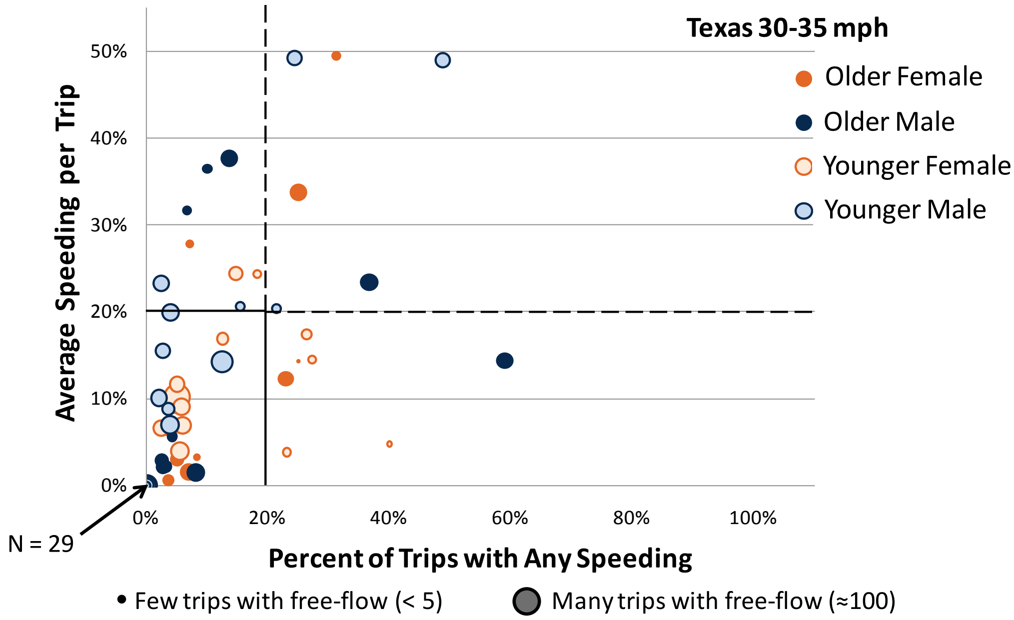


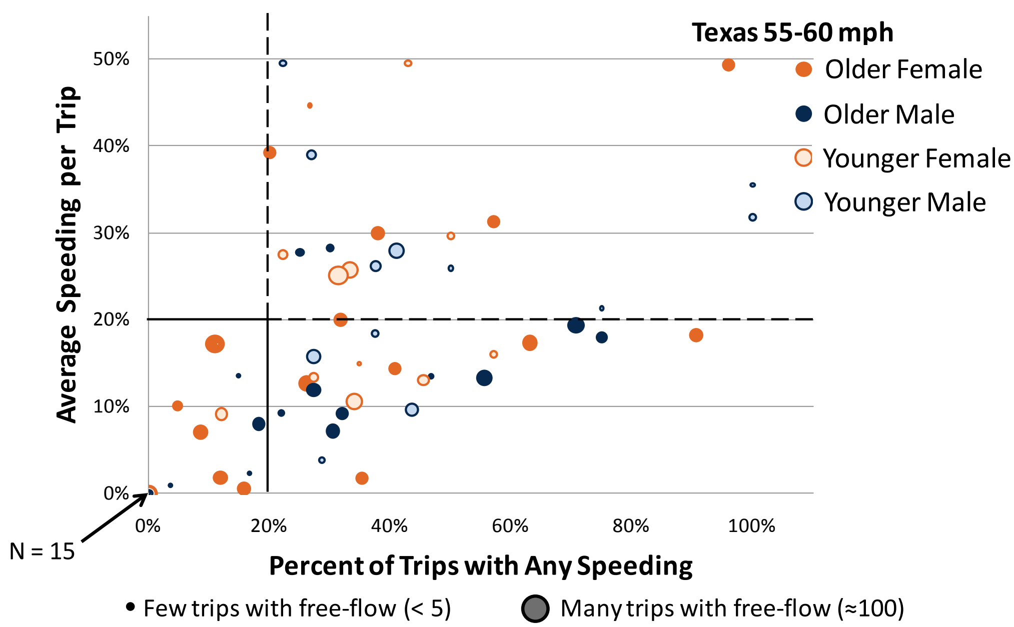
The scatter plots for Texas are shown on the next page (Figure 51). A notable finding for this location is that the scatter plot pattern for each speed band is markedly different than the others. Over one-third of the sample had no speeding on these 30-35 mph roads. There is also more of a "vertical" distribution of data points, which indicates that speeding is relatively uncommon on these roads. However, some drivers made a few trips where they sped for significant portions of the trips.

On 55-60 mph roadways, most drivers have fewer trips compared to the 30-35 mph speed band (i.e., smaller dots). In general, the speeders occupy a more central part of the graph than in other speed bands, with moderate amounts of speeding occurring per trip on a fairly regular basis (30-50% of trips). Another finding is that females make up the bulk of the "incidental" speeder group (i.e., Zone A). Similar to the Seattle 55-60 mph speed band, there is *no* evidence of "situational" speeding among the group of drivers that speed infrequently (i.e., Zone B is empty).

On 70 mph roadways, most drivers also have fewer trips compared to the 30-35 mph speed band (i.e., smaller dots). Speeding per trip was substantially lower in this speed band than in any other. The lower speeding per trip may reflect the possibility that these averages are depressed by longer trips taken on these roads.

In summary, the scatter plots presented in this section show clear evidence for different types of speeding. Moreover, these types are expressed differently depending on the type of driving they are associated with (i.e., different locations and speed bands), which suggests that roadway and driving conditions have an important impact on speeding behavior.


Texas 30-35 mph
Older Female
Older Male
Younger Female
Younger Male
Average Speeding per Trip
50%
40%
30%
20%
10%
0%
0%
20%
40%
60%
80%
100%
N = 29
Percent of Trips with Any Speeding
Few trips with free-flow (< 5)
Many trips with free-flow (≈100)


Texas 55-60 mph
Older Female
Older Male
Younger Female
Younger Male
Average Speeding per Trip
50%
40%
30%
20%
10%
0%
0%
20%
40%
60%
80%
100%
N = 15
Percent of Trips with Any Speeding
Few trips with free-flow (< 5)
Many trips with free-flow (≈100)

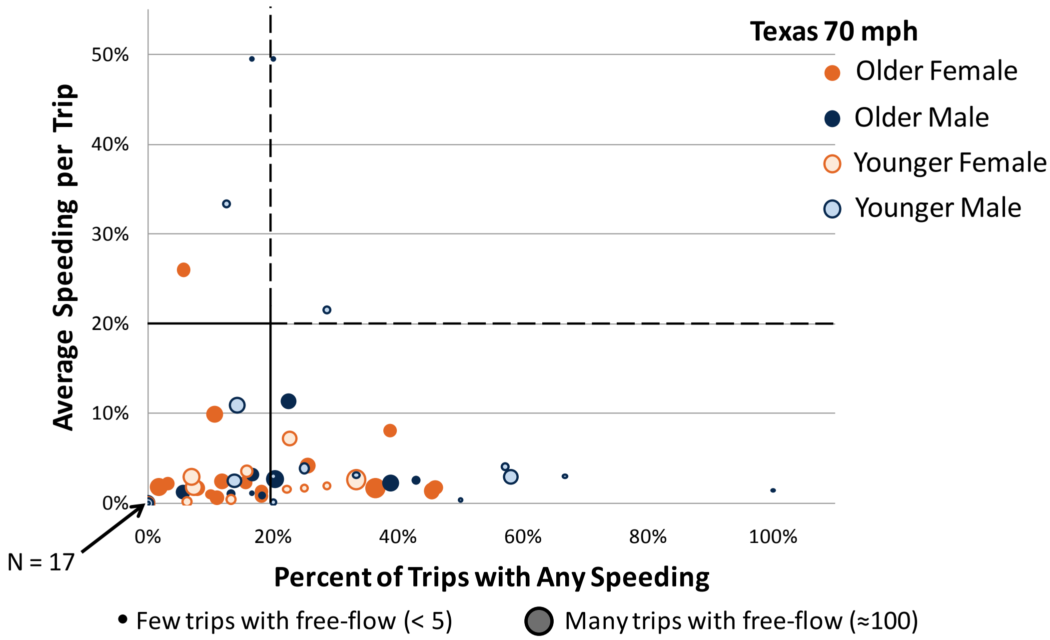


Figure 51. Texas – Scatter plots of types of speeders in each zone.

Inferential Statistics

Inferential analyses were conducted on the speeding data to identify significant predictors of speeding behavior. The basic approach was to use regression analyses to find demographic, trip, and personal inventory variables that are associated with either (1) the occurrence of any speeding on a trip, or (2) the amount of speeding on a trip. Regression analysis is the most suitable approach for analyzing our current data set because our objective is to find variables that predict driver behavior on individual trips. Moreover, participants took their trips at the time and location of their own choosing. This means that key predictor variables and covariates (i.e., time of day, trip duration) were completely outside of any experimental control. Also, while we tried to compose the driver sample to have a balance of old and young, and male and female drivers, no attempt was made to equate groups on other relevant covariates, such as income, education, vehicle type, personality traits, etc.[5]

The primary questions addressed in these analyses were:

- *Who is speeding*? And can we identify who they are by their demographic group, and/or by certain behaviors, motivations, or beliefs they have about speeding (i.e., personal inventory items)?

- *Who speeds the most?* And can we identify who they are by their demographic group, and/or by certain behaviors, motivations, or beliefs they have about speeding (i.e., personal inventory items)?

[5] The authors gratefully acknowledge the assistance of Ashley Loving, Elizabeth Jackson, Ta Liu, and Dale Rhoda in developing the approach to the inferential analyses.

The first question addresses whether there are systematic driver characteristics that predict the occurrence of any speeding on a particular trip. The second question is an extension of the first: Specifically, if drivers do speed, are there any systematic characteristics that predict how much speeding they will do?

These questions translate into four sets of analyses, based on different dependent measures and different sets of predictor variables. In particular, two types of regression analyses were used--one for each of the key questions listed above. The first was a logistic regression to examine predictors of whether or not drivers do any speeding on a trip. This analysis provided information about the relative odds for significant predictors (i.e., the odds of there being any speeding in group X was two times greater than in group Y). The second was a linear regression conducted only on trips that had any speeding. The objective of this analysis was to determine if the proportion of time spent speeding on a trip could be predicted by the variables of interest.

Also, for each of the questions and regression approaches, two sets of models were developed. The first set examined demographic predictors, and the second set were the same, but with the inclusion of personal inventory factors as additional predictors (based on a factor analysis of personal inventory items, which is described in Appendix E). The primary reason for looking at these additional personal inventory predictors in separate models was to determine if they change the relationships between demographic variables and speeding. For example, are personal inventory factors better predictors than demographic variables alone? Or does controlling for risk-taking factors change differences in speeding patterns across demographic groups?

In all regression models, a limited set of trip variables was included to account for differences in driving patterns across demographic groups (trip variables are discussed in more detail below). Table 28 below provides a summary of the four sets of regression models included in the inferential analyses. STATA 10.1 was used to conduct all regression analyses.

All regression analyses listed above were run as random effects models. In particular, individual trips were used as the unit of analysis, but these were grouped by participant, which provides a way to include trip-level and driver-level factors in the regression. The logic for this approach is that individual trips should be considered separately, since driver performance on a single trip can vary systematically depending on factors such as where they are driving, the time of day, the type of trip, etc. Trips are not completely independent, however, since they are made by the same driver. Consequently, by including participant number as a grouping variable, the within-driver variance can be better captured by the regression models.

Table 28. Variables and data used in the regression models.

	Question Addressed	Analysis Type	Data Used	Independent Variables	Dependent Variable Type
1	***Who is speeding?***	Logistic Regression	All trips with free-flow time in a speed band	Demographic, Trip	Binary (no speeding vs. any speeding on a trip)
2	(Likelihood of drivers having any speeding on a trip)	Logistic Regression	All trips with free-flow time in a speed band	Demographic, Trip, *Socioeconomic, Personal Inventory Factors*	Binary (no speeding vs. any speeding on a trip)
3	***Who speeds the most?***	Linear Regression	All trips with any speeding in a speed band	Demographic, Trip	Continuous (proportion of free-flow driving on a trip that is speeding)
4	(Amount of speeding on a trip)	Linear Regression	All trips with any speeding in a speed band	Demographic, Trip, *Socioeconomic, Personal Inventory Factors*	Continuous (proportion of free-flow driving on a trip that is speeding)

It should also be noted that in all of the analyses, age and gender together were treated as a single categorical variable, rather than as two separate variables. This was done to better accommodate interactions between age and gender. In each analysis, Older Females were used as the comparison group for the other demographic groups because they were typically less likely to speed or to speed as frequently as the other groups. However, we also calculated the odds ratio comparisons between each group separately to show which groups differed from one another.

The regression analyses were conducted separately for each location. This was done because the descriptive analyses indicated that the driving environments and corresponding factors that can influence speeding behavior were substantially different at each location, even in comparable speed bands. We conducted preliminary regression analyses with data pooled across sites (not reported in this document), but the results suggested that there were elements related to site-differences and data differences (i.e., number of trips, demographic differences in driving patterns) that made the findings difficult to interpret. Based on these findings, we decided that we required a better understanding of these elements, and needed to find suitable ways to compensate for them before we could conduct a valid statistical comparison across location. Consequently, these analyses are not included in the current report.

Trip Variables: In all analyses, we included several trip variables as control variables. Because this was a naturalistic driving study, there were several important aspects of participant driving that were outside of experimental control, such as when participants drove, and how much they drove. More importantly, as discussed in the Descriptive Results section above, there were systematic differences across these trip variables across demographic groups. Therefore, to control for these differences, the trip variables shown in Table 29 were included in each logistic regression analysis.

Table 29. Description of trip variables.

Variable	Type	Comparison	Description
Weekend	Categorical	Weekday	Whether the trip occurred on a weekend (Sat, Sun) or a weekday
Time of Day (ToD)	Categorical	Morning Rush hour [5 a.m.-9 a.m.]	The part of the day in which the trip was started: • Early morning (12 a.m.-5 a.m) • Morning rush hour (5 a.m.-9 a.m.) • Midday (9 a.m.-3 p.m.) • Afternoon rush hour (3 p.m.-7 p.m.) • Late evening/night (7 p.m.-12 a.m.)
logFFT*	Continuous	---	The natural log of the total number of seconds of free-flow driving in a trip that occurred on the designated speed band (e.g., logFFT30 = 30-35mph speed band)

* logFFT is defined as the natural log of the total number of seconds of free-flow driving in a trip that occurred on the designated speed band (e.g., logFFT30 = 30-35mph speed band).

The Weekend and ToD variables were included because there were systematic differences across demographic groups in terms of when they drove (i.e., younger drivers generally had a greater proportion of trips late at night and on weekends). Because traffic conditions and the corresponding opportunities to speed vary across time of day and on weekends, it makes sense to control for these variables.

Table 29 above identifies and defines a new variable: log FFT. This variable is defined as the natural log of the total number of seconds of free-flow driving in a trip that occurred on the designated speed band (e.g., logFFT30 = 30-35mph speed band). The variable logFFT is important to include for two reasons. The first is that there were substantial differences across demographic groups in terms of the amount of driving each did on the different types of road (i.e., Older Females in Texas drove almost as much as all other groups combined on 70 mph roads). The second, and more important reason, is that this variable is intrinsically correlated with the dependent measures used. For example, in the logistic regression model, in which the dependent variable is whether there is any speeding, the longer a trip is (higher logFFT), the more likely it is that any speeding occurs just by chance alone (since there is more opportunity for this to happen). Thus, there should be an inherent positive correlation between logFFT values and the dependent variable.[6] In the linear regression model, in which the dependent variable is the proportion of time speeding on a trip, the longer a trip is (higher logFFT), the lower the proportion of speeding should be.[7] This is because it is much easier to speed for 50% of a 10-minute trip, than 50% of a 2-hour trip, under most conditions. Thus, there should be an inherent negative correlation between logFFT values and the dependent variable, since the largest proportions of time speeding should occur on shorter trips.

Socioeconomic Variables: Another type of control variable that was considered in the current analyses was socioeconomic variables related to income, education level, and vehicle type. It is plausible that the demographic variables simply serve as a proxy for factors such as income or education level that vary based on a person's stage in life (i.e., if more educated and affluent drivers are less likely to speed). Accordingly, if these socioeconomic variables were included in the models, then they might eliminate

[6] This hypothesis was confirmed by all the analyses using logistic regression.

[7] This hypothesis was also confirmed by all the analyses using linear regression.

any demographic predictors (particularly in Texas, where most young drivers were lower-income college students). A parallel set of analyses was conducted on the base logistic and linear regression models that included these socioeconomic factors (see Appendix F). Incorporating these variables did not remove demographic variables as predictors, which means that age and gender were still significant predictors of speeding (on some roadways) even after controlling for education, income, and vehicle type. These socioeconomic variables were not included in the base models described below to keep the models simple. However, these variables were included as predictors in the expanded models that also examined personal inventor predictors.

Logistic Regression Models

The logistic regression models were run using the dependent variable of whether or not there was any speeding on a trip (i.e., who is speeding?). A trip was counted as a "speeding trip" if the travel speed ever exceeded the posted speed by 10 mph or more (i.e., Type 3 and Type 4 speeding combined). The numbers of drivers that had any speeding or no speeding in each speed band are shown in Table 30 below. Some drivers did not have any free-flow driving in a certain speed band, and they are indicated separately in the rightmost column. There are several reasons why this may have occurred. The most likely ones are that they either did not drive on those types of roads, or if they did, they drove on roads that were not validated, or at speeds that were too slow to count as free-flow driving. Drivers with no free-flow time were excluded from the analyses for the speed band in which they had no driving, but they were included in any other speed bands in which they did have driving.

Table 30. Numbers of drivers that had any speeding or no speeding in each speed band.

Speed Band	Drivers with Any Speeding	Drivers with No Speeding	Drivers without Free-Flow in the Speed Band
Seattle 30-35	76	9	3
Seattle 55-60	83	5	0
Texas 30-35	45	29	2
Texas 55-60	60	15	1
Texas 70	52	17	7

Separate logistic regression models were run for each speed band, and these were run in two versions. The first included just demographic driver factors to determine if demographic category alone was sufficient to predict speeding behavior. The second retained the demographic factors but added personal inventory predictors to provide a more comprehensive model of the driver-related factors associated with whether or not drivers have any speeding on a trip. The personal inventory predictors were not individual variables but factor loadings obtained in a separate factor analysis conducted on the personal inventory items (see Appendix E). This approach was used because there were over 100 personal inventory items, and since many were related (i.e., multiple risky driving items), factor analysis provides a way to distill these items into underlying factors that account for patterns of responses across personal inventory items. The factor analysis results are summarized in a section that follows.

The logistic regression models are described in the next sections, with the models that contain only the demographic variables presented first. The overall findings are discussed in more detail at the end of the inferential statistics section, along with the findings from the linear regression models. Note that the trip variables used to control for differences in driving patterns (i.e., Weekend, ToD, and LogFFT), are included in each model below (shown in blue text).

For the logistic regression outputs, odds ratios (OR) are reported instead of the regression coefficients. The reason for this is that the odds ratios are easier to interpret since they represent the relative odds that one group has any speeding when compared to another group—the comparison group (i.e., the odds of there being any speeding in group X was 2 times greater than in group Y). In the output tables, Older Females are used as the comparison group in all analyses, since they generally did the least speeding. However, odds ratios were computed for all other demographic-group comparisons (by changing the comparison group and re-running the model), and presented in a separate table after each regression output table.

Since this is an exploratory investigation into speeding across a wide range of drivers, we used a more liberal alpha value (<0.10) for reporting results and retaining variables in the logistic models and odds ratio outputs. Significant (<0.05) and marginally significant(0.05-0.10) predictors are indicated in the output tables with bold font. In the discussion of the models, findings between 0.05 and 0.10 are described as marginally significant, but are still discussed.

Random Effects Logistic Regression with Demographic and Trip Variables: Seattle 30-35 mph Roadways

Table 31, the output table from the regression analysis, shows the relationship between demographic and trip variables and whether or not drivers had any speeding on Seattle 30-35 mph roadways. The trip variables, primarily used to control for differences in driving patterns, are shown in blue text. Demographic variables are shown in black. Variables shown in bold are either statistically significant or approaching statistical significance.

Table 31. Output from the logistic regression analysis showing the relationship between demographic and trip variables: Seattle 30-35 mph roadways.[8]

	Odds Ratio	Standard Error	z-score	p-value	[OR 95% Conf. Interval]	
Older Males	1.176	0.423	0.45	0.651	0.581	2.381
Younger Females	1.849	0.676	1.68	0.092†	0.904	3.785
Younger Males	2.420	0.894	2.39	0.017*	1.173	4.990
Weekend	1.301	0.162	2.11	0.035*	1.018	1.662
ToD [12 a.m.-5 a.m.]	0.722	0.264	-0.89	0.374	0.352	1.480
ToD [9 a.m.-3 p.m.]	1.397	0.239	1.95	0.051†	0.998	1.954
ToD [3 p.m.-7 p.m.]	1.263	0.214	1.37	0.170	0.905	1.762
ToD [7 p.m.-12 a.m.]	0.950	0.180	-0.27	0.785	0.654	1.378
logFFT30	2.206	0.148	11.78	0.000***	1.934	2.517

***p<.001; **p<.01; *p<.05; †p<.10
Number of observations: 2953
Number of groups: 84
Wald chi2(9) = 157.38
Prob> chi2 = 0.0000

Log likelihood = -1361.9217
Likelihood-ratio test of rho=0
Chibar2(01) = 196.62
Prob>=chibar2 = 0.000

Demographic Variables: Compared to Older Females, Younger Males are at significantly increased odds of speeding. Younger Females also have increased odds of speeding, but this effect is only marginally significant. Table 32 below provides the odds ratio comparisons relative to Older Females (second column), Older Males (third column) and Younger Females (fourth column) based on the coefficients from the logistic regression analysis. The table shows that Young Males are also at increased odds of speeding compared to Older Males.

Table 32. Comparison of odds ratios across demographic groups.

Demo Group	vs. Older Females Odds Ratio [95% CI]	vs. Older Males Odds Ratio [95% CI]	vs. Younger Females Odds Ratio [95% CI]
Older Males	1.18 [0.58-2.38]		
Younger Females	1.85 [0.90-3.79]†	1.57 [0.80-3.09]	
Younger Males	2.42 [1.17-4.99]*	2.06 [1.04-4.08]*	1.31 [0.65-2.62]

***p<.001; **p<.01; *p<.05; †p<.10

Trip Variables: Trips made on weekends were at significantly increased odds of speeding compared to those made on weekdays. Driving between the hours of 9 a.m. and 3 p.m., compared to morning rush hour, was also at significantly increased odds of speeding. The amount of free-flow time spent on 30-35 mph roads in a trip (logFFT30) was associated with increased odds of speeding.

[8] Note that although the variables included base Seattle and Texas models are the same as the Phase 1 Report, the table outputs are slightly different. This is because the current analyses dealt with missing cases in a more appropriate manner. The overall pattern of significant variables was unaffected by this change.

Trip Variables: Trips made on weekends were at significantly increased odds of speeding compared to those made on weekdays. Driving between the hours of 9 a.m. and 3 p.m., compared to morning rush hour, was also at significantly increased odds of speeding. The amount of free-flow time spent on 30-35 mph roads in a trip (logFFT30) was associated with increased odds of speeding.

Random Effects Logistic Regression with Demographic and Trip Variables: Seattle 55-60 mph Roadways

The output table from the regression analysis, showing the relationship between demographic and trip variables and whether or not drivers had any speeding on 55-60 mph Seattle roadways, is shown in Table 33 below. The trip variables, primarily used to control for differences in driving patterns, are shown in blue text. Demographic variables are shown in black. Variables shown in bold are either statistically significant or approaching statistical significance.

Table 33. Output from the logistic regression analysis showing the relationship between demographic and trip variables: Seattle 55-60 mph roadways.

	Odds Ratio	Standard Error	z-score	p-value	[OR 95% Conf. Interval]	
Older Males	1.249	0.602	0.46	0.645	0.485	3.214
Younger Females	**4.530**	**2.256**	**3.03**	**0.002****	**1.706**	**12.024**
Younger Males	**4.024**	**2.004**	**2.80**	**0.005****	**1.516**	**10.680**
Weekend	**1.467**	**0.202**	**2.78**	**0.005****	**1.120**	**1.921**
ToD [12 a.m.-5 a.m.]	**0.207**	**0.084**	**-3.87**	**0.000*****	**0.093**	**0.459**
ToD [9 a.m.-3 p.m.]	**1.331**	**0.223**	**1.71**	**0.087†**	**0.959**	**1.848**
ToD [3 p.m.-7 p.m.]	1.089	0.184	0.50	0.615	0.781	1.518
ToD [7 p.m.-12 a.m.]	**0.719**	**0.137**	**-1.73**	**0.084†**	**0.495**	**1.045**
logFFT60	**4.715**	**0.379**	**19.29**	**0.000*****	**4.028**	**5.520**

***p<.001; **p<.01; *p<.05; †p<.10
Number of observations: 2782
Number of groups: 87
Wald chi2(13) = 393.01
Prob> chi2 = 0.0000

Log likelihood = -1247.3751
Likelihood-ratio test of rho=0
Chibar2(01) = 398.29
Prob>=chibar2 = 0.000

Demographic Variables: Both Younger Females and Younger Males were at significantly increased odds of speeding compared to Older Females. Table 34 also shows that these groups are also at significantly increased odds of speeding compared to Older Males.

Table 34. Comparison of odds ratios across demographic groups.

Demo Group	vs. Older Females Odds Ratio [95% CI]	vs. Older Males Odds Ratio [95% CI]	vs. Younger Females Odds Ratio [95% CI]
Older Males	1.25 [0.485-3.21]		
Younger Females	4.53 [1.70-12.02]**	3.63 [1.41-9.32]**	
Younger Males	4.02 [1.52-10.68]**	3.22 [1.25-1.92]*	0.89 [0.37-2.35]

***p<.001; **p<.01; *p<.05; †p<.10

Trip Variables: Driving on the weekend significantly increased odds of speeding compared to trips made on a weekday. Compared to driving during morning rush hour, driving between 12 a.m. and 5 a.m. significantly decreased odds of speeding. Driving between 9 a.m. and 3 p.m., and between 7 p.m. and 12 a.m., also marginally increased and decreased odds of speeding, respectively. Greater amounts of free-flow time spent on 50-60mph roads in a trip (logFFT60) significantly increased the log odds of speeding.

Random Effects Logistic Regression with Demographic and Trip Variables: Texas 30-35 mph Roadways

The output table from the regression analysis, showing the relationship between demographic and trip variables and whether or not drivers had any speeding on 30-35 mph Texas roadways, is shown in Table 35 below. The trip variables, primarily used to control for differences in driving patterns, are shown in blue text. Demographic variables are shown in black. Variables shown in bold are either statistically significant or approaching statistical significance.

Table 35. Output from the logistic regression analysis showing the relationship between demographic and trip variables: Texas 30-35 mph roadways.

	Odds Ratio	Standard Error	z-score	*p-value*	[OR 95% Conf. Interval]	
Older Males	1.250	0.842	0.33	0.740	0.334	4.681
Younger Females	1.541	0.977	0.68	0.496	0.444	5.341
Younger Males	0.813	0.539	-0.31	0.755	0.222	2.980
Weekend	**1.632**	**0.360**	**2.22**	**0.026***	**1.060**	**2.514**
ToD [12 a.m.-5 a.m.]	(omitted - no speeding time)					
ToD [9 a.m.-3 p.m.]	**0.484**	**0.118**	**-2.97**	**0.003****	**0.300**	**0.781**
ToD [3 p.m.-7 p.m.]	**0.530**	**0.130**	**-2.60**	**0.009****	**0.328**	**0.856**
ToD [7 p.m.-12 a.m.]	**0.488**	**0.142**	**-2.47**	**0.013***	**0.277**	**0.862**
logFFT30	**2.617**	**0.319**	**7.90**	**0.000*****	**2.061**	**3.322**

***p<.001; **p<.01; *p<.05; †p<.10
Number of observations: 2377
Number of groups: 74
Wald chi2(13) = 73.98
Prob> chi2 = 0.0000

Log likelihood = -552.75248
Likelihood-ratio test of rho=0
Chibar2(01) = 203.95
Prob>=chibar2 = 0.000

Demographic Variables: There are no significant differences between demographic groups in this analysis, as shown in Table 36.

Table 36. Comparison of odds ratios across demographic groups.

Demo Group	vs. Older Females Odds Ratio [95% CI]	vs. Older Males Odds Ratio [95% CI]	vs. Younger Females Odds Ratio [95% CI]
Older Males	1.25 [0.33-4.68]		
Younger Females	1.54 [0.44-5.34]	1.23 [0.37-4.14]	
Younger Males	0.81 [0.22-2.98]	0.65 [0.18-2.33]	0.53 [0.16-1.74]

***p<.001; **p<.01; *p<.05; †p<.10

Trip Variables: Weekend trips are at significantly increased odds of speeding compared to weekday trips. Driving at any time other than morning rush hour significantly decreased odds of speeding, though the 12 a.m. to 5 a.m. time band was omitted due to collinearity.

Random Effects Logistic Regression with Demographic and Trip Variables: Texas 55-60 mph Roadways

The output table from the regression analysis, showing the relationship between demographic and trip variables and whether or not drivers had any speeding on 55-60 mph Texas roadways, is shown in Table 37 below. The trip variables, primarily used to control for differences in driving patterns, are shown in blue text. Demographic variables are shown in black. Variables shown in bold are either statistically significant or approaching statistical significance.

Table 37. Output from the logistic regression analysis showing the relationship between demographic and trip variables: Texas 55-60 mph roadways.

	Odds Ratio	Standard Error	z-score	p-value	[OR 95% Conf. Interval]	
Older Males	1.787	0.818	1.27	0.205	0.728	4.385
Younger Females	1.951	0.887	1.47	0.142	0.800	4.755
Younger Males	4.060	2.026	2.81	0.005**	1.527	10.797
Weekend	1.016	0.189	0.09	0.932	0.706	1.462
ToD [12 a.m.-5 a.m.]	0.422	0.290	-1.25	0.209	0.110	1.623
ToD [9 a.m.-3 p.m.]	1.210	0.244	0.95	0.344	0.815	1.797
ToD [3 p.m.-7 p.m.]	1.197	0.224	0.96	0.338	0.829	1.727
ToD [7 p.m.-12 a.m.]	0.682	0.175	-1.50	0.135	0.412	1.126
logFFT60	3.465	0.358	12.02	0.000***	2.829	4.243

***p<.001; **p<.01; *p<.05; †p<.10
Number of observations: 1484
Number of groups: 75
Wald chi2(13) = 151.47
Prob> chi2 = 0.0000

Log likelihood = -740.85818
Likelihood-ratio test of rho=0
Chibar2(01) = 153.88
Prob>=chibar2 = 0.000

Demographic Variables: Compared to Older Females, Younger Males are at significantly increased odds of speeding. As shown in Table 38, no other comparisons of demographic groups were significant.

Table 38. Comparison of odds ratios across demographic groups.

Demo Group	vs. Older Females Odds Ratio [95% CI]	vs. Older Males Odds Ratio [95% CI]	vs. Younger Females Odds Ratio [95% CI]
Older Males	1.79 [0.73-4.38]		
Younger Females	1.95 [0.80-4.75]	1.09 [0.44-2.71]	
Younger Males	4.06 [1.53-10.80]**	2.27 [0.85-6.11]	2.08 [0.79-5.49]

***p<.001; **p<.01; *p<.05; †p<.10

Trip Variables: The amount of free-flow time spent on 55-60 mph roads in a trip was associated with increased odds of speeding. Neither the day of the week nor time of day influenced speeding behavior.

Random Effects Logistic Regression with Demographic and Trip Variables: Texas 70 mph Roadways

The output table from the regression analysis, showing the relationship between demographic and trip variables and whether or not drivers had any speeding on 70 mph Texas roadways, is shown in Table 39 below. The trip variables, primarily used to control for differences in driving patterns, are shown in blue text. Demographic variables are shown in black. Variables shown in bold are either statistically significant or approaching statistical significance.

Table 39. Output from the logistic regression analysis showing the relationship between demographic and trip variables: Texas 70 mph roadways.

	Odds Ratio	Standard Error	z-score	p-value	[OR 95% Conf. Interval]	
Older Males	1.983	0.806	1.69	0.092†	0.894	4.398
Younger Females	1.079	0.473	0.17	0.863	0.457	2.547
Younger Males	3.029	1.393	2.41	0.016*	1.230	7.461
Weekend	1.316	0.263	1.38	0.169	0.890	1.947
ToD [12 a.m.-5 a.m.]	0.690	0.615	-0.42	0.677	0.120	3.961
ToD [9 a.m.-3 p.m.]	0.910	0.200	-0.43	0.668	0.592	1.400
ToD [3 p.m.-7 p.m.]	0.834	0.167	-0.91	0.365	0.563	1.235
ToD [7 p.m.-12 a.m.]	0.712	0.218	-1.11	0.268	0.390	1.299
logFFT70	2.786	0.294	9.69	0.000***	2.265	3.427

***p<.001; **p<.01; *p<.05; †p<.10
Number of observations: 1458
Number of groups: 69
Wald chi2(13) = 100.55
Prob> chi2 = 0.0000

Log likelihood = -586.27294
Likelihood-ratio test of rho=0
Chibar2(01) = 84.58
Prob>=chibar2 = 0.000

Demographic Variables: Compared to Older Females, Younger Males are at increased odds of speeding. Similarly, Older Males are at marginally increased odds of speeding. As shown in Table 40, Younger Males are also at increased odds of speeding compared to Younger Females.

Table 40. Comparison of odds ratios across demographic groups.

Demo Group	vs. Older Females Odds Ratio [95% CI]	vs. Older Males Odds Ratio [95% CI]	vs. Younger Females Odds Ratio [95% CI]
Older Males	1.98 [0.89-4.40]†		
Younger Females	1.08 [0.46-2.55]	0.54 [0.22-1.35]	
Younger Males	3.03 [1.23-7.46]*	1.53 [0.60-3.89]	2.81 [1.04-7.61]*

***p<.001; **p<.01; *p<.05; †p<.10

Trip Variables: The amount of free-flow time spent on 70 mph roads in a trip was associated with increased odds of speeding. Neither the day of the week nor time of day influenced speeding behavior.

Logistic Regression with Personal Inventory Factors and Socioeconomic Variables

A separate set of regression analyses was conducted to identify driver attitudes, motivations, and beliefs that might predict driver speeding behavior. Because of the large number of questions included in the personal inventory (N = 111), measures were taken to reduce the number of those variables considered in the models for each speed band. Specifically, we conducted factor analyses to create factor scores for groups of related variables (described in Appendix F). Separate factor analyses were run on the three primary personal inventory instruments used, and the resulting factors are described in Table 41 below.

in the models for each speed band. Specifically, we conducted factor analyses to create factor scores for groups of related variables (described in Appendix F). Separate factor analyses were run on the three primary personal inventory instruments used, and the resulting factors are described in Table 41 below.

Table 41. Names and descriptions of factors obtained in the factor analysis.

Personal Inventory Instrument	Factor Name	Factor Description
Driver Behavior Questionnaire (DBQ)	Inattention	Items that describe errors that drivers make due to a lack of concentration on driving
	Bad Driving	Items that include driving mistakes or apparent lack of skill
	Reckless Driving	Items that deal with dangerous violations such as racing, driving drunk, and tailgating
	Road Rage	Items that involve showing hostility and anger to other drivers
Theory of Planned Behavior (TPB)	*Behavioral and Control beliefs related to Temptation to speed (BCB-Temptation)*	This factor incorporates a subset of control beliefs and behavioral beliefs. These items seem to be related to emotional or impulsive reasons for speeding. Higher factor loadings are related to resisting temptation to speeding, with negative values indicating negative attitudes toward reasons for speeding
	Subjective Norms	This factor includes mostly items that reflect how people who are important to the driver feel about speeding. Higher factor loadings indicate that important people have a larger influence on the driver's behavior.
	Behavioral Beliefs related to Safety (BB-Safety)	This factor was comprised of behavioral belief items that were primarily associated with safety-related aspects of speeding. Higher factor loadings indicate more concern with safety.
	Control Beliefs related to Opportunity to speed (CB-Opportunity)	This factor contained a subset of control beliefs that mostly reflected situations in which there was limited opportunity to speed (i.e., traffic calmed areas), however with some clear exceptions (e.g., on straight long roads). The greater the loadings on this factor, the more likely a driver is influenced by external factors related to opportunity.
	Normative Beliefs	This factor contained mostly items related to how different groups of people (e.g., parents/kids, spouses, police, etc.) would influence drivers to comply with the speed limit. Higher factor loadings suggest greater influence of these groups on the driver's behavior.
CARDS Risky Driving Questionnaire	Dangerous Driving	This factor was comprised of risk taking behaviors. Higher factor loadings indicate more dangerous driving behaviors.

Using the base model, which included only the control and dependent variables, all factor scores described above were added to the model with the corresponding speeding-related dependent variables. These models were also run with socioeconomic variables (see below). The models were then simplified by reducing non-significant factors and socio-economic variables until only the significant variables remained. The cut off point for significance was $p<0.10$. A final model was chosen based on the available measures of fit (i.e., chi-squared) and the interpretability of the model. Note, however, that the results of the factor analysis and regression relying on the factor scores should be interpreted cautiously. First, our samples are somewhat smaller than what are recommended for factor analysis. Second, the use of factor scores in linear regression has been criticized (Zuccaro, 2007) due to the asymmetry of the standardized factor scores and unstandardized dependent variable.

The socioeconomic variables that were examined included:

Truck or Sports Car: type of vehicle driven. Sedan, Minivans, and SUV were the referent group, and Trucks and Sports Cars were the reported group.

College Degree: Whether drivers had completed a college degree.

Income: A 4-level categorical level representing household income range.

The regression model results for each speed band and location are presented separately in the following sections.

Random Effects Logistic Regression with Demographic, Socioeconomic, Trip, and Factor-Score Variables: Seattle 30-35 mph Roadways

The output table from the regression analysis, showing the relationship between demographic, socioeconomic, trip, and factor-score variables and whether or not drivers had any speeding for 30-35 mph Seattle roadways, is shown in Table 42 below. The trip variables, primarily used to control for differences in driving patterns, are shown in blue text. All other variables are shown in black. Variables shown in bold are either statistically significant or approaching statistical significance.

Table 42. Output from the logistic regression analysis showing the relationship between demographic, trip, and factor-score variables: Seattle 30-35 mph roadways.

	Odds Ratio	Standard Error	z-score	p-value	[OR 95% Conf. Interval]	
Older Males	1.107	0.357	0.32	0.752	0.589	2.083
Younger Females	**2.777**	**0.991**	**2.86**	**0.004***	**1.380**	**5.589**
Younger Males	**2.708**	**0.920**	**2.93**	**0.003***	**1.392**	**5.269**
Weekend	**1.294**	**0.192**	**1.74**	**0.081†**	**0.969**	**1.730**
Reckless/Road Rage	**1.347**	**0.158**	**2.54**	**0.011***	**1.070**	**1.695**
Inattention	**1.548**	**0.180**	**3.76**	**0.000*****	**1.233**	**1.944**
Subjective Norms	**0.826**	**0.090**	**-1.75**	**0.079†**	**0.667**	**1.023**
CB-Opportunity	**0.626**	**0.084**	**-3.51**	**0.000*****	**0.481**	**0.813**
ToD [12 a.m.-5 a.m.]	1.166	0.502	0.36	0.722	0.501	2.713
ToD [9 a.m.-3 p.m.]	1.244	0.244	1.11	0.265	0.847	1.829
ToD [3 p.m.-7 p.m.]	1.186	0.228	0.89	0.373	0.814	1.728
ToD [7 p.m.-12 a.m.]	0.898	0.196	-0.49	0.621	0.586	1.377
logFFT30	**2.233**	**0.175**	**10.24**	**0.000*****	**1.915**	**2.604**

***p<.001; **p<.01; *p<.05; †p<.10
Number of observations: 2037
Number of groups: 62

Wald chi2(13) = 142.83
Prob> chi2 = 0.0000

Demographic and Socioeconomic Variables: Compared to Older Females, Younger Females and Younger Males have significantly increased odds of speeding. There is no difference between Older Females and Older Males. Socioeconomic variables such as having a college degree, income, and type of vehicle were not found to be significant predictors of speeding behavior (these are not shown in the table).

Factor-Score Variables: The relationships between the dependent variable and the statistically significant factor-score variables are listed below. In particular, drivers that were *at significantly increased odds* of speeding during the study were associated with:

[Reckless/Road Rage] More frequently committing dangerous violations such as racing, driving drunk, and tailgating and expressing hostile or angry actions towards other drivers.

[Inattention] More frequently forgetting or making errors due to a lack of concentration on driving.

In contrast, drivers that were at *significantly decreased odds* of speeding during the study were associated with:

[Subjective Norms] Stronger agreement that people who are important to them would approve of them driving near the speed limit.

[CB-Opportunity] Being more likely to drive near the speed limit when they generally do not have a good opportunity to speed.

Trip Variables: Trips made on weekends had increased odds of speeding compared to trips made on weekdays, but this effect was only marginally significant. The amount of free-flow time spent on 30-35 mph roads in a trip significantly increased odds of speeding. Time of day did not impact speeding behavior.

Random Effects Logistic Regression with Demographic, Socioeconomic, Trip, and Factor-Score Variables: Seattle 55-60 mph Roadways

The output table from the regression analysis, showing the relationship between demographic, socioeconomic, trip, and factor-score variables and whether or not drivers had any speeding on 55-60 mph Seattle roadways, is shown in Table 43 below. The trip variables, primarily used to control for differences in driving patterns, are shown in blue text. All other variables are shown in black. Variables shown in bold are either statistically significant or approaching statistical significance.

Table 43. Output from the logistic regression analysis showing the relationship between demographic, trip, and factor-score variables: Seattle 55-60 mph roadways.

	Odds Ratio	Standard Error	z-score	p-value	[OR 95% Conf. Interval]	
Older Males	1.793	0.821	1.28	0.202	0.731	4.399
Younger Females	**4.582**	**2.108**	**3.31**	**0.001****	**1.860**	**11.290**
Younger Males	1.665	0.734	1.16	0.248	0.701	3.953
Truck or Sports Car	**0.335**	**0.202**	**-1.81**	**0.070†**	**0.103**	**1.093**
Weekend	**1.570**	**0.268**	**2.64**	**0.008****	**1.124**	**2.193**
Bad Driving	**1.563**	**0.296**	**2.36**	**0.018***	**1.079**	**2.266**
BCB-Temptation	**0.396**	**0.092**	**-3.97**	**0.000*****	**0.251**	**0.626**
Subjective Norms	**0.688**	**0.103**	**-2.50**	**0.013***	**0.513**	**0.923**
CB-Opportunity	**0.677**	**0.116**	**-2.28**	**0.023***	**0.484**	**0.947**
ToD [12 a.m.-5 a.m.]	**0.196**	**0.100**	**-3.19**	**0.001****	**0.072**	**0.533**
ToD [9 a.m.-3 p.m.]	1.299	0.247	1.37	0.170	0.894	1.886
ToD [3 p.m.-7 p.m.]	1.118	0.211	0.59	0.555	0.772	1.620
ToD [7 p.m.-12 a.m.]	**0.683**	**0.154**	**-1.69**	**0.091†**	**0.439**	**1.063**
logFFT60	**4.955**	**0.466**	**17.02**	**0.000*****	**4.121**	**5.957**

***p<.001; **p<.01; *p<.05; †p<.10
Number of observations: 2048
Number of groups: 65

Wald chi2(14) = 324.83
Prob> chi2 = 0.0000

Demographic and Socioeconomic Variables: Compared to Older Females, Younger Females had significantly increased odds of speeding but neither Older Males nor Younger Males were significantly different. Driving a truck or a sports car, compared to all other types of vehicles, had lower odds of speeding, but this effect was only marginally significant. Income and having a college degree were not included in the final model because they were not significant predictors of speeding behavior.

Factor-Score Variables: The relationships between the dependent variable and the statistically significant factor-score variables are listed below. In particular, drivers that were at significantly increased odds of speeding during the study were associated with:

[Bad Driving] More frequently making driving mistakes that show a lack of skill.

In contrast, drivers that were at significantly decreased odds of speeding during the study were associated with:

[BCB-Temptation] Being more likely to drive near the speed limit in situations when roadway factors provide temptation to speed.

[Subjective Norms] Stronger agreement that people who are important to them would approve of them driving near the speed limit.

[CB-Opportunity] Being more likely to drive near the speed limit when they generally do not have a good opportunity to speed.

Trip Variables: Trips made on weekends were at significantly increased odds of speeding than those made on weekdays. Driving during the early morning hours (12 a.m.-5 a.m.), was associated with significantly decreased odds of any speeding on a trip relative to the morning rush hour period. Driving between 7 p.m. and 12 a.m. also marginally decreased the odds of speeding. The amount of free-flow time spent on 55-60 mph roads in a trip was also associated with increased odds of speeding.

Random Effects Logistic Regression with Demographic, Socioeconomic, Trip, and Factor-Score Variables: Texas 30-35 mph Roadways

The output table from the regression analysis, showing the relationship between demographic, socioeconomic, trip, and factor-score variables and whether or not drivers had any speeding for 30-35 mph Texas roadways, is shown in Table 44 below. The trip variables, primarily used to control for differences in driving patterns, are shown in blue text. All other variables are shown in black. Variables shown in bold are either statistically significant or approaching statistical significance.

Table 44. Output from the logistic regression analysis showing the relationship between demographic, trip, and factor-score variables: Texas 30-35 mph roadways.

	Odds Ratio	Standard Error	z-score	p-value	[OR 95% Conf. Interval]	
Older Males	2.194	1.672	1.03	0.302	0.493	9.771
Younger Females	1.890	1.409	0.85	0.393	0.439	8.146
Younger Males	1.269	0.984	0.31	0.758	0.278	5.801
Weekend	**1.985**	**0.482**	**2.82**	**0.005****	**1.233**	**3.195**
BB-Safety	**1.678**	**0.454**	**1.91**	**0.056†**	**0.988**	**2.852**
ToD [12 a.m.-5 a.m.]	Omitted (no speeding time)					
ToD [9 a.m.-3 p.m.]	0.690	0.190	-1.35	0.179	0.401	1.185
ToD [3 p.m.-7 p.m.]	0.720	0.205	-1.15	0.248	0.412	1.258
ToD [7 p.m.-12 a.m.]	0.706	0.233	-1.05	0.292	0.369	1.350
logFFT30	**2.344**	**0.325**	**6.15**	**0.000*****	**1.787**	**3.075**

***p<.001; **p<.01; *p<.05; †p<.10
Number of observations: 2213
Number of groups: 72

Wald chi2(13) = 110.29
Prob> chi2 = 0.0000

Demographic and Socioeconomic Variables: None of the demographic or socioeconomic variables were significant predictors of speeding behavior.

Factor-Score Variables: The relationships between the dependent variable and the statistically significant factor-score variables are listed below. Drivers that were at marginally increased odds of speeding during the study were associated with:

[BB-Safety] Stronger agreement that driving near the speed limit has safety benefits.

Trip Variables: Trips made on weekends were at significantly increased odds of speeding compared to those made on weekdays. The early morning period was excluded from the analysis due to collinearity since there was no speeding time in this category. No other time band variables were significant predictors of speeding behavior. The amount of free-flow time spent on 30-35 mph roads in a trip was also associated with increased odds of speeding.

Random Effects Logistic Regression with Demographic, Socioeconomic, Trip, and Factor-Score Variables: Texas 55-60 mph Roadways

The output table from the regression analysis, showing the relationship between demographic, socioeconomic, trip, and factor-score variables and whether or not drivers had any speeding on 55-60 mph Texas roadways, is shown in Table 45 below. The trip variables, primarily used to control for differences in driving patterns, are shown in blue text. All other variables are shown in black. Variables shown in bold are either statistically significant or approaching statistical significance.

Table 45. Output from the logistic regression analysis showing the relationship between demographic, trip, and factor-score variables: Texas 55-60 mph roadways.

	Odds Ratio	Standard Error	z-score	p-value	[OR 95% Conf. Interval]	
Older Males	0.995	0.446	-0.01	0.991	0.413	2.395
Younger Females	1.756	0.995	0.99	0.320	0.579	5.331
Younger Males	**2.258**	**1.074**	**1.71**	**0.087†**	**0.889**	**5.733**
Income [15-45K]	**11.470**	**12.100**	**2.31**	**0.021***	**1.451**	**90.676**
Income [45-75K]	**26.783**	**27.070**	**3.25**	**0.001****	**3.694**	**194.175**
Income [75K+]	**44.174**	**48.354**	**3.46**	**0.001****	**5.169**	**377.498**
Weekend	0.944	0.207	-0.26	0.791	0.614	1.451
Bad Driving	**0.623**	**0.130**	**-2.26**	**0.024***	**0.414**	**0.939**
Reckless	**1.629**	**0.334**	**2.38**	**0.017***	**1.090**	**2.436**
BCB-Temptation	**0.435**	**0.097**	**-3.73**	**0.000*****	**0.281**	**0.673**
Normative Beliefs	**2.427**	**0.380**	**5.66**	**0.000*****	**1.786**	**3.298**
Dangerous Driving	**0.507**	**0.121**	**-2.86**	**0.004****	**0.318**	**0.808**
ToD [12 a.m.-5 a.m.]	0.767	0.559	-0.36	0.716	0.184	3.198
ToD [9 a.m.-3 p.m.]	**1.627**	**0.366**	**2.17**	**0.030***	**1.047**	**2.527**
ToD [3 p.m.-7 p.m.]	**1.416**	**0.293**	**1.68**	**0.093†**	**0.944**	**2.124**
ToD [7 p.m.-12 a.m.]	0.900	0.256	-0.37	0.712	0.516	1.571
logFFT60	**3.494**	**0.419**	**10.43**	**0.000*****	**2.762**	**4.420**

***p<.001; **p<.01; *p<.05; †p<.10
Number of observations: 1128
Number of groups: 56

Wald chi2(17) = 138.29
Prob> chi2 = 0.0000

Demographic and Socioeconomic Variables: Compared to Older Females, Younger Males are at marginally increased odds of speeding. Although vehicle type and having a college degree did not influence speeding behavior, having any income above $15,000 significantly increased odds of speeding. However, these variables have very large standard errors, indicating small cell sizes.

Factor-Score Variables: The relationships between the dependent variable and the statistically significant factor-score variables are listed below. In particular, drivers that were at significantly increased odds of speeding during the study were associated with:

[Reckless] More frequently committing dangerous violations such as racing, driving drunk, and tailgating.

[Normative Beliefs] Reporting that their driving speed is greatly influenced by their friends, parents, children, spouses, and others.

In contrast, drivers that were at significantly decreased odds of speeding during the study were associated with:

[Bad Driving] More frequently making driving mistakes that show a lack of skill.

[BCB-Temptation] Being more likely to drive near the speed limit in situations when roadway factors provide temptation to speed.

[Dangerous Driving] More frequently engaging in dangerous driving habits in the past three months.

Trip Variables: The amount of free-flow time spent on 55-60 mph roads in a trip was associated with increased odds of speeding. Compared to driving during rush hour traffic, driving between 9 a.m. and 3 p.m. was associated with significantly increased odds of speeding. Driving between 3 p.m. and 7 p.m. also marginally increased odds of speeding.

Random Effects Logistic Regression with Demographic, Socioeconomic, Trip, and Factor-Score Variables: Texas 70 mph Roadways

The output from the regression analysis, showing the relationship between demographic, socioeconomic, trip, and factor-score variables and whether or not drivers had any speeding on 70 mph Texas roadways, is shown in Table 46 below. The trip variables, primarily used to control for differences in driving patterns, are shown in blue text. All other variables are shown in black. Variables shown in bold are either statistically significant or approaching statistical significance.

Table 46. Output from the logistic regression analysis showing the relationship between demographic, trip, and factor-score variables: Texas 70 mph roadways.

	Odds Ratio	Standard Error	z-score	p-value	[OR 95% Conf. Interval]	
Older Males	**0.400**	**0.216**	**-1.70**	**0.090†**	**0.139**	**1.153**
Younger Females	**0.294**	**0.159**	**-2.26**	**0.024***	**0.102**	**0.851**
Younger Males	0.594	0.366	-0.84	0.398	0.177	1.990
Truck or Sports Car	**2.224**	**0.887**	**2.00**	**0.045***	**1.018**	**4.862**
College Degree	**2.139**	**0.730**	**2.23**	**0.026***	**1.096**	**4.176**
Income [15-45K]	1.999	2.359	0.59	0.557	0.198	20.190
Income [45-75K]	1.991	2.168	0.63	0.527	0.236	16.819
Income [75K+]	4.936	5.543	1.42	0.155	0.547	44.587
Weekend	1.195	0.268	0.79	0.428	0.769	1.856
Reckless	**2.000**	**0.479**	**2.89**	**0.004****	**1.250**	**3.199**
Road Rage	**1.872**	**0.364**	**3.22**	**0.001****	**1.279**	**2.740**
Normative Beliefs	**1.670**	**0.292**	**2.93**	**0.003****	**1.185**	**2.353**
ToD [12 a.m.-5 a.m.]	0.360	0.412	-0.89	0.372	0.038	3.390
ToD [9 a.m.-3 p.m.]	1.090	0.261	0.36	0.719	0.681	1.745
ToD [3 p.m.-7 p.m.]	0.794	0.176	-1.04	0.299	0.514	1.227
ToD [7 p.m.-12 a.m.]	0.891	0.292	-0.35	0.725	0.468	1.695
logFFT70	**2.527**	**0.287**	**8.15**	**0.000*****	**2.022**	**3.157**

***p<.001; **p<.01; *p<.05; †p<.10
Number of observations: 1195
Number of groups: 52

Wald chi2(17) = 90.01
Prob> chi2 = 0.0000

Demographic and Socioeconomic Variables: Compared to Older Females, Younger Females are at significantly increased odds of speeding and Older Males are at marginally significantly increased odds of speeding. Having a college degree is associated with significantly increased odds of speeding, as is driving a truck or sports car compared to any other vehicle. While there are no significant differences between the reference group (under $15,000) and the income brackets shown here, when the model is run without dummy variables, the income variable is significant. Higher income significantly increased odds of speeding.

Factor-Score Variables: The relationships between the dependent variable and the statistically significant factor-score variables are listed below. In particular, drivers that were *at significantly increased odds* of speeding during the study were associated with:

[Reckless] More frequently committing dangerous violations such as racing, driving drunk, and tailgating.

[Road Rage] More frequently expressing hostile or angry actions towards other drivers.

[Normative Beliefs] Reporting that their driving speed is greatly influenced by their friends, parents, children, spouses, and others.

Trip Variables: The amount of free-flow time spent on 70 mph roads in a trip was associated with increased odds of speeding.

Linear Regression Models

The linear regression models were run using the dependent variable of the proportion of free-flow time in a trip that was speeding (i.e., who speeds the most?). The proportion of speeding provides a measure of the magnitude of speeding on individual trips. Only trips for which there was any speeding were included in this analysis, and the corresponding numbers of drivers in each demographic group that have any speeding in each speed band are shown in Table 47 below.

It should be noted that the regression models described in this section are likely comprised of a different set of drivers than the logistic regression models discussed above. In particular, the factors that are systematically associated with no speeding should be largely absent from the driver sample examined below. Accordingly, we would expect to see differences in predictors in comparison to the logistic regression models. However, some personal inventory factors may occur in both types of models (i.e., a behavior that mostly speeders do, but high-speeders do a lot more of).

Table 47. Numbers of drivers in each demographic group with speeding in each speed band.

Speed Band	Older Females	Older Males	Younger Females	Younger Males
Total Ss - Seattle	*21*	*25*	*21*	*21*
Seattle 30-35	17	22	19	18
Seattle 55-60	18	23	21	21
Total Ss - Texas	*19*	*16*	*21*	*20*
Texas 30-35	9	11	14	11
Texas 55-60	16	15	15	14
Texas 70	16	13	10	13

Compared to Table 30, the number of drivers included in the linear regression analyses is markedly lower since only drivers that had any speeding are included. This also resulted in a substantial reduction in the number of observations (i.e., trips), and a corresponding loss of statistical power. Given the exploratory nature of the current investigation, we compensated for the reduced power by using an alpha level of 0.10 was used as the criterion for reporting and discussing predictor variables in the linear regression models.

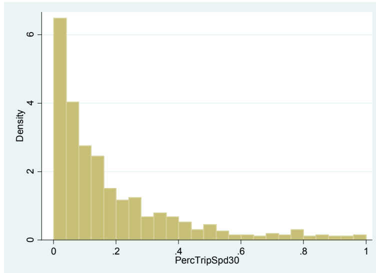
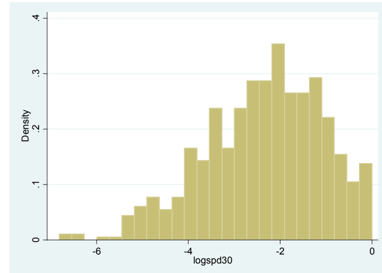
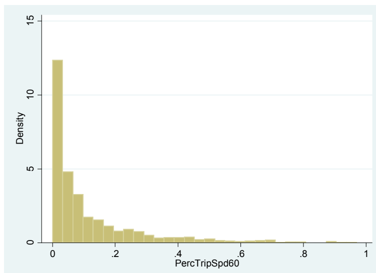
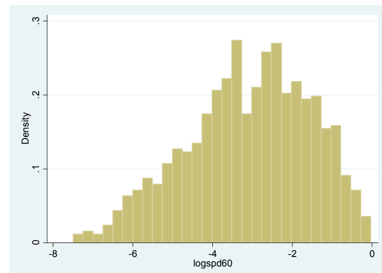
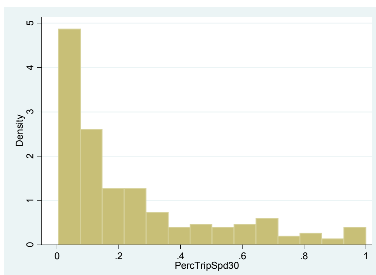
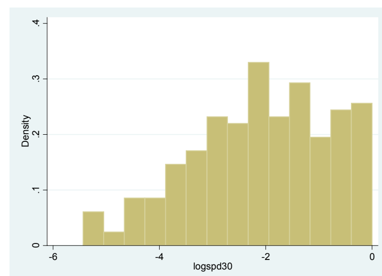
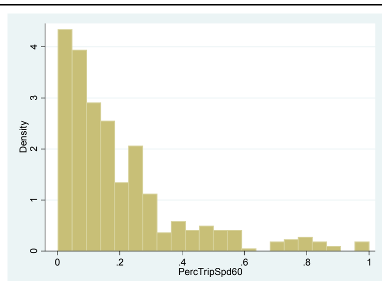
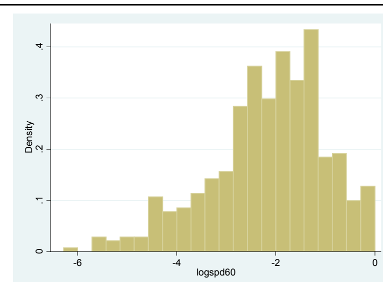
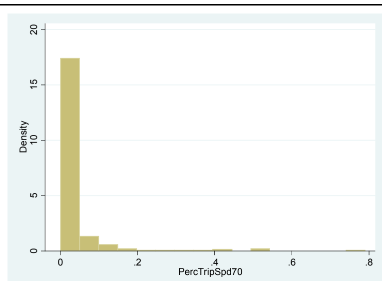
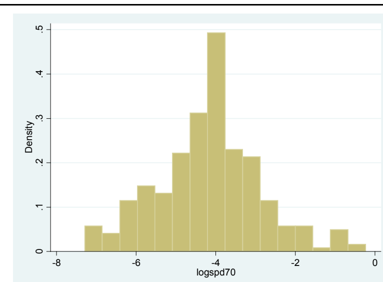
Separate linear regression models were run for each speed band. These are presented in the following sections. The overall findings are discussed in more detail at the end of the inferential statistics section.

Normality Assumption: Histograms of log transformed variables

Before calculating the linear models, we tested some of the underlying assumptions of the linear regression analyses. The dependent variable used in the linear models (proportion of free-flow time in a trip that was speeding) had a highly positively skewed distribution, as shown in the first column of Table 48 below. To correct for this, the dependent variable was log-transformed, which made the distributions more normal. Although this had a positive effect on the model, it made the magnitudes of the model coefficients difficult to interpret in a meaningful way. Consequently, the discussion of the model results is limited to the direction and significance-level of the effects.

One pattern, clearly indicated by the distributions shown in the first column of Table 48, is that most trips with any speeding have a relatively low proportion (less than 20%) of free-flow time on a trip that is classified as speeding. This pattern likely further limits the usefulness of the linear regression models for identifying significant predictors, in addition to the reduced statistical power from the lower N in this analysis described in the previous section.

Table 48. Graphs showing the transformations of the dependent variable: percentage trip speeding.

	Before Transformation	After Transformation
Seattle 30-35 mph (n=664)		
Seattle 55-60 mph (n=1012)		
Texas 30-35 mph (n=211)		
Texas 55-60 mph (n=493)		
Texas 70 mph (n=276)		

Random Effects Linear Regression with Demographic and Trip Variables: Seattle 30-35 mph Roadways

The output from the linear regression analysis, showing the relationship between demographic and trip variables, and the proportion of speeding on 30-35 mph Seattle roads in individual trips is shown in Table 49 below. The trip variables, primarily used to control for differences in driving patterns, are shown in blue text. All other variables are shown in black. Variables shown in bold are either statistically significant or approaching statistical significance. Note that the dependent variable (proportion of free-flow time in an individual trip that is speeding) is log transformed, which makes the magnitude of the coefficient difficult to interpret.

Table 49. Output from the linear regression analysis showing the relationship between demographic and trip variables and the proportion of free-flow driving that is speeding: Seattle 30-55 mph roadways.

logspd30	Coefficient	Standard Error	z-score	p-value	[95% Conf. Interval]	
Older Males	0.231	0.154	1.50	0.133	-0.071	0.534
Younger Females	0.137	0.151	0.91	0.365	-0.159	0.433
Younger Males	0.044	0.154	0.28	0.777	-0.257	0.345
Weekend	0.015	0.104	0.14	0.886	-0.189	0.219
ToD [12 a.m.-5 a.m.]	0.477	0.319	1.50	0.135	-0.148	1.103
ToD [9 a.m.-3 p.m.]	-0.143	0.145	-0.99	0.322	-0.426	0.140
ToD [3 p.m.-7 p.m.]	**-0.317**	**0.143**	**-2.21**	**0.027***	**-0.598**	**-0.036**
ToD [7 p.m.-12 a.m.]	-0.243	0.160	-1.52	0.128	-0.557	0.070
logFFT30	**-0.824**	**0.056**	**-14.76**	**0.000*****	**-0.933**	**-0.714**
Constant	**1.475**	**0.304**	**4.86**	**0.000*****	**0.880**	**2.070**

***p<.001; **p<.01; *p<.05; †p<.10
Number of observations: 656
Number of groups: 75
Wald chi2(9) = 241.46
Prob> chi2 = 0.0000

R-squared
Within = 0.2467
Between = 0.4353
Overall = 0.2778

Demographic Variables: No age and gender interactions significantly predicted any change in the logged speed variable.

Trip Variables: Driving between the hours of 3 p.m. and 7 p.m., compared to driving during morning rush hour, was significantly more likely to decrease the logged speed variable. As the time of free-flow time spent on 30-35mph roads in a trip increased one standard unit, the logged speeding variable decreased by one unit.

Random Effects Linear Regression with Demographic and Trip, Variables: Seattle 55-60 mph Roadways

The output from the linear regression analysis, showing the relationship between demographic and trip variables, and the proportion of speeding on 55-60 mph Seattle roads in individual trips is shown in Table 50 below. The trip variables, primarily used to control for differences in driving patterns, are shown in blue text. All other variables are shown in black. Variables shown in bold are either statistically significant or approaching statistical significance. Note that the dependent variable (proportion of free-flow time in an individual trip that is speeding) is log transformed, which makes the magnitude of the coefficient difficult to interpret.

Table 50. Output from the linear regression analysis showing the relationship between demographic and trip variables and the proportion of free-flow driving that is speeding: Seattle 55-60 mph roadways.

logspd60	Coefficient	Standard Error	z-score	p-value	[95% Conf. Interval]	
Older Males	0.020	0.326	0.06	0.950	-0.618	0.659
Younger Females	0.471	0.324	1.46	0.145	-0.163	1.105
Younger Males	0.483	0.326	1.48	0.139	-0.157	1.122
Weekend	**0.303**	**0.101**	**3.02**	**0.003****	**0.106**	**0.500**
ToD [12 a.m.-5 a.m.]	**-0.839**	**0.335**	**-2.50**	**0.012***	**-1.495**	**-0.182**
ToD [9 a.m.-3 p.m.]	0.015	0.129	0.12	0.908	-0.238	0.267
ToD [3 p.m.-7 p.m.]	0.171	0.129	1.32	0.186	-0.082	0.424
ToD [7 p.m.-12 a.m.]	0.003	0.148	0.02	0.983	-0.286	0.293
logFFT60	**-0.200**	**0.058**	**-3.46**	**0.001****	**-0.313**	**-0.086**
Constant	**-2.541**	**0.445**	**-5.71**	**0.000*****	**-3.414**	**-1.668**

***p<.001; **p<.01; *p<.05; †p<.10
Number of observations: 1012
Number of groups: 83
Wald chi2(9) = 38.72
Prob> chi2 = 0.0000

R-squared
Within = 0.0292
Between = 0.1681
Overall = 0.0648

Demographic Variables: No demographic variables significantly predicted a change in the logged speeding variable.

Trip Variables: Driving on the weekend significantly increased the logged speeding variable. Driving between 12 a.m. and 5 a.m., compared to morning rush hour, significantly decreased the logged speeding variable. Similarly, every unit increase of free-flow time spent on 55-60 mph roads (logFFT60) significantly decreased the dependent variable by one unit. Note that the dependent variable (proportion of free-flow time in an individual trip that is speeding) is log transformed, which makes the magnitude of the coefficient difficult to interpret.

Random Effects Linear Regression with Demographic and Trip Variables: Texas 30-35 mph Roadways

The output from the linear regression analysis, showing the relationship between demographic and trip variables, and the proportion of speeding on 30-35 mph Texas roads in individual trips is shown in Table 51 below. The trip variables, primarily used to control for differences in driving patterns, are shown in blue text. All other variables are shown in black. Variables shown in bold are either statistically significant or approaching statistical significance.

Table 51. Output from the linear regression analysis showing the relationship between demographic and trip variables and the proportion of free-flow driving that is speeding: Texas 30-35 mph roadways.

logspd30	Coefficient	Standard Error	z-score	p-value	[95% Conf. Interval]	
Older Males	0.144	0.325	0.44	0.659	-0.493	0.780
Younger Females	-0.195	0.313	-0.62	0.534	-0.808	0.419
Younger Males	0.482	0.340	1.42	0.157	-0.185	1.149
Weekend	-0.058	0.168	-0.35	0.730	-0.387	0.271
ToD [12 a.m.-5 a.m.]	(omitted) no speeding time					
ToD [9 a.m.-3 p.m.]	0.111	0.180	0.62	0.537	-0.241	0.463
ToD [3 p.m.-7 p.m.]	-0.054	0.193	-0.28	0.780	-0.433	0.325
ToD [7 p.m.-12 a.m.]	0.060	0.236	0.25	0.800	-0.402	0.522
logFFT30	**-0.862**	**0.102**	**-8.45**	**0.000*** **	**-1.063**	**-0.662**
Constant	**1.301**	**0.523**	**2.49**	**0.013***	**0.275**	**2.326**

***p<.001; **p<.01; *p<.05; †p<.10
Number of observations: 211
Number of groups: 45
Wald chi2(8) = 84.34
Prob> chi2 = 0.0000

R-squared
Within = 0.1977
Between = 0.4699
Overall = 0.4079

Demographic Variables: No demographic variables were significant.

Trip Variables: Neither time of day nor day of week significantly changed the logged speeding variable. Every unit increase in the amount of free-flow time spent on 30-35 mph Texas roads significantly decreased the speed by one unit.

Random Effects Linear Regression with Demographic and Trip Variables: Texas 55-60 mph Roadways

The output from the linear regression analysis, showing the relationship between demographic and trip variables, and the proportion of speeding on 55-60 mph Texas roads in individual trips is shown in Table 52 below. The trip variables, primarily used to control for differences in driving patterns, are shown in blue text. All other variables are shown in black. Variables shown in bold are either statistically significant or approaching statistical significance. Note that the dependent variable (proportion of free-flow time in an individual trip that is speeding) is log transformed, which makes the magnitude of the coefficient difficult to interpret.

Table 52. Output from the linear regression analysis showing the relationship between demographic and trip variables and the proportion of free-flow driving that is speeding: Texas 55-60 mph roadways.

logspd60	Coefficient	Standard Error	z-score	p-value	[95% Conf. Interval]	
Older Males	-0.247	0.306	-0.81	0.421	-0.847	0.354
Younger Females	-0.072	0.313	-0.23	0.818	-0.686	0.541
Younger Males	0.190	0.332	0.57	0.568	-0.462	0.841
Weekend	-0.010	0.118	-0.08	0.932	-0.242	0.222
ToD [12 a.m.-5 a.m.]	**-1.037**	**0.495**	**-2.10**	**0.036***	**-2.006**	**-0.067**
ToD [9 a.m.-3 p.m.]	0.105	0.125	0.84	0.400	-0.140	0.351
ToD [3 p.m.-7 p.m.]	-0.005	0.116	-0.04	0.968	-0.232	0.223
ToD [7 p.m.-12 a.m.]	-0.052	0.178	-0.29	0.770	-0.402	0.297
logFFT60	**-0.470**	**0.069**	**-6.78**	**0.000*****	**-0.606**	**-0.334**
Constant	0.012	0.422	0.03	0.977	-0.814	0.838

***p<.001; **p<.01; *p<.05; †p<.10
Number of observations: 493
Number of groups: 60
Wald chi2(11) = 58.23
Prob> chi2 = 0.0000

R-squared
Within = 0.0983
Between = 0.1867
Overall = 0.0558

Demographic Variables: No demographic variables were significant.

Trip Variables: Driving between the hours of 12 a.m. to 5 a.m., compared to driving during morning rush hour, was significantly more likely to decrease the logged speed variable. Every unit increase in the amount of free flow time spent on 55-60 mph Texas roads significantly decreased the speed by one unit.

Random Effects Linear Regression with Demographic and Trip Variables: Texas 70 mph Roadways

The output from the linear regression analysis, showing the relationship between demographic and trip variables, and the proportion of speeding on 70 mph Texas roads in individual trips is shown in Table 53 below. The trip variables, primarily used to control for differences in driving patterns, are shown in blue text. All other variables are shown in black. Variables shown in bold are either statistically significant or approaching statistical significance. Note that the dependent variable (proportion of free-flow time in an individual trip that is speeding) is log transformed, which makes the magnitude of the coefficient difficult to interpret.

Table 53. Output from the linear regression analysis showing the relationship between demographic and trip variables and the proportion of free-flow driving that is speeding: Texas 70 mph roadways.

logspd70	Coefficient	Standard Error	z-score	p-value	[95% Conf. Interval]	
Older Males	0.052	0.236	0.22	0.826	-0.411	0.515
Younger Females	0.075	0.268	0.28	0.779	-0.451	0.601
Younger Males	0.394	0.281	1.40	0.161	-0.157	0.944
Weekend	0.130	0.160	0.81	0.418	-0.184	0.444
ToD [12 a.m.-5 a.m.]	0.275	0.749	0.37	0.713	-1.193	1.743
ToD [9 a.m.-3 p.m.]	0.139	0.188	0.74	0.460	-0.230	0.508
ToD [3 p.m.-7 p.m.]	0.144	0.164	0.88	0.377	-0.176	0.465
ToD [7 p.m.-12 a.m.]	-0.194	0.257	-0.76	0.450	-0.697	0.309
logFFT70	**-0.861**	**0.078**	**-11.03**	**0.000*** **	**-1.014**	**-0.708**
Constant	0.804	0.523	1.54	0.124	-0.220	1.829

***p<.001; **p<.01; *p<.05; †p<.10
Number of observations: 276
Number of groups: 52
Wald chi2(10) = 140.43
Prob> chi2 = 0.0000

R-squared
Within = 0.2495
Between = 0.6409
Overall = 0.3798

Demographic Variables: No demographic variables were significant.

Trip Variables: Neither time of day, nor day of week significantly changed the logged speeding variable. Every unit increase in the amount of free-flow time spent on 70 mph Texas roads significantly decreased the speed by one unit.

The following sections present the results of the linear regression analyses that included the personal inventory factor scores and socioeconomic variables. Note that unlike the logistic regression analyses, none of the socioeconomic variables were significant predictors in any of the linear regression models.

Random Effects Linear Regression with Demographic, Socioeconomic, Trip, and Factor-Score Variables: Seattle 30-35 mph Roadways

The output from the linear regression analysis, showing the relationship between demographic, socioeconomic, trip, and factor-score variables, and the proportion of speeding on 30-35 mph Seattle roads in individual trips, is shown in Table 54 below. The trip variables, primarily used to control for differences in driving patterns, are shown in blue text. All other variables are shown in black. Variables shown in bold are either statistically significant or approaching statistical significance. Note that the dependent variable (proportion of free-flow time in an individual trip that is speeding) is log transformed, which makes the magnitude of the coefficient difficult to interpret.

Table 54. Output from the linear regression analysis showing the relationship between demographic, socioeconomic, trip, and factor-score variables and the proportion of free-flow driving that is speeding: Seattle 30-55 mph roadways.

logspd30	Coefficient	Standard Error	z-score	p-value	[95% Conf. Interval]	
Older Males	0.195	0.189	1.03	0.303	-0.176	0.566
Younger Females	0.074	0.192	0.38	0.701	-0.303	0.451
Younger Males	-0.110	0.191	-0.57	0.567	-0.485	0.265
Weekend	-0.005	0.112	-0.05	0.962	-0.225	0.214
BCB-Temptation	**-0.136**	**0.078**	**-1.73**	**0.084†**	**-0.289**	**0.018**
Subjective Norms	**-0.115**	**0.062**	**-1.86**	**0.063†**	**-0.236**	**0.006**
ToD [12 a.m.-5 a.m.]	-0.391	0.343	-1.14	0.255	-1.064	0.282
ToD [9 a.m.-3 p.m.]	**-0.561**	**0.328**	**-1.71**	**0.087†**	**-1.204**	**0.082**
ToD [3 p.m.-7 p.m.]	**-0.745**	**0.327**	**-2.28**	**0.023***	**-1.386**	**-0.104**
ToD [7 p.m.-12 a.m.]	**-0.655**	**0.332**	**-1.97**	**0.048***	**-1.306**	**-0.005**
logFFT30	**-0.841**	**0.063**	**-13.35**	**0.000*****	**-0.965**	**-0.718**
Constant	**1.992**	**0.457**	**4.36**	**0.000*****	**1.097**	**2.888**

***p<.001; **p<.01; *p<.05; †p<.10
Number of observations: 555
Number of groups: 65
Wald chi2(11) = 210.16
Prob> chi2 = 0.0000

R-squared
Within = 0.2493
Between = 0.4188
Overall = 0.2958

Demographic and Socioeconomic Variables: None of the demographic or socioeconomic variables were significant at the 0.10 alpha level.

Factor-Score Variables: The relationships between the dependent variable and the statistically significant factor-score variables are listed below. In particular, drivers who had a *lower* proportion of speeding per trip were associated with:

[BCB-Temptation] Being more likely to drive near the speed limit in situations when roadway factors provide temptation to speed.

[Subjective Norms] Stronger agreement that people who are important to them would approve of them driving near the speed limit.

Trip Variables: Greater amounts of free-flow time spent on 30-35 mph roads in a trip (logFFT30) were associated with less speeding. Compared to driving during morning rush hour traffic, driving at any point after 9 a.m. was associated with significantly less speeding.

Random Effects Linear Regression with Demographic, Socioeconomic, Trip, and Factor-Score Variables: Seattle 55-60 mph Roadways

The output from the linear regression analysis, showing the relationship between demographic, socioeconomic, trip, and factor-score variables, and the proportion of speeding on 55-60 mph Seattle roads in individual trips, is shown in Table 55 below. The trip variables, primarily used to control for differences in driving patterns, are shown in blue text. All other variables are shown in black. Variables shown in bold are either statistically significant or approaching statistical significance. Note that the dependent variable (proportion of free-flow time in an individual trip that is speeding) is log transformed, which makes the magnitude of the coefficient difficult to interpret.

Table 55. Output from the linear regression analysis showing the relationship between demographic, socioeconomic, trip, and factor-score variables and the proportion of free-flow driving that is speeding: Seattle 55-60 mph roadways.

logspd60	Coefficient	Standard Error	z-score	p-value	[95% Conf. Interval]	
Older Males	0.008	0.303	0.03	0.980	-0.587	0.602
Younger Females	-0.052	0.297	-0.17	0.862	-0.634	0.530
Younger Males	-0.248	0.296	-0.84	0.401	-0.828	0.332
Weekend	**0.365**	**0.105**	**3.47**	**0.001****	**0.159**	**0.571**
BCB-Temptation	**-0.560**	**0.125**	**-4.49**	**0.000*****	**-0.805**	**-0.316**
Subjective Norms	**-0.290**	**0.101**	**-2.88**	**0.004****	**-0.488**	**-0.092**
ToD [12 a.m.-5 a.m.]	**0.967**	**0.367**	**2.63**	**0.008****	**0.247**	**1.686**
ToD [9 a.m.-3 p.m.]	**0.991**	**0.359**	**2.76**	**0.006****	**0.287**	**1.695**
ToD [3 p.m.-7 p.m.]	**1.102**	**0.359**	**3.07**	**0.002****	**0.398**	**1.806**
ToD [7 p.m.-12 a.m.]	**0.951**	**0.365**	**2.61**	**0.009****	**0.237**	**1.666**
logFFT60	**-0.219**	**0.060**	**-3.63**	**0.000*****	**-0.336**	**-0.101**
Constant	**-3.110**	**0.563**	**-5.53**	**0.000*****	**-4.213**	**-2.007**

***p<.001; **p<.01; *p<.05; †p<.10
Number of observations: 900
Number of groups: 71
Wald chi2(11) = 66.47
Prob> chi2 = 0.0000

R-squared
Within = 0.0350
Between = 0.3039
Overall = 0.1966

Demographic and Socioeconomic Variables: None of the demographic or socioeconomic variables were significant at the 0.10 alpha level.

Factor-Score Variables: The relationships between the dependent variable and the statistically significant factor-score variables are listed below. In particular, drivers who had a *lower* proportion of speeding per trip were associated with:

[BCB-Temptation] Being more likely to drive near the speed limit in situations when roadway factors provide temptation to speed.

[Subjective Norms] Stronger agreement that people who are important to them would approve of them driving near the speed limit.

Trip Variables: Driving on the weekends significantly increased the logged speeding variable, as did all time variables compared to morning rush hour traffic. Greater amounts of free-flow time spent on 55-60 mph Seattle roads in a trip (logFFT60) were associated with less speeding.

Random Effects Linear Regression with Demographic, Socioeconomic, Trip, and Factor-Score Variables: Texas 30-35 mph Roadways

The output from the linear regression analysis, showing the relationship between demographic, socioeconomic, trip, and factor-score variables, and the proportion of speeding on 30-35 mph Texas roads in individual trips, is shown in Table 56 below. The trip variables, primarily used to control for differences in driving patterns, are shown in blue text. All other variables are shown in black. Variables shown in bold are either statistically significant or approaching statistical significance. Note that the dependent variable (proportion of free-flow time in an individual trip that is speeding) is log transformed, which makes the magnitude of the coefficient difficult to interpret.

Table 56. Output from the linear regression analysis showing the relationship between demographic, socioeconomic, trip, and factor-score variables and the proportion of free-flow driving that is speeding: Texas 30-55 mph roadways.

logspd30	Coefficient	Standard Error	z-score	p-value	[95% Conf. Interval]	
Older Males	-0.217	0.380	-0.57	0.569	-0.961	0.528
Younger Females	-0.261	0.355	-0.74	0.462	-0.956	0.434
Younger Males	0.461	0.345	1.34	0.182	-0.216	1.137
Weekend	-0.081	0.167	-0.48	0.628	-0.408	0.246
Reckless	**0.287**	**0.169**	**1.69**	**0.090†**	**-0.045**	**0.619**
Road Rage	**0.376**	**0.118**	**3.19**	**0.001****	**0.145**	**0.608**
Dangerous Driving	**-0.360**	**0.160**	**-2.26**	**0.024***	**-0.672**	**-0.047**
ToD [12 a.m.-5 a.m.]	Omitted (no speeding time)					
ToD [9 a.m.-3 p.m.]	0.081	0.187	0.43	0.664	-0.284	0.447
ToD [3 p.m.-7 p.m.]	-0.032	0.207	-0.16	0.877	-0.437	0.373
ToD [7 p.m.-12 a.m.]	0.074	0.239	0.31	0.758	-0.394	0.541
logFFT30	**-0.872**	**0.102**	**-8.51**	**0.000*****	**-1.073**	**-0.671**
Constant	**1.492**	**0.508**	**2.94**	**0.003****	**0.496**	**2.488**

***p<.001; **p<.01; *p<.05; †p<.10
Number of observations: 190
Number of groups: 39
Wald chi2(11) = 107.28
Prob> chi2 = 0.0000

R-squared
Within = 0.2080
Between = 0.5867
Overall = 0.5013

Demographic and Socioeconomic Variables: None of the demographic or socioeconomic variables were significant at the 0.10 alpha level.

Factor-Score Variables: The relationships between the dependent variable and the statistically significant factor-score variables are listed below. In particular, drivers who had a *higher* proportion of speeding per trip were associated with:

[Reckless] More frequently committing dangerous violations such as racing, driving drunk, and tailgating.

[Road Rage] More frequently expressing hostile or angry actions towards other drivers.

In contrast, drivers who had a *lower* proportion of speeding per trip were associated with:

[Dangerous Driving] More frequently engaging in dangerous driving habits in the past three months.

Trip Variables: Greater amounts of free-flow time spent on 30-35 mph Texas roads in a trip (logFFT30) were associated with less speeding. Time of day did not influence the model, and the early morning driving period was omitted due to collinearity.

Random Effects Linear Regression with Demographic, Socioeconomic, Trip, and Factor-Score Variables: Texas 55-60 mph Roadways

The output from the linear regression analysis, showing the relationship between demographic, socioeconomic, trip, and factor-score variables, and the proportion of speeding on 55-60 mph Texas roads in individual trips, is shown in Table 57 below. The trip variables, primarily used to control for differences in driving patterns, are shown in blue text. All other variables are shown in black. Variables shown in bold are either statistically significant or approaching statistical significance. Note that the dependent variable (proportion of free-flow time in an individual trip that is speeding) is log transformed, which makes the magnitude of the coefficient difficult to interpret.

Table 57. Output from the linear regression analysis showing the relationship between demographic, socioeconomic, trip, and factor-score variables and the proportion of free-flow driving that is speeding: Texas 55-60 mph roadways.

logspd60	Coefficient	Standard Error	z-score	p-value	[95% Conf. Interval]	
Older Males	0.018	0.314	0.06	0.953	-0.596	0.633
Younger Females	0.262	0.394	0.67	0.506	-0.510	1.033
Younger Males	0.019	0.352	0.05	0.956	-0.671	0.710
Weekend	0.122	0.139	0.88	0.380	-0.150	0.394
Bad Driving	**-0.300**	**0.169**	**-1.78**	**0.075†**	**-0.631**	**0.031**
Normative Beliefs	**0.325**	**0.124**	**2.63**	**0.009****	**0.082**	**0.568**
ToD [12 a.m.-5 a.m.]	**-1.052**	**0.509**	**-2.07**	**0.039***	**-2.049**	**-0.054**
ToD [9 a.m.-3 p.m.]	0.151	0.145	1.04	0.298	-0.133	0.434
ToD [3 p.m.-7 p.m.]	-0.027	0.136	-0.20	0.840	-0.294	0.239
ToD [7 p.m.-12 a.m.]	-0.014	0.197	-0.07	0.942	-0.401	0.372
logFFT60	**-0.458**	**0.081**	**-5.67**	**0.000*****	**-0.617**	**-0.300**
Constant	-0.205	0.496	-0.41	0.679	-1.177	0.767

***p<.001; **p<.01; *p<.05; †p<.10
Number of observations: 397
Number of groups: 46
Wald chi2(11) = 62.99
Prob> chi2 = 0.0000

R-squared
Within = 0.0966
Between = 0.3703
Overall = 0.1653

Demographic and Socioeconomic Variables: None of the demographic or socioeconomic variables were significant at the 0.10 alpha level.

Factor-Score Variables: The relationships between the dependent variable and the statistically significant factor-score variables are listed below. In particular, drivers who had a *higher* proportion of speeding per trip reported:

[Normative Beliefs] Reporting that their driving speed is greatly influenced by their friends, parents, children, spouses, and others.

In contrast, drivers who had a *lower* proportion of speeding per trip were associated with:

[Bad Driving] More frequently making driving mistakes that show a lack of skill.

Trip Variables: Neither time of day nor day of the week were associated with increased logged speeding. Greater amounts of free-flow time spent on 55-60 mph roads in a trip (logFFT60) were associated with less speeding.

Random Effects Linear Regression with Demographic, Socioeconomic, Trip, and Factor-Score Variables: Texas 70 mph Roadways

The output from the linear regression analysis, showing the relationship between demographic, socioeconomic, trip, and factor-score variables, and the proportion of speeding on 70 mph roads in individual trips, is shown in Table 58 below. The trip variables, primarily used to control for differences in driving patterns, are shown in blue text. Note that the dependent variable (proportion of free-flow time in an individual trip that is speeding) is log transformed, which makes the magnitude of the coefficient difficult to interpret.

Table 58. Output from the linear regression analysis showing the relationship between demographic, socioeconomic, trip, and factor-score variables and the proportion of free-flow driving that is speeding: Texas 70 mph roadways.

	Coefficient	Standard Error	z-score	p-value	[95% Conf. Interval]	
Older Males	0.052	0.236	0.22	0.826	-0.411	0.515
Younger Females	0.075	0.268	0.28	0.779	-0.451	0.601
Younger Males	0.394	0.281	1.40	0.161	-0.157	0.944
Weekend	0.130	0.160	0.81	0.418	-0.184	0.444
ToD [12 a.m.-5 a.m.]	-0.275	0.749	-0.37	0.713	-1.743	1.193
ToD [9 a.m.-3 p.m.]	-0.136	0.750	-0.18	0.856	-1.605	1.333
ToD [3 p.m.-7 p.m.]	-0.131	0.746	-0.18	0.861	-1.593	1.331
ToD [7 p.m.-12 a.m.]	-0.469	0.768	-0.61	0.541	-1.973	1.035
logFFT70	**-0.861**	**0.078**	**-11.03**	**0.000*** **	**-1.014**	**-0.708**
Constant	1.079	0.891	1.21	0.226	-0.666	2.825

***p<.001; **p<.01; *p<.05; †p<.10
Number of observations: 221
Number of groups: 44
Wald chi2(10) = 124.27
Prob> chi2 = 0.0000

R-squared
Within = 0.2726
Between = 0.6336
Overall = 0.4093

Demographic and Socioeconomic Variables: No demographic or socioeconomic variables are significant predictors of the logged speeding variable.

Factor-Score Variables: None of the factor-score variables were significant at the 0.10 alpha level.

Trip Variables: Neither the time of day nor the day of week variables were significant at the 0.10 alpha level. However, greater amounts of free-flow time spent on 70 mph roads in a trip (logFFT70) were associated with less speeding.

Summary of Regression Modeling

Note that in addition to the factor scores, the regression models that examined personal inventory factors were also run by entering individual question items in the same set of logistic and linear model. (These analyses are not included in this report.) Most of the models had several significant personal inventory items as predictors. In general, similar patterns as with the factors were obtained, including the finding that demographic categories become largely non-significant predictors with the addition of personal inventory items. Another similar finding was the unintuitive directionality of significant personal inventory factors in the Texas models. These personal inventory models were run with both the original untransformed item responses, and with these variables truncated or dichotomized to reduce skewing of the response distributions. The latter analyses yielded qualitatively similar models to those with untruncated item response distributions.

A summary of the regression modeling results reported in the previous sections is provided below. In particular, the models for the five speed-bands are combined into a single table for each type of regression, to facilitate direct comparisons of the findings. An abbreviated nomenclature is used to indicate which predictor variables are significantly greater than the comparison levels (i.e., Younger Male > Older Female means Younger Males were significantly more likely than Older Females to have any speeding in the logistic regression). In addition, to provide a better comparison of which personal inventory items are significant across models, each item was characterized using a brief phrase. More precise descriptions are available in the main inferential statistics results section and the complete personal inventory with response scales is provided in Appendix C in Volume III of this report.

Basic Logistic Regression: Who is Speeding?

A summary of the five logistic regression models conducted with trip and demographic variables is shown in Table 59 below. Because this is an exploratory study with a relatively small sample size, we have also included some variables in the tables that are borderline statistically significant at $p<.10$. This is useful for comparing results across analyses, especially since the linear regression models in later sections had lower statistical power because several drivers had to be excluded for having no speeding.

Table 59. Summary of the five logistic regression models conducted with trip and demographic variables.

	Seattle 30-35 mph	Seattle 55-60 mph	Texas 30-35 mph	Texas 55-60 mph	Texas 70 mph
Demographic Variables	– Younger Males > Older Females* – Younger Males > Older Males* – Younger Females > Older Females†	– Younger Males > Older Females** – Younger Males > Older Males* – Younger Females > Older Females** – Younger Females > Older Males**	– None	– Younger Males > Older Females**	– Younger Males > Older Females* – Older Males > Older Females† – Younger Males > Younger Females*
Trip Variables (MR=Morning Rush Hour)[a]	– Wkend > Wkday* – 9 a.m.-3 p.m. > MR†	– Wkend > Wkday** – MR > 12 a.m.-5 a.m.*** – 9 a.m.-3 p.m. > MR† – MR > 7 p.m.-12 a.m.†	– Wkend > Wkday* – MR > 9 a.m.-3 p.m.** – MR > 3 p.m.-7 p.m.** – MR > 7 p.m.-12 a.m.*	– None	– None

***p<.001; **p<.01; *p<.05; †p<.10

[a]logFFT (amount of Free-flow time per trip was significant in all models)

Demographic Variables: A general pattern in the logistic regression models is that Younger Males and Younger Females (in Seattle) are more likely than older drivers to have any speeding in a trip. This pattern is more consistent with Younger Males in both locations, and it appears that Younger Females may exhibit qualitatively different speeding behavior in Seattle and Texas (i.e., Younger Females drive more like Younger Males in Seattle, but more like Older Females in Texas).

Trip Variables: The odds of having any speeding are greater on weekend trips in the more built-up areas (Seattle and in-town Texas). There are also some time-of-day effects in these areas, in which there is more likely to be any speeding during the morning rush hour comparison time period than during certain other times (this finding is discussed later). An exception to this is the midday time period in Seattle, which sometimes is more likely to have speeding than the morning rush hour. Another pattern is that trip variables were not significant predictors on Texas high-speed roads (55-60 and 70 mph). This might reflect generally lower traffic volumes on these roads.

Logistic Regression with Personal Inventory Variables: Who Is Speeding?

A summary of the five logistic regression models conducted with demographic, socioeconomic, trip, and factor-score variables[9] is shown in Table 60 below.

[9] File names and descriptions of the factors obtained in the factor analysis are provided in Table 41.

Table 60. Summary of the five logistic regression models conducted with trip, demographic, and factor-score variables.

	Seattle 30-35 mph	Seattle 55-60 mph	Texas 30-35 mph	Texas 55-60 mph	Texas 70 mph
Demographic Variables	– Younger Males > Older Females** – Younger Females > Older Females**	– Younger Females > Older Females***	– None	– Younger Males > Older Females†	– Younger Females > Older Females* – Older Males > Older Females†
Socioeconomic Variables	– None	– Family Vehicle > Truck or Sports Car†	– None	– Income [15-45K] > Income [0-15K]* – Income [45-75K] > Income [0-15K]*** – Income [75K+] > Income [0-15K]***	– College Degree > No College Degree* – Truck or Sports Car > Family Vehicle*
Trip Variables (MR=Morning Rush Hour)[a]	– Wkend > Wkday†	– Wkend > Wkday** – MR > 12 a.m.-5 a.m.***	– Wkend>Wkday**	– 9 a.m.-3 p.m. > MR* – 3 p.m.-7 p.m. > MR†	– None
Factor score variables associated with *increased* odds of any speeding	– Reckless/Road Rage* – Inattention***	– Bad Driving*	– BB-Safety†	– Reckless* – Normative Beliefs***	– Reckless**[b] – Road Rage***[b] – Normative Beliefs**
Factor score variables associated with *decreased* odds of any speeding	– Subjective Norms† – CB-Opportunity***	– BCB-Temptation*** – Subjective Norms* – CB-Opportunity*	– None	– Bad Driving* – BCB-Temptation*** – Dangerous Driving**	– None

***p<.001; **p<.01; *p<.05; †p<.10

[a]logFFT (amount of Free-flow time per trip was significant in all models)

[b]Reckless and Road Rage were two separate factors in Texas

Demographic Variables: The inclusion of the socioeconomic variables and factor scores did not affect most of the significant demographic predictors in Seattle and Texas; however, some significant variables were eliminated on the high-speed roads in both locations (particularly young males). Additionally, when the socioeconomic and factor scores were considered, Younger Females emerged as significant relative to Older Females in the Texas 70 mph model.

Socioeconomic Variables: A range of socioeconomic variables were significant in the different speed bands. Owning a family vehicle was a significant predictor of decreased odds of any speeding 55-60 mph roadways in Seattle. Significant predictors of decreased odds of speeding in Texas were lower income, no college degree, and driving a family vehicle (70 mph speed band only).

Trip Variables: Fewer trip variables were significant than in the base models without the factor scores. The same pattern of significance for weekend trips still occurred. Also, the mid-morning time periods were significant in the Texas 55-60 mph speed band, and the evening time period began to approach significance.

Factor-Score Variables: Controlling for demographic variables, several factor-score variables were significant predictors of whether or not there was any speeding on a trip. As factor-score variables associated with increased odds of speeding, Reckless and/or Road Rage were significant in three of the five speed bands. On the higher speed roads in Texas, Normative Beliefs was also associated with increased odds of speeding. This may be an indication that drivers who reported being influenced by those individuals did not drive with them during the study.

Multiple factor scores were also associated with decreased odds of speeding. In Seattle, Subjective Norms (people who are important to them think they should keep near the speed limit) and CB-Opportunity (likely to drive the speed limit when there is a limited opportunity to speed) indicated decreased odds of speeding in both speed bands. Another interpretation of the latter finding is that those drivers who reported being likely to speed when there was not a good opportunity to do so, had greater odds of having any speeding on a trip. BCB-Temptation was a predictor in both 55-60 mph speed bands, indicating that drivers who indicated resisting the temptation to speed had lower odds of speeding. Bad Driving and Dangerous Driving also appeared on 55-60 mph roadways in Texas. This is a somewhat counterintuitive result, since Bad and Dangerous Driving suggest that poorer driving skills and dangerous driving habits indicate a decreased likelihood of speeding. However, it could also reflect the possibility that speeders believe that they are better drivers than everyone else.

These patterns illustrate a practical difficulty in broadly applying the current modeling approach in all of the speed-band conditions. In particular, drivers in Texas were more heterogeneous than in Seattle in terms of their driving patterns across participants. For example, Older Females did substantially more driving in outlying rural areas, while many younger drivers did most of their driving in-town on lower speed roads. However, the personal inventory questions do not make specific references to either driving environment. Thus, participants may answer the questions with one type of driving/speed band in mind (e.g., they may be cautious drivers in town on 30-35 mph roads), but if they behave differently in other driving environments/speed bands (e.g., driving faster to cover longer rural distances on 55-60 mph roads), those same questions could be associated with different types of behaviors. An example of this could be the Texas 55-60 model in which the Bad Driving factor was associated with decreased odds of speeding. The specific items associated with this factor (i.e., red-light running, missing yield signs, etc.) are actions that would be more commonly expected to occur in-town on 30-35 mph roads rather than on 55-60 mph roads in rural areas.

Basic Linear Regression: Who Speeds the Most?

A summary of the five linear regression models conducted with trip and demographic variables is shown in Table 61 below.

Table 61. Summary of the five linear regression models conducted with trip and demographic variables.

	Seattle 30-35 mph	Seattle 55-60 mph	Texas 30-35 mph	Texas 55-60 mph	Texas 70 mph
Demographic Variables	– None	– None	– None	– None	– None
Trip Variables (MR=Morning Rush Hour)[a]	– MR > 3 p.m.-7 p.m.*	– Wkend > Wkday** – MR > 12 a.m.-5 a.m.*	– None	– MR > 12 a.m.-5 a.m.*	– None

***p<.001; **p<.01; *p<.05; †p<.10

[a]logFFT (amount of Free-flow time per trip was significant in all models)

Demographic Variables: None of the demographic variables were significant predictors of the proportion of speeding on a trip. This finding is discussed further in the section on linear regression models with factor-score variables below.

Trip Variables: There is an inconsistent set of trip variables included across the speed bands at both sites. In Seattle and Texas on the 55-60 mph roadways, there was a higher proportion of speeding in morning rush hour trips than in nighttime trips. On 30-35 mph roadways in Seattle, there was a larger proportion of speeding during the morning rush hour than during the afternoon period. In the Seattle 55-60 mph speed band, trips taken on the weekend had more speeding than those during the weekdays, but otherwise this variable was not a significant predictor in other speed band models.

Linear Regression with Personal Inventory Variables: Who Speeds the Most?

A summary of the five linear regression models conducted with demographic, socioeconomic, trip, and personal inventory variables is shown in Table 62 below.

Table 62. Summary of the five linear regression models conducted with trip, demographic, and factor-score variables.

	Seattle 30-35 mph	Seattle 55-60 mph	Texas 30-35 mph	Texas 55-60 mph	Texas 70 mph
Demographic Variables	– None	– None	– None	– None	– None
Socioeconomic Variables	– None	– None	– None	– None	– None
Trip Variables (MR= Morning Rush Hour)[a]	– MR > 9 a.m.-3 p.m.† – MR > 3 p.m.-7 p.m.* – MR>7 p.m.-12 a.m.*	– Wkend > Wkday*** – 12 a.m.-5 a.m. > MR** – 9 a.m.-3 p.m. > MR** – 3 p.m.-7 p.m. > MR** – 7 p.m.-12 a.m. > MR**	– None	– MR > 12 a.m.-5 a.m.*	– None
Factor variables associated with *larger* proportion of any speeding:	– None	– None	– Reckless† – Road Rage***	– Normative Beliefs**	– None
Factor variables associated with *smaller* proportion of any speeding:	– BCB-Temptation† – Subjective Norms†	– BCB-Temptation*** – Subjective Norms**	– Dangerous Driving*	– Bad Driving†	– None

***p<.001; **p<.01; *p<.05; †p<.10

[a]logFFT (amount of Free-flow time per trip was significant in all models)

Demographic variables: The demographic variables were poor predictors of the proportion of speeding in a trip. Part of this may arise from the loss of statistical power that occurred once drivers and trips with no speeding were removed from the data set. However, another factor may be that the set of “high speeders” in each location contains drivers from all demographic categories, as seen in Figure 29 (found on page 60) and in Figure 48 (found on page 86) from the descriptive statistics section. Similarly, Table 19 (found on page 59) and Table 27 (found on page 86), which report the average speeding within each demographic group (counting only trips with any speeding), shows that there are no clear patterns with regard to the magnitude of this measure. Taken together, this pattern of results suggests that the factors that predict how much speeding a driver does are more complicated than a simple demographic-category membership.

Socioeconomic Variables: None of the socioeconomic variables were significant predictors of the proportion of speeding.

Trip Variables: In Seattle, more of the trip variables were significant in the linear regressions, whereas in Texas they stayed the same. For the time-of-day variables in Seattle, more time periods were associated with a decreased proportion of speeding compared to morning rush hour, on 30-35 mph roadways. This may be related to the type of trips that drivers make during this time. In particular, drivers going to work may be under greater pressure to avoid being late and consequently more willing to drive faster if they get any opportunity to do so. However, on the 55-60 mph roadways in Seattle, driving at other times was associated with more speeding than driving during morning rush hour.

Factor-Score Variables: Most of the models had factor variables that were significant predictors of the proportion of speeding during a trip. Many of these variables are the same as they are in the logistic regression models, though in general the majority of the factors from the logistic regression models were not significant in the linear regression models. In Seattle, both speed bands had the same predictive factors. BCB-Temptation (resisting temptation to speed) and Subjective Norms (people who are important to them think they should keep near the speed limit) predicted a smaller proportion of speeding. The Texas 30-35 mph model showed that the Reckless factor (dangerous violations) and Road Rage (hostility and anger toward others) both predicted a greater proportion of speeding, while Dangerous Driving (dangerous driving habits) predicted a smaller proportion of speeding. The inclusion of Dangerous Driving as a predictor of a decreased proportion of speeding is counterintuitive.

Another finding is that the Texas 70 mph model had no significant factor predictor variables. This suggests that different types of variables may be stronger predictors of the proportion of speeding on these roads (i.e., geometry, roadway design, driving comfort, vehicle power) than the ones investigated in the current analysis.

Chapter 4: Focus Groups

Introduction

In Phase 2 of the Motivations for Speeding project, Focus groups were conducted to gain insight about drivers' attitudes, beliefs, and motivations regarding speeding. The focus groups also gathered data on driver opinions about the challenges and benefits of various countermeasures to identify those that would be most effective with both risky speeders and opportunistic speeders. The objectives for the focus groups were to:

Add to our understanding of speeding and speeders, over and above what was learned in Phase 1.

Develop a more accurate taxonomy of high/low speed driver subgroups.

Better understand the motives—as well as attitudes and habits—of these subgroups.

Explore attitudes and behavioral influences pertinent to various countermeasures (e.g., increased enforcement, engineering and in-vehicle countermeasures, automated enforcement, and speed awareness courses) as well as the acceptance and potential effectiveness of the countermeasures.

Descriptions of key motivations, attitudes, normative commitment to law, driving habits relevant to speeding and speeding countermeasures.

These objectives were addressed in four focus groups held in the two on-road data collection locations (two in each location) using drivers that participated in Phase 1 of this project. As best as possible, the sessions at each location were separated by speeder type. The methodology and findings are further discussed in the sections below.

Methods

This section describes the methods used to conduct and analyze the focus group data.

Participants

Four focus group discussions were held, including two at each of the rural (College Station, TX) and urban (Seattle, WA) data collection sites. Note that the goal was to have four groups in each location, but due to the length of time since the initial data collection phase, many drivers were unavailable for participation in this phase of the project. In each location, the objective was to have one focus group session of mostly speeders, and another of mostly non-speeders for comparison. Focus group participants were selected from the pool of drivers who participated in the on-road data collection phase of the study. The reason for this selection method is that we wanted to group participants based on observed speeding behavior.

A key challenge in populating the focus groups was determining how to identify drivers as speeders or non-speeders. After considering a variety of approaches, we used a simple method to assign drivers to the low and high speeder groups. More specifically, drivers were sorted based on the percentage of their trips with any speeding because this was our best measure of chronic/persistent speeding behavior. This is the most appropriate type of speeding behavior to discuss reliably in a focus group.

We rank ordered drivers in each speed band to sort them into speeders and non/low-speeders. We settled on a rank-order approach to compensate for substantial variability in ranges across speed bands. Then, an ultimate rank was found by taking the maximum rank out of all of the speed band rankings. The listing of ultimate ranks was used to form driver groups. General descriptions of the groups are:

Non/low speeders: Drivers who had the least speeding *in all* speed bands were low speeders

High speeders: Drivers who had the most speeding *in any* band were high speeders

To form our focus groups at each site, we started at each end of the full list (representing the lowest speeders at one end and the highest at the other), and worked our way towards the middle. We tried to leave out the middle third in both locations since the drivers in the middle have inconsistent or mixed behaviors. The resultant participant demographics from each group are shown in the table below. Note that the young drivers in Texas were very difficult to obtain because most had moved away from the area. This is one of the reasons why the numbers are lower for the Texas non-speeder group.

Each focus group was comprised of up to 13 adult, licensed drivers. Table 63 below shows the actual demographic composition of the sessions.

Table 63. Demographic composition of each focus group.

Session	Group Type	Females		Males		Total
		Older	*Younger*	*Older*	*Younger*	
Seattle, Jun 9, 2 p.m.	Non-Speeder	8	0	4	0	12
Seattle, Jun 9, 6 p.m.	Speeder	3	3	1	4	11
College Station TX, Jun 14, 6 p.m.	Speeder	3	2	5	3	13
College Station TX, Jun 15, 6 p.m.	Non-Speeder	4	1	1	0	6
	Total	18	6	11	7	42

Transcription Abbreviations

To simplify the transcription of the focus groups, a four-letter acronym was used to attribute each quote to a region, demographic group, and speeder type. The key to the acronyms is as follows.

First letter: Region (S for Seattle, T for Texas)

Second letter: Age group (Y for Younger, O for Older)

Third letter: Gender (F for Female, M for Male)

Fourth letter: Speeder type (S for Speeder, N for Non-speeder)

Each quote is followed by a combination of these four letters to attribute it to a speaker. An exception to this classification is in the speeder type category. Participants were assigned to a focus group based on their driving data, so they were all assigned a letter consistent with the focus group that they attended. For example, all of the participants who attended the non-speeder focus group were assigned an "N." However, in both of the Seattle focus groups, one individual attended who had views consistent with the opposite group. One female in the speeder group had been in a speed-related crash following the study and therefore had vastly different views about speeding (even though her driving data indicated that she was a speeder during data collection). Likewise, there was a comparable participant in the non-speeder group. When these two individuals are quoted, they are assigned a letter consistent with the group they attended, but also are marked with an asterisk to indicate their opposing views.

Focus Group Activities

The focus group sessions included the following activities

1. Opening/introduction
2. Warm-up exercise
3. General discussions of speed choices and speeding behaviors, and the factors that influence them
4. Discussions of beliefs and attitudes toward speeding
5. Individual/group responses to various speeding countermeasures, including:
    a) Higher penalties and increased enforcement
    b) Engineering countermeasures
    c) Vehicle-based countermeasures
    d) Automatic enforcement
    e) Speed awareness course

The Moderator Guide for the focus groups is provided in Appendix G.

Data Analysis

The "raw data" in the analyses were the words, phrases, sentences, and nonverbal responses of the focus group participants, and the analyses followed an approach similar to ones Battelle has used in previous focus group research (Richard & Lichty, 2011; Richard, Michaels, & Campbell, 2005). Focus group sessions were attended by a moderator and another researcher who acted primarily as an observer/note-taker and helped with focus group materials. Both these personnel were responsible for the analysis and they examined all data (video recordings, notes, post-session summaries) for patterns emerging from participant discussions. To analyze and summarize the focus group discussions, researchers:

Developed a summary of each focus group session organized around the key questions/issues addressed during each session. This involved recording individual participant comments that pertained to topics of interest.

Contributed interpretations and inferences; pointed out any possible biases and contradictions.

Reviewed video recordings of the focus groups.

Performed a content analysis on the relevant participant comments.

Compiled key findings in a results summary.

Results

The focus group findings are separated into three sections. The first section covers driver opinions of travel speed, while the second describes driver views regarding specific factors that affect travel speed. The third section covers driver responses to the countermeasures discussed in the focus group sessions.

Note that this organization represents somewhat of a departure from the specific questions asked in the Moderator's Guide (see Appendix G in Volume III). The reasons for taking this approach are that respondents blurred the distinction between several of the questions and different themes emerged during discussion. Therefore, the comments are organized by theme rather than by the specific questions to which each comment was associated. Also, the discussions related to travel speed and speed choice were organized more in line with the behavioral framework that was used as the rationale for selecting the speeding thresholds in the quantitative data analysis component of this project. The broad topics covered by the focus groups include:

Self-Reported Travel Speeds

Interpretation of Posted Speed

Perception of Ticket Speed

Perception of Safe Speed

Factors that Increase Driver Travel Speed

Factors that Decrease Driver Travel Speed

Countermeasure Discussions

- Higher Penalties and Increased Enforcement
- Engineering Countermeasures
- Vehicle-based Countermeasures
- Automatic Enforcement
- Speed Awareness Course
- Driver-Mentioned Countermeasures

Summary of Countermeasure Discussions

Driver opinions on selected topics are presented in the following sections as specific quotes. The quotes should be read while keeping in mind the relatively small number of focus group sessions held. Because of this, quotes and themes that were voiced by only a few individuals appear in the analysis, whereas with a greater number of sessions they would have been washed out by the larger and more widespread views. Therefore, some of the quotes may not represent a large segment of the driving population, but it was not possible to identify and properly weight these based on the small sample of opinions obtained.

Self-Reported Travel Speeds

Drivers were asked approximately how fast they typically traveled relative to the posted speed. The Seattle groups differed in terms of their self-reported speeds, depending on their speeding behavior, while the Texas drivers had more homogenous self-reported behavior.

In the Seattle speeding group, only one driver indicated she usually drove at or below the posted speed. The rest reported driving at 4-8 mph above on lower speed roads and 8-15 mph above on freeways.

"I usually go 4 over, except on highway driving where I go faster—10, 15 over usually." —SYFS

"I go about 8 over—as a rule—even on a back road. If it's a 35, I'm not going any higher than 43." —SOMS

In contrast, the non-speeders in Seattle were more likely to report driving at or near the posted speed. These comments were often associated with specific reasons for not speeding.

"I'm convinced that unless you are seriously speeding, you don't get anywhere any faster. So I almost never speed." —SOMN

"I stick to the speed limit 99% of the time because there is this stress factor that comes with speeding, where you have to worry about police around the corner, or being unsafe. I've just come to accept that if I'm going to be 5 minutes late, I'm going to be late, but at least I'll be alive." —SOFN

In contrast to the Seattle groups, both the speeder and non-speeder groups in Texas reported a range of travel speeds, from 5 mph below to 2-5 mph over the posted speed.

"About five miles an hour each way (over or under)." —TOMS

"I drive 5 miles below the speed limit. It lowers the gas bill and just requires me to plan further ahead." —TOMN

"I usually drive 2-3 miles over the speed limit" —TOFN

A dominant theme in driver discussions about their travel speeds was the type of road. Drivers in all groups indicated that they were more willing to speed on freeways or other high-speed roads than on residential roads.

"I'm more willing to speed on the freeway." —TYMS

"I would say that if I consistently speed, it's on the highway. But occasionally I will speed on residential roads because it is difficult to maintain the low speed limit, especially after I've been on the highway." —TOFN

"It just very much depends on the road. On major freeways, if there is no traffic, 80 [20 above] is pretty easy. On Aurora [major arterial], it's so easy to go 60 even though the speed limit is 40. Then on side streets, it's kind of hard to speed with pedestrians, buses, and cyclists." —SYMS

"Neighborhoods are not a good place to be going over the speed limit. The city does not keep the trees trimmed, and you can't see all the signs." —SOFS

In summary, drivers select a range of travel speeds, and their selection criterion strongly depends on road type.

Interpretation of Posted Speed

There were differences in how some drivers interpreted the posted speed. In particular, the most common views were that the posted speed was either a maximum speed (firm limit), a target speed, or more of a minimum speed.

Drivers in all groups understood the posted speed technically to be a maximum speed, and non-speeders in both locations reported that they considered it to be a hard limit.

*"That's where you stop, and you don't go any faster." —SOFS**

"It's the maximum. If it says 35, then I don't go past 35." —SOFN

"I consider it the limit (maximum)." —TOFN

"To me the posted speed limit is the number you can go in optimal conditions. Then if I go above that, I'm running my own risk at that point. It's more like a maximum. You are going to get in trouble if you are going above it." —SYMS

A contrasting view, shared by drivers in all groups, was that the posted speed was more of a target speed than a maximum.

"I see the speed limit as more of a target than a maximum. I try to keep within a range of it." —TOMS

"I interpret it as the maximum speed you are supposed to travel. In neighborhoods and residential areas, that's what I drive. But when I am on the highway, I understand that it is still a maximum, but I tend to try to be within 5 to 10 mph of that speed." —SOFN

"I know it's supposed to mean a limit. As fast as you can go. But I don't really take it that way. I take 35 to mean 40." —SOFS

A related view that was only mentioned in the speeder groups was that the posted speed was more of a minimum speed.

"Depending on the road type and conditions, I sometimes regard the posted speed as a minimum. If it's an Interstate I'm always going to be above it. It's usually my base point and then I work up from there." —TOMS

"I consider it a minimum." —TOFS

"It means that's how fast the worst drivers should drive." —SYMS

In summary, the posted speed is technically perceived as a limit, but drivers have different interpretations of how fast it means they can drive.

Perception of Ticket Speed

Almost all drivers believed that they could exceed the posted speed before they would have to worry about getting a speeding ticket. However, there were differences in opinions regarding how far above the posted speed they could travel (referred to as the Ticket Speed), especially on different types of roads. Interestingly, both speeders and non-speeders had similar views regarding speeds at which there was an increased risk of getting a speeding ticket. Drivers also had different views based on the type of roadway (discussed separately below).

On low-speed roads:

"I think you could go four miles over on a 35 and be okay." —SOFN (most drivers agreed)*

"On a 35 I would not be nervous going 40, but I would going 44." —Most Seattle Speeders and Non-speeders

"Depends on where you're at - if you're going 5 mph over in a residential area you're probably going to get a ticket" —TYFN

On high-speed roads:

"Reasonably you can get a ticket any time you are going 5 mph over the speed limit. But it is much less likely that you will get one in the 5-10 mph [over the posted speed] range on freeways." —SOFN

"I would say less than 10 [mph above the posted speed before worrying about a ticket]." —TOMS

"If I'm intentionally speeding on the highway, I try to keep it within 10 miles." —SOFN

Some drivers viewed the threshold for getting a speeding ticket as being proportional to the posted speed.

"Ten% rule; 45 mph limit I'd probably stick pretty close, but 50 mph and above I would go 5 over." —TYMS

"It's definitely proportional. For higher speed roads (60 mph) you can get away with more." —SOFN

"I drive by police when I'm going 40 in a 35 all the time. If it is 25 and you are going 5 over it's definitely risky, but every 10 mph you add, you can go another 1 or 2 mph over." —SYMS

In summary, drivers thought that, while they could technically get a ticket for driving any speed above the posted speed, the threshold for ticketing is generally proportional to the posted speed.

Perception of Safe Speed

Some drivers in most groups mentioned the relationship between speeding and safety. As their speed increases, their safety risk generally increases. However, drivers also mentioned that the posted speed did not reflect their judgment of a safe speed.

*"The faster you go, your risks go up. You could blow a tire or roll your car. Things can jump out in front of you. The faster you are going, the less chance of keeping control of your car." —SOFS**

"The result if something does happen—the damage done and injuries incurred get exponentially higher for every 5mph, 10mph." —TOMN

"You really shouldn't be going more than 5 miles over the limit. You have to be cognizant of your surroundings and the environment and what's going on. More than 5 miles an hour over feels dangerous to me. It's hard to control your vehicle at high speeds." —TOFS

"For me it's an incremental thing. I recognize that the faster you go, the higher your risk. I really look at it as someone has done some studies about speed and that information goes into setting the speed limit." —SOFN

However, drivers in all groups believed that there was often a disconnect between the posted speed/ticket speed, and how fast they thought they could safely travel.

"Generally when I see a speed limit sign, the reason I check my speed is to avoid getting a ticket, rather than am I driving safely, because I already feel like I'm driving at a safe speed." —SOMN

"Most times, driving 5 mph above the speed limit doesn't seem any less safe. There are times on Aurora that I feel safe driving 60 on a 40. The lanes are wide and there are no side streets for miles. To me that [posted] speed is ridiculously low for the conditions." —SOMN

"Anything can happen even if you didn't speed, so is 2-3 mph over the limit significantly increasing your risk? I'd say no." —TOFN

"I can hold at 80 mph all day. Most of the major highways are good for it. I mean, they're straight shots. There are no visibility problems, they're not in neighborhoods. I think on a highway I could easily drive 80 mph for a long time and not think much about it." —TOMS

In summary, travel speed was seen as related to safety risk, but safety speed was not the same as the posted speed or Ticket Speed.

Factors that Increase Driver Travel Speed

Drivers identified a few factors that caused them to drive faster. These included situational or trip-specific factors, social pressure from other drivers, inattention to driving, and positive feelings about driving fast. These factors are described in more detail below.

Situational Factors

There were multiple situational or trip-level factors mentioned by drivers. These factors apply to individual trips, and do not necessarily reflect behaviors that are persistent across trips.

A couple of drivers said that they become more aware of their driving speed when they are in a hurry.

"It also depends on if I'm in work mode or just traveling. If I'm not really in a hurry, I'm a better and safer driver." —TOFS

"Depends if I need to be 10 minutes away in 8 minutes. Then I'm really aware of [slow driving]. Usually the cars in front of me are all going 5 mph under the speed limit." —SOFS

Other drivers mentioned trip length and driving environment as situational factors that promote speeding

"If I'm on a long trip versus just commuting to work or running errands, I will push the speed limit because I can actually make up some travel time. On little short runs, going fast doesn't really gain me anything because you're being stopped by stoplights and traffic. But on long trips where I'm on the interstate for a long time I tend to push the speed a little more, depending on road conditions. There going a little faster is an advantage." —TOMS

"Often when I would get on the freeway for a long trip, I would realize that I'm doing 90, but it didn't seem like it because the cars around me were still passing me." —SOMN

"I grew up in a rural area. Technically the speed limit was 25, but all of the roads around there were 55, so no one was going close to 25. There's no police around, there's no people around, you can go that fast on the road, they don't seem any different than the 55 roads. It just doesn't seem practical to go 25 when there is no one around and you are on an open road." —SYMS

In summary, situational factors apply to only trips with certain qualities and can cause a driver to speed.

Social Pressure

Social pressure was described as a source of both increased speeding behavior and decreased speeding behavior, depending on the situation, and who was influencing the driver. Situations related to speed increases are described below.

The primary source of social pressure to drive faster originates from other vehicles on the roadway. Some drivers, especially non-speeders, feel the need to speed to stay out of the way of others who are speeding or to keep up with the flow of traffic. With at least that one driver, there was the sense that following the flow of traffic was safe in terms of ticket risk. Some other non-speeders mentioned the pressure of keeping up with traffic.

> *"I don't like to drive in the first or second lane of the freeway, because people are getting on and off, and I feel like you almost have to speed if you are in the left lanes, otherwise you are just in everyone's way." —SOMN*

> *"It can be a challenge to stay within 5-10 mph above the speed limit in the HOV lanes, because it is usually more open than the other lanes, and other cars stack up behind you because they want to go faster. Here, you can't just move out of the lane because the regular lanes are moving too slow." —SOFN*

> *"On the highway, I go as fast as the traffic's going. I'm not going to get run over." —TOMS*

> *"Sometimes if I am in the slow lane going the speed limit and everyone is passing me, I don't feel as safe as I do going with the flow of traffic. If I'm going with the flow, I'm also not too worried about getting a ticket either." —SOFN*

Some other drivers used traffic flow as a metric when asked how fast they could go before worrying about getting a ticket.

> *"Depends on where you're at. If you're on Interstate 45 and the speed limit is 70, everybody else is probably not too worried about it. I'd follow traffic." —TOMS*

> *"I don't seem to watch for [posted speed signs], even though I care. I've never gotten a ticket for going with the flow of traffic." —SOFS*

Overall, most of the discussion of social pressure encouraging speeding came from the Seattle focus groups. This could be due to the increased level of traffic in Seattle and the amount of driving done on multilane freeways. Additionally, it seemed that the Seattle speeders generally describe traffic flow as something to which they are bound. That is, they feel the need to keep up with traffic, and if that requires speeding, then they feel that it is appropriate. They also describe speeding as necessary to stay out of everyone's way and avoid cars stacking up behind them.

In summary, social pressure (primarily mentioned in Seattle) seems to obligate many drivers to follow traffic flow, but at the same time provides a sense of protection from speeding tickets.

Inattention

A related behavior that increased speeding was inattention. Drivers can end up going too fast because they are paying less attention to their speed. The factors that were mentioned as contributing inattention-related speeding include traffic flow, a powerful vehicle, or other in-vehicle distractions such as music.

The most common inattention-related factor was getting caught up in freeway traffic, or just going with the traffic flow.

> *"I just go with the flow of traffic. I might be going 15-20 over. I'm usually not aware." —SYMS*

"I tend to first go with the flow of traffic. If I realize that I'm passing a bunch of people, that's when I'll pay attention. Or if I feel like I'm going really slow, which might be when I'm in a hurry, that's when I'm aware. But the majority of the time, like on the freeway, you just have to go with the flow of traffic." —SYFS

"I drive with the traffic and sometimes I look down and I'm going over the speed limit so I slow down." —TOFN

"I am afraid to go over the speed limit, but sometimes I catch myself doing it unintentionally." —TOFN

"When I have someone in the car, I'm not paying attention to how fast I'm driving, and I kind of have a lead foot, so I end up driving a little faster." —SYFS

One driver expressed how his passenger and listening to music caused him to increase his speed.

"I tend to go faster when my 23 year-old son is in the car and we're listening to his music." —TOMS

One driver quoted above described how a more powerful vehicle increased her speeding behavior without her realizing it. This could mean that she is not receiving the same indications from her vehicle that it is going fast.

"If I'm driving my son's mustang or my husband's truck, then I can go faster without realizing it, so I really have to pay attention." —TOFN

In summary, drivers who lapse into inattention commonly fall into pace with the traffic flow, even if that means speeding.

Feels Good

There were a few drivers who mentioned that they enjoyed speeding because it felt good. These attitudes seem to reflect thrill seeking or sensation seeking behavior.

*"I'm a very courteous driver, but I like to go fast. It's just the rush of it." —SOFN**

"Driving fast is fun. It's like going on a roller coaster. No amount of rule changes that they are going to do are really going to stop people. If people are in a hurry, they are going to drive as fast as they can." —SYMS

"I used to be a speeder. It was a rush and there was the thrill of going fast, and I had a sports car. But now I have a mini-van." —SOFN

Factors that Decrease Driver Travel Speed

Focus group participants also identified several factors that made them less likely to speed. These included ticket or crash risks, social pressure, and critical events that they had experienced in the past. These factors are described in more detail below.

Ticket Risk

Many drivers noted that a heightened awareness of the risk of getting a speeding ticket reduces their speeding behavior.

Clearly seeing a police officer made some drivers in both Seattle and Texas more aware of their speed.

"[I am more aware of my speed] when I pass a highway patrolman." —TOMS

"[I am more aware of my speed] when I see someone else pulled over on the road." —TYMS

However, just anticipating where police officers might be seemed to also be effective. Several drivers noted that they know where the officers patrol and they purposefully slow down when driving through those areas.

"If you take the same route every day, you know where the police wait. There is a State patrol by my house. I go 60 mph past that and then speed up once I'm past." —SYMS

"Within my town, I'll stick within a mile or two of the [posted speed] on 25 and 35 mph roads because they are notoriously patrolled and I think that is where they get 50% of their [town's] revenue." —SOMN

*"The only time I'm usually aware of my speed is if I know there is a police officer ahead, or if it's a known place where they hide. I'll look down and see how fast I'm going, but I often times have no idea how fast I'm going." —SOFN**

Speed cameras also received similar mention by drivers.

"If I see a lot of cameras, I'll slow down. Other than that, I'm always above the speed limit." —SYMS

"I don't speed in the school zone in Lynnwood. They have too many cameras there." —SYMS

In summary, drivers reported that the presence of active, passive, or expected enforcement decreased their travel speeds.

Implications for Countermeasures

It is clear that the perceived risk of getting a speeding ticket influences drivers' speeding behavior. Although a few drivers mentioned that actually seeing an officer makes them more aware or decrease their speed, for several drivers, knowing that they are approaching a speed trap or location that is patrolled often is enough to make them slow down.

Crash Risk

Drivers also discussed the impact of perceived crash risk when speeding. Drivers felt that various factors could decrease their safety enough to affect their speed choices.

A few drivers noted that as their speed increased, their level of vehicle control decreased.

"You really shouldn't be going more than 5 miles over the limit. You have to be cognizant of your surroundings and the environment and what's going on. More than 5 miles an hour over feels dangerous to me. It's hard to control your vehicle at high speeds." —TOFS

"You're taking chances. You're taking that 10, 20, 30% chance that you or someone will mess up and you're not going to be able to respond like you normally would." —TOFN

"If the speed limit is 45 mph and you're going 50 I think you have control, but if its 70 mph and you're going 75, then I think you have a lot less ability to control your vehicle. It truly depends on the speed limit and what you're doing." —TOFN

Other drivers mentioned the role of road conditions in the relationship between safety and speed.

"For me, the risk depends on what I can see. If it's broad daylight, a wide open space, and I can see a long way down the road, chances are I'm going to go a lot faster than if it's a two lane narrow road or curvy and I don't know what's coming the other way. I t varies, but for me a lot of it is visibility and what I can and cannot see." —TOMS

"Depends on the type of road. If the road is curvy or hard to see ahead, I need to go 30 but if it's a long stretch of 10 miles of highway with a speed limit of 45 I'm probably going to be going 70." —TOMS

One driver mentioned that their stopping distance was different at higher speeds.

*"Your stopping distance changes quite a bit in 10 mph." —SOFS**

In summary, vehicle control and road conditions were acknowledged to affect drivers' crash risk, and in turn their comfort level with speeding.

Social Pressure

Several drivers mentioned that social pressure, especially from passengers, caused them to drive slower.

"If I have passengers with me I may speed but not at the same level when I'm by myself, because I'm a little concerned about what they're thinking or what they might say. If I'm by myself I'm probably going faster." —TOMS

"If I have certain passengers in my car, then I am more conscious of my driving." —TOFN

One driver mentioned that the reason that she does not speed with others in the car is that they lack control over the situation.

"I feel more responsible for someone else in my car because they can't control anything that happens, so I feel the need to drive closer to the speed limit." —SYFS

"When I am in somebody's car, I would like them to drive the speed limit, because you have zero control. I trust myself, and I'm sure they trust themselves too, but I don't trust them. So when I've got someone in my car, I'm pretty much driving the speed limit." —SYFS

Two groups that were particularly consistent with regard to promoting slower driving were parents and children. Both speeders and non-speeders reported driving slower with members of these groups in the vehicle.

Children

"I drive with a four-year-old every day he goes to school and back. When he's with me, I tend to drive the speed limit or a little bit slower." —TOMS

"If I am taking someone else's child, I tend to pay very close attention to the speed limit and other traffic around me. It's probably what I should be doing anyways." —SOFN

Parents

"My mother is always making braking motions with her foot when I drive her around. So with her, I always tend to drive a little bit slower than usual." —SOFN

"My parents, who are 90 and 91, if they're in the car with me I'm more careful [about] going the speed limit. Even though my dad isn't careful about it, I'm considerably more careful because he's going to say something." —TOMS

One driver also mentioned social pressure from people outside of the vehicle.

"Neighborhoods are the only place I try to stay around the speed limit, usually 25 mph. I'm usually worried about cats and dogs running out, and kids. And then there's people sitting on their porch staring at you if you drive more than 25." —SYFS

In summary, many drivers reported that social pressure, particularly from parent and child passengers, decreases travel speeds.

Critical Events

Several drivers experienced critical events such as crashes or close calls that were related to speed. These seemed to make drivers more aware of their speeding, situations in which speeding could be particularly dangerous, and the potential consequences of speeding.

Near Misses

Some drivers described the effects of some crash near-misses that affected their speeding behavior. These incidents included events ranging from loss of vehicle control to near-crashes.

"I was driving I-90 and it was pretty light traffic. I couldn't see in the tunnel because of the sun, but it was packed with slow-moving cars. I had to slam on the brakes to slow down in time. That really freaked me out. So now I drive slower approaching the tunnel, but I still drive my regular [faster] speed everywhere else." —SOFS

"That kind of spin happened to me once when it was raining. I tend to not drive at all or drive much slower in the rain, because I did spin 360 degrees with my truck and I thought I was going to start rolling—so that really decreased my tendency to speed on wet roads." —TOMS

Most of these experiences were shared by drivers in the speeder group. Interestingly, these experiences seemed to change their behaviors only in comparable situations to which they experienced the near miss (e.g., in the rain, in tunnels), but it did not seem to affect their general driving behavior.

Crashes

Some drivers described the effects of crashes that they were involved in due to their own, or others' speeding. One driver in particular was classified as a speeder based on her driving data, but held attitudes consistent with those of a non-speeder. This driver described how a serious crash over the past year completely changed her attitude regarding speeding.

*"I kind of got forced into keeping my speed down to what it should be. I rolled my car last year, and they thought I [was at fault] and I got a ticket. If I don't get another one for a whole year it will be wiped off. But I found that you really don't get anywhere that much faster. And it saves gas. Since my accident, I go slower through intersections, and I've missed a few [crashes] since then." —SOFS**

Other Drivers' Crashes

A few drivers described how watching incidents with other vehicles influenced their driving behaviors.

> *"I worked as a paramedic. I've seen some bad accidents and it's made me drive more carefully. I really think, for young people getting their licenses, it wouldn't be bad to have these kids see what can happen." —TOFN*

In summary, experiencing critical events reduced driver speeds, but sometimes in only specific situations.

Implications for Countermeasures

Critical events left an impression on several focus groups participants. After witnessing an incident, many drivers stated that they changed their driving behaviors, even if it was only in select environmental conditions (rain, curved road segments, etc.). As one driver suggested, a potential countermeasure could be to show drivers the effects of speeding and speeding-related incidents in driver education courses. Perhaps if drivers, particularly younger drivers, were more aware of the consequences of speeding, they would choose safer driving behaviors. However, the situation-specific nature of driver behavior changes poses a challenge for promoting overall shifts in driver attitudes.

Situational Factors

There were a number of factors related to the driving environment or other roadway factors that influenced people to drive slower. These factors range from weather conditions to specific roadway hazards (e.g., construction, livestock). For the following factors, drivers felt it was necessary to change their speed choices (reduce speed) or became more aware of their speed.

Weather

Several drivers in the Texas non-speeder group agreed with statements about how fast driving was limited by weather.

> *"Weather—it's irritating to watch people fly by you at 70 in rain or snow when I'm going 30 and see them swerve and see brake lights instead of slowing down and going nice and easy." —TOMN*

However, someone in the Seattle non-speeder group expressed an opposing sentiment.

> *"I drive the same speed when it rains here, even though everyone else goes slower. My car doesn't behave any differently." —SOFN**

Work Zones

A couple of non-speeders in Texas mentioned work zones as places where they reduce their speed.

> *"I also consider construction. Recently there was construction on the highway and there were several accidents because people were just going too fast in the area and slamming into each other." —TOFN*

Roadway Hazards

There were numerous roadway hazards mentioned as affecting driver speed choice. Two non-speeders mentioned reducing their speed due to livestock or other animals during the evening/nighttime.

> *"I live on a rural highway and I have to watch for livestock. I always watch how fast I am going on that road because I know that black cows are very hard to see at night." —SOFN*
>
> *"I worry about animals at night so if it's evening I go slower because I don't want to hit anything. I've hit a deer going 70mph and it's not fun." —TOFN*

A few non-speeders in Texas stated that they became more aware of their driving speed when other drivers who they deem unsafe are around.

> *"[I am more aware of my driving speed] when someone passes me like a crazy driver." —TYFN*
>
> *"[I am more aware of my driving speed] when I see texting and phones." —TOMN*

Some drivers stated that they use the presence/absence of pedestrians as a factor in setting their speeds. Many of these drivers were speeders.

> *"On side streets, it's kind of hard to speed with pedestrians, buses, and cyclists." —SYMS*
>
> *"I usually go slower downtown because there are always people who walk when the light is red. There are too many cyclists and people crossing." —SYMS*
>
> *"I'm very particular about going under the speed limit, especially in neighborhoods. I'm always worried about some kid kicking the ball out." —SOFN*
>
> *"I always try to drive the speed limit in school zones. There have been kids hit at the schools near where I live." —SOFS*

Implications for Countermeasures

From the environmental factors that drivers mentioned, it is clear that the roadway environment affects driver speed choices and awareness. The presence of hazards or potential hazards decreases driver speeds as they prepare to deal with them. Although making roadways more hazardous is not a reasonable countermeasure, promoting the perception that a road is potentially hazardous could have a similar effect.

Countermeasure Discussions

A separate discussion in the focus groups was conducted on speeding countermeasures. Six different types of countermeasures were discussed. Each is covered in a separate section below.

Higher Penalties and Increased Enforcement

This countermeasure was discussed in two parts. The first was in terms of higher fines in general or higher penalties for repeated speeding tickets (habitual speeders). The second was increased police patrols and speed traps on the roadways. Both countermeasures are outlined in Figure 52 below.

INCREASED PENALTIES & ENFORCEMENT

Higher Penalties

MPH over Limit	Current Fine	Higher Fine
1-5	$93	$116
6-10	$113	$141
11-15	$144	$180
16-20	$175	$219
21-25	$206	$258
26-30	$247	$309
31-35	$298	$373
36-40	$349	$436
Over 40	$411	$514

Higher fines for higher speeds and/or repeat speeders

Targets only drivers who are caught speeding

Increased Police Presence

Increased number of police patrols and "speed traps" which increases chances of getting caught speeding

Targets all speeders

Figure 52. Increased penalties and enforcement handout.

Higher Penalties

The increased penalties would either be enforced for higher speeds or for habitual speeders. Many drivers thought that a general increase in speeding ticket fines would not be effective.

> *"If it's $110 or $125, I'm still going to write the check anyways. An extra $15-20 is not going to change anything." —SOMN*

> *"I don't know if higher penalties makes a difference at all. When you get a ticket, it's just a ticket. You don't get that many tickets. It's not like a recurring bill you get every month where you notice a $30 difference. When I've gotten a ticket for 10 over or one for 30 over, it's just a ticket. You pay it once and it's done. So I don't think higher penalties would do anything." —SYMS*

> *"I think it depends on the person. No matter how high your penalties are they will affect people differently—like for her [indicates another participant], since she drives constantly, higher penalties would affect her a lot; but for people who don't spend as much time driving it may be less effective because they know that they'll have a lower chance of getting caught." —TYMS*

Many drivers thought that increased penalties for habitual speeders would be effective in reducing speeding.

> *"The targeting of habitual speeders makes sense to me. Someone who never speeds can get a ticket because they made a mistake. The same act from a habitual speeder is probably not a simple mistake, it's a deliberate act. They should have to pay a lot more if you got a bunch of other tickets." —SOMN*

> *"I kind of like higher penalties for repeat offenders. I think if I got pulled over and got a speeding ticket, to me that would be a wake-up call. And for someone who doesn't make a lot of money, $200 is a lot of money." —SYFS*

> *"The difference between $300 and $200 for a ticket is a lot of money. If they marketed it and played it up in the news about how it's going to hurt more, it might work. How many people are really aware of how much a ticket is?" —SOFS*

A few drivers stated that they would be affected more by an increase in their insurance rates.

"It has to be more than just about the fee. If I get a ticket, I'll pay that and so what. But, higher insurance rates would make me take notice." —SYMS

"For me the money has nothing to do with it. What I worry about is my insurance going up. I've got a perfect record and I don't want to screw that up. I wouldn't be thinking, it's going to cost me an extra thirty bucks, I'm going to behave now." —SOFN

One older female in Texas mentioned that the threat of losing her license would be more attention-getting.

"Money [fines] would not do it for me. The prospect of losing my license, of not being able to drive legally, is the thing that gets my attention. I get tickets every so often, but I'm conscious of not getting too many points on my license before the old ones expire." —TOFS

A couple of older males felt that the increased penalties would unfairly target less affluent drivers.

"Higher penalties can be unfair. It would be a true hardship for some honest people trying to pay back expensive fines, and it might impact their lives. But other drivers just wouldn't care. If they are going to speed that much, they won't care about paying their fines." —SOMN

"It depends on a person's affluence, too. Higher fines will be harder on someone whose income isn't very high, compared to someone who's president of a big national bank—to someone like that, higher fines would be pocket change. To me this is some serious money." —TOMS

Increased Enforcement

Increased enforcement was discussed in terms of either increased levels of police presence or speed traps to increase the chances of being caught speeding. Many drivers thought that increased police presence would reduce speeding. Drivers also shared their experiences with speed reduction due to police.

"When people see policemen, they slow down. It's almost instinctual for you to look down at your speedometer." —TOFN

"I've noticed when a police cruiser is going down Highway 6, even if he's going 5 mph under the speed limit, nobody passes him. So just having that police car cruising up and down the roadway makes a big difference." —TOMS

"[The police officer] is what scares me the most, not the money." —SOFN

"I think we all slow down where we think there are police. So I think if more police were covering more areas, it would slow people down." —SYFS

A few older Texas drivers noted that police cars, even if they are empty, often succeed in reducing driving speeds.

"I think increased enforcement helps. Even the presence of a police car on the side of the road slows people down." —TOFN

"In some towns I go through, they will set a police car at the city limits with nobody in it. You'd be surprised how many brake lights come on. Very effective." —TOMN

A couple of drivers expressed concern that the increased police presence would increase erratic driving of people who are nervous about the police presence.

"One possible disadvantage of increased enforcement—when people know there are lots of police around, they may be more likely to drive nervously, slam on brakes, etc. to avoid getting pulled over." —TOFS

A couple of Seattle drivers also stated that the experience of getting pulled over and interacting with the police officer is the worst part of getting a ticket.

"The worst part is getting pulled over, the officer takes his time, hangs out." —SYMS

"They are mean, they are impatient, it's unpleasant getting pulled over even if they let you off with a warning. That's a deterrent to me." —SOFN

Several Texas drivers cited specific roadways where increased enforcement has had a noticeable effect.

"I don't speed down Harvey Road because I know there are cops out there all the time. I slow down because of that. I know where the speed traps are and I drive differently there. So it is about what I can get away with." —TOFS

"A great example is Highway 6 between College Station and Navasota. It's a big, beautiful highway, easy to drive on, and they have an average of five highway patrolmen between the two towns [about a 20-mile distance]. I drive the speed limit on that road every time, because that increased enforcement presence definitely increases the chance of me getting caught." —TOMS

All of the drivers in the Seattle non-speeder group agreed that they wanted to see more positive reinforcement rather than negative punishments.

"This is all about punishment. How about using a carrot instead of a stick. What if they made your license renewal free if you did have any speeding tickets since your last renewal that would probably encourage a lot of drivers to not speed." —SOMN

Engineering Countermeasures

Three different types of engineering and/or roadway countermeasures were discussed, including rumble/vibration treatments (such as speed tables), pavement markings, and speed displays. These three countermeasures target all drivers, whether they are speeders or not. The handout showing these three countermeasures is presented in Figure 53 below.

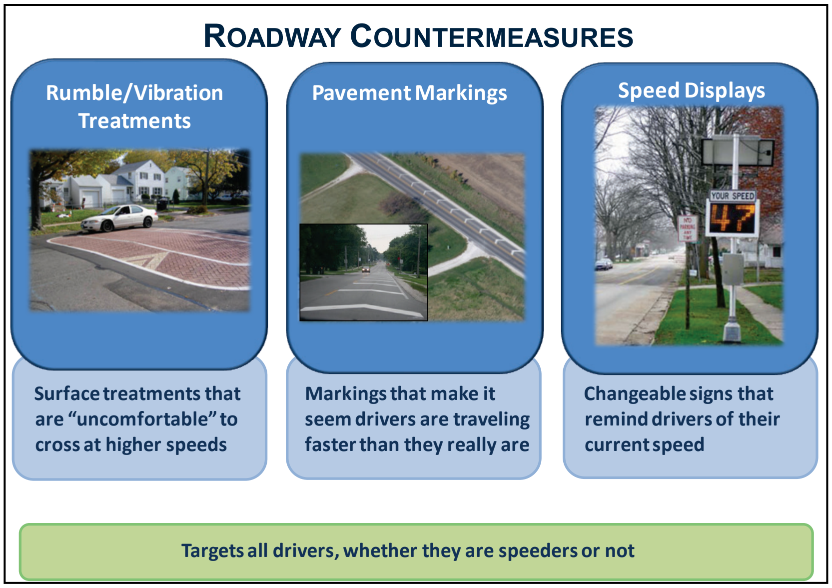


Figure 53. Roadway countermeasures handout.

Each countermeasure is presented separately in the following section.

Speed Tables

The first category of roadway countermeasures is rumble/vibration treatments. Drivers were shown a picture of a speed table and it was described as one of a type of surface treatment that slows people down by making it uncomfortable to cross them at higher speeds. Drivers referred to these types of treatments as speed bumps, speed humps, or rumble strips. In this discussion, we will refer to the whole category of treatments as speed tables or speed bumps.

Some drivers thought that speed tables and other treatments that cause vibration were effective because they cause discomfort, they cannot be avoided, and they cannot be acclimated to.

> *"The rumble strips and speed displays slow me down. I frequently pass through a neighborhood with cobblestones and I immediately start to go slower because the rattling is the worst feeling." —SOFN*

> *"If you drive the road every day you're going to get used to pavement markings and to [dynamic speed displays] and stop paying attention. But you can't get used to [speed tables]. Those would definitely make me want to slow down or find a different path." —TOMS*

Some drivers felt that speed tables are effective because they simply could not go fast over them.

> *"I used to live in a neighborhood with speed bumps and you couldn't go more than 5 mph over those things. They were quite effective in slowing people down. I didn't like them, but they did the job." —SOFN*

> *"I think speed humps definitely work. There is a road by my parents' house that has those humps every 50 yards and you cannot go faster than 15mph because they will damage your car. Those are annoying enough to make you go slow if they are big enough." —TYMS*

However, there were multiple ways in which drivers felt that the treatments were ineffective. One aspect that drivers felt made them less effective was that they could either drive around the speed table (i.e., in the parking lane) or find a different route and avoid them entirely.

"For [speed tables], I would drive to the side and avoid them." —TOMS

"I just see people going out of their way to go around them or on a different road." —SOMN

"Dips in the road are similar. If there's a possibility I'll hit a dip, I'd probably slow down, but once I know where it is, I'll find a way around it." —TOFS

Some drivers felt that speed bumps were not effective in their design.

"They'd have to make the whole road rumble for it to work." —SOFS

"Speed bumps are not enough to slow people down if they drive large cars or SUVs." —SOFN

"My neighborhood has speed bumps. I just go over them at speed. It doesn't hurt my car." —SOFN

One driver expressed concern that drivers slowing down for speed bumps would lead to rear-end crashes.

"My road is 30 mph, but it has speed bumps that slow you down to 10-15 mph. This kind of messes up the flow of traffic. You have people going the speed limit, and cars in front of them slowing down for the speed bumps, and they have to slam on their brakes. I've seen a couple rear-end [crashes]." —SOFN

Pavement Markings

The pavement markings were described to drivers as a treatment that leads to the perception that drivers are travelling faster than they really are. This subtle point was not easily understood in a focus group. In general, drivers had difficulty understanding the purpose of the markings and felt that they would not affect speeding behavior. Very few drivers mentioned the pavement markings.

"The pavement markings seem stupid." —SYMS

"The one in here that is least effective is the pavement markings. If I saw those markings I would go faster - they look like an air strip." —TOMS

One driver observed that the markings she had experienced made noise when vehicles travelled over them. She thought that this may be a part of the countermeasure.

"There are some pavement markings on Highway 21 coming back from Bastrop (city about 60 miles Southeast of College Station). I always wonder if there's a cop sitting there waiting because when you go over those markings they make a noise; maybe if you go too fast a cop could hear that you're going too fast? They make me slow down." —TYFN

Speed Displays

During the discussions of travel speed, drivers were asked how aware they were of their driving speed as they were travelling along and how their driving was affected when they saw posted speed signs. A few Seattle drivers mentioned the speed displays were particularly noticeable and effective, even before they were discussed as a countermeasure. The presence of these comments in Seattle may be because the speed displays are more common in urban areas.

"I only really notice [my driving speed] when I go past those signs that flash your speed." —SYMS

"I think I pay more attention to the ones that are [speed displays] versus ones that are just signs." —SYFS

"Especially in school zones. If I see a [posted speed] sign that's flashing, I'll slow down every time." —SOMN

During the countermeasures discussion, speed displays were presented as changeable signs that remind drivers of their current speed. In general, many drivers felt that speed displays are effective countermeasures.

Two non-speeders mentioned ways in which the displays used social pressure to affect driver speeds. Showing their speed to the drivers behind them either lessened the perceived pressure from others to speed, or informed other drivers of their wrongdoing.

"[The speed display] is a shame thing. All the people behind you can see that you are driving too fast. It makes you slow down." —SOFN

"I feel that the visual speed display gives me more license to slow down to the speed limit, without feeling pressure from the drivers behind me." —SOMN

A more common reason that drivers liked the speed displays was that they were effective in calling drivers' attention to their driving speed.

"I think the speed displays, at least in residential areas are really good. I know there are times when I am driving that I'm not paying attention. Then you've got something right there that is in your field of vision that says you are doing 30 when you should be going 25. You are going to drop your speed at least a little bit." —SYMS

"Where these catch me the most is when I am going with the flow of traffic, and I'm not checking my speedometer. There are a lot of things to watch out for while driving, so I'm not always paying attention to my speed. These signs are a good reminder." —SOFN

"When I see my speed flashing, it makes me go: Oh my gosh! And I slow down right after that." —SOFN

The primary limitation that some speeders mentioned was that speed displays are only effective for limited roadway segments.

"The problem with the speed flashing signs is that once you're five or ten miles past them, you've forgotten about them." —TYMS

"I think they would only work for about a minute. People just speed up again once they get past them. They don't really affect me." —SYFS

A couple of drivers felt that speed displays would be more effective if they were moved around so that they would be unfamiliar to drivers or used in locations that require drivers to pay more attention and reduce their speed.

"I think the speed displays would be really effective if they were moved around and appeared at various areas along a road. Maybe keep them around school zones, put them up outside events where there will be lots of people walking; but even on open highways or farm to market roads, having them there occasionally will make you think about your speed on those roads. Having them crop up a little more unexpectedly, versus keeping them in the same location for a long time, will make the sight more unfamiliar and may make you more likely to check your speedometer." —TOMS

Overall Effectiveness of Engineering Countermeasures

In general, drivers expressed that roadway and engineering countermeasures would be effective, particularly in areas with numerous hazards.

> *"These [measures] need to be in locations [with lots of hazards, such as] pedestrians or people pulling out of side streets." —SOMN*

> *"These are all useful for targeting specific areas. If I lived in a neighborhood and had kids, I'd probably like these kinds of things in my area. All these things probably work, which is why they use them." —SOFS*

Speed displays were spontaneously mentioned by drivers during the travel speed discussions and appear to be an effective countermeasure as reported by drivers from an urban area. The signs lead to decreases in speeds and raised awareness of drivers' driving speed.

Vehicle-based Countermeasures

Drivers were asked to share their views on three vehicle-based countermeasures: speed limiters in engines, in-vehicle speed limit displays, and fuel economy displays. Each of these countermeasures is shown in Figure 54 below.

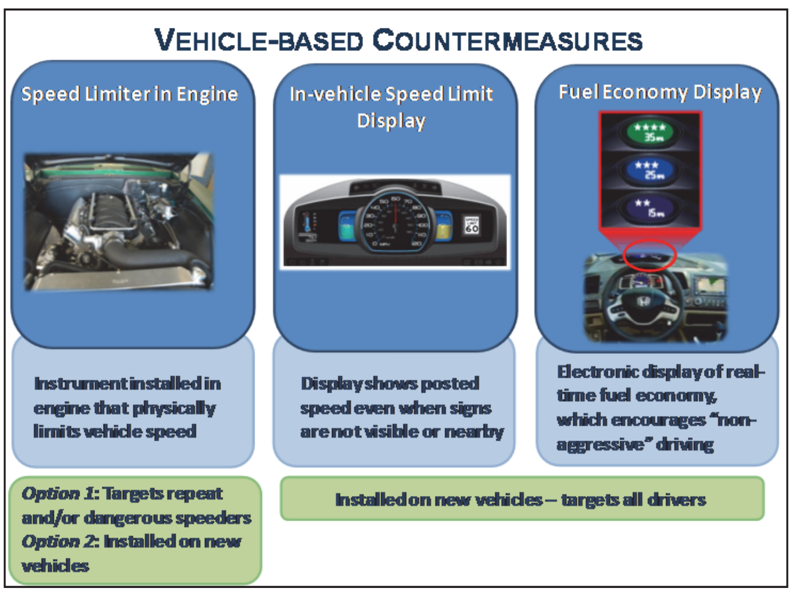


Figure 54. Vehicle-based countermeasures handout.

Speed Limiter

The speed limiter was described as an instrument installed in the engine that would limit engine speeds. These limiters would either be just for speeders or installed in all new vehicles. Very few drivers liked the idea of the speed limiter. Many drivers felt that they would be better for special populations such as teen drivers or habitual speeders. In particular, a few Texas drivers liked the idea of a limiter for teen drivers.

"I think the instrument in the engine is ideal for teenage boys, because [they think] they're invincible and they all go fast. I think that would save a lot of teenagers' lives." —TOFN

"I would like to have the limiter for kids or when my son started driving, but I don't think it would really work in reality." —TOMS

"One of my friends had something like that on his car in high school, but he found out it was set at 90 mph; you might want to be careful about letting your kid know what the limit is." —TYMS

Some drivers felt that the limiter was a really drastic measure to be reserved for habitual speeders. However, those drivers also expressed the opinion that perhaps habitual speeders just should not have licenses.

"This is a really drastic measure. If you are getting to that point, you really shouldn't have a license." —SYMS

"I don't think a speed limiter should be in everyone's car, but if you've gotten five, six, seven, ten tickets in a year, I'm sorry, your driving is not a right. That's stated when you get your license—it's a privilege. When someone's speeding all the time and endangering that many people out there I don't have a problem with having that limiter on their car." —TOMN

"There are repeat DUI offenders who have breathalyzers in their cars. This seems like that to me. It's the next best option to not letting them drive at all." —SYFS

The main concern with the limiter, expressed by a few Seattle drivers, is that sometimes extra speed is needed to pass or avoid hazards. These drivers did not want their speed to be restricted in a way that would impact their safety.

"I've lived on rural roads. Those roads are very windy and a lot of the time you only have one short section to pass someone every 5 miles, or you're screwed. You have no choice but to pass very fast those times." —SYMS

"Sometimes you need to get out of the way of a hazard. I've seen tires bouncing down the freeway or debris and you have to have that power [to get out of the way]." —SOFN

"The speed limiter is really dumb. If you have your wife going into labor or have someone who just got shot, or someone's had a heart attack, you're not going to drive them to the hospital in a golf cart." —SYMS

A few other drivers took a more philosophical stance against the limiter. They felt that speed limiting violated their rights or their independence. One driver mentioned that in order to reduce speeding, cultural changes were necessary.

"I wouldn't want the speed limiter myself because I'm enough of an American that I want to be able to make my own decisions. To me, that's Big Brother watching and controlling my choices." —TOFN

"There's a reason why cars can go up to 140 mph. You can't say 'no, you can't go over 60 or 70.'" —SYMS

"It's a cultural thing. We make cars that go 200 mph, but where are you going to do that? The limiter is not going to help something like that." —SOFN

Speed Limit Display

The speed limit display would show the posted speed of the current roadway even when the signs were not nearby. Most drivers thought that the speed limit display would be effective. Multiple drivers agreed that on some roadways, especially in unfamiliar areas, they can travel far before encountering a speed limit sign. One driver also noted that police officers often enforce speed transition zones, where drivers may not have warning that a change in posted speed is coming.

> *"I would love the [speed limit display] on my car. I always ask my passenger what the current speed limit is, especially on an unfamiliar road. Speed limit signs are usually spaced so far apart and I miss them so I don't know exactly how fast I'm supposed to be." —TOFS*
>
> *"Sometimes you turn on roads and you don't know what the speed limit is, and you are just waiting and waiting for the next sign. So the speed limit display would be kind of nice for that." —SYFS*
>
> *"[The speed limit display] would be great because a lot of times signs are down or blocked by a passing truck." —TOMN*
>
> *"Especially because cops like to wait right where the speed limit changes, so it would be good to have a heads up that it was coming." —TYMS*

One driver noted that the speed limit display was the only positive countermeasure included in the set.

> *"That's the only positive reinforcement at all. There are all these negative things about speeding, but being able to choose for yourself based off of something positive I think would work." —SYFS*

Drivers had a couple of ideas for speed limit display and speedometer design to assist their driving.

> *"It would be good if it had a visual cue, like to turn a shade of red, not overbearing, just something to make sure you're aware." —TYMS*
>
> *"I think they should think about the speedometer dials; a lot of cars have changed the position of that in the past few years. You used to have 60 mph as the straight up and down position of the dial, and that was a subliminal reminder. They've taken that away in a lot of cars. I think that is something that would be easy to go back to." —TOFN*

There were a few reasons why drivers did not think that the speed limit display would be effective.

> *"The GPS is not always correct. What they say is the posted limit is not always the posted limit." —TOMS*
>
> *"I never look. I just go at a speed that I think seems okay until I see a speed limit sign." —SOMS*
>
> *"This does nothing. If you've decided to go 90, you pretty much already know that you are speeding." — SYMS*
>
> *"If people don't care about the speed limit on the road, they are not going to care about it on their dashboard." —SOFS**

One driver thought that the speed limit display could be self-enforcing.

> *"If the car knows what the speed limit is and how fast you are going, why can't it just save that information and report it to the police?" —SOMN*

Fuel Economy Display

This electronic display of real-time fuel economy would discourage aggressive driving. Many Seattle drivers thought that the fuel economy display would be helpful.

> *"I've driven in friends' cars with these before. It works so well because it's like a game. I figure out that if I ease up a bit here, I'll get better fuel economy. My goal is always to leave the vehicle with better average fuel economy than it had before." —SOFN*

> *"I'm always looking for ways to save money. For me, a fuel economy display would help." —SYFS*

> *"My husband's car has one of these. I notice it when I do jack-rabbit starts off the line and the fuel economy goes way down. [The display] makes me stop doing those." —SOFN*

A few drivers thought that the effectiveness of the display would depend on the vehicle type and gas prices.

> *"I've had the same type of SUV for several years and I know it gets bad gas mileage, so it wouldn't make much difference to me." —TOFS*

> *"It depends on the kind of car you drive. If you've got a [really expensive car], you are not going to care about any of this, because then you can afford to pay for tickets and gas." —SOFS**

Overall Effectiveness of Vehicle-Based Countermeasures

Multiple drivers made comparisons across the in-vehicle countermeasures.

A couple of drivers were partial to the fuel economy display. It is the least focused on speed enforcement and provides the most direct feedback to drivers regarding their instantaneous driving behavior.

> *"If they put a limiter on my engine, I'd find someone to take it off, and I'd pull the fuse on that speed limit display, but the fuel economy display would be something I would pay attention to." —TOMS*

> *"I think that always knowing what the speed limit is would be a convenience. I would like to have it, but I don't know if that would necessarily change the way people drive. I think the fuel economy display would change how they drive more, but for an entirely different reason." —SOFN*

Interestingly, one driver acknowledged that having the speed limit display would not stop her from speeding, but would rather help her manage what she saw as an acceptable level of risk.

> *"I would want the speed limiter on my car to help me not to speed because that's my thing, but having the speed limit display in the car would also help. I'd still drive 5 mph over [the speed limit], but I'd like to know where it is to manage the risk in my mind and make me a safer driver." —TOFS*

One driver worried about driver distraction with the in-vehicle displays.

> *"There is already so much to look at in the car [dashboard] that I'd worry a bit about driver distraction, especially if they are paying so much attention to it." —SOFN*

Automatic Enforcement

Automatic enforcement was described as either fixed or truck-mounted cameras that detect speeding vehicles through a detection zone and issue tickets by mail. Some drivers responded to these countermeasures differently since the fixed location cameras would always focus on the same areas while the random location cameras could target different areas each day. Both are shown in Figure 55 below.

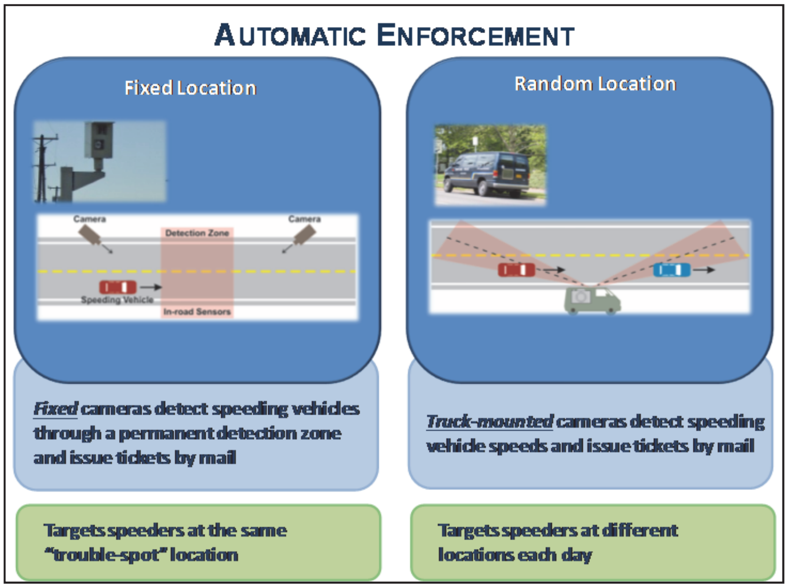


Figure 55. Automatic enforcement handout.

Several speeders (mostly in Texas) thought that automatic enforcement would be a very effective technique for deterring speeders.

> *"Most people if they get a ticket, even if it's in the mail, they're going to be a little more cautious." —SYMS*

> *"They work, especially for teenagers. My brother hated them because if they send the ticket home, it goes straight to the parents, so my brother had to be cautious if he wanted to keep driving." —TYFS*

> *"As long as you know they're going to be there, then they're effective. People who live there will know to keep their speed down, but not those [who are] travelling through and the first ticket is going to get them." —TOMS*

A few drivers thought that the random location cameras would be effective because the drivers would not know their locations.

> *"I think cameras in random locations would deter me. It's kind of like the police presence where you never quite know where they are going to be. I'm not necessarily for it, but I think it would deter people." —SYFS*

> *"It has some deterrent effect because you never know when it could happen." —SOFN*

Several other drivers thought that drivers would learn the locations of the fixed location cameras and would just speed in other areas.

> *"That's their disadvantage. I would learn about them and go a different way, but they do, in that immediate moment, keep me from speeding because I can't deal with the ramifications. I'm not a better driver, just a better driver down Harvey Road." —TOFS*

“The fixed location is less of a deterrent because, once you know they are there, you will either avoid them or go the speed limit. The [truck-mounted cameras, those] scare me.” —SOFN

A few drivers mentioned that the effectiveness of the method would depend on the amount of publicity that was generated.

“If you don’t live in the area and you don’t see it on the news, how would you know? [The cameras] probably won’t reduce overall speeds for those people because they won’t know about it until later when they get the ticket in the mail.” —TOFN

“It depends on how much they publicize it. I hope they show some of the PSA campaigns on TV. Hopefully that makes people aware.” —SOFS

Drivers had many concerns about the automatic enforcement. A couple of drivers thought that the wait between the driver’s infraction and their reception of the ticket would render the system less effective.

*“After the speeder has run someone over or gotten into a crash, it probably doesn’t help much to get a ticket two months later.” —SOFS**

“You don’t get the immediate feedback that you need. That this is where it is, and this is where it happened.” —SOFN

Some speeders did not like the automatic enforcement because they would not have a chance to state their case with a police officer.

“With these, you don’t even have a chance to explain circumstances. If you get pulled over by a police officer, you can explain what is going on. It seems like cheating.” —SYMS

“If you could have a court case and discuss it with a judge, it may change my mind.” —TOMS

“Knowing how red light cameras work, you have no defense to these tickets. You have no due process as you do with a police officer and a radar gun. Depending on the circumstances, a cop may let you off without a ticket.” —TOMS

In fact, multiple drivers in Texas compared the automatic enforcement to red light cameras. In Texas, red light cameras have been removed in Houston and College Station due to drivers’ objections. Additionally, drivers have experienced the cameras flashing at inappropriate times, perhaps lessening the credibility of automatic enforcement in general.

“Those devices don’t always work right, either. I’ve watched some of the red-light cameras in Tomball (town outside of Houston). I’ve watched vehicles at the intersection sitting still—in all four directions—and watched the camera flash as many as ten times while everybody’s sitting still.” —TOMN

“I think the response would be similar to how people reacted to the red-light cameras. They had those in Houston and College Station, and they’ve taken them out now because of objections.” —TOMS

One driver mentioned that the flashes produced by cameras are potentially distracting.

“One thing that I don’t like about fixed cameras is that they are sometimes distracting for me. If the cars in front of me get caught, especially at night, these big bright flashes go off and I get startled. I don’t like all the flashing, it annoys me because I don’t know what’s going on, or why it is there.” —SOFN

A few drivers compared the presence of the automatic enforcement cameras to that of police officers.

“It’s still a machine out there, where police presence would be more effective. Then they could be looking for all kinds of dangerous driving. Speeding should just be one of those things.” —SOFS

"Nothing will make you later than getting pulled over; they take their sweet time giving you a ticket. If you know there are patrols around, and you are late, the quickest way to get to your [destination] is to avoid speeding." —SOFS

A few drivers thought that the cameras may be just revenue generators and that they represent some cost savings over having police officers present to give speeding tickets.

"The red-light cameras are more about safety, to protect pedestrians and so forth. These [i.e., speed cameras] are just about money." —SYMS

"The cost of a police officer is a lot higher than a machine. The camera pays for itself quickly." —SYMS

"I don't mind it if it's being done for law enforcement and safety reasons, but not if it's being done as a revenue collector. Too often people have their hands in it who are not law enforcement, it's for monetary reasons and I have a big problem with that." —TOMN

A few drivers also had concerns that they may get tickets for their vehicle when another driver was driving it (e.g., a child or friend who borrowed the vehicle, a stolen vehicle).

"It's unconstitutional. You're attaching a ticket to a car not a person. There's no face-to-face interaction and you don't have any idea what really happened. All you have is an electronic measurement saying my car went too fast." —TYMS

"I don't like automated enforcement because I had a situation where somebody was driving my daughter's car, which was in my name, and I got the ticket in the mail. It really caused me a lot of headache because I had never even driven the car, ever. The person who'd borrowed it wouldn't pay the ticket. I have five vehicles in my name because of my kids. I don't want tickets for anything that they do." —TOFN

Drivers had various other individual concerns, a few of which are mentioned below.

"If they made the [threshold] 10 mph over [the speed limit], they would effectively just of changing the speed limit." —SYMS

"Speeding is not the main danger for most people. That's why [automated enforcement] feels vicious. I'm going five miles over, but I'm not hurting anybody. On the other hand, if I'm burning through a red light, chances are I could T-Bone somebody." —SYFS

Speed Awareness Course

The last type of countermeasure discussed was speed awareness courses. These were described as multi-session "classroom" courses that teach the dangers of speeding and speed awareness strategies to a targeted audience of repeat and/or dangerous speeders. The handout for this countermeasure is shown in Figure 56 below.

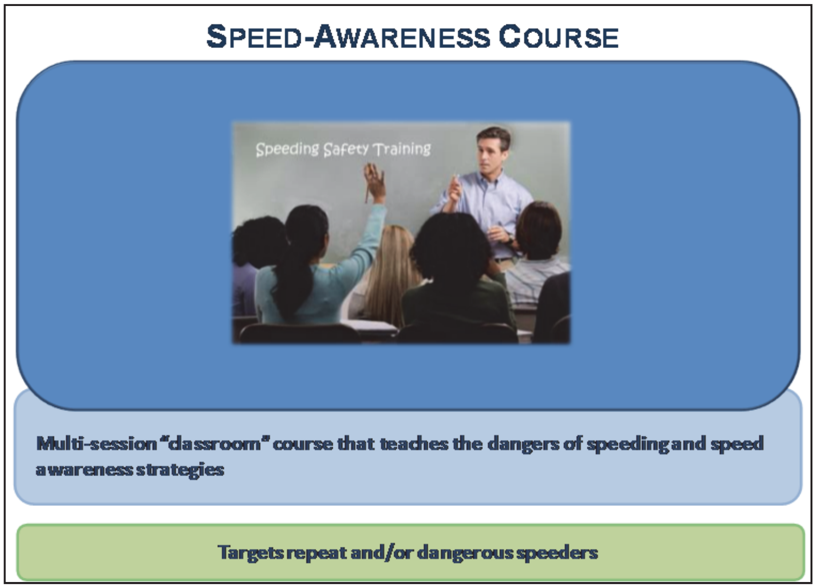


Figure 56. Speed awareness course handout.

In general, the comments related to this countermeasure were targeted at improvements to this approach, or reasons why it is ineffective. Most drivers did not think this countermeasure would work.

> *"I think the courses are okay. My brother got a ticket one time and he took the course just to get the ticket off his record, and afterward he was telling me about all these things he learned that he hadn't known about before, like new traffic laws." —TOFN*

> *"I think it would work for some people, because a lot of people don't think about the impact of what they do on other people. But once they are made aware of it, they'll adjust their behavior and understand their actions have consequences. But for some people, I don't think it will work." —SOFN*

Similarly, many drivers thought that the attendees did not take the courses seriously. These drivers were mainly young speeders.

> *"I think of it more like detention. You do it because you have to, but then I'm going to speed on my way home just to spite you." —SYMS*

> *"They'll go to the class to get it off their record and go out and speed again." —TOFN*

> *"One of my driving instructors called it "adult time-out". You don't learn anything - they tell knock-knock jokes and then give you the answers to the tests. You sit there and just endure it for 6 hours." —TYMS*

Drivers also identified multiple ways in which the courses might be made more effective for or taken more seriously by those who are required to take them. The first was that they need a higher cost for attending in terms of a time commitment, monetary cost, or other penalty. These comments were also provided mainly by speeders.

> *"The key is multi-session—maybe for the next 6 weeks or something. Not just a one day sacrifice of a few hours. Several hours taken out of your life for the next 6 weeks may make a difference." —TOMS*

> *"Put a high price on it and you're going to think twice about it—[give a] $300 ticket and [raise their insurance rate] or [require a] $400 speed awareness class." —TOFS*

"I think it might work better along with a license suspension. After 10 tickets they lose their license and have to take a course to get it back." —SYMS

Some Texas drivers thought that the courses should have mandatory in-person attendance.

"Make them where you actually have to appear. I know someone who routinely gets the DVD version of the course because he gets tickets two or three times a year, and his son has taken the DVD course for him multiple times." —TOMN

"[If someone else takes the course for you,] then it's not a deterrent. If you have to go in person, you may just sit there and pout the whole time, but you may pick up something there; one or two items may actually get between your ears." —TOMN

"[The classes] don't keep me from speeding. To keep me from speeding I would either need a limit to the classes and I couldn't just do it online in my house - that's entirely too easy. In California, you had to go to a place to take a class, [you] couldn't do it at home. Also, maybe they should keep track of points like in California and Florida." —TOFS

A few drivers thought that showing more graphic crash footage would be more effective.

"Watching real life scenarios where people have died or something would be effective, because those things happen in real life. It almost happened to me and I think maybe people need to see that more in the classrooms. Not some cheesy video but something like it may make them more aware." —TYFS

"I think the videos used in those courses need to show more graphic things, results of terrible accidents caused by speeding. Some of the videos are goofy, almost cartoony, and really that doesn't affect you. It sounds bad, but a graphic picture makes a big impact." —TOFN

"I've seen pedestrians get hit and people crashing into other cars. It makes you think about how you drive. If more people experienced those sorts of things they would be more careful." —SOMN

Several older drivers (mostly in Texas), thought that speed awareness courses would be useful for other drivers, in addition to those caught speeding.

"I think there should be more public awareness of the impacts of speeding. It's not just the repeat speeders that can benefit from this." —SOMN

"Traffic laws change through the years and we should all have to go through training every few years to be aware of the changes in traffic safety laws. A refresher course like that would be good for all of us to go through every few years. I would go to something like that." —TOFS

"Assuming that something like that would be effective for some portion of the population, reserving it to drivers caught speeding may not be the most effective use of this approach. Maybe making this part of renewing your license, or a public service announcement might be more broadly effective." —SOFN

Driver-Mentioned Countermeasures

Although countermeasures were specifically discussed in the second half of the focus groups, participants spontaneously gave some comments related to potential countermeasures in the discussions about general speeding factors. These were primarily related to in-vehicle devices, such as cruise control and the speedometer.

Cruise Control

The use of cruise control for self-speed regulation was common in all groups. Both speeders and non-speeders managed their speed with less effort by using cruise control to set their selected speed (for speeders, above the speed limit), which meant that they did not have to worry about speed control.

> *"I use cruise control on certain slower [in-town] roads. It keeps me from speeding, where it's so easy to go fast because the speed limit is so slow." —SOMN*

> *"I use cruise control, so I know how fast I'm going." —SOFS**

> *"I hit 68 [on the freeway] and hit cruise control, and I never look at [my speedometer] after that. If there's too much traffic to use cruise control, then I'm not looking anyways, because chances are you can't speed anyways." —SOMS*

> *"On the freeway I use cruise control, too. Any time I'm driving for an extended period and the speed limit is over 50, then I use cruise control and set it for 5 miles under the limit. In towns I stick to the speed limit. I've never gotten a ticket and don't intend to." —TOMN*

The use of cruise control is likely an effective strategy for mitigating inattention-related speeding. One notable aspect about this behavior is that it represents a self-initiated countermeasure and suggests that there is a willingness among some drivers to accept a somewhat invasive approach to control their speed in exchange for a high degree of confidence that it will help them avoid getting a speeding ticket.

Speedometer

The other source of information that was indirectly mentioned with regard to speed control was the speedometer. In particular, one driver described how she has an easier time staying closer to the speed limit when she has a digital versus analog speedometer.

> *"I think it depends on the car. I rent cars a lot when I travel. Usually if the car has a digital speedometer, then I go 5 over. But if it has a [needle], then I usually go 10 over because it's harder to tell." —SYFS*

This is another example suggesting that if drivers have a willingness to stay within the posted speed, providing tools that help drivers accomplish this may result in less speeding. In this case, more precise information about travel speed helps this driver comply with her intentions to drive within a certain target speed range.

Money-saving

Another aspect of speeding is the added cost of fuel. One Texas speeder mentioned fuel prices as something that reduces his speed.

> *"When I pass the gas stations and see the fuel prices, I slow down." —TOMS*

Although the correlation of that comment with money-saving is somewhat speculative, it seems as though this driver knows that by reducing his speed, he could save money. This motivation could be effective for other drivers as well and utilized by a countermeasure such as a fuel economy display.

Summary of Countermeasure Discussions

A summary of the key themes of the focus group responses to the countermeasures are presented in Table 64 below.

Table 64. Summary of driver responses to the countermeasures presented in the focus groups.

Counter-measure	Effective	Ineffective	Comments
Higher Penalties and Increased Enforcement			
Higher Penalties	Target habitual, deliberate speeders	One-time higher bill is paid and then forgotten	Would be more effective if insurance rates increased or licenses were lost
Increased Enforcement	Seeing police officers or police cars seems to cause speed reductions; interaction with police officers is very unpleasant	None	Erratic driving around police officers may increase; could involve a positive action such as a free license renewal if they've received no tickets
Engineering Countermeasures			
Speed Tables	Cause discomfort; unavoidable; can't habituate	Can drive around them in a parking lane; can find an alternate route; not always effective at higher speeds (particularly in an SUV/truck)	May lead to rear-end collisions due to unnecessary slowing
Pavement Markings	May make noise so police can hear that you're driving too fast	Seem ineffective; may cause speed increases due to their design	None
Speed Displays	Very noticeable; more salient than regular speed limit signs; can lessen or increase social pressure to reduce speed; counter inattention	Forgotten soon after passing them; increase speed after passing them	Could be moved around to be in unfamiliar locations; should target specific areas with many hazards
Vehicle-based Countermeasures			
Speed Limiter	Good for target populations such as teens or habitual speeders	None	Perhaps the licenses of habitual speeders should just be taken away; sometimes extra speed is needed to pass or avoid hazards; violates driver rights and independence
Speed Limit Display	Only positive countermeasure in the set; informs drivers of the posted speed when it's unknown or when roadway signs are blocked; helps drivers manage their speed choice risk	GPS locations are sometimes inaccurate; drivers go with the flow of traffic anyway; if drivers have decided to speed then they'll still speed; redundant with the roadway signs	Might cause driver distraction; vehicles could auto-report speeders to the police with this kind of information
Fuel Economy Display	Like a game; saves drivers money; provides real-time driving feedback	Some vehicles just get bad mileage; wealthy drivers won't care	Might cause driver distraction
Automated Enforcement			
Automatic Enforcement	Drivers would be unable to anticipate signs in random locations	The fixed location cameras might just lead to speed in other areas; the length of time between the infraction and the ticket reception is too long	Drivers don't have a chance to state their case with a police officer; cameras are not always accurate (e.g., red light cameras); may cause driver distraction; drivers may get tickets when someone else was driving their vehicle

Speed Awareness Course			
Speed Awareness Course	Raises awareness of speeding behavior	Drivers don't take the courses seriously	Need a higher time or monetary cost; should require mandatory in-person attendance; should show more graphic crash footage; would be educational for all drivers (not just speeders)

Chapter 5: Conclusions

General Conclusions

This study sought to gather information about driver speeding behavior. Using naturalistic driving data combined with data from focus groups, we set out to examine several basic questions about driver speeding patterns. These include:

1. What is the relative importance of situational factors, demographics, and personality in predicting episodes of speeding?
2. What are the subtypes of drivers with respect to speeding?
3. To what extent are these classes of speeders defined by demographics?
4. To what extent is the predilection to speed correlated with the tendency towards other unsafe driving acts?
5. What attitudes, habits, and behaviors are directly or indirectly related to possible countermeasures (points systems, points reduction classes, checkpoints, automated enforcement, crackdowns, traffic calming measures, etc.), so that subgroups can be compared on these measures?

The findings related to each of these questions are discussed below.

What is the relative importance of situational factors, demographics, and personality in predicting episodes of speeding?

Using the criterion of 10 mph above the posted speed as our working definition of "speeding," drivers engaged in speeding behavior during approximately 1-10% of their free-flow driving. However, that amount depended on a number of factors. For example, in Seattle, drivers sped during less than 5% of their free-flow driving time overall, and this amount was slightly higher on 55-60 mph roads than on 30-35 mph roads. In Texas, there was very little speeding on 30-35 mph (≈2%) and 70 mph roads (≈1%), but substantially more on 55-60 mph roads (≈10%).

These findings provide a useful frame of reference for speeding behavior at a high level; however, they obscure a more important finding, which is the variability in speeding across situational/trip-specific factors, demographic groups, and individual driver/personal characteristics. The majority of the analyses in the current report were focused on finding ways to quantify speeding behavior and identify different speeding patterns. This is a significant challenge with naturalistic data because of the wide range of driver-related, roadway-related, and situational/trip factors that cannot be controlled—or even fully documented—but are strong determinants of speeding behavior during a trip. Despite this challenge, we were able to identify some key trends in terms of speeding behavior, including:

It is relatively common for drivers to have at least some speeding on a given trip; however, there are some drivers that rarely speed.

Younger drivers, especially Younger Males, are more likely to have at least some speeding on a trip than other demographic groups.

Certain driver beliefs and attitudes (described below) are associated with increased odds of any speeding, and a greater amount of speeding on individual trips.

In general, there is a small set of habitual speeders in both Seattle and Texas, but this group seems to be defined more by certain beliefs and attitudes, rather than by their demographic category.

There is evidence for different types of speeding behaviors (i.e., situational, habitual, casual, and incidental speeders), and their relative prevalence—at least in part—depends on road type.

Weekend and morning trips are more likely to be associated with speeding.

It is also interesting to consider some common views about speeding that were not borne out by the data:

Speeding does not appear to be limited to a small group of drivers defined primarily by age (i.e., young) and/or gender (i.e., males).

Speeding does not appear to be limited to a small group of drivers defined primarily by attitudes (reckless, risk-seeking, etc.).

Speeding does not appear to be limited to rural or high-speed roadways (i.e., 55-60, 70 mph).

Speeding is clearly a complex behavior that is strongly influenced by a number of factors. Some of the specific situational, demographic, and personal inventory factors related to speeding behavior are discussed below.

Situational Factors

As listed above, there were a number of significant effects associated with pervasive variables like age/gender and personality, but it seems likely that situational variables play a key role as well (type of trip, length of trip, presence of others in the car, presence of enforcement, opportunities to speed, road conditions, geographic location, etc.). Opportunity to speed is undoubtedly a key factor in this, as evidenced by the prevalence of the free-flow time (logFFT) and weekend predictors of speeding. Also, the focus groups indicated that speed seems to be a deliberate choice made with consideration of outcomes (tickets, safety, approval of others, thrills, etc.), which highlights the influence of situational factors. We have probably paid the least attention (in terms of our data analyses) to these situational variables; some of them cannot be properly measured or characterized with the existing data set. But some can, and should be looked at in future analyses.

Demographic Factors

A key objective of this research was to examine the extent to which speeding behavior can be predicted based are typically not among the high speeders, whereas Males in general are more likely to speed on demographics. In terms of the descriptive analyses, this study found that Older Females as a group are typically not among the high speeders, whereas Males in general are more likely to speed (e.g., Figure 29, Figure 50, Figure 51, and Table 19 on pages 60, 89, 92, and 59, respectively). These findings should be interpreted cautiously, however, since driving patterns differ among the demographic groups and the inferential analyses indicate that these relationships change once trip variables and driving patterns are accounted for.

groups. In Seattle, Younger Females show similar significant effects to the Younger Males, but not in Texas (as compared to any other group). In Texas, Younger Males also have significantly higher odds of speeding than females, and Older Males exhibited higher odds of speeding relative to Older Females on the 70-mph roads. There were also other effects that approached significance. In Seattle, Younger Females had greater odds of speeding than Older Females. In Texas, Older Males were more likely than Older Females to speed.

Table 65. Summary of demographic differences based on the likelihood of any speeding on a trip.

Speed Band	Likelihood of Any Speeding	
	Seattle	*Texas*
30-35 mph	– Younger Males 2.4 times more likely than Older Females* – Younger Males 2.1 times more likely than Older Males* – Younger Females 1.9 times more likely than Older Females†	– None
55-60 mph	– Younger Males 4.0 times more likely than Older Females** – Younger Males 3.2 times more likely than Older Males* – Younger Females 4.5 times more likely than Older Females** – Younger Females 3.6 times more likely than Older Males**	– Younger Males 4.1 times more likely than Older Females**
70 mph		– Younger Males 3.0 times more likely than Older Females* – Older Males 2.0 times more likely than Older Females† – Younger Males 2.8 times more likely than Younger Females*

***p<.001; **p<.01; *p<.05; †p<.10

These patterns, however, only seem to hold for the speeding measure related to percentage of trips with any speeding. More specifically, the linear regression analyses conducted on speeding indicated that none of the demographic variables were significant predictors of the amount of speeding per trip, in any speed band. It is unclear at this time why demographic variables are relatively poor predictors of the amount of speeding, although the low statistical power arising from the relatively small number of trips with any speeding was likely a factor.

Another sign that demographic category is a poor predictor of the amount of speeding is seen in the various scatter plot diagrams that show speeding levels for individual drivers (Figure 27, Figure 29, Figure 47, and Figure 48 on pages 56, 60, 85, and 86, respectively).

A consistent pattern across most speed bands is that the clusters of habitual-speeders are often comprised of drivers from all demographic groups. In this case, it seems plausible that large amounts of speeding on a trip reflect certain personality traits, attitudes, or situational variables, rather than simple demographic category memberships. This is consistent with the findings from the linear regression analyses (i.e., there were significant personal inventory factor predictors found in most linear regression models) and the focus groups (i.e., drivers described a wide range of situational variables that affect their speeding behavior).

An additional set of demographic-type variables examined in the regression models were the socioeconomic variables such as income, education, and vehicle type (see Table 66 below). In some ways, the different sites represent demographic differences based on differences in driving experiences and cultural views. The analyses indicated that some socioeconomic variables were significant predictors of speeding in the logistic regressions that included personal inventory factors, but not the

An additional set of demographic-type variables examined in the regression models were the socioeconomic variables such as income, education, and vehicle type (see Table 66 below). In some ways, the different sites represent demographic differences based on differences in driving experiences and cultural views. The analyses indicated that some socioeconomic variables were significant predictors of speeding in the logistic regressions that included personal inventory factors, but not the linear regressions. Also, different patterns of results were obtained between Seattle and Texas. For example, in Texas, driving a truck or sports car was associated with higher odds of any speeding, whereas the opposite was true in Seattle. Additionally, having completed a college degree, and higher income levels were also associated with increased odds of any speeding in Texas. It is unclear if the vehicle-type measure reflected vehicle power or cost, but if it is the latter, either directly or indirectly, then there is a trend towards speeding being associated with affluence in Texas.

Personality

Driver motivations, beliefs, and attitudes were found to be highly significant predictors of both the odds of any speeding on a trip *(who speeds)*, and the amount of speeding on a trip *(who speeds the most)*. In some instances, these variables were generally stronger predictors than the demographic variables, displacing many of the demographic variables from the final regression models.

The Seattle regression models that incorporated factor score variables were more interpretable than the Texas models. In Seattle, factors related to dangerous/aggressive driving, inattentive driving, and bad driving habits were associated with increased odds of any speeding (see Table 66 below). In contrast, agreement that important people would approve of their driving near the speed limit and tendencies to resist the temptation to speed were associated with decreased speeding (both odds and amount of speeding) for this location.

The Texas regression models found some of the same factors to be significant as the Seattle regression models. Factors related to dangerous/aggressive driving were associated with an increased odds of speeding and those related to resisting the temptation to speed were associated with a decreased odds of speeding (in some speed bands). However, the Texas data yielded regression models that also had a few counterintuitive predictors. In particular, some factors that might be expected to be associated with increased odds of speeding were actually associated with decreased odds, and vice versa. For example, more frequently making driving mistakes that show a lack of skill was associated with decreased odds of speeding and a smaller proportion of speeding on 55-60 mph roadways. Also, more frequently engaging in dangerous driving habits was associated with decreased odds of speeding on 55-60 mph roadways and a smaller proportion of speeding on 30-35 mph roadways (see Table 66). However, this pattern of results could also be explained if speeders simply believe that they are better drivers than everyone else and do not view their own driving as unskilled or dangerous.

As detailed in the discussion of these findings in the *Results* chapter, these patterns in the Texas data illustrate some of the practical difficulties in trying to apply global measures of driver factors (i.e., personal inventory questions) to speeding behaviors that occur in specific contexts. If participants answered the personal inventory questions with one type of driving in mind (e.g., they may be cautious drivers in town), but then behave differently in other driving environments (e.g., driving faster to cover longer rural distances), then the counterintuitive results could be explained. However, the personality predictors become more difficult to interpret for this speed band, since they reflect attitudes and beliefs about a different driving environment than that in which the speeding was measured. In other words, when completing the personal inventory, participants may have had some specific driving context in mind that was not specified in the inventory questions; however, when we examine these personal inventory items in the context of driving on a specific road type, it may not be the same context the participant had in mind when doing the inventory.

Table 66. Summary of factor-score variables that were significant predictors of speeding behavior.

	Seattle 30-35 mph	Seattle 55-60 mph	Texas 30-35 mph	Texas 55-60 mph	Texas 70 mph
Logistic Regression (Predicting likelihood of any speeding on a trip)					
Factor score variables associated with *increased* odds of any speeding	– Reckless/Road Rage* – Inattention**	– Bad Driving*	– BB-Safety†	– Reckless* – Normative Beliefs***	– Reckless** – Road Rage*** – Normative Beliefs**
Factor score variables associated with *decreased* odds of any speeding	– Subjective Norms† – CB-Opportunity***	– BCB-Temptation*** – Subjective Norms* – CB-Opportunity*	– None	– Bad Driving* – BCB-Temptation*** – Dangerous Driving**	– None
Socioeconomic variables	– None	– Family Vehicle > Truck or Sports Car†	– None	– Income [15-45K] > Income [0-15K]* – Income [45-75K] > Income [0-15K]*** – Income [75K+] > Income [0-15K]***	– College Degree > No College Degree* – Truck or Sports Car > Family Vehicle*
Linear Regression (Predicting average amount of speeding on a trip, for trips that have speeding)					
Factor variables associated with *larger* proportion of any speeding:	– None	– None	– Reckless† – Road Rage***	– Normative Beliefs**	– None
Factor variables associated with *smaller* proportion of any speeding:	– BCB-Temptation† – Subjective Norms†	– BCB-Temptation*** – Subjective Norms**	– Dangerous Driving*	– Bad Driving†	– None
Socioeconomic variables	– None	– None	– None	– None	– None

***p<.001; **p<.01; *p<.05; †p<.10

Nevertheless, although the previous section shows that demographic variables may be sufficient to predict some speeding trends, the significance of these personal inventory factors suggests a more complicated relationship between speeding and demographics. It is likely that there are some attitudes and beliefs—which may be thought of as primarily age related—that are more relevant to speeding than age alone. This was apparent in the focus group discussions of some older drivers who speed. In contrast to the more safety-conscious views of their non-speeder peers, the older speeders expressed views usually associated with prototypical young speeders – such as describing speeding as an adrenaline rush. However, the number of participants in each demographic category was not large enough to examine personal inventory predictors of speeding separately within each group and to better map out the relationship between these views and speeding behavior.

Another notable finding is that demographic groups also differed in terms of their answers to several of the personal inventory questions. This was not examined in detail, but the sample personal inventory questions presented in the descriptive statistics section show stereotypical differences across groups in terms of risk-taking, attitudes, motivations, and behaviors. These differences likely explain some of the patterns found in the regression models that included factor score variables.

What are the subtypes of drivers with respect to speeding?

Another interesting set of findings involved characterizing drivers based on scatter plots of the proportion of trips with any speeding versus the average speeding (for only trips with speeding; also see Figure 49 on page 88). Different combinations of these measures generally can be mapped to different types of speeders reflecting:

Incidental/non-speeders: drivers who speed on a small number of trips and for only a small portion of those trips if at all.

Situational speeders: drivers who speed a lot on a small number of trips.

Regular/casual speeders: drivers who speed a small amount on a large proportion of their trips.

Habitual speeders: drivers who speed regularly for relatively large portions of their trips.

It may be possible to map these speeder types to specific situational aspects, such as being late, or more enduring factors, such as personality traits associated with chronic speeding. There was also some evidence of these speeder types found in the focus group discussions. For example, incidental/non-speeders, which were targeted in the non-speeder sessions, were more likely to describe the posted speed as a maximum limit. Non-speeders also described how if they sometimes ended up speeding because they got caught up with the flow of traffic, they would likely slow down once they realized they were doing so. A couple of drivers also described engaging in "situational" speeding on long trips only, since only on those trips would speeding result in an appreciable time savings.

However, it should be noted that on 55-60 mph roadways in both Seattle and Texas there were no situational speeders. There are multiple possible explanations for this finding. The drivers who fall into this group may be pragmatic about their decision to speed, and only speed when they can save a noticeable amount of time (i.e., on longer trips). These trips were likely excluded from the analysis set because they occurred on roadways that were very far away from the installation sites, and therefore on unvalidated roadways. Another explanation could be that the demarcation for situational speeding indicated in these graphs is set too high for this speed band. Drivers may be taking advantage of smaller situational speeding events, which do not appear on the graphs.

At this time, the demarcation into these categories is somewhat arbitrary; however, the relative distribution of individual points within the scatter plots is fixed, providing a useful indication of general patterns. On the other hand, if it were possible to develop a defensible speeding-type classification scheme, then this approach could form the basis for a classification-based analyses that could identify the personal inventory, driving behavior, and/or other variables that form the defining characteristics of each speeder type.

To what extent are these classes of speeders defined by demographics?

The classes of speeders described above are not well defined by demographics. Drivers from most demographic groups are represented in all of the speeder classes. There were differences across speed bands in the distribution of drivers across categories; however, with the exception of Older Male Situational speeders on Seattle 30-35 mph roads, it is difficult to identify clear clustering in speeder categories based on demographic group.

Another related finding is that the distributions of individuals across the different speeder types depended greatly on the particular speed band (i.e., Figure 50 and Figure 51 on pages 93 and 95). Specifically, different speed bands in each location tended to show systematic patterns in terms of where individuals ended up in the scatter plots. These patterns may reflect global driving conditions (e.g., trip duration, roadway design) that lead to fast driving. We did not examine the consistency of the classification of individual drivers across different speed bands; however, this could be investigated in future analyses.

To what extent is the predilection to speed correlated with the tendency towards other unsafe driving acts?

The primary measures of unsafe driving acts collected in this project were the self-report personal inventory factors calculated from related item responses on the personal inventory instruments. Three factors that had relatively direct mappings to unsafe acts, included the following:

Reckless Driving: Items that deal with dangerous violations such as racing, driving drunk, and tailgating

Road Rage: Items that involve showing hostility and anger to other drivers

Dangerous Driving: Items related to risk taking behaviors such as accelerating through a yellow light, taking risks when in a hurry, and cutting off other drivers

Overall, the findings regarding the relationship between these factors and the predilection towards speeding are mixed. In particular, the Reckless Driving and Road Rage factors were among the better predictors of increased speeding behavior, across all factors (see Table 67). However, the Dangerous Driving factors, based on the DeJoy/CARDS Risky Driving scales risk taking items were associated with lower odds of speeding in some of the Texas models, but not associated with higher odds speeding in any of the models.

Table 67. List of models in which factors related to unsafe acts were predictors of speeding.

Factor	Positive Correlation with Speeding	Negative Correlation with Speeding
Reckless Driving	– Seattle 30-35 mph Logistic Regression* – Texas 55-60 mph Logistic Regression – Texas 70 mph Logistic Regression – Texas 30-35 mph Linear Regression	– None
Road Rage	– Texas 70 mph Logistic Regression – Texas 30-35 mph Linear Regression	– None
Dangerous Driving	– None	– Texas 55-60 mph Logistic Regression – Texas 30-35 mph Linear Regression

Interestingly, the comments from the focus groups do not support the mapping between speeding and other unsafe driving acts. When drivers (particularly speeders) discussed their speeding behavior, they described how—when they were speeding—they felt that it was safe for the condition of the roadway on which they were travelling (e.g., good visibility, wide roads). The crashes or near-misses that they experienced generally changed their driving behavior in related driving environments, but not in all situations. Additionally, some drivers expressed the opinion that the posted speed is more of a minimum speed, or that it is set by considering the worst drivers in the population. Very few drivers expressed frustration at other slower-moving vehicles (Road Rage). Therefore, there were some factors correlated with speeding behavior that drivers did not mention in the focus groups. However, the focus groups were primarily a discussion of general speeding behavior, rather than unsafe acts specifically.

What attitudes, habits, and behaviors are directly or indirectly related to possible countermeasures, so that subgroups can be compared on these measures?

The analyses conducted in this project do not provide a satisfactory answer to this question. There was simply too much diversity in the factors that were associated with speeding, either in the regression analyses, or in the qualitative focus group discussions. Part of this may be due to our decision to select participants from a broad driver population, including groups such as Older Females that are not typically thought of as speeders. While this decision was consistent with the exploratory nature of this study, it likely made it difficult for potentially strong predictors of speeding to stand out among other factors because they may have been represented by only a small proportion of participants. Related to this is the fact that participants were not screened for markers of speeding behaviors, such as previous speeding tickets or certain attitudes. Consequently, there were no more than a few potentially "egregious" speeders that might have represented the rebellious or risk-taking attitudes typically associated with chronic speeding. Another contributing issue is that the small number of drivers participating in the focus groups makes it difficult to sort out central, commonly-held opinions from esoteric, isolated views. This leaves us with insufficient information to adequately evaluate the relative merits of different countermeasures.

However, one thing that we can say about the findings is that—in terms of countermeasures—no single "catch all" solution emerged in the focus group discussions that could address the multiple facets of speeding as a whole. A repeated theme in the focus groups was that countermeasures were limited in terms of their geographic distribution (i.e., dynamic speed signs and police officers cannot be everywhere that people speed all the time). However, there are some ways to improve on these limitations by introducing unpredictability into where these measures are located. Another, related limitation of other countermeasures is that they are fixed in time rather than location. These include speeding awareness classes, public education campaigns, and to some extent infrequent encounters with police. The impact of these measures on drivers likely diminishes over time as drivers experience repeated trips without new reinforcement of the associated safety beliefs. For example, if a new driver leaves driver education successfully "scared" of the risks of speeding, repeated exposure to driving above the posted speed in harmless situations (i.e., inattention or keeping up with traffic) may undermine this driver's original concerns.

The one class of countermeasures that is less affected by the limitations described above is in-vehicle devices. Since these devices are with the driver all the time, their "impact" is immediate and more relevant in time and location, assuming that drivers do not ignore them (in the case of the displays). The speed limiter clearly had low acceptance and is probably impractical to deploy on a wide scale.

However, the speed limit and fuel efficiency displays are intriguing for three reasons. The first is that the participants in the focus groups liked the idea of speed limit and fuel efficiency displays and these displays seemed to address some of their desires for countermeasures to provide a reward rather than just a punishment (Note: none of these countermeasures were used in this study). The second is that they appear to indicate that situational factors may play a greater role in speeding than we originally anticipated; specifically, they provide useful and relevant information to the driver at all times, regardless of the specific circumstances. Third, they have not been deployed extensively in the United States, and at least have the merit of being a new approach to addressing the speeding problem. They have been shown to provide a significant mean reduction in vehicle speeds in some posted speed zones. (Regan et al., 2006).

A comprehensive framework of speeding is needed to guide countermeasure development.

The findings from this study provide support for an integrated behavioral framework that incorporates predictor variables, speeding behaviors, and countermeasures. This effort had an overall goal of learning how countermeasures would be accepted by, and effect the behavior of, subgroups of speeders. To support this objective, the planning and conduct of the activities in the current project were guided by a framework that captures key factors relevant to driving, as well as their relationship to potential speeding countermeasures.

Figure 57 describes this conceptual framework and how it relates key Driver, Vehicle, Roadway, and Environment (DVRE) factors to a driver who is speeding (Driver Performance), and its associated safety outcomes. The framework is firmly grounded in relevant studies and analyses of driver behavior. It reflects Battelle's past analyses and syntheses of the research literature on driver behavior and crash risk (Campbell et al., 2003; Kludt, Brown, Richman, & Campbell, 2006); Battelle's investigations of intersection safety behaviors (Richard, Michaels, & Campbell, 2005; Richard, Campbell, & Brown, 2006); UMTRI's run-off-road safety work (LeBlanc et al., 2006); safety countermeasures (NCHRP, 2005; NHTSA, 2007); and results from the recent 100-car study conducted by VTTI (Klauer et al., 2006), as well as research that covers driving or crashes more generally (e.g., Hendricks, Fell, & Freedman, 1999; Groegar, 2000; Treat et al., 1979). We should note that an earlier version of this conceptual framework was used as a high-level guide for planning our technical activities, such as identifying relevant personal inventory instruments, but it was not used as a fully validated empirical model. Also, only some of these elements were investigated in the current study. However, the framework was revised using relevant findings from the current work, such as adding a component related to trip/situational factors, which were found to be important in the inferential analyses and Focus Group discussions. Importantly, the framework also includes a variety of countermeasure types, explicitly targeted at specific DVRE interactions. Countermeasures related to each type of factor/outcome are color-coded in the figure.

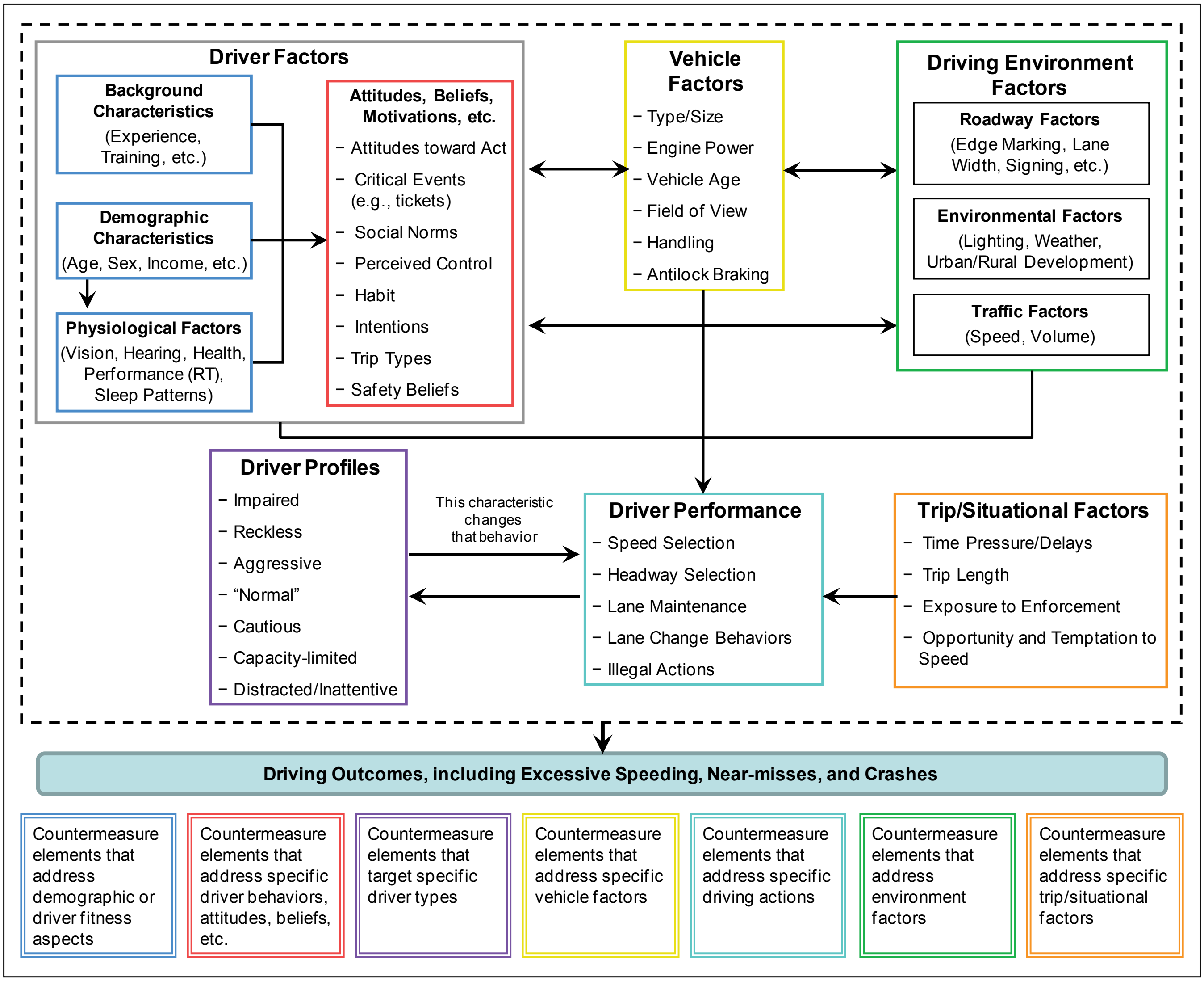


Figure 57. Conceptual framework showing the relationship between driver, vehicle, roadway, and environment factors and corresponding driver performance/profiles.

The data collected and analyzed in this project identified several elements of the framework that were associated with increased speeding. For example, demographic characteristics; certain attitudes, motivations, and beliefs; vehicle types, environment factors; and driver profiles (e.g., reckless) were all found to be significant predictors of speeding in some regression models. Note that the analyses were conducted at a broad level, and no attempt was made to verify this model. Its purpose is primarily to aid with the interpretation of the results in this case, and to put them in the appropriate context when considering implications for countermeasures.

In general, as the analyses indicate, this framework is relevant for identifying factors associated with speeding. Future efforts to take a more detailed look at predictors of speeding can be aided by using this framework to identify additional factors (especially Environment and Situational factors), in addition to potential secondary relationships among factors.

Methodological Conclusions

How useful was the overall approach methodology in this study?

Another conclusion that deserves mention is that the overall approach taken in this study seems to be extremely useful for investigating speeding behavior, and it affords an understanding of speeding that was previously unavailable through crash data analyses, surveys, or traffic studies. In particular, this naturalistic driving approach yields unique data about individual drivers' speeding behavior tracked over time, and across multiple trips. This provides new measures of speeding behavior (i.e., percentage of trips with any speeding and speeding) that enable us to investigate aspects of speeding that represent persistent factors such as driver traits, roadway characteristics, driving experiences and patterns that may influence driving behaviors across time, even though they may not always be present during every individual trip.

It is also worth emphasizing that the current approach provides a performance-based dependent measure of speeding, in contrast to most other speeding studies, which have involved self-reported speeding behavior or the results of simulator studies. Specifically, the current study marks one of the first attempts to match driver-, roadway-, and trip-specific factors with on-road performance. This obviously leads to some challenges since the specific analytical approaches had to be developed anew. However, as we refine the analytical approaches and speeding measures, it should be possible to develop a more comprehensive understanding of the range of driver speeding behaviors, and how they are influenced by driver-, roadway-, and trip-specific factors.

Another contribution of the current approach was in developing and using a measure of "opportunity to speed" to control for driving exposure, rather than just using miles driven or total trip times. Certainly, controlling for the amount of driving is important (and a common approach among studies that measure risk), since the absolute amount of speeding generally varies as a function of the amount of driving. In this study, there were clear differences between individuals and demographic groups in terms of how much driving they did and on the types of roads they drove. Drawing conclusions about speeding behaviors without accounting for these differences would have added considerable uncertainty to our findings. Moreover, using "opportunity to speed" as the basis for our exposure measure provides a more accurate measure of driving behavior than miles driven etc., since speeding is only a viable behavioral option under a limited set of driving conditions (e.g., sufficiently open road ahead). As discussed in the caveats in Chapter 7, our measure of "opportunity to speed" was imperfect; however, given the study constraints, it represents a reasonable approach for estimating exposure.

How useful was our definition of speeding?

The use of a behavior-based definition of speeding was a key element of our basic analytical strategy (as described in Tables 9 and 10, respectively). A relevant question to ask in hindsight is how appropriate and valid was this approach overall. Both the on-road and focus group data analysis can provide insight regarding this question.

On-Road Data

An early modification of our basic approach was to combine Type 3 (PS+10 mph) and Type 4 (PS+20 mph) speeding, since the latter was too rare to support a separate set of global analyses. Specifically, there was a very low incidence of Type 4 speeding, which would be expected, since it represents egregious exceedence of the speed limit. This threshold has merit in focused analyses targeting the worst speeders, but it was a poor measure for the broad analysis of speeding behavior conducted in the current project.

The challenge was to strike a balance between having sufficient speeding data to analyze, but not having so much that real effects get washed out by too many false positives. The overall results of this study indicate that combining Type 3 and Type 4 was an effective approach for summarizing and analyzing trip data. In particular, the descriptive analyses showed that, based on the definition used, speeding was relatively infrequent, which suggests that the threshold was not too easy to exceed. It was also the case that many drivers showed little or no speeding. Also, the significant and interpretable regression model results suggest that—at least at a high level—the current speeding definition provided an adequate demarcation between speeding and non-speeding. Using the speeding measures alone, it is difficult to definitively confirm the appropriateness of the speeding definition since behavior is measured on a continuous scale with unclear demarcation points. Additional confirmation could be obtained by conducting a sensitivity analysis with different Type-3 speeding thresholds.

Focus Group Data

The focus group discussions were a good way to provide some validation to the behavior-based definition of speeding since it represents a concept that is internal to drivers. In particular, this definition assumes that drivers recognize and act on set boundaries above the posted speed that are related to speeding enforcement (lower boundary of Type 3 speeding), and related to driving recklessly or driving too fast for conditions (lower boundary of Type 4 speeding). In general, the focus groups provided good support for this assumption. More specifically, it is clear from the driver comments that they had specific speed-based demarcations that had behavioral significance to them. These included the posted speed, the speed at which they risk getting a ticket (ticket speed), and the safe driving speed for conditions (safe speed), which were all seen as being conceptually different.

A key departure from the behavioral definition of speeding was that the specific values of the speeding type boundaries differed in some instances. Although posted speed plus 10 mph was a reasonable Type 3 threshold on higher speed roads (i.e., 55-70 mph), most drivers thought that the posted speed plus 5 mph was more appropriate on lower speed roads (i.e., 30-35 mph). Another difference is that there seemed to be greater variation across drivers as to what constituted the threshold for safe driving speed (i.e., Type 4 speeding). This latter point supports the decision to combine Type 3 and Type 4 speeding in the quantitative analyses. In general, the focus group findings suggest that the overall behavior-based approach is valid and useful; however, driver comments also indicated that their views on what constitutes speeding are nuanced and incorporate a wider range of elements than just the desire to avoid a speeding ticket.

More broadly, this behavior-based approach leads to a simple but useful framework for organizing driver motivations, attitudes, and beliefs about speeding. In particular, the posted speed, ticket speed, and safe speed seem to represent identifiable “set points” on the travel-speed continuum. There are likely other identifiable set points related to other dimensions of speed, such as a “socially acceptable” driving speed, or “uncomfortable” driving speed (e.g., speed at which the vehicle begins to vibrate heavily)[10] or when they feel a lack of control. These speed set points can become a “target speed” that governs a driver’s speed monitoring or adjustment behavior during all or part of a trip. Logically, when given an opportunity to drive as fast as they want, all drivers will still limit their speed in some way (even if it is just to maintain control of their vehicle). The set points can be thought of as the underlying motivation for how drivers limit their speed, whether it is a conscious or unconscious decision. Different drivers will have different set points motivating their decision. For example:

Some drivers may be focused on being absolutely law abiding, so for them the posted speed is the limit;

Other drivers are concerned about getting a ticket, so the ticket speed is the limit; and

Other drivers may not care about paying tickets, but they do not want to crash their car, so the safety speed is the limit.

These set points may also change based on roadway conditions. In particular, the safety speed may be lower in poor weather conditions, or on different types of roads (no shoulder, residential area, etc.). Also, the particular set point that is motivating driver speed choice can also change. For example, if a driver who typically tries to stay within the ticket speed is late for an important appointment, he or she may be trying to make up for lost time and willing to risk getting a ticket by speeding, but not having a crash. In this case, driver speed behavior is limited by the safe speed rather than the ticket speed.

Importantly, these set points also represent a separate dimension from factors that directly influence immediate speed (e.g., inattention, being late, perceived danger). Accordingly, the set points and speed factors represent two different mechanisms for influencing driver speed. The set points are a high level speed goal. The speed factors have a more direct influence on speed, such as following the flow of traffic, or enjoying the sensation of traveling fast. For example, a driver with the intention of traveling at the posted speed could end up driving faster than that because he or she is inattentively keeping up with traffic that is speeding. In this case, the set point is unchanged but influencing factors (i.e., inattention) cause travel speed to exceed driver intentions. However, once the driver realizes that the travel speed is high, he or she might slow back down to the posted speed.

The practical implication of this view is that both mechanisms can be targeted by countermeasures. For example, a countermeasure such as increased enforcement could affect travel speed in different ways. Increased police presence can be a direct influencing factor by causing drivers to slow as they see patrols more frequently. For drivers with a higher set point (i.e., safety speed), getting pulled over may cause them to switch to a lower, ticket-speed set point. Alternatively, consistent enforcement of a lower ticket-speed and/or corresponding public safety campaigns could eventually lead to drivers associating the ticket speed with a lower set point. In general, this framework provides insight into the underlying behavioral basis of driver motivations and intentions regarding speeding.

[10] The focus group discussions did not cover these additional set point topics, but some drivers did indirectly mention these ideas.

Chapter 6: Methodological Considerations

There are some important methodological considerations and caveats with regard to the interpretation of the study findings; these are summarized below.

Absolute Estimates of Speeding Time

The first consideration relates to how free-flow and speeding time were determined in this study. In particular, both values were calculated based on when the recorded speed exceeded a specified threshold relative to the posted speed (PS minus 5 mph for free-flow driving, and PS plus 10 mph for speeding). Although we developed and have documented a logical justification for selecting these specific criterion values, applying different criterion would result in different estimates of speeding time. Consequently, care must be taken when interpreting the estimates of how much drivers speed in terms of the absolute values reported. This is particularly true when comparing the findings from the current study to findings from other studies.

Estimate of "Opportunity to Speed"

Another important consideration (related to the first) has to do with the accuracy of free-flow time as an estimate of opportunity to speed, especially in Seattle. Free-flow time provides an exposure-based denominator for the speeding measures. However, a limitation of the current approach is that there was no objective measure of how open the road was in front of the participant's vehicle during free-flow driving. Consequently, under some traffic conditions, driving that is categorized as an "opportunity to speed" may actually not represent such an opportunity (i.e., if the vehicle was "stuck" behind/surrounded by other fast-moving vehicles or traveling slower than the participant would like). It is possible that the opportunity to speed was substantially over-estimated in Seattle because of traffic density levels (possibly resulting in under-estimates of speeding), whereas this is less likely to have been the case in Texas. The end result of this is that caution must be used when comparing the absolute levels of estimated speeding of Seattle and Texas, since the free-flow time measure does not represent the same opportunity to speed in both cases.

Note that, although we have identified important considerations regarding how speeding is calculated as a relative measure, we still think that the basic approach of comparing speeding time to an estimate of the opportunity to speed is valid and useful, and provides a more informative measure of speeding compared to the alternatives of reporting speeding time on its own without an exposure-based reference point.

Time/Duration Criterion of Speeding

In the current data set, a single criterion based on the travel speed (i.e., 10 mph above PS) was used for categorizing driving as speeding time. However, another option that we did not implement was to add a duration-based criterion as well (e.g., 10 mph above PS *for 5 consecutive seconds*). The decision to exclude a duration-based criterion was made to avoid introducing another dimension to the definition of speeding that reflected experimenter judgment, since there is little a priori basis for selecting a specific time threshold. However, this has implications for the "percentage of trips with speeding measure," since the lack of a duration criterion made it easier for participants to record a speeding event. Specifically, it may have increased the number of "false positive"/incidental speeding episodes, which adds "noise" to the process of distinguishing between speeders and non-speeders. This effect was probably mitigated somewhat by the speed threshold, which was still well above the posted speed (i.e., 10 mph). Adding a time-duration criterion is an approach that could be revisited in future analyses if it becomes important to better segment different types of speeders.

Excluded Driving Data in Texas

Another consideration with regard to the data set is that there was a greater amount of driving in Texas that was excluded from the data set than in Seattle because the posted speed could not be validated on as many roads. This is because more effort was required to validate roads in Texas (using Google StreetView™ or by driving them and manually recording posted speeds), and we had to stop these activities before we could validate all of the roads with useful driving data. While we still tried to validate roads comprising 50% of the driving, a lower proportion of roads were validated than in Seattle. Also, the constraints on how we could validate roads led to the systematic exclusion of certain types of roads, such as 30-35 mph roads in outlying towns. Since there were relatively large asymmetries in driving patterns across Texas demographic groups, it is possible that the data validation approach systematically biased the data sample against a particular group (i.e., Older Females had the least in town driving, however, because they lived in outlying areas, their in-town driving may have been on excluded roads). This could affect the pattern of results, especially given how there was less data collected in Texas overall.

Another set of excluded roads in Texas were 40-45 mph roads. These roads were not analyzed because there was no comparable, viable speed band in Seattle, and a broader objective was to focus on speed bands that clearly represented different types of driving (i.e., low-speed in-town roads and high-speed limited-access or rural roads). However, the 40-45 mph roads contained substantially more driving in Texas than the 30-35 mph roads, so they represent a promising source of additional data if we want to increase the Texas data set.

Generalizability of Personal Inventory Items

As discussed in the Results sections, a limitation of the personal inventory items is that they were very general in terms of the driving context, but the driving behavior measured is basically the opposite of this—often a direct response to immediate driving conditions. In other words, when completing the personal inventory, participants may have had some specific driving context in mind that was not specified in the inventory questions; however, when we examine these personal inventory items in the context of driving on a specific road type, it may not be the same context the participant had in mind when doing the inventory. In Seattle, there might be sufficient uniformity in overall driving conditions to minimize the effects of this concern; however, the regression results from Texas suggest that this may have been an important issue at that location. In particular, the in-town and rural driving environments were substantially different. Moreover, the driving done by certain groups was more concentrated in certain areas (i.e., Older Females did more rural driving, while Younger Males did proportionally more of their driving in town). If drivers in these groups answered the questions with their typical driving environment in mind, the personal inventory predictors may be counterintuitive when applied to a different environment (e.g., drivers may be cautious drivers in town, but drive faster or more carelessly on rural roads). Therefore, caution must be applied when interpreting the results that map certain personal inventory questions to specific driving contexts.

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DOT HS 811 818
September 2013

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9786-091813-v4a