Using Health Behavior Theory and Relative Risk Information to Increase and Inform Use of Alternative Transportation

January 2024 | Final Report

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16. Abstract
One of the main goals of the Virginia Tech (VT) Alternative Transportation Department is encouraging the VT community (including students, faculty, and staff) to walk, use the bus, carpool, or ride bicycles for alternative transportation to decrease dependency on vehicle use and traffic around campus and increase overall safety. This project develops an intervention and education program to encourage alternative transportation to, from, and around campus to reduce campus traffic. In addition, since there is currently no standardized approach for computing the injury rates for non-vehicle roadway users, this project also refines and assesses a methodology for estimating injury rates for pedestrians and pedalcyclists, which was used to inform the developed educational alternative transportation safety course.

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Abstract

One of the main goals of the Virginia Tech (VT) Alternative Transportation Department is encouraging the VT community (including students, faculty, and staff) to walk, use the bus, carpool, or ride bicycles for alternative transportation to decrease dependency on vehicle use and traffic around campus and increase overall safety. This project develops an intervention and education program to encourage alternative transportation to, from, and around campus to reduce campus traffic. In addition, since there is currently no standardized approach for computing the injury rates for non-vehicle roadway users, this project also refines and assesses a methodology for estimating injury rates for pedestrians and pedalcyclists, which was used to inform the developed educational alternative transportation safety course. The findings indicate a rising exposure for pedalcyclists, in contrast to pedestrians, for which exposure is on the decline. Injury rates were highest when travel duration was used as the measure of exposure. These results were then used to inform the development of the educational alternative transportation safety course. This course also used the findings from the formative evaluation that revealed that faculty/staff members and students use alternative transportation and believe that having multiple transportation options is essential, but they lack knowledge of how to implement transportation mode changes. The developed course fills these knowledge gaps.

Acknowledgements

This project was funded by the Safety through Disruption (Safe-D) National University Transportation Center, a grant from the U.S. Department of Transportation – Office of the Assistant Secretary for Research and Technology, University Transportation Centers Program.

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Introduction

Alternative modes of transportation, such as walking, bicycling, scooter riding, and busing, are often touted as effective ways to boost physical and mental health while reducing greenhouse gas emissions (Garrett-Peltier, 2011). Increasing a university community's (including students, faculty, and staff) utilization of alternative transportation has the potential to decrease dependency on vehicle use, reduce traffic around the university campus and surrounding areas, and enhance the wellbeing of the university community. In recognition of these many benefits of shifting the mode share of transportation on campus away from solo personal vehicle use, Virginia Tech (VT) has taken strides toward promoting alternative transportation, including active transportation such as walking and cycling, with a focus on sustainability. To increase the mode share of alternative transportation on the VT campus, it is critical to understand the reasons for non-use and to educate the community on how to safely travel to, from, and around campus using alternative transportation. Any educational materials should consider one common reason reported for not using active transportation modes—safety concerns—in consideration of the injury rates of different modes of transportation on campus. This project aimed to address these issues by (1) refining the methodology used to compute injury rates and relative risks for pedestrians and bicyclists and (2) developing and pilot-testing an educational module focused on the safe use of alternative transportation around the VT campus and surrounding town of Blacksburg, VA in consideration of the newly calculated injury risk data.

Background

Among the VT community of students, faculty, and staff, approximately 47% commute 5 miles or less to campus. Despite this relatively short commuting distance and the ubiquity of Blacksburg Transit, which provides frequent and free bus service between most main residential, campus, and town locations, single-occupant vehicles (SOVs) remain the primary mode of transportation for both faculty and staff (73%) as well as students (29%; Jarvis, 2017; Virginia Tech Parking and Transportation, 2019). The University recognizes the importance of reducing the reliance on SOVs for campus transportation; shifting the dominant mode of movement from SOVs to alternative modes of transportation, such as taking the bus, walking, cycling, or riding a scooter, has the potential to reduce traffic on and around campus, decrease greenhouse gas emissions, and enhance the physical and mental wellbeing of the VT community. Specifically from a sustainability perspective, the current predominance of SOV usage is at odds with VT's Climate Action Commitment, which serves as the university's framework for sustainability and energy efficiency with the goal of reaching carbon neutrality on campus (Virginia Tech, 2023). Thus, the University is motivated to reduce reliance on personal vehicles and encourage the adoption of alternative modes of transportation on and around campus.

To discourage continued or even increased reliance on SOVs and promote alternative transportation modes for getting to, from, and around the VT campus, it is critical to understand how individuals make their transportation choices as well as the perceived barriers to the use of alternative transportation. Previous studies focused on college campuses indicate that the primary barriers to taking the bus for campus transit are travel time, reliability, cost, and off-peak service coverage (Schneider & Hu, 2015). When specifically considering active transportation modes such as walking and cycling, travel time/distance, weather, and safety concerns become the most frequently reported deterrents (Whannell et al., 2012; Swiers et al., 2017). Thus, any initiatives or educational endeavors designed to promote the use of alternative and active transportation should take these key barriers into account and ideally consider the deterrents specific to the individual university.

To promote the safe use of active modes of transportation in particular, we first need to understand the risk of these travel modes in campus settings. While the numbers of fatalities and injuries attributable to crashes involving pedestrians and cyclists are available (e.g., Centers for Disease Control and Prevention, 2023), few studies have focused on the rates of pedestrian and bicycling injuries on college campuses (e.g., Loukaitou-Sideris et al., 2014), and it remains difficult to compare the rates of injuries among different modes of transportation. The lack of accurate risk estimates for different modes is partially attributable to deficiencies in the methodology used to estimate risk. There are two components to estimating injury risk: *injury count (the numerator*) and *measure of exposure (the denominator)*. The most popular and commonly used measure of exposure is population, as it is an easily available metric. However, Keall (1995) noted that population, while a measure of the burden of injury, ignores the difference in frequency and duration of road crossings and can therefore over or underestimate the risk among different population groups. Buehler and Pucher (2021) argued that while per-capita rates are useful for controlling for changes in population across different countries when making country-level comparisons, they do not control for changes in walking, cycling, and driving rates over time within each country. Thus, improvements to the methodology are needed to accurately estimate the risk associated with various transportation modes on campus.

To address the above issues, Researchers from the Virginia Tech Transportation Institute (VTTI), Texas A&M Transportation Institute (TTI), Population Sciences Department at VT and Transportation Services at VT collaborated to complete two primary activities:

1. Construct and evaluate different measures of exposure to risk for active transportation users to allow more accurate risk evaluations in campus settings. Using injury data from state crash records supplemented with hospital records, TTI estimated risk to pedestrians and cyclists both in Texas as a whole and in the area of Texas A&M University (to validate the approach for use in a college town). These estimates can be reproduced for other states and campuses following the same approach.

2. Develop and pilot an educational program to facilitate and support safe alternative transportation around the VT campus to reduce vehicular traffic while ensuring safety. VT developed an educational module based on a formative evaluation of the VT population and information on injury risk to pedestrians and pedalcyclists derived from the refined methodology. The education module was grounded in health behavior theory of the transtheoretical model with additional constructs incorporated from the health belief model. These models address individual and intrapersonal level factors of behavior change, including "knowledge, attitudes, beliefs, motivation, self-concept, developmental history, past experiences and skills" (Hayden, 2019).

The key outputs of this project are a refined approach for estimating the injury rates and relative risks for users of active transportation and a data-based educational module designed to promote the safe use of alternative transportation for the VT community and to serve as a model for other universities.

Methods

Refining an Approach for Estimating Denominator Counts

We enhanced an existing approach (FHWA-SA-18-032; Turner et al., 2018) for estimating exposure metrics to ultimately quantify injury/fatality risk for pedestrians and bicyclists. The original approach (i.e., the Areawide Non-Motorized Exposure Tool) uses National Household Travel Survey (NHTS; a periodic travel survey) data to estimate pedestrians' and bicyclists' exposure to risk at the state and Metropolitan Planning Organization (MPO) level. The tool provides three different measures of exposure: (i) total estimated annual trips, (ii) total estimated annual miles travelled, and (iii) total estimated annual hours travelled.

To process the NHTS data, the research team utilized an open-source R package available on GitHub (https://github.com/Westat-Transportation/summarizeNHTS), which handles the downloading, organizing, and loading of the datasets. Specifically, the 2017 Texas Department of Transportation (TxDOT) add-on data was used and processed using Rstudio and the aforementioned package. This allowed the team to calculate various travel statistics such as person trip rate, average person trip duration in minutes, and average person trip distance in miles for different gender, race, and age groups for both walking and biking trips. Using the open-source R package allowed efficient processing of the NHTS data and derivation of meaningful insights into travel patterns across different demographics and modes of travel.

The research team made two key additions to the original tool. The team updated the original tool, which estimated exposure only from 2013 through 2017, by including estimates from 2018 through 2021 (except for year 2020 due to the non-availability of data for that year). In addition to NHTS data, exposure estimates rely on census data (American Community Survey [ACS] 1-year estimates) – total area population and population by commute mode (walk and bicycle). The

Census Bureau did not release the ACS 1-year estimates for 2020 because of the impacts of the COVID-19 pandemic on data collection. They did, however, release experimental data that may not meet quality standards[1], and as a result, those were not used to estimate exposure measures. To extrapolate measures of exposure beyond the year of the last NHTS (i.e., 2016,) a constant person trip rate was assumed across the years 2013–2021. The variation in exposure measures is, therefore, driven by changes in population and number of people walking to work (obtained from Census bureau) relative to 2016.

In addition, the team stratified the state level exposure measures by gender and race. Demographic stratification remedies overestimation of exposure based on trip duration among select race groups who may walk slower or faster or males, who typically walk faster than females (Chandra & Bharti, A., 2013; Keall, M, 1995). Racial stratification helps with understanding if select racial groups are overrepresented in crash fatalities or injuries after accounting for exposure rather than relying on per-capita injury.

Prioritizing Candidate Numerator Data Sources

Researchers identified and prioritized candidate numerator data (injury counts associated with pedestrian and bicycle events) based on a variety of injury surveillance systems in Texas. There are two benefits to this exercise. First, it allows inclusion of injury surveillance systems beyond the state crash database, which only includes events that involve a motor-vehicle. Second, hospital data offers detailed information on injury severity and diagnosis. Injury details (injury type, injury location, time of injury, injury diagnosis among others) are useful in comprehensively understanding pedestrians' and pedalcyclists' injury risk.

The research team periodically engaged with data managers at the Texas Department of State Health Services (DSHS) to discuss project data needs and health data that meets the research objective. Given the timeline of the project and COVID-related delays, the research team agreed to focus on Emergency Medical Services and Trauma Registries (EMSTR) data available from the Office of Injury Prevention, DSHS. The EMSTR consist of four different registries: the (i) EMS registry, (ii) the acute Traumatic Injury Registry, (iii) the Traumatic Brain Injury Registry/Spinal Cord Injury Registry, and (iv) the Submersion Registry. For the purpose of the study, the team utilized the (i) EMS registry, and (ii) the acute Traumatic Injury Registry, as they are most relevant to traffic safety.

EMS data: All EMS runs are required to be submitted to the Texas DSHS. A run is defined as a resulting action from a call for assistance where an EMS provider is dispatched to, responds to, provides care to, or transports a person. EMS providers submit data electronically within 3 months from the date of an assistance call.

[1] https://www.census.gov/data/experimental-data-products.html. The experimental data did not have individual estimates of the population walking and bicycling to commute to work. Taxicab, Motorcycle, Bicycle, Walked, or Other Means were placed together in one category.

Trauma Registry Data: Hospitals are required to report all major trauma cases where the patient died or arrived dead, was admitted for more than 48 hours, was transferred into the hospital, or was transferred out to another hospital. All data are submitted electronically and must be submitted within 3 months from the date of discharge.

The data were obtained for Texas and at the seven MPO levels from 2018–2021. The research team utilized the International Classification of Diseases and Related Health Problem (ICD-10) codes to identify injuries that involved pedestrians and pedalcyclists. More specifically, all entries where the *cause of injury* was any of the following ICD-10 codes were identified as pedestrian or/and pedal cyclist injuries (see Table 1).

Table 1. ICD-10 Codes

V00: Pedestrian conveyance accident
V01: Pedestrian injured in collision with pedal cycle
V02: Pedestrian injured in collision with two- or three-wheeled motor vehicle
V03: Pedestrian injured in collision with car, pick-up truck or van
V04: Pedestrian injured in collision with heavy transport vehicle or bus
V05: Pedestrian injured in collision with railway train or railway vehicle
V06: Pedestrian injured in collision with other nonmotor vehicle
V09: Pedestrian injured in other and unspecified transport accidents
V10: Pedal cycle rider injured in collision with pedestrian or animal
V11: Pedal cycle rider injured in collision with other pedal cycle
V12: Pedal cycle rider injured in collision with two- or three-wheeled motor vehicle
V13: Pedal cycle rider injured in collision with car, pick-up truck or van
V14: Pedal cycle rider injured in collision with heavy transport vehicle or bus
V15: Pedal cycle rider injured in collision with railway train or railway vehicle
V16: Pedal cycle rider injured in collision with other nonmotor vehicle
V17: Pedal cycle rider injured in collision with fixed or stationary object
V18: Pedal cycle rider injured in non-collision transport accident
V19: Pedal cycle rider injured in other and unspecified transport accidents

Computing Injury Rates and Relative Risks

The research team divided the numerator by the denominator data to estimate the injury rates of all pedestrians and pedalcyclists in Texas. The team then stratified the injury rates for pedestrians and pedalcyclists by race to evaluate any racial inequity in safety. These estimates are key to determining whether select races disproportionately bear the burden of injuries.

The research team used numerator data estimated from EMS, the Trauma Registry, and TxDOT. Denominators included annual pedestrian trips, annual pedestrian miles, and annual pedestrian hours. Injury rates were estimated by dividing each numerator by the three different measures of exposure.

To estimate racial inequity (if any), the research team utilized pedestrian and pedalcyclist fatality counts obtained from the Fatality Analysis reporting System (FARS). Fatality counts from 2016 (also the year in which the NHTS survey was conducted) were divided by the three different measures of exposure to evaluate any potential variation in equity assessment when different exposure measures were utilized.

Injury rate was also estimated for pedestrians and pedalcyclists in the Bryan-College Station (B-CS) MPO, which includes the Texas A&M University.

Formative Evaluation

Researchers conducted interviews and focus groups from August to October 2021. Faculty/staff and students were given a detailed description of the study, and questions about the study were answered prior to obtaining verbal consent. Interview and focus group questions addressed issues related to transportation on and around the VT campus using 18 interview/discussion questions spanning three topic categories: (1) General transportation, (2) Alternative transportation, specifically busing, biking, and walking, and (3) Perceptions of facilitators and barriers related to all transportation options (See Appendix A). General transportation included questions about transportation options to get to and from campus, familiarity with alternative transportation options offered on campus, views on transportation with regards to university and town infrastructure, and the impact of COVID-19 on transportation options. Alternative transportation included questions about (1) challenges with use of alternative transportation, (2) challenges with use of busing, biking, and walking on campus, and (3) safety implications, including injuries or near misses, from biking and walking to and from campus. Perceptions related to all transportation options provided participants the opportunity to express any additional thoughts about transportation and alternative transportation.

Sessions were audio-recorded via Zoom and were also recorded using a separate audio recorder. Audio-recordings were then transcribed using Rev transcription software. Transcriptions and recordings were scrubbed of any personal identifying information and reviewed by two team members to ensure accuracy of the transcriptions.

A thematic analysis, a method used for analyzing qualitative data, was conducted to identify, analyze, and report major themes and subthemes using an inductive approach. Major themes and subthemes were identified using specific questions asked during focus group discussions and interviews. Braun and Clarke's multidirectional six-phase guide was used to conduct the thematic analysis which included: (**1**) becoming familiar with the data (including transcription of verbal data), (**2**) generating initial codes, (**3**) searching for themes, (**4**) reviewing themes, (**5**) defining and naming themes, and (**6**) writing up the report (Braun and Clarke, 2012). The thematic analysis was conducted by four team members using ATLAS.Ti 9 qualitative analysis software (ATLAS.it, 2022).

Development of and Pilot Testing an Educational Module on Safe Use of Alternative Transportation

Researchers selected the creation of an online educational module on safe use of alternative transportation as the intervention for Task 5. Canvas, an online learning management system, was chosen as the platform to design and deliver the educational intervention to participants, as VT faculty and students have access to and are familiar with this platform. A Canvas course titled "Alternative Transportation at Virginia Tech" was created and piloted.

This education module was grounded in the health behavior theory of the transtheoretical model, which included the constructs of stages of change; decisional balance; processes of change, and self efficacy. The transtheoretical model proposes that behavior change is a dynamic five stage process (precontemplation, contemplation, preparation, action, and maintenance). This education module was designed to match the stages of change that best matched focus groups participants; these were the preparation and active stages of change. In the preparation stage, individuals are planning to take action and are making initial steps towards using alternative transportation. In the active stage, individuals have recently begun to make changes to their behavior and are in need of strategies to sustain the behavior. Therefore, education was provided to equip those in the preparation stage with the resources and skills they need to successfully try alternative transportation or those in the active stage with strategies and resources to support their new behavior change. The transtheoretical model asserts that progression to behavior change is also facilitated by 10 processes of change (consciousness raising, dramatic relief, environmental re-evaluation, self re-evaluation, social liberation, self-liberation, helping relationships, counter-conditioning, reinforcement management, stimulus control); and a decisional balance of weighing pros and cons. In addition, constructs from the health belief model were incorporated, namely the constructs of perceived benefits and perceived barriers. Similar to the idea of decisional balance, the health belief model proposes that the perceived benefits of engaging with a behavior must outweigh the perceived barriers. To conceptualize these ideas and apply them to alternative transportation, focus group themes were used to identify barriers and facilitators to using alternative transportation at VT.

Focus group results and the constructs of the transtheoretical model and health belief model guided the selection of alternative transportation university resources as well as how resources and skills were framed and presented. Focus group results from the formative evaluation design informed the selection and framing of module content as well as the selection of health behavior theories. For example, focus group results informed the inclusion of the following topics: how to share paths from the perspective of multiple users; how to safely navigate sidewalks, roads, and intersections from the perspective of a biker; how to access ADA-accessible alternative transportation options; how to improve visibility in poor weather conditions; and how to find alternative transportation routes.

To address all focus group themes and theory constructs, the pilot course was structured as follows: a pre-program self assessment; five education modules each with a pre-test, recorded presentation, post test, direct links to resources, and an activity that allowed participants to apply the alternative transportation education to their own transportation habits; and a post-program self assessment. The five educational modules included information on public transportation, active transportation, health benefits of alternative transportation, the connection between the environment and transportation, and alternative transportation safety.

To evaluate the change in behavior, alternative transportation use, and change in theory constructs among pilot participants, pre and post self-assessments were embedded within the "Alternative Transportation at Virginia Tech" course. This self-assessment was based on and adapted from a validated alternative transportation transtheoretical model questionnaire (Redding et al., 2015). The self-assessments were designed and delivered in QuestionPro. A link to the self-assessments were embedded into the educational program. The pre- and post-knowledge tests were used to evaluate change in knowledge of alternative transportation resources and safe use.

To evaluate participant interaction with the module, barriers and facilitators to participant interaction with the module, and technical difficulties encountered, a process evaluation was conducted through a combination of focus groups and surveys with pilot participants. Participants completed focus groups and surveys in March and April 2023. A priori coding was used to identify themes from focus groups and surveys.

Results

Refining an Approach for Estimating Denominator Counts

All measures of exposure increased between 2013 and 2019. Figure 1 presents the exposure measures from 2013–2021, with the exception of 2020 for pedestrians. There was a drop in annual trips, miles of travel, and hours of travel in 2021. Specifically, the number of commuters who walked to work in 2021 dropped 10% from 201,154 to 180,039 (commuter data not shown) in comparison to 2016 (the reference year for estimating commuter population adjustment factor). People who worked from home increased by 474% from 2016 to 2019 and by 183% from 2019 to 2020.

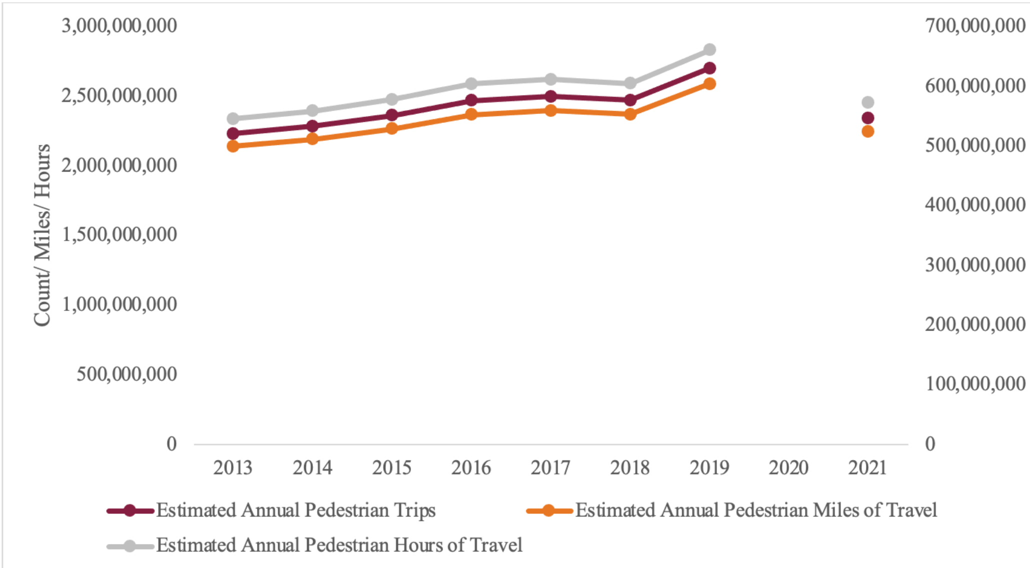

Figure 1. Exposure measures from 2013–2021 (pedestrians). Note: 2020 data not available.

Among pedalcyclists, the exposure remained largely constant across the three measures after 2015 (Figure 2). The number of trips and miles travelled using bicycles decreased slightly between 2013 and 2015 and then increased steadily thereafter, although the number of bicycle commuters in 2021 remained below that in 2013 (37,269; commuter data not shown). The number of people who reported working from home, however, increased substantially, by approximately 60%, from 2013 to 2019.

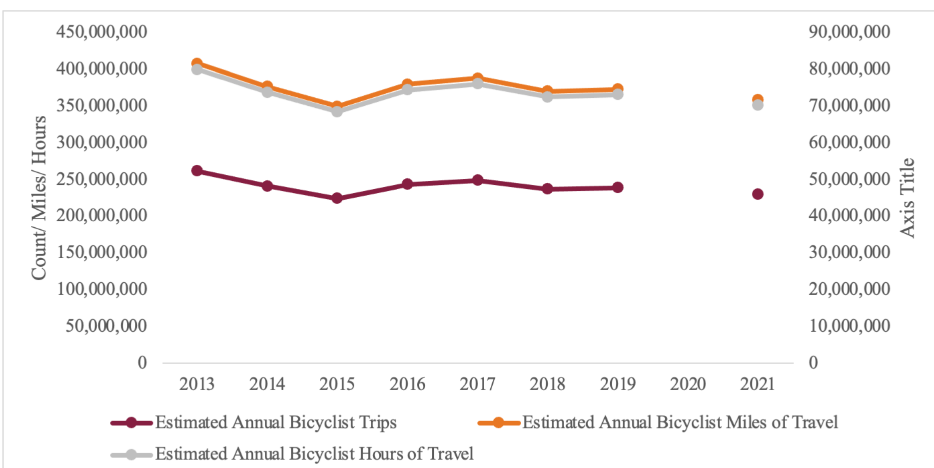

Figure 2. Exposure measures from 2013–2021 (pedalcyclists). Note: 2020 data not available.

Exposure by Race

Figure 3 shows the difference in exposure to risk among pedestrians by race. Notably, people who self identified as White made the greatest number of pedestrian trips followed by those who identified as Black or African American. Those identifying as Black made fewer but longer-distance trips. The longer annual miles travelled and shorter trip durations of Black pedestrians relative to Whites may indicate that Black pedestrians walk at a faster rate.

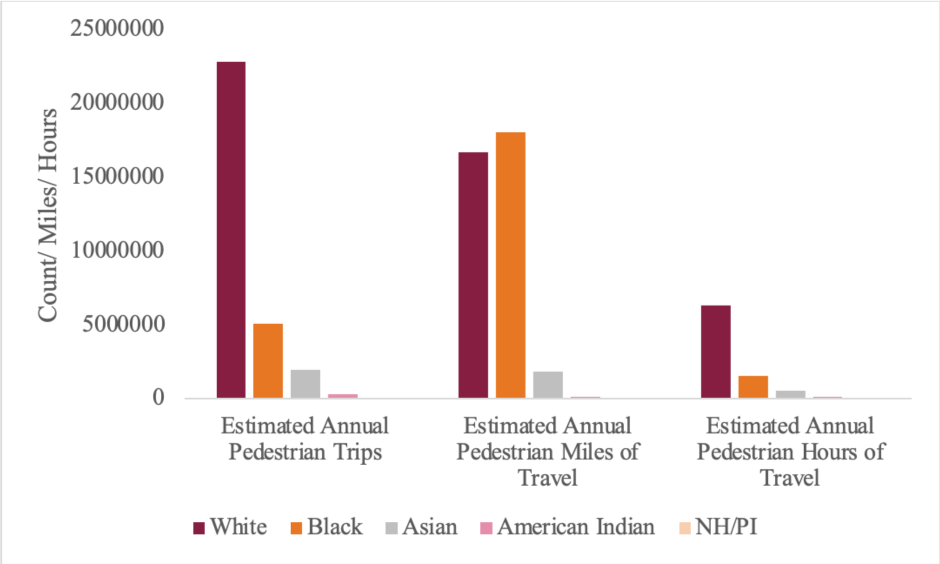

Figure 3. Exposure to injury risk by race (pedestrians).

Exposure at the MPO level

We evaluated exposure in MPOs of different sizes, including small MPOs with a large university population, to have useful comparable data relevant to towns such as Blacksburg, Virginia, where VT is located. Figure 4 and Figure 5 present pedestrians' exposure to injury in two of the seven MPOs examined in the study: B-CS MPO (Texas A&M university) and Waco MPO (Baylor University).

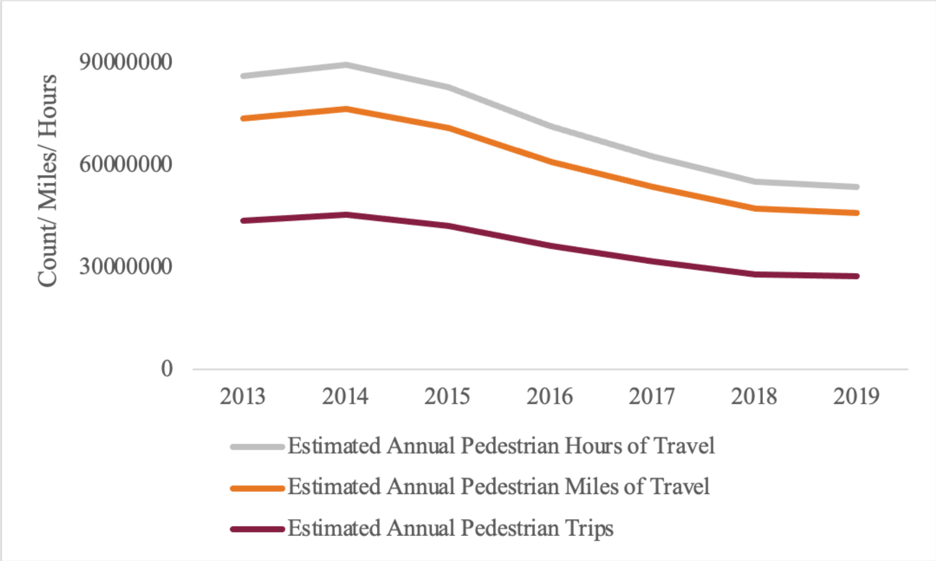

Figure 4. Exposure to injury, B-CS MPO (Pedestrians).

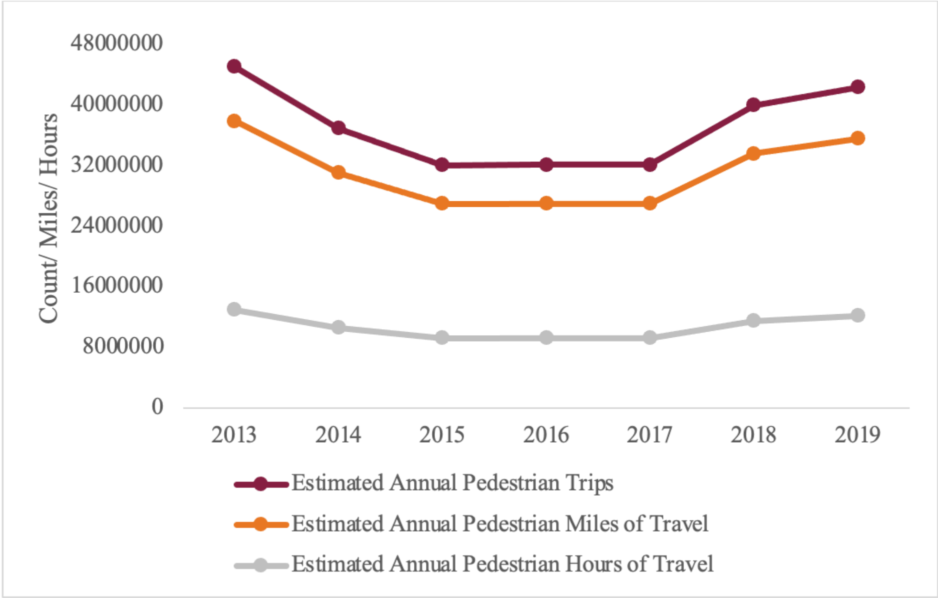

Figure 5. Exposure to injury, Waco MPO (Pedestrians).

All measures of exposure decreased consistently between 2013 and 2019 in the B-CS MPO (Figure 4). In contrast, in the Waco MPO (Figure 5), the exposure measures first decreased between 2013 and 2017 and then increased from 2018 to 2019.

Prioritizing Candidate Numerator Data Sources

Figure 6 and Figure 7 show the comparison of injury counts from EMS data, Trauma Registry, and the TxDOT Crash Records Information System (CRIS). The following details about the data sources should be noted: 1) TxDOT injury counts exclude injuries from events that do not involve a motorized vehicle; 2) the EMS data system only registers patients who receive assistance from an EMS provider and can miss patients that are brought into the hospital through another mechanism; and 3) the trauma registry is hospitalization based and will have multiple entries for qualifying patients who are transferred between hospitals, as each hospital must independently report data. There may also be overlaps between the EMS data system and trauma registry—that is, patients from EMS runs who qualify for an entry in the trauma registry will be found in both surveillance systems.

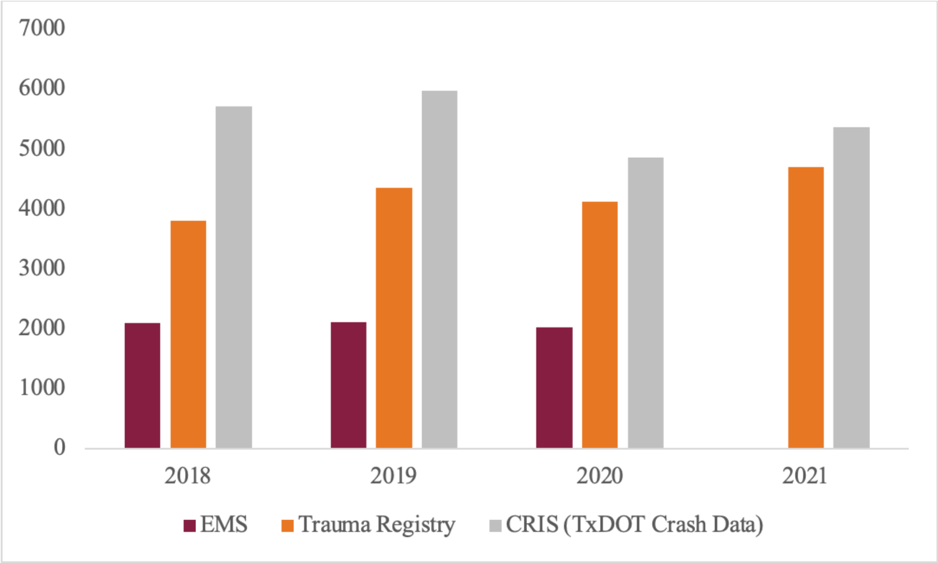

Figure 6. Comparison of pedestrian injury counts from three data sources (EMS, Trauma Registry, and CRIS). Note: EMS data for 2021 were not available.

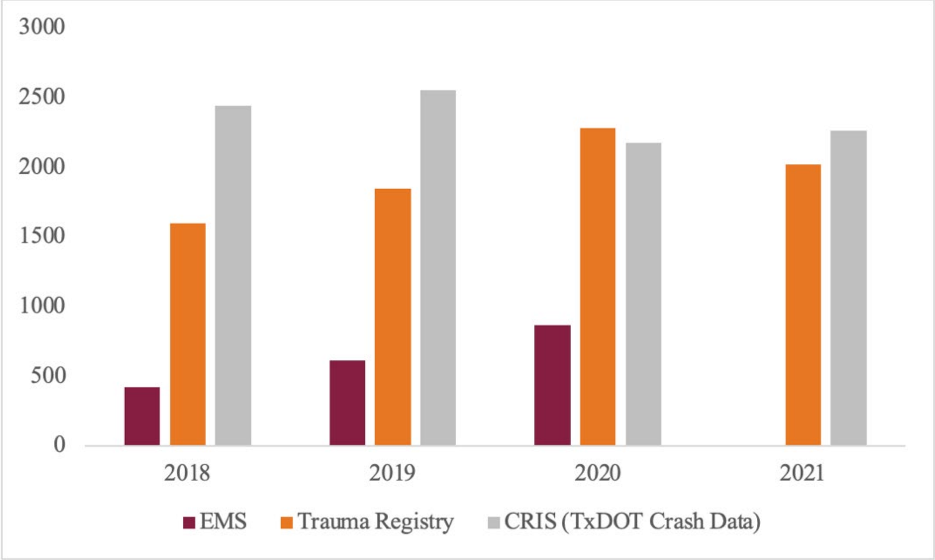

Figure 7. Comparison of pedalcyclist injury counts from three data sources (EMS, Trauma Registry, and CRIS).

As seen in both of the above figures, the state crash database reported the highest number of injuries, even though it only includes injuries from events that involved a motor-vehicle. The EMS database reported the smallest count, but the research team noted the large amounts of missing values for *cause of injury* variable therein. For example, for 2018, only 14% of the cases indicated cause of injury. In contrast, cause of injury was indicated for 98% of entries in the Trauma Registry for year 2018.

MPO-level Injury Counts

Figure 8 compares injury counts from the three injury surveillance systems (EMS, Trauma Registry, and CRIS) for the B-CS MPO. Data for the Waco MPO was not found in the EMS datasets. In contrast to the above findings for the entire state, in the B-CS MPO, EMS data had the highest count of injuries among pedestrians followed by CRIS and the Trauma Registry. In the case of pedalcyclists (data not shown here), CRIS recorded the highest number of injuries followed by EMS and then the Trauma Registry. In addition to fewer missing injury causes in the EMS dataset, it is likely that most injuries in the B-CS MPO may not be sufficiently serious to require hospital admission and therefore appear in the EMS database but not the Trauma Registry. More MPOs with college towns should be investigated to understand if injuries are less severe in MPOs with large university populations or whether this finding is unique to the B-CS MPO.

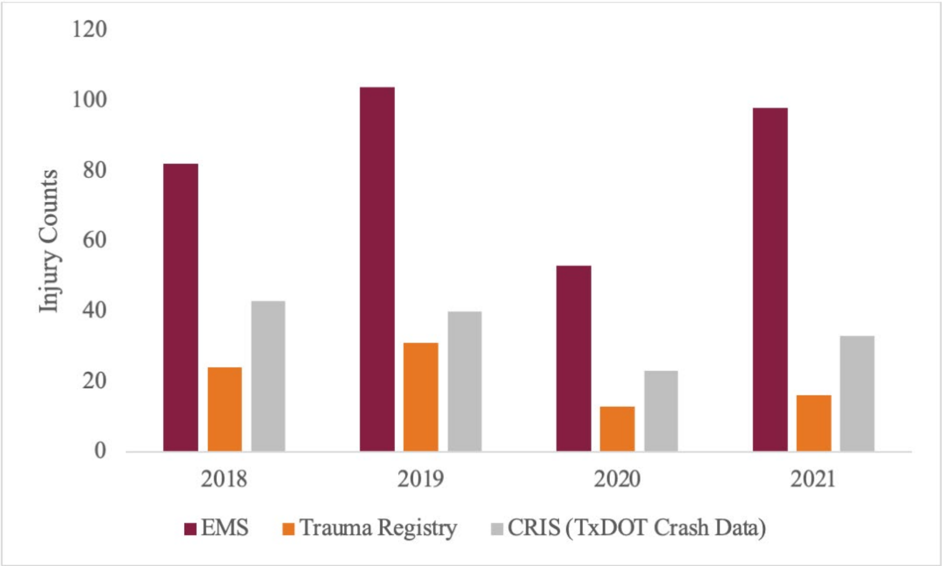

Figure 8. Comparison of pedestrian injury counts in the B-CS MPO from three data sources (EMS, Trauma Registry, and CRIS).

Computing Injury Rates and Relative Risks

Injury rates were estimated using the numerators and denominators estimated by the research team. Figure 9 and Figure 10 show the injury rate of pedestrians in Texas and specifically in the B-CS MPO. In both figures, the injury risks measured using trip count and distance travelled as exposure were largely similar. However, injury risk increased substantially when travel duration (annual pedestrian hours) was used as a measure of risk exposure. Notably, distance travelled, while a useful measure of exposure, can underestimate the exposure for older adults, who may be slow walkers. Moreover, people may be less likely to remember distance travelled compared with trip duration.

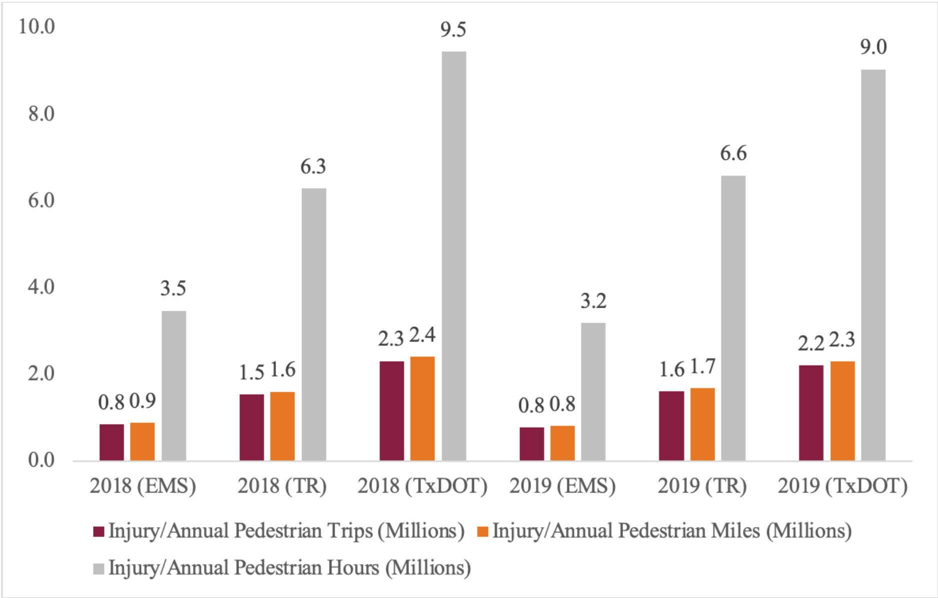

Figure 9. Comparison of pedestrian injury rates (Texas).

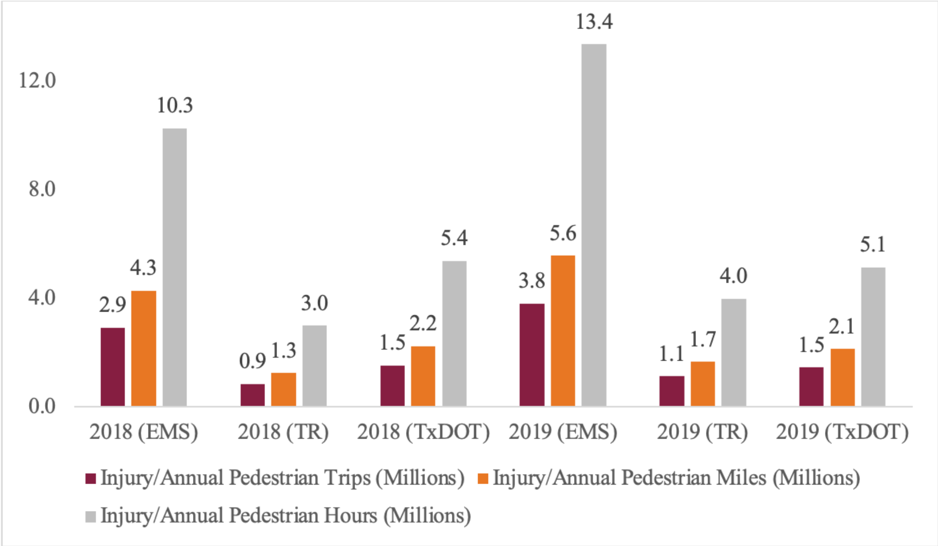

Figure 10. Comparison of pedestrian injury rates (B-CS MPO).

Similar to pedestrians, the injury rate in the B-CS MPO was highest when annual pedalcyclist hours was used as the measure of exposure, followed by annual pedalcyclist miles of travel. When using TxDOT data to estimate injury counts, the injury rate was estimated at 2.35 per million pedalcyclist hours of travel and 0.80 per million pedalcyclist miles travelled.

Finally, when the rates were stratified by race (data source: FARS), the injury rate was highest when using pedestrian hours of travel as a measure of exposure. Additionally, the risk was highest amongst Blacks (784.2 fatalities per million annual pedestrian hours) followed by Whites (623.9) and Asians (359.9). Similar to for pedestrians, the pedalcyclist injury rate was highest when travel duration was used a measure of exposure. For fatality rate, Blacks had the highest rate (1549.9 fatalities per million annual pedalcyclist hours) followed by Whites (736.6) and Asians (389.5).

Formative Evaluation

Fifty-six individuals participated in this study, including 15 faculty/staff members and 41 students. Seven focus group sessions were conducted with six to eight participants in each group and 10 individual interviews. Six of the focus groups were conducted with student participants and one focus group was conducted with faculty/staff participants. The 10 individual interviews were conducted with faculty/staff participants. The major themes derived from the focus groups and interviews were: (1) Alternative Transportation Mode Accessibility and Utilization, (2) Alternative Transportation Challenges, and (3) Alternative Transportation Safety Issues and Precautions.

Alternative Transportation Mode Accessibility and Utilization

Most faculty/staff members thought that the infrastructure in Blacksburg best supported bicycling as an alternative transportation to driving a vehicle, while most students thought it best supported busing. The top alternative mode choice (i.e., primary mode of alternative transportation used for the longest and/or most frequent trips) for faculty/staff members was biking; if they could not bike, their preferred backup mode was walking, followed by taking the bus. The top alternative transportation mode choice for students was taking the bus, and their backup modes were equally biking and walking. Faculty and staff members specifically indicated that having multiple options (SOVs and alternative transportation) was important to them, while students specified that it was important that those options be alternative (to driving alone) modes of transportation.

Alternative Transportation Challenges

Most faculty/staff and student participants indicated "convenience" as their primary reason for opting to drive over an alternative mode of transportation. Convenience was defined as the ease of getting from one place to the next. The top three challenges faculty/staff and students faced when choosing to use alternative modes of transportation were *time*, *inconvenience*, and *weather*. The main concerns faculty/staff members had were time and their responsibilities outside of work/school. The main concerns students had were weather and time.

Similar challenges arose regarding specific modes: busing, bicycling, and walking. Most participants indicated that the main challenges in taking the bus were inconvenience and proximity to a bus stop. Faculty/staff specifically indicated these challenges as related to their *responsibilities outside of work* and the *lack of accessibility*, while students also specifically indicated *bus crowding*. Other significant public transportation challenges brought up were weekend and summer availability as well as negative perceptions of bus stop locations and bus routes. All participants specifically indicated concerns about bus accessibility due to the proximity of the bus stops and a lack of service in their residential area.

Alternative Transportation Safety Issues and Precautions

Of the faculty/staff and student participants who indicated experiencing a near-miss while walking, most indicated that it had been with either drivers/automobile traffic, bicyclists, and/or e-scooter riders. They specified that near-misses involving *driver/automobile traffic* and *bicyclists* happened because the driver or bicyclists lacked awareness that they (the pedestrian) were there or because these modes did not allow for the pedestrian to safely walk through crosswalks. Near misses involving *e-scooters* occurred due to the e-scooters being ridden on sidewalks instead of in the street or bike lane. Pedestrians also noted that e-scooter riders discarded their e-scooters on the sidewalks in a way that made walking more difficult and/or created a hazard.

The primary safety precautions taken by faculty/staff and student participants who biked were wearing a helmet and/or wearing visibility gear while bicycling. Faculty/staff and student participants who walked indicated their main safety precautions were having awareness while walking and utilizing the crosswalks and/or sidewalks. Students specifically mentioned having an awareness in areas around campus that lack visibility due to little or no outdoor lighting, with some opting to not walk at night at all. Though helmets and visibility gear are some safety measures that can be taken by users of alternative transportation, they are by no means the only possible protective safety actions, reflecting the need for more education in this area.

Develop and Pilot Test an Educational Module on Safe Use of Alternative Transportation

Of the 38 students who participated in the educational intervention pilot, 10 attended focus groups and 22 completed a survey. Nineteen questions covered four topics: (1) site navigation, (2) modules, (3) activities, and (4) pre/post tests. A total of 72.88% of students (n = 23) reported completing the entire educational program within 2 hours. Components of the educational module that facilitated participant interaction: (1) ease of program navigation attributed to the Canvas platform and program structure; (2) acceptance of the time commitment required to complete the program; (3) acceptance of the length and number of modules; (4) presentation visuals and content; (5) alignment of knowledge tests to information provided in the program; and (6) testing of small amounts of knowledge throughout the program. The inclusion of learning activities was both a facilitator and barrier. Participants cited that activities can reinforce learning. They showed a preference for interactive or practical skill-based activities. Barriers occurred when experiencing difficulty understanding activity instructions, and technical difficulties occurred when navigating an external site required to complete an activity.

Implementing this education module required one staff member a total of 1 hour and 10 minutes. Ten minutes were required to introduce the education program to pilot participants. One hour was needed to verify participant completion of program tests and activities.

Participants completed before and after knowledge tests consisting of five questions for each module (public transportation, active transportation, health benefits, environmental connection to transportation, safety) in the Canvas educational program. A paired t-test was used to determine if a change in knowledge occurred based on the number of correct answers. The adjusted p-value was set at 0.005. The number of correct responses increased statistically significantly across all modules among participants ($p < 0.001$). Table 2 compares the mean scores before and after participating in each educational module.

Table 2. Change in Knowledge Mean Score Among Pilot Participants Per Educational Module

Module	*n*	PreMean ± SD	PostMean ± SD	Difference of means	Significance
Active Transportation	38	2.95±1.0	4.68±0.74	1.74	p < 0.001
Environment and Transportation	38	4.42±0.6	4.92±0.27	0.50	p < 0.001
Safety	38	3.74±.83	4.87±0.41	1.13	p < 0.001
Health	38	3.74±.83	4.82±0.46	1.08	p < 0.001
Public Transportation	38	4.55±.69	4.95±0.23	0.39	p < 0.001

Participants also completed a pre and post program survey to evaluate if a change in behavior related to alternative transportation use and change in theory constructs occurred. Independent t-tests were used to compare pre and post survey results. The adjusted p-value was 0.001. There was not a statistically significant change in behavior related to alternative transportation use or change in theory constructs.

Based on the results of the educational intervention evaluation, the final development of the educational module will include updated activity, injury rate, and relative risk statistics resulting from this project, and the removal of pre knowledge tests. At the time of piloting the education modules, project-related injury rates and relative risks were not yet available; these data will be included in the final development of the educational module.

Discussion

This project produced estimates of injury rates that account for three different measures of exposure as an alternative to relying on population to estimate injury burden. The findings indicate a rising exposure for pedalcyclists, in contrast to pedestrians, for which exposure is on the decline across all measures (trip counts, distance travelled, and travel duration). Injury rates were highest when travel duration was used as the measure of exposure. We estimated both state- and MPO-level injury rates. At present, MPO-level exposure measures are the best available denominator data to account for exposure in areas that have a large student population. There is a need to measure exposure at the local level to improve the accuracy of injury risk estimates.

Findings from the formative evaluation revealed that faculty/staff members and students not only use alternative transportation, but believe that having multiple transportation options is essential.

In addition, though some safety precautions, such as wearing helmets or visibility gear, were used by VT community members, there was a gap in knowledge about all the options that are available and how to safely use them. Additionally, safety issues and precautions must be addressed to advocate for increased use of alternative transportation. The formative evaluation conducted in this study should be replicated and expanded to include unconventional methods like skateboarding or e-scooters to further assess their use among faculty/staff and students.

Overall, the evaluation of the educational intervention supports the premise that a program focused on promoting alternative transportation can be accepted by university members. University students found the time commitment required for this program to be appropriate and manageable. The Canvas platform enabled many of the key features of the program that facilitated acceptance by students. Survey results revealed that pretests may be setting unintentional expectations and limiting participants' consideration of program content. The inclusion of a pre- and post-module knowledge test allowed for tracking a change in knowledge; this activity may not be necessary in the final development of the program. Post-module knowledge tests may be sufficient in assessing whether participants are aware of alternative transportation options.

Conclusions and Recommendations

The formative evaluation indicated that most faculty/staff and students desire engagement and involvement in making active modes of transportation, such as biking and walking, safe and easy. Offering safe, accessible and reliable alternative transportation options, implementing better infrastructure and policies that support use of alternative transportation options, and educating commuters about alternative transportation options are key pathways VT can take to achieve the CAC's goal of reducing single-occupancy-vehicle commuting to campus by 20% by 2025 and reducing transportation-related greenhouse gas emissions by 40% by 2030, and can improve quality of life for the VT and local community. VT will continue to develop and use the theory-based educational modules based on the feedback from this formative evaluation and set of recommendations, which includes ongoing testing of the educational module to create awareness of alternative transportation options, environmental impacts, and transportation safety in and around campus. Recommendations for reducing pedestrian and pedalcyclist injuries include improving infrastructure and educating both cyclists and pedestrians on various safety behaviors in which they can engage. Injury risk estimates are a critical input in prioritizing infrastructure spending, planning educational programs, and implementing other countermeasures. Regional travel surveys provide critical data in estimating injury risk at the sub-national level. Unfortunately, they are not common in college towns and other small sub-regions. Therefore, this study utilized travel data from MPOs with a large university to approximate trip counts, trip duration and trip distance in college towns. Estimation of travel surveys in college towns could further improve the accuracy of injury risk estimates, and therefore, their ability to inform injury surveillance and appropriate safety interventions.

It is important to note that while the educational module was designed to focus on the transtheoretical model stages of preparation and action, the pilot group who tested the module primarily reported beginning the program in the stage of precontemplation. Future testing of this intervention may include recruiting individuals who represent other stages of change to compare the impact of the program across various stages as well as evaluate whether the change in knowledge will also actually change behavior. In addition, the transtheoretical model defines behavior stages in 6-month time increments. Taking this into consideration, future testing should recruit individuals in the preparation and active stage and allow for 6 months between the pre-and post-test to align with transtheoretical definitions of behavior change.

Additional Products

https://safed.vtti.vt.edu/projects/using-health-behavior-theory-and-relative-risk-information-to-increase-and-inform-use-of-alternative-transportation-2/

Data on Dataverse from Project 05-008: This includes the Areawide Non-Motorized Exposure Tool (FHWA-SA-18-032; Turner et al., 2018) that utilizes the National Household Travel Survey (NHTS) data to estimate pedestrian and cyclist risk to all states and Metropolitan Planning Organizations (MPOs) in the United States, including Virginia. Interested readers can utilize the exposure estimates provided in the tool to estimate injury rates for other states and MPOs in the United States.

Education and Workforce Development Products

Researchers gave an interactive presentation on this research for a group of 67 students between 10 **and** 11 years old for the "Hokie for a Day" event. Glenn, L. and Quint, N. (2023, February 22). *How To Conduct Research Using Theory to Increase Use of Biking, Walking, Skateboarding etc. around Virginia Tech and Blacksburg.* Hokie for a Day, Blacksburg, VA.

An online educational program aimed at increasing alternative transportation use and safety was piloted with 38 students. The program contained five units each with a pre-test, recorded presentation, post test, direct links to resources, and activities. The five educational units included information on public transportation, active transportation, health benefits of alternative transportation, the connection between the environment and transportation, and alternative transportation safety. (2023, February–March). *Alternative Transportation at Virginia Tech*. https://canvas.vt.edu/courses/170358

Technology Transfer Products

Sinha, N., Shipp E.M., Martin, M and Ramezani, M. (2022, October 10-12). Quantifying Alternative Transportation Injury Risk using Health Records and Household Travel Survey Data. *19th International RS5C Conference*, Grapevine, Texas.

A podium style presentation of research findings was given at the 19th Road Safety on Five Continents, RS5C Conference held October 10-12 in Grapevine Texas, United States. This international conference provided a platform to share exposure-based injury rates with researchers and safety stakeholders. A total of 25 people attended the presentation, which included a panel of four presenters.

Data Products

The Virginia Tech team uploaded the qualitative data analysis spreadsheet from Atlas Ti.9. Additionally, the Atlas Ti.9 data file will be attached that includes all faculty/staff and student focus group and interview transcripts and thematic coding.

The Texas A&M Transportation Institute uploaded the Denominator Data Tool and Documentation (FHWA-SA-18-032; Turner et al., 2018). The tool is a spreadsheet that estimates pedestrian and bicyclist exposure to risk at statewide and MPO Area scales. The exposure estimates are available from 2013–2019. Three different measures of exposure estimates are presented in the tool—annual trips, miles of travel and hours of travel—for pedestrians and bicyclists.

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Appendices

Appendix A: Focus Group/Interview Questions

Ice Breakers:

- What is one item on your bucket list?
- What is your favorite Blacksburg restaurant?

GENERAL TRANSPORTATION block:

1. How many times per week do you travel to campus on average?
2. What is your primary mode of transportation (the mode used for the longest and/or most frequent trips)?
3. How familiar do you feel you are with the transportation options available to you for getting to and from campus?
    a. How did you learn about what transportation options were available to you for getting to and from campus?
4. What modes of transportation could you take?
5. What prevents you from taking alternative modes of transportation (ex: bike, bus, etc.)? (challenges/deterrents)
6. Why would/do you choose driving alone to get around over alternative transportation modes (walk, bike, bus)?
7. How important is it to you to have multiple options for getting to campus?
8. What kinds of transportation do you feel are made easiest by the infrastructure of the Blacksburg community?
9. How do you think COVID-19 has impacted your travel modes?

BUS block:

Think about Blacksburg Transit and the ways in which you use or do not use it.

1. What prevents you from taking the bus?
   (Prompts: Locations of stops, Scheduled Times, Routes)
2. Is the Blacksburg Transit offered at the times that you need it?
3. What do you think about current bus stop locations?

BIKE block:

1. What prevents you from biking to and from campus more often? (challenges/ deterrents)
2. What safety measures or precautions do you take while biking?
3. Have you had any injuries or near misses (if biking is a mode that some in the group have used)?

WALK/PEDESTRIAN block:

1. What prevents you from walking to and from campus more often? (challenges/ deterrents)
2. Are there any safety measures or precautions do you take while walking?
3. Have you had any injuries or near misses (if walking is a mode that the group has used)?

CLOSING block:

1) Is there anything else you would like to discuss that you felt wasn't?

Appendix B: Injury Count Data Comparison (Figures B 1–B 4)

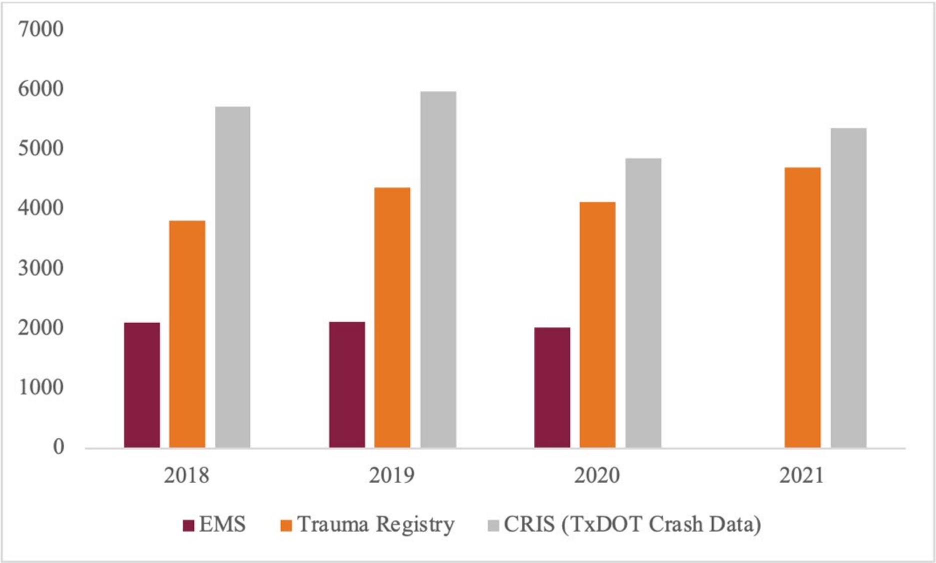

Figure B 1. Comparison of Pedestrian Injury Count (EMS-Trauma Registry-CRIS).

Note: EMS data for 2021 were not available

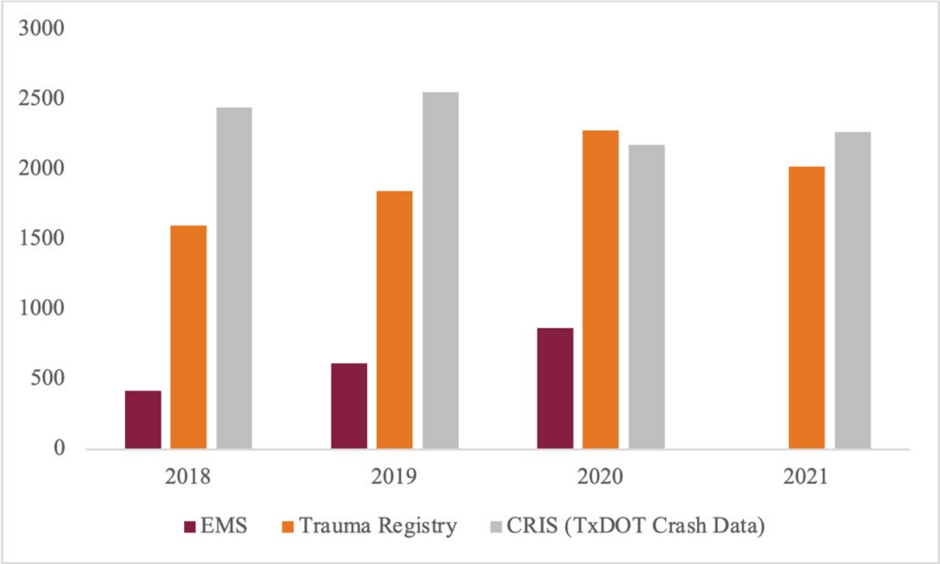

Figure B 2. Comparison of pedalcyclist injury count (EMS-Trauma Registry-CRIS).

Note: EMS data for 2021 were not available

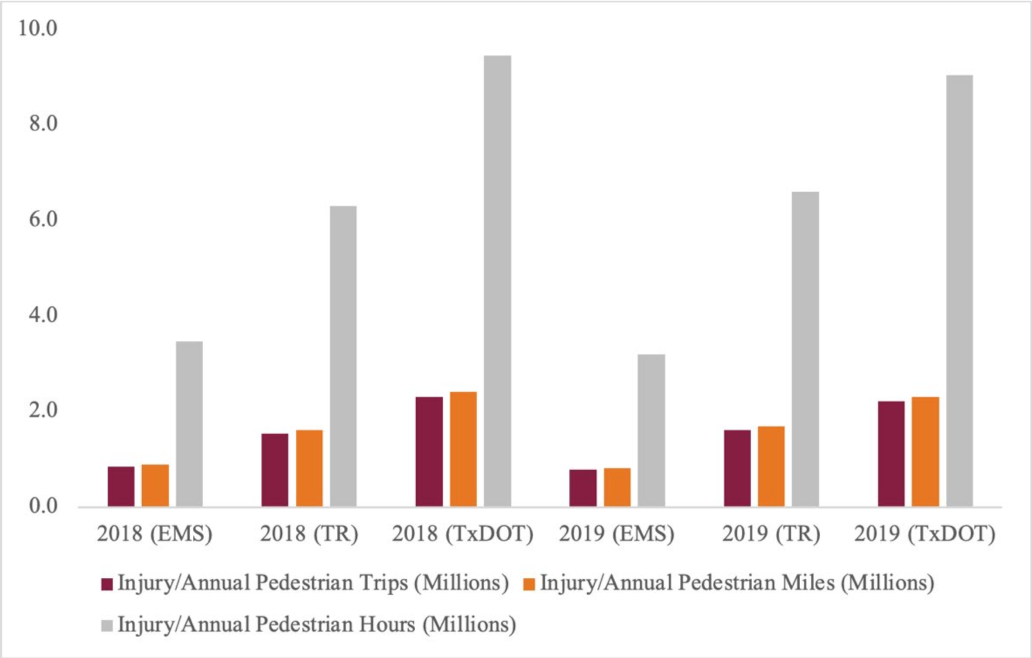

Figure B 3. Comparison of pedestrian injury rates (Texas).

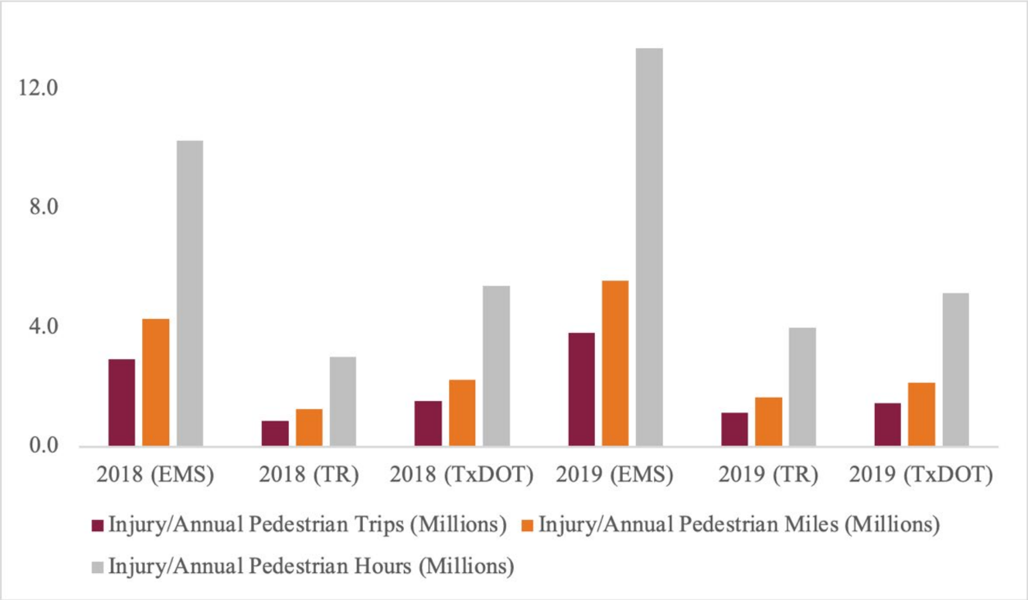

Figure B 4. Comparison of pedestrian injury rates (B-CS MPO).