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GUIDELINES FOR DEVELOPMENT OF EVIDENCE-BASED COUNTERMEASURES FOR RISKY DRIVING – VOLUME 1

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16. Abstract The overall objective of this project was to create a set of guidelines that can be used to inform the development of risky driving countermeasures that are evidence-based, guided by theory, and lead to sustained behavioral change. Several tasks were completed to achieve this objective including: developing a behavior change inventory; identifying candidate behaviors; identifying characteristics of candidate behaviors; cross validating driver characteristics and target behaviors through an online survey and naturalistic driving study; and developing countermeasure recommendations. This reports describes the purpose of each task, the approach used to complete each task, and the results of each task. It also presents 26 guidelines for countermeasure development.		
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1 INTRODUCTION

Motor vehicle crashes represent a significant public health problem in the United States (US) and elsewhere (OECD/ITF, 2016). Efforts to reduce crashes and improve driving safety have been multifaceted, focusing on the vehicle, roadway, and driver (Eby, Molnar & St. Louis, 2019). In each of these areas, driver behavior plays an integral role in influencing safety outcomes. For example, roundabouts have known safety benefits but drivers must first understand how they are designed and use them appropriately to optimize their intended outcomes. Similarly, vehicle design improvements such as advances in vehicle technologies hold promise for increasing vehicle safety, reducing injuries, and making the driving task more comfortable.

Yet, at least for the foreseeable future, driver decision making and behavior will continue to play a critical role. For example, based on SAE International definitions adopted by the National Highway Traffic Safety Administration (NHTSA) in September 2016: at Level 2, an automated system on the vehicle can conduct some parts of the driving task, while the human continues to monitor the driving environment and performs the rest of the driving tasks; and at Level 3, an automated system can both conduct some parts of the driving task and monitor the driving environment in some instances, but the human driver must be ready to take back control when the automated system requests (NHTSA, 2016). Even a Level 4 automated vehicle will only be able to be used in certain areas and under certain conditions. Thus, countermeasures to improve safety at all levels need to take into account human behavior and many of the risky behaviors we see today will continue to be relevant for many years to come.

There is also an opportunity to improve the effectiveness of such countermeasures by ensuring that they incorporate appropriate behavior change theory. While much has been learned about theories underlying behavior change in areas outside of traffic safety, particularly the health and wellness domain, this knowledge has generally not been applied in the development of countermeasures for risky driving. This project was intended to extend research in this area; it directly addresses the *Behaviors* category of the Collaborative Safety Research Center's Fostering Behavior Change for Safer Driving program.

2 PROJECT AIMS

The overall project objective was to create a set of guidelines that can be used to inform the development of risky driving countermeasures that are evidence-based, guided by theory, and lead to sustained behavioral change. The project had three guiding aims:

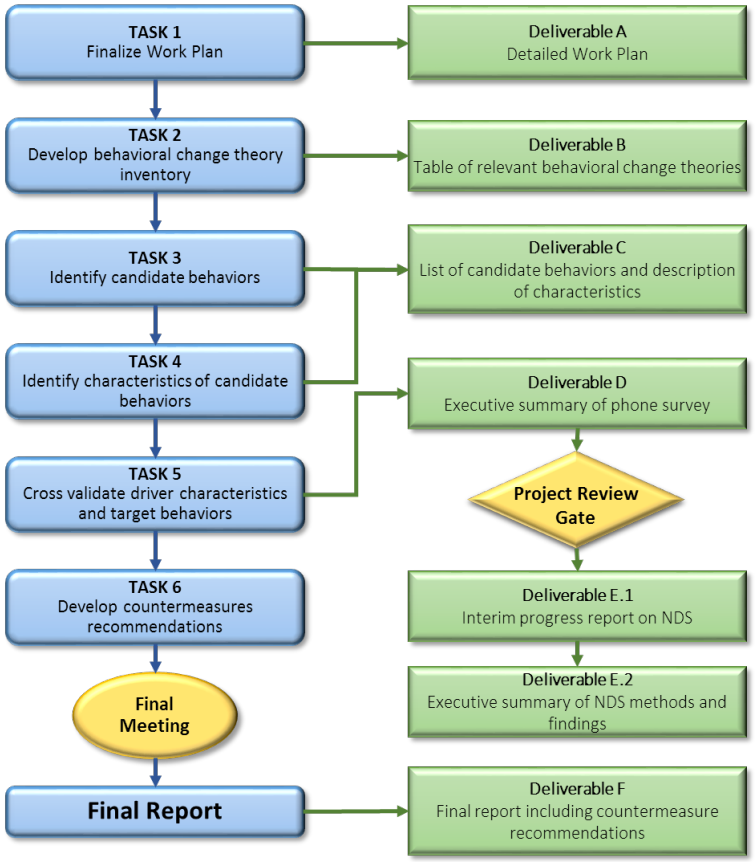
1. Identify a set of theories and underlying constructs that would be applicable to risky driving behaviors of road-users.
2. Identify the characteristics of risky driving behaviors and additional factors that may mediate the effectiveness of a countermeasure (e.g., personality, cognitive ability, socio-demographics, and attitudes).

3. Develop recommendations for evidence-based countermeasures that can be used to examine risky driving behaviors.

3 PROJECT TASKS

Six tasks were identified to achieve the project aims, with corresponding deliverables (Figure 1). A brief overview of tasks, excluding the Work Plan (Task 1), is provided below, including the purpose of each task, the approach used to carry it out, and the results from the task. Fuller detail on each of these tasks can be found in the corresponding deliverables previously submitted (i.e., B, C, D, E), which are provided in a supplement to this report. This report constitutes Deliverable F, the final deliverable for the project. Deliverable F – Supplement contains deliverables B, C, D, and E.

Figure 1. Project Overview



3.1 Task 2: Develop Behavior Change Theory Inventory

3.1.1 Purpose

Theory refers to a set of interrelated propositions including concepts that describe, explain, and/or predict a phenomenon (Glanz, Rimer, and Lewis, 1997). Applying this description to

injury prevention, Gielen and Sleet (2003) noted that "…the phenomenon of interest is human behavior, specifically injury-related behavior (e.g., risk behavior, safety practices). Concepts or constructs are the component parts or 'building blocks' of a particular theory (e.g., attitudes, norms, perceived risk). Theories are important not simply because they help us understand causes of problems but because they also allow us to identify mechanisms of change, determine why programs succeed or fail, and, perhaps most importantly, guide us to build better prevention programs" (p. 66). The purpose of this task was to develop an inventory of relevant behavior change theories that included descriptions of the theories, target populations, types of behaviors addressed and relevant contexts, and underlying constructs. The inventory served as the source for selecting a subset of theories to help guide countermeasure development for addressing risky driving. Fuller detail on this task can be found in Deliverable B (see Deliverable F - Supplement). A brief overview of our approach and results is presented here.

3.1.2 Approach

Our approach involved several activities. First, we reviewed previous UMTRI work that used behavioral change theory as the basis for understanding and/or influencing various driving-related behaviors. Second, given the breadth and depth of the literature on behavior change theory, we developed a set of criteria to ensure that the search was comprehensive but also manageable within the scope of the project (e.g., documents other than dissertations and full books, documents published since 2007, publications both within and outside US but written in English, research studies rather than editorial or opinion pieces, and meta-analyses, systematic reviews, or reviews rather than individual studies). Third, using the set of search criteria and search terms, we searched several databases (e.g., MEDLINE, PSYCINFO, TRID, ProQuest, ScienceDirect, Web of Science), as well as web-based search engines (Google and Google Scholar) to locate current information available only through the Internet. Fourth, all documents were reviewed for appropriateness, and findings from documents considered appropriate were synthesized in tabular form. Finally, we selected a subset of theories most appropriate for the project, taking into account the project objectives and aims, as well as how often and effectively different theories were used in other studies to explain and/or change driving related behaviors.

3.1.3 Results

The most commonly examined theories in the literature were Theory of Planned Behavior/Theory of Reasoned Action (mentioned in 29 documents), Health Belief Model (19), Social Cognitive Theory/Social Learning Theory (20), and Transtheoretical Stages of Change Model (18). In addition, three of these theories (Theory of Planned Behavior, Health Belief Model, and Social Cognitive Theory) were among five theories identified that collectively contain most of the variables that have been used to understand a wide variety of human behaviors (e.g., attitudes, norms, self-efficacy, intentions, and risk/threat perceptions; Gielen & Sleet, 2003). Therefore, constructs from Theory of Planned Behavior, Health Belief Model, and Social Cognitive Theory were incorporated into data collection for the project.

It was also clear from the review that even for the theories commonly used to understand or predict behaviors or behavioral interventions, the effect sizes on the behaviors of interest were generally small to moderate. Thus, there were other factors than just those related to the theories that appeared to come into play to influence health and driving behaviors (e.g., age, gender, and personality traits). The finding that health and driving behaviors are influenced by a wide array

of personal and environmental factors beyond just theory-related characteristics provides strong support for our approach to this study. In designing the study, we saw great value in incorporating behavioral change theory, but we were also interested in collecting information on other individual characteristics and factors such as personality traits and psychosocial characteristics to assess their relationship with risky driving.

3.2 Task 3: Identify Candidate Behaviors

3.2.1 Purpose

The purpose of this task was to identify candidate risky behaviors for the project, comprised of both secondary task behaviors and driving behaviors. The intent was to build on knowledge gleaned from past analyses of UMTRI's naturalistic driving databases to help identify candidate risky behaviors, estimate their frequency in the driving population, and identify any sociodemographic driver characteristics associated with prevalence. We focused on existing coded events from two of UMTRI's largest datasets: Integrated Vehicle-Based Safety Systems and Safety Pilot Model Deployment. Behaviors identified from this process were then further examined within the context of how well they fit the purpose, scope, and design of the project. Fuller detail on this task can be found in Deliverable C (see Deliverable F - Supplement). A brief overview of our approach and results is presented here.

3.2.2 Approach

In this task, we talked with UMTRI faculty about outcomes from their analyses of two of UMTRI's largest existing naturalistic driving databases (Integrated Vehicle-Based Safety Systems and Safety Pilot Model Deployment) to help identify candidate risky behaviors, estimate their frequency in the driving population, and identify any sociodemographic driver characteristics associated with their prevalence. This "data mining" process was intended to build on previous UMTRI efforts to code and/or identify risky driving behaviors. Based on information collected during the discussions, as well as discussions with Toyota and our experience with past projects, we developed a list of potential candidate risky behaviors. We then narrowed down the candidate behaviors to a final set based on the following criteria: feasibility of assessing the behavior with either the primary DAS or the "always on" camera system added to capture behaviors prior to participants' turning the ignition on; level of effort and time to assess the behaviors; and whether we could easily code certain behaviors given that we would already be looking at video for other behaviors of interest. Most of the coded events were for distracted driving behaviors and these are presented in Table 2 of Deliverable C (see Deliverable F – Supplement) along with their frequencies, based on the data mining of UMTRI's naturalistic driving datasets. In addition, we omitted a few behaviors that we had originally considered because they did not meet the criteria (e.g., using signals, disobeying a traffic signal).

3.2.3 Results

The final set of candidate behaviors for this study included behaviors that increase the risk of being in a crash (including 7 distraction/secondary tasks and 5 driving behaviors), a behavior that increases the risk of being injured if involved in a crash, and behaviors that facilitate/increase the likelihood of engaging in risky behavior or that inhibit/decrease the likelihood of engaging in risky behavior (Table 1). In all, 17 behaviors were identified as candidates for inclusion in the subsequent study tasks.

Table 1. Task 3 Candidate Behaviors from Table 3 in Deliverable C (see Deliverable F – Supplement)

	Candidate Behaviors
Behaviors that increase risk of crash	
Distraction or Secondary Tasks	-Answering/making calls on cell phone -Manipulating cell phone for texting, email, web searching, social media, etc.
	Eating/drinking
	Grooming
	Reaching for, holding, looking at or manipulating other object inside vehicle
	Talking to/listening to passengers
	Looking at object external to vehicle
Driving Behaviors	Speeding
	Tailgating/following too closely
	Failure to yield
	Unsafe lane change/merge/passing
	Running/rolling through stop sign
Behaviors that increase risk of injury given a crash	
Seat Belt use	Not using a seat belt
Behaviors that increase or decrease likelihood of risky behavior (risk facilitators or inhibitors)	
Facilitators	Placing phone in a position for use during driving (e.g., in center console/cups)
	Placing other objects in a position for use during driving
Inhibitors	Putting phone away
	Putting other objects away

3.3 Task 4: Identify Characteristics of Candidate Behaviors

3.3.1 Purpose

The purpose of this task was to identify characteristics or underlying dimensions of candidate risky behaviors, with the intent of developing a classification scheme that could be applied to future (but yet unknown) behaviors. This task grew out of the recognition that we do not yet know which risky behaviors may emerge in the future. Therefore, as we become aware of such behaviors, it will be useful to have a way to map back to characteristics already identified to determine which countermeasures might be effective in addressing them. Fuller detail on this task can be found in Deliverable C (see Deliverable F - Supplement). A brief overview of our approach and results is presented here.

3.3.2 Approach

In selecting these dimensions for the study, our main criteria included:

- whether the dimension seemed reasonable with the scope and focus of the study, and more generally from a research perspective;

- how cleanly the behaviors of interest could be classified within the dimension (i.e., the ease of assigning each behavior to one category of the dimension), and
- how useful the dimension will be in developing the guidelines (the ultimate product from the study).

Given that these are human behaviors, we recognize that there may be some "messiness" in classifying the behaviors in one and only one category of each dimension. This is a challenge with any classification scheme for human behavior that needs to be taken into account.

3.3.3 Results

Four dimensions were selected for this study. Each is briefly described below.

Temporal: This dimension has to do with the time period during which the decision is made about engaging or not engaging in the behavior of interest. Decisions can be made either before or during driving. For example, the decision to tailgate another vehicle is typically made while an individual is driving, while the decision to put away one's cellphone is a pre-driving decision.

Location: This dimension has to do with whether the behavior has an internal or external focus, within the context of the car. That is, we are interested in whether the behavior is in response to some situation inside the car, or is a response to or is in relation to another vehicle or other situation outside the car. Engagement in secondary tasks inside the vehicle would have an internal focus. Behaviors such as tailgating would occur within the context of other vehicles on the roadway, outside of the car.

Emotional: This dimension has to do with how large of a role emotion or personality plays in engagement in the behavior, versus the extent to which the behavior results from a more cognitively-based decision. Behaviors that are largely triggered by emotion or personality are ones that might be characterized as aggressive or impulsive, while behaviors that are more cognitively-based are ones that are more likely to result from some process of reasoning or thinking through the decision.

Countermeasure type: This dimension has to do with the type of countermeasure for which the behavior is best suited. For the purposes of this project, we considered two types to be most relevant – technological and behavioral. What we mean is that for some behaviors, the most effective efforts to bring about change will require the individual to voluntarily change his or her actions. This will need to be largely through education campaigns and persuasive messaging. Other behaviors may be amenable to a technological solution to bring about behavior change.

3.4 Task 5: Cross Validate Driver Characteristics and Target Behaviors

3.4.1 Purpose

The purpose of this task was to collect new data to explore the interrelationships between the candidate risky behaviors, personal characteristics and other factors associated with these behaviors, and behavior change theory constructs. The task consisted of two main data gathering activities: an online survey of drivers (Task 5a); and a naturalistic driving study (NDS) of a smaller group of drivers from the online survey (Task 5b). The online survey data were intended to provide important insights into the target behaviors and underlying driver

characteristics, as well as be used to screen for "risk tendencies" and serve as the pool from which to draw participants for the naturalistic driving study. The NDS was intended to examine the objective everyday driving behaviors of participants. Fuller detail on the online survey can be found in Deliverable D (see Deliverable F - Supplement). Fuller detail on NDS can be found in Deliverable E (see Deliverable F - Supplement). A brief overview of our approach and results is presented here.

3.4.2 Task 5a: Online survey

3.4.2.1 Approach

The research team identified topical areas to cover in the survey instrument (e.g., sociodemographics, personal characteristics, the characteristics of the selected behaviors, and the selected behaviors themselves), based on the work completed in earlier tasks, recent reviews of the literature, the project team's expertise, and the focus areas of the project. Two of the candidate behaviors were excluded from the study at this time (not included in the online survey or NDS) because we determined that they could not be reliably or feasibly measured in NDS: talking to/listening to passengers and looking at objects external to the vehicle (see Column A in Table 2). As a result, the secondary task behaviors, driving behaviors, and facilitators/inhibitors measured in the online survey included: 1) answering/making calls or talking/listening on a cellphone; 2) manipulating a cellphone for texting, email, web searching, social media, etc.; 3) eating/drinking; 4) grooming; and 5) reaching for, holding, or manipulating another object in the vehicle; 6) speeding; 7) tailgating; 8) rolling through or running a stop sign; 9) unsafe merging; 10) failure to yield; 11) placing phone in a position for use during driving (e.g., in center console/cups); 12) placing other objects in a position for use during driving; 13) putting phone away; and 14) putting other objects away (see Column B in Table 2). Answering/making calls on a cellphone was measured separately for hand-held cellphones (hold phone conversation on a hand-held cellphone) and hands-free cellphones (hold phone conversation on a hands-free cellphone) in the scales used in the survey (see Column B in Table 2).

Table 2. Evolution of the Study Behaviors across Tasks: Candidate Behaviors (Task 3) to Surveyed Behaviors (Task 5a/5b) to Observed Behaviors (Task 5b)

	Behaviors			**Short Name**
	A	**B**	**C**	
	Candidate Behaviors from Task 3 (see Deliverable C in Deliverable F – Supplement)	**Surveyed Behaviors** from Task 5a (online survey) and Task 5b (follow-up survey) (see Deliverable D and Deliverable E in Deliverable F – Supplement)	**Observed Behaviors** from Task 5b (NDS DAS data) (see Deliverable E in Deliverable F – Supplement)	
Behaviors that increase risk of crash				
Distraction or Secondary Tasks	Answering/making calls on cellphone[1]	Hold phone conversation on a hand-held cellphone[2]	Holding/using hand-held cell phone[1]	**Holding/Using Phone**
		Hold phone conversation on a hands-free cellphone[2]		
	Manipulating cell phone for texting, email, web searching, social media, etc.[1]	Manually interact with a phone (e.g., sending text messages).		
	Eating/drinking	Eat or drink something.	Eating/drinking	**Eating/Drinking**
	Grooming	Engage in personal grooming or adjusting clothing.	Groom and/or adjust clothing	**Grooming**
	Reaching for, holding, looking at or manipulating other object inside vehicle	Reach for or manually interact with other objects in the car.	Reach for or manually interact with other objects in the vehicle (other than a cell phone)	**Reaching**
	Talking to/listening to passengers[3]			
	Looking at object external to vehicle[4]			
Driving Behaviors	Speeding	Exceed the speed limit by more than 10 miles per hour.	Speeding	**Speeding**
	Tailgating/following too closely	Drive especially close to the car in front of you (called tailgating or following too closely).	Tailgating	**Tailgating**

[1] Unable to differentiate between manipulating phone and making phone call in NDS videos. Pooled for secondary task video coding and analyses using those data.
[2] Hand-held and hands-free cellphone use measured separately in scales used for online and follow-up surveys.
[3] Not included in study: Could not reliably measure observed behavior; unable to see passengers.
[4] Not included in study: Could not feasibly measure observed behavior; did not code eye glances.

	Behaviors A	B	C	Short Name
	Failure to yield	Fail to yield to another driver when he or she has the right of way.	Failure to yield at roundabout or crosswalk	**Failure to Yield**
	Unsafe lane change/merge/passing	Change lanes, merge, or pass another vehicle in such a way that the car you pull in front of has to brake very abruptly.	Unsafe highway merging	**Merging**
	Running/rolling through stop sign	Cross an intersection with a stop sign without coming to a full stop.	Stop sign running	**Rolling Stop**
Behavior that increases risk of injury given a crash				
Seat Belt Use	Seat belt use	Not use your seat belt.	No Seat Belt	**No Seat Belt**
Behaviors that increase or decrease likelihood of risky behavior (risk facilitators or inhibitors)				
Facilitators	Placing phone in a position for use during driving (e.g., in center console/cups)	Put your mobile phone in a place close to you, in case you have to interact with it during the trip (e.g., in the center console or in the cup holders).	Places phone nearby for easy access during a driving trip	**Facilitate Phone**
	Placing other objects in a position for use during driving	Put other objects such as food or drinks in a place close to you, in case you have to interact with them during the trip (e.g., in the center console or in the cup holders)	Places an object nearby for easy access during a driving trip	**Facilitate Other**
Inhibitors	Putting phone away	Put your mobile phone away (e.g., in your purse or in the back seat) so that you will not have to interact with it during the trip.	Places phone in a location to restrict access to it during a driving trip	**Inhibit Phone**
	Putting other objects away	Put other objects such as food or drinks away (e.g., in the back seat) so that you will not have to interact with them during the trip.	Places an object in a location to restrict access to it during a driving trip	**Inhibit Other**

The team then identified a set of questionnaire items for each topical area. Where possible, the team sought tested/validated measures and items for each identified topical area. For many of these, the response categories were slightly adapted to provide a uniform set of categories for the study. For cases for which no existing items/measures could be found, the research team drafted new items for the survey. The survey instrument and all procedures related to the administration and analysis of the survey were reviewed and approved by the University of Michigan's Health Sciences and Behavioral Sciences Institutional Review Board.

A professional survey company (Morpace International) was hired to recruit a sample of adults from online survey panels, and program, administer, and manage the online survey. The sampling frame included three age groups: 18-25, 35-55, and 65 and older, and was stratified by age and sex, with the aim of obtaining equal groups by age-sex. Because the intent was to use the online survey to draw a sample for the naturalistic driving study, inclusion criteria were created to ensure that survey respondents could also be eligible to participate in that phase of the project. To qualify for the survey, participants had to:

1) live within 60 minutes of Ann Arbor, Michigan;
2) have a valid driver's license;
3) own/lease a vehicle;
4) drive their vehicle 80% of the time;
5) drive at least 4 days per week and drive at least 30 minute per day; and
6) qualify for one of the following age groups: 18-25, 35-55, 65 & older.

3.4.2.2 Results

The survey was conducted from December 11, 2018 – January 7, 2019. The average length of the interview was 25.7 minutes. A sample of 445 adult drivers from Southeastern Michigan completed the online survey. The sample was stratified by age and sex: male 18-25 (7.7%); female 18-25 (14.8%); male 35-55 (19.8%); female 35-55 (19.8%); male 65 and older (18.4%); and female 65 and older (19.6%). Results were analyzed using Poisson regression analysis and cluster analysis. The cluster analysis grouped the respondents into clusters such that the driving behaviors of each member of a cluster were more similar to each other and less similar to that of members of other clusters. This yielded four interpretable clusters of respondents with distinct and different patterns of self-reported risky driving behaviors (a fifth cluster of four participants with nonpatterned/random self-reported risky driving behaviors was excluded from analyses comparing clusters). Distinct indicators from demographics, travel patterns, driver histories, mental and social health, locus of control, and personality traits of groups of drivers clustered on their risky driving behaviors were identified. Detailed results on the Poisson regression analysis and cluster analysis can be found in Deliverable D and Deliverable E (see Deliverable F – Supplement).

3.4.3 Task 5b: NDS

3.4.3.1 Approach

The original NDS design called for selecting a subsample of drivers from the larger online survey sample, and installing in-vehicle technology in their personal vehicles to record driving behaviors. However, we had to expand our recruitment efforts to reach our recruitment goals through outreach to community partners and online postings. Participants recruited from this expanded approach still needed to meet the study's inclusion and exclusion criteria and, if eligible for study participation, complete all data collection requirements.

All NDS participants had their personal vehicle instrumented with a data acquisition system (DAS) that collected the following measures: GPS data (including location, speed, heading, and time), yaw rate, accelerations, daytime/nighttime, road type, distance from intersection, commuting or familiar trips, driving straight/on curves/turning, forward conflicts, lane changes, and hard braking. The DAS also included two cameras and a Mobileye camera for

forward target information and lane position (that can also tag pedestrians, cyclists, and motorcyclists). The DAS was activated with vehicle ignition and turned off when the ignition was turned off. A separate component of the DAS that did not turn on and off with ignition but always stayed on (the "always on" DAS) was installed in the vehicles of a subset of participants to record driver behaviors that occurred after getting in the vehicle but prior to ignition on. This system had a camera positioned such that portions of both the driver and front passenger were visible to capture drivers' interactions with objects in the front and backseat of the vehicle. Each participant drove for a period of three weeks with the DAS installed in his or her vehicle.

Participants recruited from the expanded recruitment methods completed the online survey at the start of the DAS installation appointment. During this appointment, all participants in the study were administered an in-person clinical assessment that consisted of a battery of tests for physical, cognitive, and perceptual functioning. The assessment was administered by a trained research staff member. The battery was comprised of standardized tests. The assessment also included a follow-up survey administered via computer to collect information about participants' perspectives and intentions to engage in several driving-related behaviors. The follow-up survey was designed to measure key constructs of the Theory of Planned Behavior and other behavior change theories (i.e., behavioral intentions, attitudes, norms, perceived risk and behavioral control, self-efficacy, and self-esteem) separately for each of the risky driving behaviors and facilitators/inhibitors explored in the original online survey (see Column B of Table 2). The test battery and survey required about 2 hours to complete.

The NDS driving data were processed prior to analysis using a combination of video/data coding of a sample of trips (10% of each participant's trips) and the development of algorithms to search the data without having to view video. However, video review was necessary for spot checking some of the behaviors and for actual identification. Based on what could be feasibly and reliably observed from the video, the two components of cellphone use were combined into using/holding a cellphone. Based on the algorithmic data processing, failure to yield was limited to roundabouts and pedestrian crossings, and unsafe merging/passing/lane changes was limited to highway merges. Thus, the final set of behaviors analyzed, using data from the NDS included: 1) using/holding a cellphone; 2) eating/drinking; 3) grooming; 4) reaching/interacting with other objects; 5) speeding; 6) tailgating; 7) rolling through a stop sign; 8) unsafe merging; and 9) failure to yield right-of-way (see Column C in Table 2). All procedures related to the collection and analysis of the naturalistic driving data were reviewed and approved the University of Michigan's Health Sciences and Behavioral Sciences Institutional Review Board.

A two-phased regression approach was used guided by the Theory of Planned Behavior: 1) behavioral intentions were predicted using attitudes about the behavior and demographics; 2) observed behavior was predicted using behavioral intentions, theory constructs, personality and psychosocial characteristics, demographics, and driving exposure. Separate regression analyses were run for each risky behavior of interest and, in the second regression phase, to predict two outcomes of interest: the number of behaviors per trip (e.g., number of using/holding cellphone tasks per trip, number of eating/drinking tasks per trip, number of speeding events per trip, number of tailgating events per trip) and the number of behaviors per minute (e.g., number of

using/holding cellphone tasks per minute, number of eating/drinking tasks per minute, number of speeding events per minute, number of tailgating events per minute). Potential predictor variables came from the online survey and follow-up survey, with variables selected for inclusion in the models based on how well they correlated with secondary task and driving behaviors.

3.4.3.2 Results

A total of 46 participants completed the NDS; 16 from the original online survey sample and 30 from the expanded recruitment efforts. A brief summary of final regression results for each risky behavior is provided below.

Cellphone: Attitudes favoring talking on a hand-held phone and manually interacting with a cellphone predicted intention to talk on a hand-held cellphone and intention to manually interact with a cellphone, respectively. In turn, the intention to talk on a hand-held cellphone and being non-White predicted the observed number of using/holding cellphone tasks per trip, while intention to talk on a hand-held cellphone and being young (age 18-25) predicted the observed number of using/holding cellphone tasks per minute.

Eating/Drinking: The attitude that eating/drinking something while driving was pleasant predicted intention to eat or drink something while driving. In turn, the attitude that it is necessary to eat or drink while driving, higher perceived likelihood to be in a crash, and being female predicted more observed eating/drinking per trip, while the attitude that it is necessary to eat or drink while driving and being female predicted more observed eating/drinking per minute.

Grooming: Attitudes favoring grooming while driving predicted the intention to groom while driving. However, none of the explanatory variables significantly predicted the number of observed grooming tasks per trip, and only self-efficacy predicted the observed number of grooming tasks per minute (with higher self-efficacy predicting more observed grooming per minute).

Speeding: The attitude that speeding was necessary predicted intention to speed. In turn, higher intention to speed, lower perceived susceptibility to crash if speeding, and longer average trip length predicted more observed speeding per trip, while higher intention to speed and longer average trip length predicted more observed speeding per minute.

Rolling Stops: Based on the lack of significant correlations for any of the variables looking at attitudes toward rolling stops, we did not run a model to predict intention to roll through stop signs, but rather modeled the outcomes of observed rolling stops per trip and per minute directly. More frequent observed rolling stops per trip were predicted by: attitudes that it is safe to manually interact with a cellphone while driving, dangerous to groom while driving, and wise to fail to yield the right-of-way; lower perceived susceptibility to being pulled over if fail to yield the right-of-way; and higher perceived likelihood of being injured if had a crash while speeding. More frequent observed rolling stops per minute were predicted by: attitudes that it would be

safe to manually interact with a cellphone while driving, dangerous to groom while driving, wise to fail to yield the right-of-way, and unwise to put away cellphone pre-trip; lower perceived likelihood (susceptibility) of being pulled over if failed to yield the right-of-way; higher perceived likelihood of being injured in a speeding-related crash (severity); and shorter average trip length.

Tailgating: The attitude that tailgating was pleasant and the attitude that tailgating was unwise predicted the intention to tailgate. In turn, higher intention to talk on a hand-held cellphone and higher injunctive norms for placing a cellphone close (most people important to them think it is all right for them to place phone close) predicted more observed tailgating per trip and per minute. Observed tailgating per trip was also predicted by longer average trip length.

Merge/Yield: For unsafe merging and failure to yield, there were insufficient events observed to complete regression analyses.

Reaching: By contrast, behaviors related to reaching/interacting with other objects were very pervasive (with drivers engaged in an average of four reaching/interacting tasks per observed trip), but the purpose of the reaching/interacting was often difficult to determine (e.g., secondary task engagement versus part of vehicle operation). Therefore, regression analyses for reaching/interactions were also not undertaken.

4 GUIDELINES

As discussed previously, one goal of this study was to develop recommendations/guidelines for evidence-based countermeasures that can be used to encourage safe driving behaviors. To that end, this section provides a set of guidelines along with a justification and rationale based on the extensive analyses conducted on the questionnaire and naturalistic driving data. Analysis results that contributed to guidelines are briefly summarized in the paragraphs below and more detailed presentations of those results can be found in Section 4.2 of Deliverable E (see Deliverable F – Supplement). Note that the questionnaire data focused largely on the constructs from Theory of Planned Behavior, Health Belief Model, and Social Cognitive Theory, personality characteristics, and self-reported secondary task and driving behaviors. Therefore, the guidelines are primarily relevant to the development of countermeasures that utilize behavior change theory in some form of an education and communication countermeasure, as opposed to providing, for example, guidance on the design of vehicles or advanced technology. Note also that because the study had a relatively small sample of participants, the guidelines are presented at a general level.

The guidelines are presented in several parts that relate directly to the framework of the research project.

- The first part provides guidelines related to the relationship among the specific behaviors addressed in the project.
- The second part considers guidelines based on the characteristics or underlying

dimensions of those behaviors including the temporal, locational, and emotional underpinnings.
- The third part discusses guidelines based on behavior change theory constructs.
- The final part presents guidelines related to the various factors that should be considered when developing traffic safety education and communication campaigns including audience, message, and message delivery factors.

Each section presents an overview of the issues, a summary of the findings from the empirical analyses in the study, and a discussion of the general guidelines.

Although the study originally considered nine risky/unsafe behaviors (using/holding a cellphone; grooming or adjusting clothing; eating/drinking something; speeding; rolling through a stop sign; tailgating; reaching/interacting with objects; unsafe merging/passing/lane changing; and failing to yield), the guidelines are focused on only four of those behaviors: **using/holding a cellphone, eating/drinking something, speeding, and tailgating**. These four behaviors were engaged by a large proportion of NDS participants (72% - 96%) and conformed to our theory-based, two-phased regression analysis approach of predicting intention to engage in a behavior and then predicting engagement in the behavior. Thus, they were most in line with our project objectives.

4.1 Guidelines Related to Relationship among Risky Behaviors

Overview of Issue. The risky driving behaviors examined in this study fall into two categories: secondary task behaviors that occur inside the vehicle (e.g., using/holding a cellphone) and other driving behaviors such as tailgating or speeding. Of particular interest is how these behaviors map together, both within each category and across categories. These potential relationships, or lack thereof, have important implications for the development of countermeasures to address risky driving, not only in terms of the type of countermeasures that are most appropriate, but also in terms of the specific aspects of countermeasures (e.g., determining appropriate target audiences, and message sources, content, and delivery for education and communication countermeasures).

Summary of Findings. Three of the four behaviors of interest were significantly correlated with other behaviors, but with the exception of speeding and tailgating ($r = .74$, $p < .0001$), the correlations were generally more modest. Using/holding a cellphone was correlated with speeding and tailgating ($r = .32$, $p = .03$ and $r = .39$, $p = .01$, respectively), but not eating/drinking. Eating/drinking was not correlated with any of the other three behaviors.

Table 3. Correlation Matrix of Select Observed Behaviors - r (p)

	Eat/Drink	Speed	Tailgate
Use/Hold Phone	.11 (.46)	.32 (.01)	.39 (.01)
Eat/Drink	-	.04 (.77)	.08 (.57)
Speed		-	.74 (.0001)

Profiles of risky driving engagement in both secondary task and driving behaviors were created for video-coded trips to better understand combinations of multiple behaviors that occurred during a trip (but not necessarily at the same time during a trip). Results from this analysis showed that there were 16 unique behavior profiles (or combinations of the four secondary task and driving behaviors of interest) across 420 video-coded trips. That is, the four behaviors of interest mapped together in 16 distinct ways. Profiles were also created for each individual driver in the study. This resulted in 11 unique behavior profiles for the coded trips for the 46 participants. Collectively, these findings suggest that while multiple behaviors often occurred during trips, their patterns were complex and not consistent across trips or drivers. The results of the profile analysis also showed that in 30% of trips, no behaviors of interest were observed, and in an additional 26% of trips, only one behavior of interest was observed. In the remaining 44% of trips, at least two behaviors were observed and sometimes three or all four were observed during the course of the trip, albeit not necessarily at the exact same time.

Guideline 4.1.1
There is value in categorizing risky behaviors as secondary task behaviors versus driving behaviors for the purpose of thinking more broadly about and planning education and communication countermeasures; however, countermeasure messaging should focus on individual behaviors rather than the categories themselves. That is, across and within each category, messaging should be tailored to each specific behavior rather than grouping them together.

Guideline 4.1.2
Education and communication countermeasure messaging should point out the compounding effects of engaging in multiple behaviors, even if the message is targeted to one specific behavior.

Guideline 4.1.3
Given that education and communication countermeasures are often intended to supplement/support high visibility enforcement, it makes sense for such enforcement to focus on multiple behaviors, especially those that often appear together during drivers' trips.

4.2 Guidelines Related to Characteristics or Underlying Dimensions of Risky Behaviors

Overview of Issue. The identification of characteristics or underlying dimensions of current risky behaviors is important because it provides a way to classify risky behaviors that may emerge in the future but are not yet known. Four dimensions were selected for this project: 1) temporal (when decision to engage in behavior is made); 2) location (whether behavior has internal or external focus); 3) emotional (whether behavior results more from cognitively-based decision or is emotionally triggered); and 4) countermeasure type (behavioral or technological).

Summary of Findings. In general, decisions to engage in secondary task behaviors tended to be made before embarking on a trip, as evidenced by drivers' stated behavioral intent predicting actual behavior. Facilitating and inhibiting behavior also came into play in the temporal dimension for many of the secondary task behaviors, especially using/holding a cellphone. That is, placing a phone close in the pre-trip period was significantly correlated with observed cellphone use ($r = .51$, $p = .0003$), as was putting a phone away pre-trip ($r = -.39$, $p = .02$). Similarly, for eating/drinking, placing other objects close pre-trip was significantly correlated with observed eating/drinking ($r = .43$, $p = .003$).

These findings also suggest that as expected, both using/holding a cellphone and eating/drinking have an internal focus in terms of the location dimension. Collectively, these temporal and location characteristics (pre-trip and internal decision making, respectively) point to these behaviors as being planful and therefore, they may be amenable to education and communication countermeasures. However, the results also suggest that there is a component to these behaviors that is emotionally/personality based, as evidenced by significant correlations between observed cellphone use and impulsiveness, sensation seeking, agreeableness, and conscientiousness ($r = .44$, $p = .002$ for impulsiveness, $r = .32$, $p = .03$ for sensation seeking, and $r = -.32$, $p = .03$ for each of the other two; see Table 9 of Deliverable E [in Deliverable F – Supplement]). This creates a challenge for the development of education and communication countermeasures that necessarily rely on changing drivers' cognitions in their decision making.

Compared to secondary task behaviors, interpretation of study results with regard to the temporal dimension were less clear for the driving behaviors. For speeding, stated behavioral intention predicted actual observed behavior, suggesting that drivers likely make the decision to speed before they embarked on a trip ($\beta=1.25$, $SE=0.48$, $t=2.62$, $p=0.01$). For tailgating, this was not the case, although drivers who seemed to decide ahead of time to talk on a cellphone were more likely to tailgate. Collectively, these findings make it difficult to reach firm conclusions about the location dimension, as one would expect that if the location was totally external, there would be no outright behavioral intention to engage in the behavior. In terms of the emotional dimension, observed speeding was significantly correlated with sensation seeking ($r = .32$, $p = .03$), suggesting there is an emotional/personality component to this behavior, as well as a cognitive basis.

Where behaviors fall within the temporal, location, and emotional dimensions has important implications for the countermeasure dimension, i.e., in terms of the type of countermeasure for which the behavior is best suited. Education and communication countermeasures, which require individuals to voluntarily change their behavior, will likely be more effective when decision making occurs prior to trip taking, and is internally and cognitively based. Technological and vehicle-design based countermeasures may be more effective for behaviors that are largely reactive (i.e., occurring on the road in response to other drivers and the driving environment), emotionally based, or hindered by personality characteristics.

Guideline 4.2.1

Education and communication countermeasures are appropriate for the secondary task and driving behaviors examined, especially those that are largely characterized by cognitively-based, internal, and planful decision making.

Guideline 4.2.2
For behaviors that involve some degree of emotionally triggered reaction, such as using/holding a cellphone and speeding, education and communication countermeasures could be supplemented with technological and/or design countermeasures.

Guideline 4.2.3
There may be an opportunity for a vehicle-design countermeasure for using/holding a cellphone that would increase the attractiveness of putting a phone away pre-trip; for example, adding a charging capability to a glove box or other less accessible area of the vehicle.

4.3 Guidelines Related to Behavior Change Theory and Constructs

Overview of Issue. An important component of this project was to examine risky driving behaviors within the context of behavior change theory and common constructs underlying such theory. Behavior change theories have been shown to be useful in not only understanding certain behaviors but also in identifying components of these theories (i.e., psychological factors that are referred to as theory constructs) that can help bring about desired behavior change. There is evidence that using such theories as an underpinning for the development of communication campaigns improves their effectiveness (see e.g., Sleet & Gielen, 2015; Trifiletti et al., 2005). To that end, behavior change theories have been successfully used in several areas of public health including exercise promotion, smoking cessation, use of sunscreen, and safe sex. While less used in the area of traffic safety, they provide an opportunity for promoting safer driving.

One challenge in using behavior change theory is that there are literally scores of individual theories (e.g., 82 identified in one review article; see Davis, Campbell, Hildon, Hobbs & Michie, 2015), and no single theory has emerged as the best for changing health or driving behaviors. However, evidence suggests that a small subset of constructs underlie many of these theories (e.g., behavior intentions, attitudes, social norms, and self-efficacy; Fishbein et al. 2000; Sleet & Gielen, 2015). Risk perception also comes into play as it underlies several of these constructs. For example, perception of the riskiness of speeding will likely influence one's attitude toward that behavior. Based on a review of the literature and relevant past UMTRI studies, we selected constructs from three behavior change theories (Theory of Planned Behavior, Health Belief Model, and Social Cognitive Theory) that have been widely used to understand behavior and/or develop campaigns to change behavior, and are among a handful of theories that collectively contain almost all of the constructs identified as most salient. The final set of constructs, examined specifically for each of the secondary tasks and driving behaviors of interest in the project included: behavioral intention; attitudes (bad to good, dangerous to safe, unpleasant to pleasant, unnecessary to necessary, unwise to wise); descriptive norms; injunctive norms; perceived behavioral control; perceived risk susceptibility and severity, self-esteem, and self-efficacy.

Summary of Findings. Collectively, across all the secondary task and driving behaviors, several behavior change theory constructs emerged as especially important for countermeasure development. First, as suggested by the Theory of Planned Behavior, attitudes were important

predictors of behavioral intentions for all but one of the secondary task and driving behaviors examined as a basis for these guidelines. For example, attitudes favoring talking on a hand-held phone (based on a composite of the attitude variables) predicted the intention to talk on a hand-held phone (see Table 10a in Deliverable E), and attitudes favoring manually interacting with a phone predicted the intention to manually interact with a phone (see Table 10b in Deliverable E). Specific attitudes that appeared most salient were those related to pleasant versus unpleasant and necessary versus unnecessary. Similarly, attitudes that favored speeding predicted intention to speed (see Table 19 in Deliverable E), especially the attitude that speeding is necessary versus unnecessary. The attitude that eating/drinking while driving is pleasant predicted the intention to eat/drink while driving (see Table 13 in Deliverable E).

In turn, the stated intention to engage in a particular behavior was highly correlated with actual engagement in that behavior for: using/holding a cellphone ($r = .61$, $p < .0001$ for intent to talk on a handheld phone and $r = .43$, $p = .004$ for intent to manipulate a cellphone); eating/drinking ($r = .50$, $p = .0003$); and speeding ($r = .48$, $p = .001$). Interestingly, while there was not a significant correlation between intention to tailgate and actual tailgating, intentions to talk on a hand-held phone and manually interact with a phone were highly correlated with tailgating ($r = .62$, $p < .0001$ and $r = .53$, $p = .0002$, respectively). In regression modeling, intention to talk on a hand-held phone predicted more observed cellphone use per trip and per minute, and intention to speed predicted more observed speeding per trip and per minute. However, more observed eating/drinking per trip and per minute was predicted by the attitude that such behavior is necessary rather than by the intent to engage in such behavior. More observed tailgating per trip and per minute was also not predicted by the intention to tailgate, but rather the intention to talk on a hand-held phone.

The other behavior change theory constructs examined in this study did not consistently come into play in terms of explaining the subset of secondary task and driving behaviors. Injunctive norms were significantly correlated with eating/drinking but at a modest level ($r = .30$, $p = .04$), while having a higher perceived likelihood to be in a crash was a predictor of more observed eating/drinking per trip but not per minute. A modest correlation was found between speeding and perceived susceptibility to a crash if speeding ($r = -.35$, $p = .02$), and in regression modeling, lower perceived susceptibility to crash if speeding predicted more observed number of speeding events per trip but not per minute. For tailgating, higher injunctive norms for placing a phone close (i.e., participants' belief that most people important to them think it is all right for them to place phone close) was a significant predictor of more observed tailgating per trip and per minute. Descriptive norms, perceived behavioral control, perceived risk severity, self-esteem, and self-efficacy were not significant in any of the models.

Underlying all of the guidelines in this section is the idea that development of education and communication countermeasures for risky driving should be based on appropriate behavior change theory constructs, with the selection of specific constructs for specific behaviors tied to empirical evidence. Specific guidelines are presented below.

Guideline 4.3.1

Education and communication countermeasures for using/holding a cellphone, should take into account that this behavior is generally a planned behavior (as evidenced by behavioral intention

being a significant predictor of actual behavior), with favorable attitudes toward using/holding a cellphone being a significant contributor to behavioral intention. Thus, addressing driver attitudes, especially those that characterize using/holding a cellphone as pleasant and necessary, needs to be a predominant part of countermeasure messaging.

Guideline 4.3.2
Education and communication countermeasures for eating/drinking should take into account that such behavior may not have as strong of a behavioral intention as other behaviors (given that behavioral intent did not predict actual behavior), but is more closely tied to the attitude that it is necessary. Thus, addressing/countering this driver attitude needs to be a predominant part of countermeasure messaging.

Guideline 4.3.3
Education and communication countermeasures for speeding should recognize that this behavior is generally a planned behavior (as evidenced by behavioral intention being a significant predictor of actual behavior), with the attitude that speeding is necessary being a significant contributor to behavioral intention. Thus, addressing the driver attitude that speeding is necessary needs to be a predominant part of countermeasure messaging.

Guideline 4.3.4
Education and communication countermeasures for tailgating should recognize that while such behavior may not be directly planned out, it is associated with the intent to engage in other behaviors, primarily talking on a hand-held cellphone and speeding. In addition, injunctive norms for placing a phone close come into play for this behavior alone. Thus, countermeasure messaging will necessarily be complex and may need to be achieved through a focus on ancillary behaviors and their association with attitudes and norms.

Guideline 4.3.5
In general, education and communication messages based largely on risk (i.e., related to risk of crash, injury, or police action) are unlikely to be persuasive in changing behavior. Risk susceptibility only came into to play for speeding but not for other behaviors. Lower perceived susceptibility to crash if speeding was correlated with observed speeding and predicted more observed speeding. Therefore, messaging to counteract speeding might benefit from addressing risk, but likely not for other behaviors.

Guideline 4.3.6
Basing education and communication messages largely on changing social and injunctive norms is unlikely to be persuasive in changing the behaviors of interest in this study. Norms (injunctive, not social) only came into play with tailgating; however, while injunctive norms for tailgating were correlated with observed tailgating, they dropped out as a predictor variable in the regression modeling.

Guideline 4.3.7
The constructs of perceived behavioral control, self-efficacy, and self-esteem were not correlated with or predictive of any of the behaviors of interest and therefore are unlikely to change

behavior on their own but may be important when combined with other constructs within a specific behavior change theory.

4.4 Guidelines Related to Audience and Message Factors

Overview of Issue. In developing traffic safety education and communication countermeasures, it is important to think about several aspects including audience, message source, message content, and message delivery factors. The group of people for whom education and communication countermeasures are intended represents the audience for those efforts. Countermeasures targeting specific groups (e.g., segmented by age or gender) may be more effective than broad measures (Hoekstra and Wegman, 2011), when behaviors are disproportionately distributed among these groups. Understanding the audience helps to make the countermeasures more compelling, and can also help ensure that they reach the target audience by understanding factors such as the type of media they engage and times and places most relevant to reach them.

Several message factors come into play in developing countermeasures, and are important to the countermeasures' effectiveness in changing the audience's behavior including message source, message content, and message delivery. Countermeasure messaging sources considered credible (e.g., qualified, sincere, trustworthy, attractive) by audiences are more likely to result in behavior change. Message content should be carefully considered within the context of the target behavior, audience factors, and how the message will be delivered. Some issues to consider when developing message content include how to frame the issue, the role of fear or risk based messaging, and what type of information to focus on (e.g., personal stories, facts, and statistics).

Effective countermeasures also need to be able to reach their audience. Message delivery to the target audience involves decisions about how (what type of media), when (message timing), where (the most effective context), and how often messages should be delivered. While it is beyond the scope of this project to recommend detailed audience and message material for use in countermeasures for each risky behavior of interest, our intent is to take these audience and message factors into account in our guidelines so that these factors can be more fully explored at the next stage of actual countermeasure development.

Summary of Findings. Cellphone: Several study results could help identify audience and message factors to inform development of education and communication countermeasures for the risky behaviors of interest. Findings related to participants' cellphone use suggest that this behavior was distributed broadly throughout the study sample (85% engaged in at least one cellphone task); however, age ($r = -.62$, $p < .0001$), race ($r = -.45$, $p = .002$), and marital status ($r = .28$, $p = .05$) were also correlated with cellphone use (see Deliverable E in Deliverable F – Supplement). In the regression analysis, a composite measure of attitudes favoring cellphone use while driving (that it is good, safe, pleasant, necessary, and wise) and younger age (18-25) predicted cellphone use while driving. The range of predictive attitudes provides rich potential for countermeasure messaging content. In particular, especially high correlations were found for cellphone use and the attitudes that talking on a hand-held phone and manually interacting with a phone are pleasant. Also of note were findings of significant correlations between observed

cellphone use and self-reported impulsiveness and sensation seeking ($r = .44$, $p = .002$ and $r = .32$, $p = .03$, respectively), agreeableness and conscientiousness (both $r = -.32$, $p = .03$), and pre-trip putting the phone close or conversely, putting it away ($r = .51$, $p = .0003$ and $r = -.39$, $p = .02$, respectively) (See Deliverable E in Deliverable F – Supplement).

Eating/Drinking: Some of the highest behavioral intentions were reported for eating/drinking while driving, with 57% of participants reporting high intention to engage in this behavior in the next month. Consistent with that, 72% engaged in at least one eating/drinking task while driving during the 3-week study period. While most participants engaged in this behavior at some point during the study period, they did not engage in it frequently. Participants engaged in eating/drinking behaviors during 25% of the study trips. In the regression analysis, the attitude that eating/drinking while driving is necessary, higher perceived likelihood to be in a crash, and being female predicted eating/drinking while driving.

Speeding: Almost the entire sample (96%) had at least one speeding event during the study and participants engaged in an average of 3.75 (SD=3.3) speeding events per trip, suggesting that speeding behavior was distributed broadly throughout the study sample. The only demographic variable significantly correlated with speeding was age ($r = -.29$, $p = .05$), although age did not significantly predict speeding in the regression analysis. In the regression analysis, the attitude that speeding is necessary predicted intention to speed. In turn, intention to speed, lower perceived susceptibility to crash if speeding, and longer trip length predicted speeding. While 96% had a speeding event during the 3-week study period, only 26% reported a high intention to speed in the next month (46% reported moderate intention). This suggests that decisions to speed are often made during driving trips as well as ahead of time.

Tailgating: Similarly to speeding, participants' tailgating behavior suggests that it was broadly distributed throughout the study sample (89% had at least one tailgating event). Age was the only demographic factor significantly correlated with tailgating ($r = -.36$, $p = .01$), although it did not significantly predict tailgating in the regression analysis. Tailgating was unique in that few attitudes or other measures specific to tailgating were significantly related to tailgating in the correlation analysis or predicted tailgating in the regression analysis. Instead, measures about behaviors such as cellphone use and speeding were strongly related to tailgating. In the regression analysis, higher intention to talk on a hand-held phone, higher injunctive norms for placing a phone close (participants perceived that most people important to them think it is all right for them to place phone close), and longer average trip length predicted more observed tailgating.

Guideline 4.4.1

Education and communication countermeasures for cellphone use, speeding, and tailgating should be targeted broadly across age groups, although some specific targeting of young drivers (age 18-25) could also be useful and appropriate.

Guideline 4.4.2

Education and communication countermeasures for eating/drinking should be targeted broadly across age groups, and some specific targeting of females could also be useful and appropriate

given the regression analysis showing that being female predicted more frequent eating/drinking while driving.

Guideline 4.4.3
Regardless of the behavior being addressed, countermeasures targeted across a broad range of age and other demographic groups should incorporate message sources and content that appeal to all within the broad audience, or be based on separate messages for segmented portions of the audience.

Guideline 4.4.4
With regard to message source, the selection of spokespeople to deliver a message should take into account how credible those people are with members of the targeted audience (e.g., selecting a young person to deliver a message on cellphone use targeted at that age group).

Guideline 4.4.5
Message content for speeding countermeasures would benefit from incorporating information to counteract perceptions that speeding is necessary and has low risk of negative consequences (e.g., facts, cost-benefit framing, and/or two-sided messaging).

Guideline 4.4.6
Message content for tailgating countermeasures should also address the potentially negative and interactive effects of other risky behaviors, particularly cellphone use and speeding.

Guideline 4.4.7
Message content for cellphone use countermeasures should incorporate information to counteract perceptions that such behavior is good, safe, pleasant, necessary, and wise.

Guideline 4.4.8
Message content for eating/drinking should emphasize that while most drivers will likely eat/drink at some point and should be part of the target audience, such behavior is likely not frequent behavior for many drivers. It should also address the attitudes that eating/drinking while driving is pleasant (a predictor of behavioral intent) and necessary (a predictor of actual behavior).

Guideline 4.4.9
The timing and location of message delivery for at least some countermeasure messaging for speeding and tailgating should be designed to reach audiences during trips (as opposed to pre-trip), particularly longer trips (e.g., billboards, radio messages).

Guideline 4.4.10
Messages targeting those behaviors for which the intention to engage in the behavior is a strong predictor of the actual behavior (cellphone use, eating/drinking, and speeding) should be designed to reach audiences pre-trip as well as during trips.

Guideline 4.4.11

Message delivery for cellphone use countermeasures should include social media and/or other viral marketing approaches that are frequently utilized by young people.

Guideline 4.4.12
The strong correlation between greater cellphone use and the personality measures of greater impulsivity, greater sensation seeking, lower agreeableness, and lower conscientiousness suggest that education and communication countermeasures may not have a large impact on reducing cellphone use. Instead, technological countermeasures, such as cellphone applications that determine when a person is driving and disallow use of the phone until the person stops driving, may be more effective.

Guideline 4.4.13
Given that attitudes toward eating/drinking as both pleasant and necessary predicted the number of eating/drinking events, but one's attitude about how dangerous this behavior can be did not, message content should attempt to raise awareness of the potential risk of being distracted while driving when eating/drinking even if this behavior is considered pleasant and necessary.

4.5 Guidelines by Behavior

Tables 4a-4e show which guidelines are associated with each of the four behaviors of interest (Tables 4a-4d) and those associated with all of the behaviors (Table 4e).

Table 4a. Guidelines Applicable to Holding/Using a Cellphone

Holding/Using a Cellphone	
Guideline Number	Description
4.2.2	For behaviors that involve some degree of emotionally triggered reaction, such as using/holding a cellphone and speeding, education and communication countermeasures could be supplemented with technological and/or design countermeasures.
4.2.3	There may be an opportunity for a vehicle-design countermeasure for using/holding a cellphone that would increase the attractiveness of putting a phone away pre-trip; for example, adding a charging capability to a glove box or other less accessible area of the vehicle.
4.3.1	Education and communication countermeasures for using/holding a cellphone, should take into account that this behavior is generally a planned behavior (as evidenced by behavioral intention being a significant predictor of actual behavior), with favorable attitudes toward using/holding a cellphone being a significant contributor to behavioral intention. Thus, addressing driver attitudes, especially those that characterize using/holding a cellphone as pleasant and necessary, needs to be a predominant part of countermeasure messaging.
4.3.4	Education and communication countermeasures for tailgating should recognize that while such behavior may not be directly planned out, it is associated with the intent to engage in other behaviors, primarily talking on a hand-held cellphone and speeding. In addition, injunctive norms for placing a phone close come into play

	for this behavior alone. Thus, countermeasure messaging will necessarily be complex and may need to be achieved through a focus on ancillary behaviors and their association with attitudes and norms.
4.4.1	Education and communication countermeasures for cellphone use, speeding, and tailgating should be targeted broadly across age groups, although some specific targeting of young drivers (age 18-25) could also be useful and appropriate.
4.4.4	With regard to message source, the selection of spokespeople to deliver a message should take into account the how credible those people are with members of the targeted audience (e.g., selecting a young person to deliver a message on cellphone use targeted at that age group).
4.4.6	Message content for tailgating countermeasures should also address the potentially negative and interactive effects of other risky behaviors, particularly cellphone use and speeding.
4.4.7	Message content for cellphone use countermeasures should incorporate information to counteract perceptions that such behavior is good, safe, pleasant, necessary, and wise.
4.4.10	Messages targeting those behaviors for which the intention to engage in the behavior is a strong predictor of the actual behavior (cellphone use, eating/drinking, and speeding) should be designed to reach audiences pre-trip as well as during trips.
4.4.11	Message delivery for cellphone use countermeasures should include social media and/or other viral marketing approaches that are frequently utilized by young people.
4.4.12	The strong correlation between greater cellphone use and the personality measures of greater impulsivity, greater sensation seeking, lower agreeableness, and lower conscientiousness suggest that education and communication countermeasures may not have a large impact on reducing cellphone use. Instead, technological countermeasures, such as cellphone applications that determine when a person is driving and disallow use of the phone until the person stops driving, may be more effective.

Table 4b. Guidelines Applicable to Eating/Drinking

Eating/Drinking	
Guideline Number	Description
4.3.2	Education and communication countermeasures for eating/drinking should take into account that such behavior may not have as strong as a behavioral intention as other behaviors (given that behavioral intent did not predict actual behavior), but is more closely tied to the attitude that it is necessary. Thus, addressing/countering this driver attitude needs to be a predominant part of countermeasure messaging.
4.4.2	Education and communication countermeasures for eating/drinking should be targeted broadly across age groups, and some specific targeting of females could also be useful and appropriate given the regression analysis showing that being female predicted more frequent eating/drinking while driving.

4.4.8	Message content for eating/drinking should emphasize that while most drivers will likely eat/drink at some point and should be part of the target audience, such behavior is likely not frequent behavior for many drivers. It should also address the attitudes that eating/drinking while driving is pleasant (a predictor of behavioral intent) and necessary (a predictor of actual behavior).
4.4.10	Messages targeting those behaviors for which the intention to engage in the behavior is a strong predictor of the actual behavior (cellphone use, eating/drinking, and speeding) should be designed to reach audiences pre-trip as well as during trips.
4.4.13	Given that attitudes toward eating/drinking as both pleasant and necessary predicted the number of eating/drinking events, but one's attitude about how dangerous this behavior can be did not, message content should attempt to raise awareness of the potential risk of being distracted while driving when eating/drinking even if this behavior is considered pleasant and necessary.

Table 4c. Guidelines Applicable to Speeding

Speeding	
Guideline Number	Description
4.2.2	For behaviors that involve some degree of emotionally triggered reaction, such as using/holding a cellphone and speeding, education and communication countermeasures could be supplemented with technological and/or design countermeasures.
4.3.3	Education and communication countermeasures for speeding should recognize that this behavior is generally a planned behavior (as evidenced by behavioral intention being a significant predictor of actual behavior), with the attitude that speeding is necessary being a significant contributor to behavioral intention. Thus, addressing the driver attitude that speeding is necessary needs to be a predominant part of countermeasure messaging.
4.3.4	Education and communication countermeasures for tailgating should recognize that while such behavior may not be directly planned out, it is associated with the intent to engage in other behaviors, primarily talking on a hand-held cellphone and speeding. In addition, injunctive norms for placing a phone close come into play for this behavior alone. Thus, countermeasure messaging will necessarily be complex and may need to be achieved through a focus on ancillary behaviors and their association with attitudes and norms.
4.3.5	In general, education and communication messages based largely on risk (i.e., related to risk of crash, injury, or police action) are unlikely to be persuasive in changing behavior. Risk susceptibility only came into to play for speeding but not for other behaviors. Lower perceived susceptibility to crash if speeding was correlated with observed speeding and predicted more observed speeding Therefore, messaging to counteract speeding might benefit from addressing risk, but likely not for other behaviors.

4.4.1	Education and communication countermeasures for cellphone use, speeding, and tailgating should be targeted broadly across age groups, although some specific targeting of young drivers (age 18-25) could also be useful and appropriate.
4.4.5	Message content for speeding countermeasures would benefit from incorporating information to counteract perceptions that speeding is necessary and has low risk of negative consequences (e.g., facts, cost-benefit framing, and/or two-sided messaging).
4.4.6	Message content for tailgating countermeasures should also address the potentially negative and interactive effects of other risky behaviors, particularly cellphone use and speeding.
4.4.9	The timing and location of message delivery for at least some countermeasure messaging for speeding and tailgating should be designed to reach audiences during trips (as opposed to pre-trip), particularly longer trips (e.g., billboards, radio messages).
4.4.10	Messages targeting those behaviors for which the intention to engage in the behavior is a strong predictor of the actual behavior (cellphone use, eating/drinking, and speeding) should be designed to reach audiences pre-trip as well as during trips.

Table 4d. Guidelines Applicable to Tailgating

Tailgating	
Guideline Number	Description
4.3.4	Education and communication countermeasures for tailgating should recognize that while such behavior may not be directly planned out, it is associated with the intent to engage in other behaviors, primarily talking on a hand-held cellphone and speeding. In addition, injunctive norms for placing a phone close come into play for this behavior alone. Thus, countermeasure messaging will necessarily be complex and may need to be achieved through a focus on ancillary behaviors and their association with attitudes and norms.
4.3.6	Basing education and communication messages largely on changing social and injunctive norms is unlikely to be persuasive in changing the behaviors of interest in this study. Norms (injunctive, not social) only came into play with tailgating; however, while injunctive norms for tailgating were correlated with observed tailgating, they dropped out as a predictor variable in the regression modeling.
4.4.1	Education and communication countermeasures for cellphone use, speeding, and tailgating should be targeted broadly across age groups, although some specific targeting of young drivers (age 18-25) could also be useful and appropriate.
4.4.6	Message content for tailgating countermeasures should also address the potentially negative and interactive effects of other risky behaviors, particularly cellphone use and speeding.
4.4.9	The timing and location of message delivery for at least some countermeasure messaging for speeding and tailgating should be designed to reach audiences during trips (as opposed to pre-trip), particularly longer trips (e.g., billboards, radio messages).

Table 4e. Guidelines Applicable to All Behaviors

All Behaviors	
Guideline Number	Description
4.1.1	There is value in categorizing risky behaviors as secondary task behaviors versus driving behaviors for the purpose of thinking more broadly about and planning education and communication countermeasures; however, countermeasure messaging should focus on individual behaviors rather than the categories themselves. That is, across and within each category, messaging should be tailored to each specific behavior rather than grouping them together.
4.1.2	Education and communication countermeasure messaging should point out the compounding effects of engaging in multiple behaviors, even if the message is targeted to one specific behavior.
4.1.3	Given that education and communication countermeasures are often intended to supplement/support high visibility enforcement, it makes sense for such enforcement to focus on multiple behaviors, especially those that often appear together during drivers' trips.
4.2.1	Education and communication countermeasures are appropriate for the secondary task and driving behaviors examined, especially those that are largely characterized by cognitively-based, internal, and planful decision making.
4.3.7	The constructs of perceived behavioral control, self-efficacy, and self-esteem were not correlated with or predictive of any of the behaviors of interest and therefore are unlikely to change behavior on their own but may be important when combined with other constructs within a specific behavior change theory.
4.4.3	Regardless of the behavior being addressed, countermeasures targeted across a broad range of age and other demographic groups should incorporate message sources and content that appeal to all within the broad audience, or be based on separate messages for segmented portions of the audience.
4.4.4	With regard to message source, the selection of spokespeople to deliver a message should take into account how credible those people are with members of the targeted audience (e.g., selecting a young person to deliver a message on cellphone use targeted at that age group).

5 DISCUSSION

The overall purpose of this project was to create a set of guidelines that can be used to inform the development of risky driving countermeasures that are evidence-based, guided by theory, and lead to sustained behavioral change. To that end, we collected a wealth of subjective and objective data, using a variety of methods, with a particular emphasis on surveys and naturalistic driving. Our primary focus was on two major types of potentially risky behaviors: secondary task behaviors (i.e., using/holding a cellphone, eating/drinking,

grooming, reaching/interacting with other objects); and other driving behaviors (i.e., speeding, tailgating, rolling through stop signs, unsafe passing/merging/lane changes, and failure to yield). Also of interest were pre-trip behaviors that might serve to facilitate or inhibit secondary task behaviors. Multiple outcome measures were developed for each risky behavior of interest; the two used in the final analyses were number of behaviors per trip and number of behaviors per minute. The pool of potential predictors for these outcomes included over 200 variables spanning demographics, self-reported driving behaviors, psychosocial and personality factors, and behavior change theory constructs, among others.

The richness of this dataset cannot be understated, and it has yielded innumerable insights into not only understanding risky behaviors but also thinking about how to develop countermeasures to combat those behaviors. At the same time, given the scope and resources available for the project, we recognize that there are still tremendous opportunities for continued analysis of these data to further explore the project's research questions, as well as answer additional research questions of interest. For example, given the relative frequency with which many of these behaviors were observed among our study participants, it would be of great interest to further characterize these behaviors from a risk perspective. That is, risk profiles could be developed that take into account the conditions under which behaviors take place on specific trips (e.g., road type and traffic environment). In addition, given the complexity of the dataset and interrelationships among the risky behaviors and potential predictors, more detailed analyses using a variety of innovative statistical techniques would be fruitful.

One limitation in our study was that our sample size for naturalistic driving data collection made it difficult to conduct certain analyses and reach meaningful conclusions for some of the behaviors of interest. Further research should focus on expanding the sample of naturalistic driving participants to increase the power for detecting differences and making predictions. However, despite this limitation, this project provides a rich source of information for understanding risky driving. Finally, while the intent of the project was to develop guidelines for countermeasures to address these risky behaviors and not the actual countermeasures themselves, a logical next step would be to use these guidelines to develop and evaluate actual countermeasures, particularly for the secondary task behaviors examined in this study.

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