

Effects of Road Collisions on the Travel Behavior of Vulnerable Groups: Expert Interview Findings

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16. Abstract We interviewed eight subject-matter experts in California in 2023 to understand how travel behavior and priorities may change in response to direct experience with road collisions. Experts represented a variety of perspectives, including medical doctors, advocates for active transportation safety, and advocates for people with disabilities. Their diverse specialties enabled us to capture a variety of concerns without triggering emotionally sensitive areas for people who have directly experienced road collisions. These experts identified common themes, including mental stress from the prospect of returning to driving—especially on freeways, lesser incidence of long-term changes in travel modes after experiencing a collision, dependence on others for rides in private vehicles, and changing routes or times of day of travel when traveling independently. These experts also explained how people's mode choices are also affected by general concerns about collisions in the news more than by specific personal experiences with near misses. Interview subjects' spoke of more specific concerns as well. These included but were not limited to, bicyclists using sidewalks instead of bike lanes when both are present, feeling stigmatized from using public transit or paratransit after experiencing a collision, and concerns with motorists treating bicyclists badly. These initial interviews clarify areas of focus and methodology for future qualitative and quantitative studies on the intersection of transportation safety and travel behavior change, particularly as they involve people who have directly experienced road collisions.			
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About the UC Institute of Transportation Studies

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Executive

Summary

Executive Summary

How do personal experiences with road collisions and near-misses affect travel behavior after such experiences? This is the central question of this project. In California, road collisions have led to tens of thousands of deaths, hundreds of thousands of serious injuries, and millions of less serious injuries since 2010. Strategic plans by California agencies aim to improve road safety in line with Vision Zero, a multi-national road traffic safety project that works toward structuring road systems so that serious injuries and fatalities in road collisions no longer occur. These plans also aim to improve socioeconomic equity and sustainability in the context of transportation safety. However, if road collision survivors hypothetically do not travel as much—or depend more on private vehicular transportation compared to before those collision experiences—those changes in travel behavior may work against efforts toward sustainability and equity. Despite this urgency, little research exists about the effects of individual experiences with road collisions and near-misses on travel behavior.

We developed a study to address the central question of this project. We originally planned to reach out directly to people who have experienced road collisions or near-misses to understand their travel behaviors before and after such experiences. However, the lack of previous research about these issues, as well as the existence of previous research suggesting broader forms of post-traumatic stress and similar psychological consequences of experiences with road collisions or near-misses, made us wary of probing such participants with untested questions. To avoid inadvertently triggering negative emotions, and to get a more detached assessment of qualitative issues facing a larger group of people with such experiences, we chose instead to interview people who work in various professional capacities with people who have experienced road collisions or near-misses. These include medical and psychiatric doctors, faith leaders, leaders of advocacy groups and other community-based organizations, and academic researchers.

In response to the central question, many interview subjects said that, after a first-hand experience with a road collision, individuals who experience serious injuries may take 3 to 12 months to return to their previous “normal” travel behavior or settle into a “new normal” travel behavior. For less serious injuries, the adjustment period is shorter and the likelihood of returning to the previous “normal” travel behavior is correspondingly greater. Most interview subjects said that, because most people who experience road collisions first-hand do not experience serious injuries, they return to using modes that they used before their respective experiences with road collisions in the long-run. Interview subjects also acknowledged that people who have experienced more serious injuries in road collisions might not be able to drive afterwards due to paralysis, muscle weakness, or brain trauma. This can significantly change transportation mode usage patterns among such individuals, and some people who struggle to learn to drive again experience clinical anxiety and similar psychological problems in that process. Interview subjects noted that persistent changes to travel behavior are more likely to include changes in route and time of day. Finally, interview subjects consistently said that individuals who only have first-hand experiences with near-misses, and not with collisions, only shift travel behavior in conjunction with

second- or third-hand experiences with road collisions, as these experiences together shape such people's perceptions of road safety.

Interview subjects' answers in some cases were less definitive. Some interview subjects said that some people may shift from public or active transportation modes to driving or vice versa, but the dichotomy between these answers came not only from different interview subjects but sometimes from the same interview subject. In any case, interview subjects emphasized their own limitations in systematically collecting such information from their respective clients and the biases associated with their respective professional perspectives. For example, interview subjects tied to active mode advocacy organizations are more likely to encounter people who use active transportation modes, so they are less likely to see people who do not use active modes. Interview subjects also noted that their observations of travel frequency returning to levels exhibited before a first-hand experience with a road collision are mostly in the context of work travel due to its economic necessity. They acknowledge having less information about changes in travel frequency for other purposes.

Per interview subjects' recommendations, in future stages of research, we will reach out directly to people who have experienced road collisions to ask about any changes in travel behavior after those experiences and their general concerns about road safety. Such future studies will be done in close collaboration with interview subjects from the current stage of research along with related organizations.

Contents

Introduction

“One of the things that happens when you've lost trust when it wasn't your fault, so you're in a car and somebody else runs a red, it's that loss of trust, and then you don't just not trust the person who ran you over, but you don't trust people, or you don't trust the world, [the idea that] ‘the world is an unsafe place’, it can globalize. Helping that person bring it back down to, ‘Yes, there is risk in the world, but there's also reasons why the world is safe and we explore the good things that are happening. We have stop signs. We have lights. Most people do follow those rules.’” (Interview subject)

In California, road collisions have led to more than 30,000 deaths and more than 100,000 serious injuries since 2010 [30]. In response, the California Transportation Plan 2050 [32], California 2020-2025 Strategic Plan [33] and California 2020-2024 Strategic Highway Safety Plan [34] have set goals to improve road safety in line with the Vision Zero movement [22-28, 31], which seeks to eliminate fatalities and serious injuries in road collisions. These plans also set goals to improve socioeconomic equity and sustainability in the context of transportation safety. However, if individuals who directly experience and survive road collisions hypothetically reduce travel—or depend more on private vehicular transportation—compared to before those collision experiences, those travel behaviors may work against such efforts.

Road safety is intimately tied to transportation sustainability and equity, as collisions are more prevalent in marginalized communities, and there are higher fatality rates among people with low income, people with disabilities, elderly people, and bicyclists [3-6]. Despite these important policy considerations, research about the effects of road collisions or near-misses on travel behavior at an individual level is sparse. For clarity, we define a road collision as occurring on or near a legal right-of-way to use a motor vehicle, public transit or paratransit bus, bicycle, or standing scooter, and as involving at least one person using at least one of these modes (private motor vehicle, public transit or paratransit bus, bicycle, or standing scooter) as a driver or passenger. The motor vehicle, bicycle, or standing scooter may hit a fixed object, another motor vehicle, bicycle, standing scooter, or a pedestrian.

We present a qualitative study of the experiences and concerns of adults in California who have experienced road collisions. The exploratory nature of this work led us to first study this issue by individually interviewing professionals who work with people who have experienced road collisions. We expected this professional filter to help us qualitatively understand how road collisions affect the travel behavior and priorities of those who experience them before diving into interactions with those who have experienced road collisions. The responses of the eight subject-matter experts to the interviews are not conclusive or exhaustive. They have suggested areas of interest for future research and policymaking. The diversity of backgrounds among these subject-matter experts has led to a broad range of interview topics. . Broadly, subject-matter experts indicated that specific experiences with near-misses are typically insufficient to change travel behavior at an individual level. However, specific experiences with road collisions paired with repeated exposure to near-misses and

other conditions perceived as unsafe can change travel behavior. Changes to perceptions of road safety can arise in different ways for different people. In particular, different people may experience different changes to perceptions of road safety when using different modes, when in different places, or when traveling at different times of day.

Literature Review

Little research exists about the specific effects of road collisions on subsequent travel behavior. The research that has been done shows mixed effects with respect to mode shifts, greater incidence of psychological problems following collisions with more severe physical injuries, and greater vulnerability of children to long-term negative effects of road collisions.

Christie and others [1] have studied changes in travel behaviors of people with disabilities in Australia after experiencing a traumatic injury in a collision. The study found that people who acquired mobility impairments and experienced discomfort while driving also became more dependent on others to drive them. In some instances, they shifted to public transit and taxis to make trips. Participants living in rural or other areas with infrequent bus service had to depend significantly on private vehicles for traveling. Collision victims who were completely dependent on family members for driving them to their destinations could not make those specific trips if no family members were available to drive them or if taxi services were very expensive. Such people made more trips for health care and fewer trips for social interaction.

Murray-Tuite and others [2] have studied the travel behavior of commuters on the Washington Metro subway after a major collision in 2009. Study subjects were not involved in the collision but used the same transit system for their commutes. Authors observed changes in travel behavior in 31% of study subjects. Most mode changes were shifts from subway use to bus use. The study also reported a reduction in trip frequency by subway after the collision. Additionally, users avoided riding in the first and last car of each subway train after the incident.

Bicyclists are among the most vulnerable road users as they have little or no physical protection from motor vehicles. According to Barajas [3], bicyclists experience more frequent collisions in areas with lower income and higher poverty rates in the US. Aldred [4] has found that bicyclists who had a near-miss with a truck felt vulnerable afterwards when close to trucks on roads. However, their sense of fear faded with time. That study also found that many bicyclists used alternate longer routes to their destination(s) compared to their previous routes. That study further found that one in six “very scary” incidents discouraged people from continuing to bicycle. Similarly, Sanders [5] has found that, in the San Francisco Bay Area, near-miss and collision experiences discourage occasional bikers from biking, yet similar experiences do not significantly impact bicycling among regular bicyclists. That study also found that, when bicyclists become more concerned about safety after experiencing a collision, they reduce bicycle trip frequency. Lee and others [6] have explored the influence of a collision on bicyclists’ attitude toward bicycling, finding that reluctance to continue bicycling increases with the severity of collisions and with knowledge of other people’s experiences with collisions as bicyclists. That study also found that experiencing a bicycling collision at a younger age has a less negative impact on attitudes toward bicycling.

Many studies have highlighted the psychological outcomes of collisions and near-miss experiences. Mayou and Bryant [7] have studied the psychological outcomes of road collisions among 1,148 patients at a hospital in the United Kingdom (UK). They found that around a third of the respondents have experienced one or more of the following symptoms: post-traumatic stress disorder (PTSD), travel phobia, general anxiety, and/or depression. Pozatto and others [8] have studied changes in the level of PTSD after one, three, and twelve months among victims of road collisions in New South Wales, Australia, finding that the severity of PTSD decreases with the passage of time.

Children are among the most vulnerable to road collisions. Schäfer and others [9] have explored travel phobia and post-traumatic syndromes among children who have experienced road collisions in Hamburg, reporting that these syndromes fade with time. Mayou and Bryant [10] and Bryant and others [11] have found that phobic travel anxiety is more prevalent among passengers than drivers. Cartwright [12] and Mayou and Bryant [7] have found that women develop more travel phobia than men after experiencing a road collision. Bryant and others [11] have found, in the UK, that road collision-induced travel phobia leads children to not make trips to meet with friends, join in leisure activities, or travel with friends to school. Parental perceptions of road safety can influence children's travel behavior. Amour and others [13] have found that parents perceive roads with high speeds and high volumes of traffic as more prone to road collisions, and these perceptions lead parents to discourage children from walking and bicycling. That study has also found that the presence of stop and yield signs at intersections contributes to perceptions that an intersection poses a lower risk of road collisions involving child pedestrians. Signs thereby encourage parents to allow children to cross the intersection as pedestrians.

Sociodemographic factors are important influences upon the vulnerability of individuals to road collisions. Uddin and Ahmed [14] have found, in Ohio, that pedestrians 65 years and older and drivers 24 years and younger are more prone to severe collisions. Obeng and Rokonzaman [15] have studied collision severity in pedestrian-automobile collisions and found that women are more likely than men to die or acquire disability from a road collision after controlling for other variables. Xue and Wen [16] have studied the injury severity for pedestrians involved in collisions with motor vehicle collisions in Yunnan province, China. They have concluded that pedestrians aged 25 to 64 years are less likely than others to have a major injury when drivers were driving both in familiar and unfamiliar environments. Morrison and others [17] have explored road collisions involving school-going children and motor vehicles, finding that children between 10 to 13 years old are more vulnerable to collisions than school-going children of other age groups. Lalika and others [18] have found, in Florida, that women drivers have a 22.1% lower risk of experiencing a collision resulting in severe injury compared to men drivers and that drivers who are 60 years or older are 26.7% less likely to experience a road collision resulting in a severe injury compared to drivers aged 20 to 59 years. Zhu and others [19] have found that pedestrian death rates per person-year for men were 2.3 times higher than those of women in the US. Race can also influence the vulnerability of people to road collisions in the US (Zhu et al., 2013). Raifman & Choma [20] have found that Black and Hispanic Americans are more susceptible to traffic deaths per mile traveled than White Americans. Barajas [3] has found that communities with higher percentages of Black and Hispanic Americans, lower median income, and higher rates of poverty have higher frequencies of bicycle collisions. Chen and

others [21] have found, in New York City, that areas with a higher concentration of Latin American, Eastern European, or Asian immigrants tend to have more road collisions involving bicyclists and pedestrians.

The US Department of Transportation has put forth Vision Zero as a goal [22]. Vision Zero works toward safe transportation systems with zero traffic fatalities by focusing on four core elements: (1) commitment and leadership, (2) engagement and equity, (3) safe roadways and safe speed, and (4) transparency and accountability [23, 24]. Vision Zero is more focused on preventing death and serious injuries in comparison to preventing road collisions, accounting for human mistakes and limitations, distributing responsibility for road collisions, and/or proactively identifying and addressing risks [25]. Currently, 53 communities in the US have committed to Vision Zero. New York, California, Florida, and Texas are states where more than three communities have committed to Vision Zero [26]. New York City is planning to add bike lanes, install protective devices on existing bike lanes, expand speed monitoring cameras, train public transit drivers, and enhance intersection safety as part of Vision Zero [27]. Florida is evaluating the leading causes of fatal and serious injury road collisions, prioritizing safety campaigns in underserved communities and law enforcement to alleviate risky behavior, improving road safety in locations prone to collisions, and engaging community and local authorities in safety campaigns [28]. California is using road collision data to identify the reasons for severe road collisions, develop better road designs for hot spots, engage with local communities, improve safety for active transportation, and finance safety programs [29, 30]. In Texas, road safety in high-risk areas for road collisions has been improved by installing traffic control devices, street marking, speed management, effective communication between agencies and communities, and mapping hot spots for road collisions to raise awareness of their occurrence [31].

The California Transportation Plan 2050 [32] and Caltrans 2020-2024 Strategic Plan [33] have aimed to improve road safety by reducing fatalities. The California Transportation Plan 2050 aims to achieve “Zero Death” in road collisions by reducing fatalities and injuries, specifically by improving personal security and infrastructure security, emergency preparedness, response, and recovery. The proposed safety strategy in the Caltrans 2020-2024 Strategic Plan includes utilizing proven safety practices, application of advanced technology, bringing change in safety cultures, reducing speeding-related fatalities and injuries, increasing collaboration with external organizations, and setting priorities with underserved communities to conduct safety campaigns to reduce fatalities. California has also undertaken the California 2020-2024 Strategic Highway Safety Plan (SHSP) [34] to make Vision Zero a reality. This has been done with the view of ensuring safe road design and the safety of all travel modes using public roads. The SHSP prioritizes the safety of active mode users, preventing road collisions involving impaired and aggressive drivers, and better management of lane departure and speed.

Little literature exists about the influence of the angle of a collision on perceptions of the collision among people involved and their subsequent change in travel behavior, the underrepresentation of marginalized communities in road safety activism, and the overrepresentation of parents who have lost children to road collisions in road safety activism. These topics may form fruitful avenues for future research.

Methods

People who have experienced disabilities, people from marginalized neighborhoods, and people who use active transportation modes [3] are more vulnerable to road collisions than other populations. This knowledge led us to seek interview subjects from across California who were likely to have insights about these groups. Through email, we contacted employees or volunteers from community-based organizations (CBOs) representing these groups, medical doctors who specialize in trauma (particularly traumatic brain injury and psychiatric illness), people who work for rural transportation providers, and employees of Caltrans. This approach allowed us to access information about how road collisions affect the travel behavior and safety perceptions of individuals who experience them, without running the risk of asking insensitive questions that could compromise those individuals' trust in us.

We contacted over 40 people from these organizations. The majority either did not respond or said that they did not have the information we needed and therefore could not meaningfully participate in our study. Some of them pointed us to other subject-matter experts who were more likely to have the information that we sought. A few subject-matter experts initially agreed to participate in the study but dropped out before they could be interviewed. Thus, we ultimately interviewed eight subject-matter experts (Table 1); of the four CBO employees interviewed, three represented CBOs operating locally, and one represented a CBO operating statewide.

Table 1. Interview subjects and expertise

Interview subject	Expertise	Notes
IS1	Active mode safety advocate	CBO employee
IS2	Active mode safety advocate	CBO employee
IS3	Active mode safety advocate	CBO employee
IS4	Active mode academic researcher	Promotes active mode safety with CBOs
IS5	Disability advocate	CBO employee
IS6	Faith leader	Focus on road safety
IS7	Medical doctor	Specialty in traumatic brain injury
IS8	Medical doctor	Specialty in psychological trauma

Each subject-matter expert was compensated \$200 for participating in the interview and \$800 for further consultation regarding products and development of future phases of this study. In what follows, we will not refer to participants by name, gender, or organization. We will also generally avoid attributing specific quotes to specific participants and referring specific themes to specific participants unless the correspondence is obvious or pertinent.

Each interview subject received an invitation (Appendix I) and an explanation of expectations for participation in our study before participating (Appendix II). Each subject was asked to set aside a two-hour block of time and was told that, if they needed to end the interview early and wanted to continue at a later date, we would organize a follow-up. The follow-up interview would pick up at the question where the initial interview left off and would run for two hours, less the time taken in the initial interview. This was not ultimately necessary, as we were able to finish each interview in one session. Some interviews took around an hour, while others took closer to two hours. We conducted each interview virtually using Zoom videoconferencing software. Each interview was semi-structured. We asked open-ended questions (Appendix III) and encouraged each interviewee to speak freely. We asked each interview subject follow-up questions about their responses but did not stray from our main questions in order to meet Institutional Review Board (IRB) requirements. We conducted all interviews in 2023, between April and July. The University of California, Davis, IRB exempted this study from full review as the project posed no more than minimal risk to participants.

Transcripts were prepared from each interview. We coded interview subjects' comments into themes. Some themes were based on our questions to ensure that interview subjects addressed those questions in some way and the remainder organically arose from interview subjects' responses. We counted the number of interview subjects who spoke of each theme to identify the most important issues across professional contexts. We repeated this process until we could not find further themes and each researcher came to the same count of each theme's occurrence across interviews.

Findings

Interview subjects' comments, taken together, encompass a variety of transportation modes, concerns about road safety, and broader concerns about transportation, along with admissions of anecdotal data quality due to small sample sizes and self-selection bias in clients sharing their own stories. Interview subject quotes below have been lightly edited after transcription for spelling, grammatical clarity, and brevity.

Common Travel Behavior Changes After First-Hand Collision Experiences

All eight interview subjects addressed first-hand collision experiences by survivors. Additionally, IS1, IS2, IS3, and IS6 addressed people who have lost loved ones in collisions, IS8 addressed people who have witnessed collisions without being part of them, and IS1 addressed people who were at fault in collisions. Seven interview subjects noted that people who experienced road collisions first-hand eventually returned to using modes that they were typically using before the collision. Only IS4 could not speak to this out of a clear acknowledgment of self-selection bias in clients presenting themselves.

Together, these interview subjects' comments suggest that the process of getting to a new or prior stable set of travel behaviors (i.e. long-run travel behavior) typically takes less than a week for people who experience no or superficial injuries, a few weeks for people who experience minor injuries, and anywhere from 3 to 12 months for people who experience more serious injuries. Their comments also suggest that, in the medium-run, the trajectory toward long-run mode choices may depend on the length of time needed to recover from injuries. This is because many people, especially those who experience moderate or severe injuries from collisions, may depend on relatives, friends, or ride hailing services for rides before they can resume walking, driving, or biking.

Three interview subjects noted that some people who formerly used active modes may have shifted to more private vehicular travel in the long-run after a collision compared to before the collision, but these interview subjects hesitated to claim this as a general rule. A few of the same interview subjects, as well as others who have worked for CBOs promoting active modes, said that people who used to use active modes regularly and were physically capable of resuming regular use of active modes rarely switched to driving and rarely stopped using active modes altogether out of fear for their own safety. These interview subjects again emphasized that their perspectives may have been biased due to their affiliations with CBOs that promote active modes.

Thus, there is not enough information about whether our initial hypothetical concerns about the frequency of shifts from active modes to other modes after road collision experiences, with such shifts potentially harming environmental sustainability and road safety, may be overstated. Additionally, road collisions that result in muscular or neurological trauma profound enough to prevent a person who used to drive from ever driving

again are rare compared to most road collisions, but they do occur. Cases of new disabilities which have been observed by medical doctors (IS7 and IS8) and a CBO advocate for people with disabilities (IS5).

Five interview subjects noted that reductions in travel frequency (without completely stopping travel) were prevalent immediately following a collision experience, during which a person may be recovering from injuries and regaining comfort with chosen modes. However, three interview subjects noted that long-term reductions in travel frequency are rare. They observe that many trips are work-related, which limits mode-choice flexibility, especially for people who have low incomes. IS3 explained further as follows:

Then there are people in communities that are really low income, they don't have access to lot of transit. For instance, in [LOCATION REDACTED], there's communities where maybe the transit doesn't run at the times people would like. So, if they don't have a car, if they are carless or they're a car-free household, they will share concerns, but they'll express that they still need to walk, or they still need to bike because that's their only way of doing it. They don't have the opportunity to consider their feelings about road safety as strongly because they don't have an option and they're going to keep doing it.

IS1 and IS8 identified the same effect. We asked these three interview subjects a follow-up question about changes in non-work trip-making among people who have experienced a collision and quickly return to pre-collision work-related travel behavior. We wanted to know if either a quick return to pre-collision work-related travel behavior is accompanied by a similarly quick return to pre-collision non-work travel behavior or if people compensate for stress from needing to travel for work quickly after a collision by reducing non-work trips. Those interview subjects did not have an answer. We did not ask other interview subjects this follow-up question, and none of them volunteered such information.

However, most interview subjects noted other changes in travel behavior after a road collision experience, separate from changes in mode use or travel frequency. These include choosing alternate travel routes and times of day when driving, walking, and biking. Adjusted behavior relates to differences in road design, street lighting, and motor vehicle traffic levels.

A majority of those interview subjects with professional experience working with people who used to drive specifically noted that, when people cannot begin driving again immediately due to an injury from a road collision, they experience short-, medium- and long-term psychological and/or physiological problems. Injuries include brain injuries that can adversely affect neurological function. Problems may include:

1. Feelings of isolation or depression from not being able to drive,
2. mental trauma from trying to drive on a freeway,
3. physiological symptoms of anxiety or post-traumatic stress when driving,
4. regression of reaction times when driving compared to before the road collision experience,

5. inability to fully automate reactions (within the brain) or dissociate when driving compared to before the road collision experience, and
6. loss of trust in other drivers on the road.

IS5 and IS7 noted that some clients refuse to leave home long-term (i.e. even after several months following a collision) after experiencing a road collision. In most cases, this is due to the physical difficulty of traveling to or being in activity places outside of the home compounded by fear for their own safety when traveling. We note that the numbers may be biased by the difficulty of someone who never leaves home to share stories with people or organizations outside of the home and the self-selection bias against sharing these stories at all.

Additionally, three interview subjects noted that people who have experienced road collisions involving motor vehicles, recovered from acute injuries, and developed new individual “normal” travel behaviors exhibit fear when getting rides from specific drivers whom those individuals perceive as unsafe. These interview subjects noted that such people, in some cases, refuse or minimize acceptance of rides from those drivers and in other cases get rides from those drivers but comment negatively on driving behavior in real-time.

Common Travel Behavior Changes after Near-Misses and Second-Hand or Third-Hand Collision Experiences

Five interview subjects noted that neither especially harrowing near-miss incidents nor large numbers of near-miss incidents in quick succession changed overall travel frequency or mode choices among people who experience them if those people had not also experienced a road collision first-hand. Interview subjects said that changes to travel behavior, whether in overall frequency or mode choice, are more often shaped by experiences with road collisions that are second- or third-hand than by first-hand near-miss experiences. A second-hand road collision experience is one in which the person’s close friend or family member experienced a road collision, and a third-hand road collision experience is one in which person may be generally aware of many local incidents involving certain combinations of roads, times of day, and modes, but was not directly involved in any collisions and did not know anyone directly involved. In this context, first-hand experiences with near-misses may be relevant as an *additional* contributor to such choices. IS8 said that such second-hand or third-hand experiences “can leave a really strong impression and create a sense of fear, insecurity, helplessness, and affect subsequent driving behavior.” IS5 said the following, explicitly relevant to people with disabilities:

[Collisions] do affect even the people that don't drive. Having knowledge of collisions, being collision-adjacent, as a person with a disability, if you're walking in town or wherever, walking around, and you hear that a certain intersection has a propensity for collisions or for accidents, then you will avoid that intersection. That may be having to take a different street, intersection, or you might have to take a different bus, pick the bus in a different spot because you want to avoid crossing or being in that street.

We directly asked IS5, IS7, and IS8 questions about how caregivers' travel needs change after a loved one experiences a collision. This would be a second-hand experience with a road collision from the perspective of the caregiver. Those interview subjects' responses make clear that a person who has a second-hand experience with a road collision can be burdened with giving care for the loved one who experienced the collision first-hand, and the burden of such care can drastically change the given person's travel choices and even that person's employment situation. IS5 said the following:

[Taking] somebody to a doctor's appointment is picking them up, waiting with them, sitting through the appointment with them, possibly going to get medications or tests done after, and then going home. That's half a day for an individual. That can absolutely be an added load to someone's burden. The pattern that I've observed is there's a high, high, high level of participation at the beginning and then it will inevitably wear off, sometimes sooner, sometimes later, but it does wear off.

IS7 had similar comments:

The more severe patients, just from a caregiver standpoint, they can't leave the house without someone being there to watch their loved one. You can imagine there's that reluctance to be a burden, but most health care systems aren't paying for care to come into the house and watch. There's not that caregiver relief that a lot of people need. They're not getting out of the house and doing the things they want to do because they have to be at home to help their loved one. When they do need to get out with their loved one, they're also having to navigate paratransit or they have to change their vehicle to accommodate a wheelchair or whatever. It places a big burden on caregivers, I would say, at least for the moderate/severe traumatic brain injury patients.

Other Travel Concerns Related to Travel Safety

Many interview subjects spoke of how, even without specific first-hand experiences of near-misses or second- or third-hand experiences of road collisions, the general feeling of being unsafe can affect a person's confidence in traveling. Many interview subjects, regardless of background, commonly cited fear of nearby fast-moving vehicles affecting people who use all modes. IS4 observed that many motor vehicle drivers also have this fear. This leads them to drive further from other lanes of traffic to avoid being hit, though this perversely pushes them close enough to a bike lane to potentially endanger bicyclists. Multiple interview subjects who work for CBOs promoting active modes noted how their clients who are bicyclists report that motor vehicle drivers express hostile attitudes toward them through behavior and words. This impacts their perception of safety even without experiencing actual collisions or near-misses. IS6 spoke multiple times of fears from community members who often observe aggressive drivers traveling independently or in groups. They violate driving laws on freeways and high-speed surface streets.

Interview subjects who work for CBOs promoting active mode safety noted how many bicyclists, when feeling that there are too many fast-moving motor vehicles nearby, are likely to choose to ride on a sidewalk even when a protected bike lane is available. IS4 directly tied this to second- and third-hand experiences with road collisions as well as first-hand experiences with near-misses using personal experience.

I have to say, for me, personally, the fear of those near-misses makes it hard for me, sometimes, to choose to ride a bike. I will drive my car or use public transit because I think about how many opportunities there are going to be for a motorist to be with me if I'm on my bike and I just decide not to ride my bike at all. Even though I've never actually been hit by a car, it still feels like a deterrent.

IS4 also noted that, in many bicycle advocacy circles, the fear for one's life when biking—even without experiencing road collisions or near-misses—is assumed to exist and to affect mode choice and behavior as much as actual experiences with road collisions and near-misses. Additionally, interview subjects who work for CBOs advocating for active modes noted that many people who walk or bike balance safety concerns with getting where they are going. They may attempt to cross a road mid-block, in some cases jumping over a median barrier, to connect to other modes in a timely manner or avoid additional physical exertion from taking a longer route, despite the dangers of doing so. IS3 connected inadequate road crossing infrastructure with how many drivers, bicyclists, and pedestrians alike do not know that mid-block unmarked crosswalks are legal in many parts of California. The interview subject pointed to their workplace's efforts to educate pedestrians, bicyclists, and drivers about these issues.

IS1, IS5, and IS8 noted the importance of therapy, desensitization, and psychological healing in improving quality of life for people who have experienced road collisions. IS8 distinguished between two types of post-collision adaptations: (1) those that enable people to maintain their quality of life versus (2) those that do not. They describe adaptations in the following way:

There might be an overlap between the two, a seemingly negative adaptation might actually be appropriate. It's really a matter of degree. Where would I draw the line is like, how do people manage risk, is it proportionate to the actual risk, and how do people feel in general? Do they still have a good quality of life? Some people might switch to remote working because they say, "I'm done with driving. I've been in too many car accidents, it's too risky, and I'm too scared." And it could still be appropriate as long as they're able to use their car when they visit friends or travel. I think it's really the quality of life and still being able to manage the risk, because we can't really change the global situation unless we have [a] top-down or bottom-up approach for approaching people on how they drive and having more severe penalties for people who don't respect the speed limit, et cetera.

IS2, IS3, and IS6 noted safety concerns from road users that are separate from collisions, and they acknowledged this divergence from our questions. These concerns include lack of shade for active mode users

in the summer heat in California, the dangers of aggressive dogs, and trepidation when traveling around people who are visibly experiencing homelessness.

Interview Subjects' Concerns about Sampling Biases

Six interview subjects emphasized that they have not heard, or do not remember, a large enough number of their clients' experiences to confidently make statements about the effects of road collisions or near-misses on travel behaviors and priorities. IS7 does not see patients who have only experienced near-misses if they have not also experienced injuries from a road collision, so we skipped all prepared questions related to near-misses in that interview. In most cases, interview subjects simply emphasized that their responses about post-collision or post-near-miss travel behavior changes and concerns were based on very small sample sizes or said something like "I don't know" or "I don't have enough evidence" in response to some questions, as they do not systematically ask such questions of their clients or patients.

These interview subjects also emphasized that the lack of systematic effort on their part to collect such information from their clients means that they are subject to self-selection bias, with certain clients voluntarily sharing stories. Such clients who experience road collisions, by being more motivated to reach out to these professionals and voluntarily share their stories without being asked, could have different pre- and post-collision travel behaviors and priorities compared to other people who experience road collisions but are less motivated to voluntarily share such stories.

As an example, our questions to CBO employees promoting active modes addressed either (1) enthusiastic active mode users who became discouraged after a first-hand collision experience using those modes or (2) becoming enthusiastic active mode users after a first-hand collision experience using any mode. Those interview subjects could provide many examples in response to the second question but could not provide any examples in response to the first question. They acknowledged that working in a CBO advocating for active modes leads them to interact mostly with enthusiastic active mode users and may lead them to miss people who have been discouraged from using active modes. One interview subject pointed out that the term "enthusiastic" in those questions may lead to confusing responses. In response, we clarified our intent in that particular interview and in subsequent interviews with others where we asked those questions.

Discussion

General Changes in Post-Collision Travel Behavior

Interview subjects made the following broad issues clear. First, changes to travel frequency and mode choice do not occur after experiencing a specific near-miss incident. Changes to travel frequency and mode choice *do* occur in the short- and medium-run after experiencing a road collision, but people who experience road collisions usually revert to pre-collision travel behaviors in the long-run. An exception is the relatively small percentage of incidents that result in long-term injury or health problems. Second, some effects of road collisions on travel behavior *do* depend on mode choice. This dependence suggests a correlation to neighborhood type (urban, suburban, or rural). Third, individuals who have first-hand experiences with near-misses tend to change travel behavior or attitudes toward road safety in a given area only in conjunction with second-hand or third-hand road collision experiences. Fourth, the burdens of caregiving for many of those who have second-hand experiences with road collisions can extensively affect their own travel behavior regardless of changes in their own attitudes toward different modes. Thus, while the common themes extracted from these eight interviews are not definitive or exhaustive, responses shed light on priorities for future research and policymaking (Figure 1).

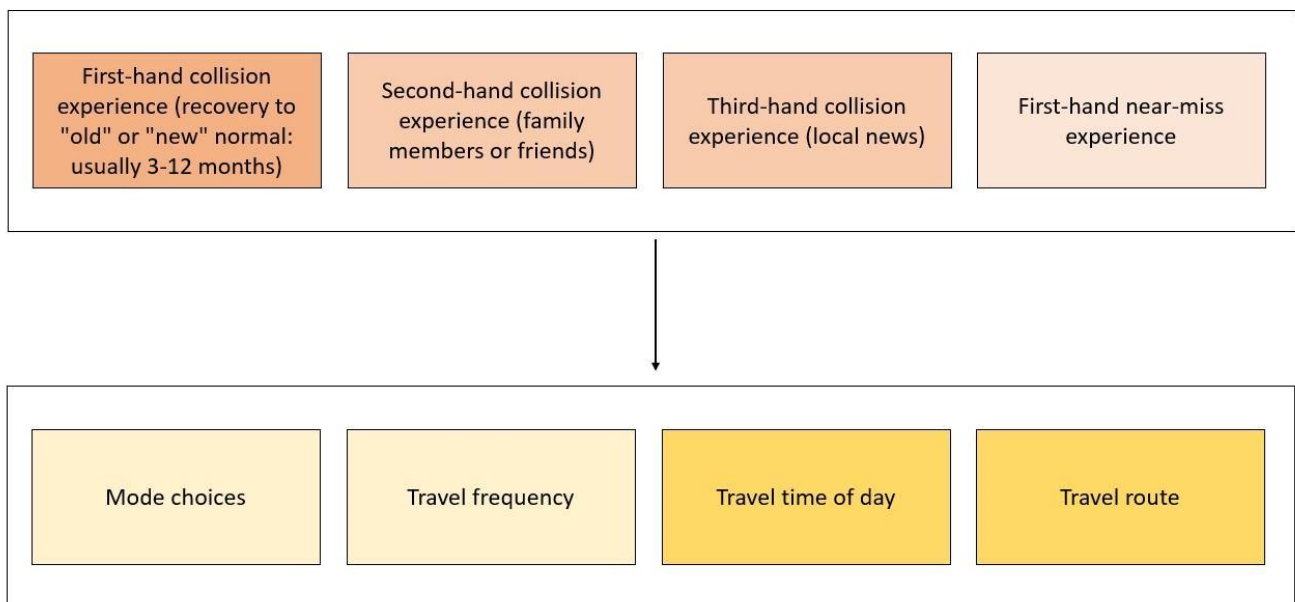


Figure 1. Hypothesized relationships between road collision and near-miss experiences and travel behavior. More saturated shades represent increasingly likely causes or effects.

We emphasize that the lesser effect of first-hand experiences with near-misses *in isolation* on an individual's travel behavior does not imply that first-hand experiences with near-misses have no effect. The effect is clearer when many such experiences happen in conjunction with second- or third-hand experiences with road collisions, thereby shaping an individual's perception of road safety for a given combination of mode, place, and time. This, in some ways, aligns with prior literature about the effects of near-misses on travel behavior. Lee and others quoted a few participants in a study of bicyclists in Davis, California, who shared how near-misses affected their attitudes toward bicycling. Only one participant explicitly said that a specific near-miss incident discouraged bicycling for a significant period of time, whereas other participants in that study did not say similar things [6]. That participant was not quoted elsewhere in that article, so it is unclear whether that participant had second-hand or third-hand experiences with road collisions that contributed to their discouragement, which might not have arisen with the near-miss experience in isolation. Aldred found, in the UK, that less than 2% of bicyclists who report experiencing an average of at least 10 “very scary” near-miss incidents per week, and less than 1% of bicyclists who report experiencing an average of at least 10 near-miss incidents per week that are not “very scary,” feel discouraged from bicycling in the future [4]. That study did not consider participants' second-hand and third-hand experiences with road collisions at all, let alone as an influence on future travel behavior in conjunction with first-hand experiences with near-misses.

Interview Subjects' Biased Observations of Travel Modes Used in Collision and Near-Miss Experiences

Our recruitment of subject-matter experts could capture the existence of different qualitative concerns around a variety of modes only if subject-matter experts represented a variety of backgrounds. Answers to questions about which modes interview subjects typically observed people having used before experiencing road collisions or near-misses depended strongly on interview subjects' professional backgrounds. IS7 and IS8 are medical doctors serving patients over large areas, including many faraway rural areas, so those interview subjects said their patients are likely to drive for most of their regular trips and for medical appointments. IS5 noted the challenges that driving poses for some, but not all, people with disabilities and described a broader mix of modes that clients regularly use. These modes include walking, driving, depending on others for rides, using public transit or paratransit, ridehailing services, and—less often—biking. Similarly, IS6 works with local community members on road safety for all modes. Therefore, they see people using all these modes, notably including walking, biking, driving, and depending on others for rides.

IS1, IS2, IS3, and IS4, by virtue of their present or past affiliations with CBOs promoting active modes, were able to speak in more depth about road safety concerns particular to active mode users that might be absent, or be very different from, the concerns of motor vehicle drivers. IS2 explicitly commented on use of those modes as a first-/last-mile connection to public transit. These observations could further inform future research about challenges facing previous active mode users after experiencing a road collision or near-miss. However, these four interview subjects also admitted that the missions of their CBOs created bias. People who do not regularly use active transportation modes are unlikely to know about those CBOs or feel any compulsion to

attend those CBOs' events. IS4 noted the defensive attitude prevalent among people at some CBOs that focus on active transportation modes. They suggested that this could contribute to a lack of engagement with those CBOs by members of the public, excepting those with the most enthusiasm for using active modes even under adverse circumstances.

I think it's quite possible that I would block out things that people might say, like, "I don't ride a bike anymore because I was in a crash," because there was a time when I was working in bicycle advocacy, I would have been dismissive of that sort of story. "I'm not going to take this person's experience seriously because they have the wrong answer. The right answer is continuing to bike. The wrong answer is 'I stopped biking.'"

Future Scope of Work

Interview subjects' inability to give definitive answers to certain questions show where future research and policy focus are needed. Topics include:

1. Capturing the concerns of people who once used active modes regularly but have been discouraged from using them by experiences with collisions or near-misses,
2. understanding whether people who once used active modes consistently switched to private vehicles after experiencing a road collision, and
3. understanding how people's work and non-work trips are affected after experiencing a road collision.

These areas relate to what interview subjects *were* able to share regarding the dependence of post-collision travel behavior on neighborhood type and transportation mode, the effects of caregiving on travel behavior, and the formation of various attitudes toward road safety in different locations. This would provide nuanced information to direct research and policy.

Interview subjects encouraged us to reach out to people who have experienced road collisions or near-misses. They have suggested that our concerns about sensitivity may be overly cautious because most people who have experienced road collisions or near-misses will be willing to share how those experiences have affected their lives as long as they are not asked to recall specific details, especially sights, sounds, or smells, surrounding a collision experience. Thus, the next step is to consult with interview subjects to shape future phases of this study. Convening a focus group and surveying of people who have first-hand experiences with road collisions are promising opportunities.

Appendices

These appendices contain (1) the invitation provided to interview subjects, (2) the explanation of expectations provided to interview subjects, and (3) the questions asked in each interview.

Appendix I



Project title: Studying the Effects of Collisions on Travel Behavior

Principal investigators: Dr. Prashanth S. Venkataram, Dr. Jesus M. Barajas

We invite you to join a research study about the effects of road collisions on individual travel behavior, run by the University of California, Davis. As part of this study, we would like to interview you so that you can share your professional expertise about the transportation challenges that people face after experiencing road collisions. The information you give us can help policymakers make it easier for people to get around safely and securely after collisions.

Being interviewed is completely up to you. No one can force you to join if you don't want to, and you can leave at any time. We will interview you up to twice; the total interview time will run up to 2 hours, and each interview **will be recorded**. You should join only if you're OK with being recorded. The audio and video recording as well as your contact information will only be used within the research team for this project and potentially for future projects only if you are OK with that, and no one else can see it afterwards. Your answers will be confidential. This means that we won't share any identifying personal data, like your name, with anyone outside of the research team. Also, we will transcribe the recording for later data analysis, but we won't directly link your name to what you say in any publications; your name and organization will only be listed in acknowledgments in those publications.

If you are interviewed, you will get **\$200 in a direct bank transfer**. The interview will happen through Zoom and will allow you to join by telephone too. After the interview, we may follow up with you for further feedback about the final report, policy brief, and development of future phases of this study.

Thank you for participating in this important study! If you have any questions or need accommodation to join the meeting, please send a message to me at the email address pvenkataram@ucdavis.edu or call the phone number 240-428-8086.

Sincerely,

Dr. Prashanth S. Venkataram, Project Director

Institute of Transportation Studies

University of California, Davis

Appendix II



Project title: Studying the Effects of Collisions on Travel Behavior

Principal investigators: Dr. Prashanth S. Venkataram, Dr. Jesus M. Barajas

Graduate student researcher: Md. Musfiqur Rahman Bhuiya

General information: participation

This project is made of 2 phases. Participants may choose to commit to both phases, only phase 1 and not phase 2, or only phase 2 and not phase 1 ahead of time. Participants may also choose to commit to only phase 1 ahead of time and decide whether to commit to phase 2 only near the end of phase 1.

Phase 1: interviews

Interviews will be to understand the challenges and concerns that people who have experienced road collision face with transportation, from the perspective of subject-matter experts who professionally work with such people. The total interview time will be at most 2 hours. One interview will be initially scheduled. If the research team determines at the end of that interview that another interview is needed, the research team will schedule another interview at that point. All interviews should ideally be scheduled for 2023 April, May, or June, though spillover into July can be accommodated if absolutely necessary. If a subject-matter expert is part of a bigger organization with a specific advocacy focus, up to 2 other colleagues from the same organization may be invited to the same initial if their expertise working with people who have experienced road collisions is especially relevant. However, the research team expects that if multiple subject-matter experts from a single advocacy organization participate in the initial interview and another interview is needed, then the same set of subject-matter experts should participate in the following interview for consistency.

Participation in the interview will be contingent upon the subject-matter experts reading and agreeing to the terms in an information sheet (separate from this document) distributed before scheduling the initial interview. The principal investigator Dr. Venkataram will conduct each interview. The graduate student researcher Mr. Bhuiya may sit in on and contribute to some interviews too. Each interview will be conducted through the Zoom videoconferencing software and recorded so that the research team may refer to the subject-matter experts' answers later when analyzing research findings; details about confidentiality are in the information

sheet distributed before scheduling the initial interview. Compensation for participation in phase 1 will be \$200.

Phase 2: consultation

The research team will further consult with subject-matter experts to understand how to design and recruit for a survey of people who have experienced road collisions that will capture the effects of road collisions on travel behavior while being sensitive to such people's traumas. The research team will also consult with subject-matter experts to get feedback about drafts of deliverables associated with the project, namely the final report and policy brief, in order to directly inform those deliverables with a broader range of perspectives.

Consultation will occur in 2023 July, August, and September for a total of 8 hours, conducted over email and Zoom videoconferencing software per subject-matter experts' availability and preferences. The principal investigator Dr. Venkataram will lead the consultation and be the point person for communication. Compensation for participation in phase 2 will be \$800.

General information: compensation

Participants will be offered compensation for each phase that they commit to but may choose to decline compensation. The research team will start the administrative processes in 2023 July for distributing compensation to participants. For subject-matter experts who are part of a bigger organization with a specific advocacy focus, the compensation will go to the organization, and it will be the organization's responsibility to disburse that compensation to any subject-matter experts from that organization who participate in each phase.

Appendix III

University of California, Davis

Script for interview

Thank you for agreeing to this interview. My name is [NAME] and I will be leading this interview. These other people, [NAMES] will be helping to manage this interview.

This interview is about your professional experiences regarding how collisions can affect individuals' travel behavior. This interview is being recorded, but the recording won't be shared with anyone outside of the research team. This interview will take about one and a half hours. You don't have to share anything that makes you feel uncomfortable, and we won't ask for specific details about your clients/patients.

[GENERAL QUESTIONS, ULTIMATELY ASKED OF ALL INTERVIEW SUBJECTS UNLESS STATED OTHERWISE]

1. What concerns do [the people that you work with] have regarding road safety?
2. Do many of [the people that you work with] have experiences with collisions? If so, please answer the following.
 - a. What kinds of transportation modes would those with experiences with collisions have used?
 - b. Do those that have experiences with collisions generally limit their travel even a long time afterwards?
 - c. Do those that have experiences with collisions generally use different modes going forward?
3. Do many of [the people that you work with] have experiences with near misses? If so, please answer the following.
 - a. What kinds of transportation modes would those with experiences with near misses have used?
 - b. Do those that have experiences with near misses generally limit their travel even a long time afterwards?
 - c. Do those that have experiences with near misses generally use different modes going forward?
4. [This will be when we ask specific questions.]
5. We would like to develop a survey to better understand how these issues intersect with disability, race, income, and other factors in the broader population. Given this, please answer the following.
 - a. What suggestions do you have for the content of the survey?
 - b. How should we conduct the survey (online, by telephone, by mail), and how should we recruit participants, to have the best chance of reaching the people we want for the survey?

[FOR CBO REPRESENTATIVES WHO WORK WITH PEOPLE WITH DISABILITIES; ULTIMATELY ASKED OF ISS]

1. Do many of your clients have disabilities that arose only after experiences with collisions or near misses? If so, how do those disabilities affect their travel frequencies and mode choices?
2. Do your clients' experiences with collisions or near misses make them depend more on family members, friends, or other caregivers for help with travel? If so, does that change those people's travel needs too?

[FOR CBO REPRESENTATIVES WHO WORK WITH OTHER MARGINALIZED COMMUNITIES; ULTIMATELY ASKED OF IS6]

1. Do many of your clients have as much choice about changing modes after experiencing collisions or near misses?
2. What local or state-level political dynamics should we be aware of in the context of road safety with respect to marginalization that your community has experienced?

[FOR CBO REPRESENTATIVES WHO ADVOCATE FOR PEDESTRIANS AND BICYCLISTS, ULTIMATELY ASKED OF IS1, IS2, IS3, AND IS4]

1. Have you been in touch with people who started off as enthusiastic pedestrians or bicyclists and then experienced a collision or near miss? If so, do such people change their choices?
2. Have you encountered people who become more enthusiastic pedestrians or bicyclists after an experience with a collision or near miss using any mode?

[FOR PROFESSIONALS WHO WORK WITH TBI PATIENTS, ULTIMATELY ASKED OF IS7 AND IS8]

1. What kinds of problems do you observe in patients that would affect their travel frequencies, mode choices, and attitudes?
2. How do travel changes affect patients' ability to come to appointments?
3. How do caregivers' travel needs change because of patients' needs?

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