From Close Calls to Crashes: Infrastructure Priorities to Improve Safety For People on Bikes
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Travel experiences are often used to understand the flow of people's daily activities and movements through a city. Building on previous work by the Kinder Institute that captured the near-miss experiences of pedestrians and bicyclists, this report focuses on how information about daily trips can be used to improve transportation safety for some of the most vulnerable road users.

For this report, we focus on safety concerns tied to people on bikes and will address those for pedestrians in later reports. Using the combination of travel diaries, self-reported near-miss data, the Texas Department of Transportation's (TxDOT) bicycle-involved crash data and bike trip information from Love To Ride, this report examines bicyclists' vulnerability on Houston-area roadways. This information is then compared to planned bikeway projects in the Houston Bike Plan that are located along or close to the locations of near-miss incidents and recorded crashes. This work can help local governments identify safety concerns when prioritizing infrastructure projects. Our analysis includes two categories in the Houston Bike Plan that can potentially contribute significantly to improving safety if implemented: short-term retrofits and long-term projects. The retrofits are low-cost, quick solutions to improve safety in areas heavily traveled by people riding bicycles. Designated future projects are part of a long-term vision to accomplish connected bikeways in Houston. As the city moves forward with its plan to add largely funded 50 miles of bike lanes in 2019, our analysis highlights the pressing need to pursue both types of projects.

**Findings**

- Both near-miss incidents and crashes mostly happened during peak hours with spikes in midday.
- Crashes and near-miss incidents have happened mostly in areas that the Houston Bike Plan identifies as places that need either short-term retrofits or longer-term projects.
  - About 60 percent of bicycle-involved crashes between 2009 and 2015 happened on or less than 1 mile from streets designated for long-term future projects and approximately 22 percent of these crashes were along those designated for short-term retrofit projects.
  - Approximately 14 percent of bicycle-involved crashes during those years happened on or less than 1 mile from streets with already funded projects including CIP, programmed projects and existing upgrades. Less than 3 percent of crashes happened on streets not identified in the Houston Bike Plan.
  - Of the reported near-miss incidents, 36 percent occurred along streets designated for long-term projects and 27 percent were along streets designated for short-term retrofit projects.
  - Crashes that happened on or less than 1 mile from streets designated for short-term retrofits projects are mostly located inside the Inner Loop representing areas where most people ride bikes on existing infrastructure.
  - Crashes that happened on or less than 1 mile from streets designated for long-term future projects are mostly located outside of the Inner Loop representing areas where people ride bikes regardless of inadequate infrastructure.
The ability to move around a city and carry out daily activities safely is a basic prerequisite to participating in civic life. However, traffic and street safety concerns often limit the ability of urban residents to move freely, especially those who rely on walking, biking or public transit. This is a concern in the Houston region where all categories of vehicle-related crashes have been increasing.\(^2\) Crashes involving vehicles and people on bikes increased 34 percent between 2015 and 2016 from a total of 650 to 874 crashes—approximately half of those occurred within the City of Houston’s boundary. This type of crash is particularly problematic because they disproportionately result in severe injuries or fatalities to those involved who are not inside a vehicle. Unsurprisingly, many Houstonians describe walking and bicycling on Houston’s streets as “somewhat dangerous” or “very dangerous.”\(^3\)
A previous study by the Kinder Institute highlighted how near-miss incidents experienced by people walking or riding a bicycle led to altercations and a sense of anxiety for vulnerable road users. The study also revealed that many of the circumstances contributing to near-misses involve behaviors that were hard to regulate—such as ensuring drivers paid attention to all road users—meaning that interventions are difficult to identify and implement. Efforts that focus on reducing dangerous behaviors of road users such as punishing drivers for texting while driving or issuing tickets to drivers who pass people on bicycles too closely may increase a driver’s awareness of other road users, but their enforcement is far from universally effective.

Interventions at the infrastructural and built environment level are also possible responses. Conflicts between road users and high vehicle speeds are often pointed to as the main cause of crashes, but built-environment characteristics play a significant role in amplifying the human error that leads to traffic crashes. The lack of adequate pedestrian and bicycle facilities signals to non-vehicle users that they do not have as much of a right to the public streets as drivers. Further, the absence or lack of such facilities tends to discourage people from walking, biking or using public transit. A national survey of bicyclists and pedestrians shows that people who have ridden a bike within the past year tend to have bicycle lanes available within a quarter mile of their homes, which influences them to bike more. Similar findings apply to pedestrians who live in areas with at least some sidewalks in their neighborhood. Putting in place a built environment and transportation facilities that minimize the risk of traffic crashes is equally as important as educating people to respect other road users and enforcing regulations. Indeed, a combination of approaches may improve safety overall. The adoption of the Houston Bike Plan by the City Council is a step toward the development of infrastructure that can minimize the risk of traffic crashes—but it’s just one of many steps involved in implementing it.

This report seeks to investigate how different information about near-miss incidents, crash and GPS data can complement official crash data to proactively identify potentially dangerous areas. Additionally, it looks at the Houston Bike Plan with an eye toward evaluating what steps have been taken or what types of future projects have been planned for areas where these incidents have occurred.
Methodology

This report aims to show how a variety of data sources can lead to a more comprehensive understanding of the factors that affect safety and perceptions of safety for people riding bicycles on city streets. We analyze travel diaries, crash data from the Texas Department of Transportation (TxDOT) and GPS data taken from users of the Love to Ride (LTR) smart phone application in Houston and pair that data with a review of the Houston Bike Plan. This report also explores how the information can contribute to identifying specific project priorities in the Houston Bike Plan. A week of travel diaries and near-miss incidents were collected between March 4 and March 10, 2017. One hundred thirty participants recorded information about their daily trips—including the origin, destination, mode and purpose. They also recorded 133 near-miss incidents that occurred during the trips and gave detailed comments about those events.

The GPS ride data are from those who used the app during the Energy Corridor Bike Month Challenge in October 2016 and those participants in the March 2017 study. Such data allows us to see whether existing infrastructure provides adequate support for areas with high volumes of bicycle trips, at least those captured by GPS ride data collected from Houston-area Love to Ride (LTR) app users. LTR compiles trip data from multiple trip recording apps (e.g. Strava, Map My Ride, Endomondo) and can provide a snapshot of which routes a bicyclist took. The LTR data was mapped to illustrate density of bike rides on certain routes.

The combination of the trip diary and LTR data allows for the location of crashes and near-misses to be overlaid with heavily traveled biking corridors. Placing crashes alongside existing and planned Houston Bike Plan projects allows for the examination of possible connections between current infrastructure and crashes. Due to the nature of the data collection, limitations of the study are reflected in the demographics of the participants of the travel diary week. Although people who participated in our near-miss study have a variety of socio-economic profiles, most are people who bike regularly and tended to be white, older and professional individuals. Likewise, the LTR data is far from a perfect representation of people who bike in Houston as it only captures those with access to smart phones. Nonetheless, given the dearth of such data, any collection adds key information. Also, this report does not aim to identify areas where future crashes are likely to happen. Still, this report highlights how future investments already planned and identified in the Houston Bike Plan can be key to improving identified dangerous areas where previous crashes and near-miss incidents have occurred. More analysis needs to be done to identify specific physical characteristics of these locations and how those traits affect the vulnerability of people riding bicycles.
Understanding trip characteristics provides insights—to some extent—of the time of day, frequency and average distance people are willing to travel when making trips. Figure 1 shows the duration of trips throughout the day during the travel diary week. The chart shows that most bike trips happened during peak times, but some trips happened late night to early morning. Most near-misses were reported within the same peak hour time range, with an additional concentration around lunch. The average duration of bike-to-work trips was 24 minutes.

Figure 2 shows the number of crashes by time of day. A similar pattern emerged as with the near-miss incidents. More crashes were reported to happen during both morning and afternoon peak hours—but much more frequently during afternoon peak hours. There is also a similar pattern of crashes reported to happen in midday as those with near-miss incidents. Together, this information can be used for enforcement of safety regulations to focus on times where people are riding the most. Meanwhile, most of the near-miss incidents happened on bike trips on the way to work or home. This makes improvements in local streets that connect highly populated residential areas with important places such as job centers and schools more important.
FIGURE 1  Trip Duration by Time of Day based on Travel Modes (min)

FIGURE 2  Bicycle Crashes by Time of Day (Source TxDOT 2009–2015)
Within the 2016 Energy Corridor Bike Month Challenge, LTR users took a number of recreational and home-to-work bike rides. Figure 3 shows concentrations of trips within Harris County. The map also shows that bike rides within the Inner Loop area mostly take place along existing off-street facilities such as the bike trails along Buffalo Bayou. Connecting these trips with existing or planned bikeway infrastructure provides a snapshot of the types of streets used by people commuting and recreating on bikes. It also provides a blueprint for potential future strategies to identify priorities for investments in bike infrastructure.

**Where People Bike and Safety Concerns**

**Concentration of People Biking in Harris County**

**Legend**
- Bike Rides Density (2016 Love To Ride)
  - No Value
  - Below Average
  - Average
  - Above Average
  - High Concentration

Source: Love To Ride, Energy Corridor Bike Month Challenge 2016
Houston currently has approximately 500 miles of bikeways in the current network, but only about 260 miles are considered high-comfort facilities where people can ride either on designated trails or dedicated space on-street. Using TxDOT’s 2009-2015 bicycle-related crash data, Figure 4 shows concentrations of bicycle crashes overlaid with existing bikeways. It shows several overlapping areas where there are high concentrations of bike rides in places with existing bikeways such as downtown, Rice-TMC areas and along the Buffalo Bayou trail. The map also shows the concentration of crashes that occurred in neighborhoods with minimum or inadequate bike-ways infrastructure such a Gulfton, Sharpstown, Near Northside and the Fifth Ward.

The Houston Bike Plan was adopted by the City Council in 2017 as a required component of Houston’s Complete Streets Executive Order. The 20-year long-range plan seeks to identify needs and strategies to make Houston a Gold-level Bicycle Friendly City by 2027. Key stakeholders and public input identified a low-stress and well-connected bikeway network as key to achieving this goal. The process of identifying specific strategies and bikeways for future investments involved a week-long network planning workshop with key stakeholders and detailed design exercises. The result is an assessment of existing bike-ways and recommendations for where the future short- and long-term bikeway projects should be located. The bike plan identifies several strategies including retrofitting existing bikeways to upgrade to high-comfort bikeways by modest investments in signs and striping with a focus on areas within a quarter-mile access to schools, libraries, community centers and multi-service centers. The plan also identifies corridors for development of city-
wide future projects through the incorporation of projects developed by partners such as the Houston Parks Board, Management Districts, Tax Increment Reinvestment Zones (TIRZ), METRO, and others. The recent announcement of a $30 million allocation for safe street improvements and specifically $10 million for bike projects located within Harris County Precinct One District is a big step toward achieving these goals. This is especially important considering that 44 percent of bicycle-related crashes between 2009 and 2015 and 48 percent of the short-term retrofit projects are located within this district.

Figure 5 shows locations of the past 2,214 bicycle-related crashes between 2009 and 2015. Of the 2,214 crashes, those that were reported on-street or less than 1 mile from streets identified in the Houston Bike Plan bikeways network account for up to 78 percent of all bike crashes during these years. To show whether locations of these incidents are also locations that have been identified in the bike plan for future improvements, locations of previous crashes and near-miss incidents were assigned project categories from the Houston Bike Plan depending upon which street they occurred on. Investment in these planned bikeways could significantly improve safety and reduce future crashes, especially considering that a significant amount of fatalities of people riding a bicycle is from rear-end collisions and overtaking. This makes an investment in safe bikeways more important since there is little a bicyclist could do to prevent being hit in these crashes.

Most bicycle-related crashes occurred on streets for designated future projects (60 percent) and on those designated for short-term retrofit projects (22 percent) in the Houston Bike Plan. Crashes located on streets designated...
for future projects were mostly located outside of the Inner Loop. In contrast, those occurring on streets with short-term retrofit projects mostly occurred within the Inner Loop.

Figure 6 above is a zoomed-in overlay of the LTR ride density data captured in the travel diaries and near-miss data collected by the Kinder Institute. It shows locations of near-miss incidents on streets identified for future projects in the Houston Bike Plan. Each near-miss incident is shown based on whether it happened on existing bikeways or on roads designated for future projects in the bike plan. The map is centered on the triangle of the Texas Medical Center, Rice University and Downtown, an area with a high density of both bicycle ridership based on the LTR data and travel diaries. Almost all reported near-miss incidents occurred in areas where people are biking. This could be explained due to the likelihood that potential for conflicts increased in these high-activity concentration areas.

The map also shows that reported near-miss incidents occurred in areas with less connected or non-existent bike infrastructure, specifically those listed as future projects (36 percent) or short-term retrofit projects (27 percent), than overall crashes. Implementing short-term retrofit projects, which are often low-cost and quick to produce, can potentially address a significant portion of safety issues without major funding efforts. The use of paint and striping can increase the visibility of safe spaces for vulnerable road users and encourage safer, more responsible driving. This is especially important in areas with high concentrations of people and activities like schools or those near public transit.
Participants of the travel diary and near-miss study also pointed to some needed infrastructure or road design elements that could help improve street safety for all. Although some existing bikeways provide safer places for people to ride, these facilities are often disconnected from each other. The combination of near-miss data and trip density illustrates the importance of having connected bikeways in getting people riding a bicycle to where they need to go. Additionally, having these multiple data sources can highlight gaps showing where people might be riding a bicycle even though there are no existing bikeways.

Figure 7 shows a comparison of where crashes and near-misses occurred compared to project categories in the Houston Bike Plan.

Over half of crashes that happened between 2009 and 2015 are located on or near streets identified as locations for future long-term projects and about 20-30 percent of both crashes and near-miss incidents happened in streets designated as short-term retrofit projects. The graph emphasizes the need to pursue both short-term and long-term strategies that can accomplish safety and connectivity goals of the bike plan.

Additionally, reported near-miss incidents occurred in all types of bikeways categories. Because near-miss incidents are essentially conflicts between different road users, a range of strategies—from educational campaigns to built-environment interventions such as improved signage and physical separation from cars—can improve the awareness of all road users and visibility of the most vulnerable ones.

Street safety treatments tend to focus on arterial or major roads but according to TxDOT data, roughly 23 percent of bicycle-related crashes between 2009 and 2015 occurred on local streets. Therefore, it is equally important to consider how sidewalks and bike lanes in highly populated local residential streets in the neighborhood can safely take residents from home to important destinations like schools and nearby bus stops.
Conclusion

This report shows how a variety of data sources can contribute to a more comprehensive understanding of factors affecting safety and the perception of safety in travel experiences. Efforts to address traffic safety concerns usually rely on crash data reported by the police. However, crash data is often under-reported, especially in communities reluctant to involve authorities. Other data sources such as near-miss incidents and bike ride density captured by exercise apps can complement crash data and point to a variety of ways to improve safety for all road users. These data points, combined with official crash data can better demonstrate patterns in road incidents and be used to prioritize future bike and pedestrian improvements. Additional assessment of how existing street facilities support walking and biking is an important step to connecting existing safety concerns with future investment strategies. The Houston Bike Plan also highlights the need to understand the local context to implement the plan.

When near-miss incidents and crashes cluster, road users’ behavior may not be the only factors contributing to the issue. Factors such as the built environment may contribute as well, meaning the availability of bikeways and its conditions in the local context matter. The way streets are designed also affects how people travel and their ability to pay attention to other road users. For example, both safety and perception of safety are influenced by different types of bike lanes. A designated shared lane suggests a space for people riding bicycles but may be more dangerous because drivers may not be aware of the laws and regulations which allow bicyclists to take the full lane. A marked bike lane provides higher visibility and signals drivers to watch out for people riding bicycles, but it does not provide adequate separation and protection from fast-moving automobiles like protected bike lanes provide. Coupling near-miss and crashes data with on the ground assessments of the built environment can better shape targeted infrastructural interventions and lead to definitive safety improvements.
The combination of crash data, near-miss incidents and assessment of existing street conditions at a neighborhood scale can provide a very powerful argument for addressing safety concerns of residents and prioritizing future investment in potentially dangerous areas. While the near-miss information described in this report is a result of a one-week travel diary, asking residents to provide near-miss information that has happened in the past may be more feasible and allow for more responses in identifying dangerous locations. Additional questions about public transit use and transportation facilities and infrastructures can link these dangerous incidents to a larger context of transportation access and safety in the neighborhood. This type of data collection can be crucial for communities where incidents are most likely underreported either because there is lack of trust in reporting to the authorities or steep cultural and language barriers. Future work can also focus on conducting an assessment of existing facilities and infrastructure like sidewalks and bikeways that improve safety for people walking and biking. This analysis can also provide information on how people get to places in the neighborhood and access places outside of the neighborhood.

Finally, while decisions about future project investment may depend on various factors, an assessment of existing facilities and infrastructures can provide information supporting where future investments are most needed. There have been many efforts nationally to assess the extent to which existing road elements provide safety, comfort and convenience for people to get around in their neighborhood. Most examples focus more on assessment of streets that support walking such as the AARP Walk Audit Tool Kit and a pedestrian evaluation tool developed by the Houston-Galveston Area Council (HGAC). Other examples such as Pedestrian Environment Data Scan (PEDS) and Microscale Audit of Pedestrian Streetscapes (MAPS) include assessment for both walking and biking in the tool. These walking and biking street inventory tools can help refine our understanding of problem areas and continue to improve our attempts to make safer streets for all users.
Endnotes


7 LTR data does not disclose trip purpose. If users did not specify the trip purpose, the trip will be recorded as recreational when it could have been work trips hence the overt representation of recreational trips in the data (97 percent).

8 LTR also does not record where people live. Therefore it is possible that the bike ride density shown excludes those not recording trips or who do not have access to a smartphone.


10 City of Houston. 2017.

11 City of Houston. 2017.

12 City of Houston. 2017


15 Due to ArcGIS spatial join limitations and data availability, points approximately represent crashes that occurred on streets reported by the police officers. Also, some crashes may have occurred in nearby areas but were reported on the next closest street where parties involved can convene safely.


17 City of Houston. 2017.


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