# My Street User Guide

The My Street User Guide provides an overview of the My Street research tool. This document explains the step-by-step process used in My Street. The following Technical Appendix provides an in-depth summary of the data and analysis methods used, unique considerations, and other assumptions made for the purposes of the tool.

## Welcome to My Street

My Street is a sketch-level planning tool that uses pedestrian crashes, roadway information and a systemic analysis approach to determine and illustrate the risk of midblock crossings and unsignalized (uncontrolled) intersections and the potential benefits of safety improvements. It provides transportation professionals with a visual to communicate the impact of decisions from a person-based perspective (avatars), so that the needs of people will ultimately be considered more effectively by decision-makers and be better understood by the public.

My Street uses **equity** or socio-economic data to identify populations that are historically disadvantaged and over-represented in fatal pedestrian crashes. This information is incorporated into the risk scoring used to identify and prioritize locations for review and to help create more safe and equitable outcomes for all pedestrians. My Street considers the needs of the populations, particularly people and communities that are traditionally underserved and defined as "vulnerable". Vulnerable populations can refer to (but is not limited to or restricted to just one of): Low Income, Limited or No Access to a Personal Vehicle, Age (Seniors and/or Children), Gender, Persons with Disabilities, or English as a Second Language (ESL). It is important to note that transportation equity does not mean equality. An equitable pedestrian safety action plan considers the circumstances impacting a community's crossing and connectivity needs, which is combined with data analysis, to determine the best countermeasures and implementation strategies for each location and community.

Important Note: To begin utilizing My Street, email Contact to be given access. The team will provide a form for users to complete, and the form will be submitted to FHWA. Following submission of the form, users will receive access credentials from FHWA. These credentials will allow full access to My Street including user instructions, data upload portals, and reports.

## Welcome to My Street

The Welcome page of the My Street tool introduces users to the pedestrian safety planning tool and ask them to create a user profile and login. This allows users to save their information, return to their uploaded shapefile, and selected sites for review for up to 60 days.

## Login

Users will begin by clicking the "Login" button to access the tool. The user will login with username and password credentials as provided by FHWA. Users may be asked to change the password after the first login.

## Acknowledge and Accept "Disclaimer" Pop Up

When users initially open My Street, they will see a disclaimer that reviews the parameters and limitations of what the application offers. Some of the highlights of the disclaimer include: the considerations made for equity in My Street and the data longevity. Once users have read the disclaimer, they will be allowed to interact with the site, but must click "Okay" first, showing that the disclaimer has been read.

## Get Started

By clicking the "Get Started" button, the user may begin the process of uploading data. If you have visited the site before, the tool will ask if you want to use previously uploaded crash data. Otherwise, the user will upload a shapefile including pedestrian crash data.

Users will be asked what agency or organization name they would like to see on the final report, select the state where the crash data is located, and select the field in your data that corresponds to crash severity. Users will then be asked to identify the fatal injury value and the serious injury value from their uploaded pedestrian crash shapefile. After users have provided their information, they will click the "View Your Results button." Utilizing the information, users will input and refine their data. My Street will now begin its systemic analysis. After receiving this information, users will be asked to click the "Map Values" button.

*Pro Tip: These items will be added to the map values and final report. Users should review their values and spellcheck their organization names if the final report is meant for public viewing.*

## Results

The Results page shows a map based on the uploaded crash data, as well as list of the facility types where fatal and severe pedestrian crashes occurred most frequently. This list reflects the weighted crash severity associated with each facility type. Users can explore the map, compare facility types, and select up to ten sites for further review.

My Street's map shows the road network for the selected state, crash density, and an index score by Census tract representing populations that are historically disadvantaged and overrepresented in pedestrian crashes. Expand the map legend to explore the layers included in the map. For more information about the data used to create state-level roadway networks and the methodology used to create the index score by Census tract representing historically disadvantaged populations, see the Technical Appendix.

## Systemic Analysis Results: Facility Types

To begin reviewing your facility types, users can use the scroll bar within the "Facility Type" grid to find a grouping of sites that they are interested in analyzing. Each row in the "Facility Type" grid has grouped facilities with similar roadway characteristics, pedestrian crash types, and number of pedestrian crashes. These grouped facilities are also given a weighted score to help determine which have the highest pedestrian crash risk and should be prioritized. Locations with the highest number of crashes and highest weighted score are filtered to the top of the grid; locations with the lowest number of crashes and weighted score are at the bottom.

*Pro Tip: To open and view more details on a select grouping of locations, users can click on the "+" (plus symbol) next to select location. A detailed drop down will appear where users can see the equity Index score, mile markers and the exact street name of each location included in the group.*

*Pro Tip: To zoom in further on your location on the map, click the empty box located next to your preferred location. Once the box is checked, the map will automatically zoom into the crash location and provide further details. Users can only check one box at a time. Users can navigate and explore the map further by using their track pad or + or – zoom feature on the map. After exploring their location, users can then click "Review Site" to further review their location.*

## Site Review

The Site Review page prompts users to provide additional information for their selected site. Users will be asked to answer the existing condition questions to inform countermeasure selection options. Users will also meet the My Street avatars for the first time. The Site Review page includes the "before" rendering representing the facility being reviewed and a selection of countermeasure packages to apply to their site.

The My Street avatars will appear on the Site Review page above the "before" rendering. Their individual five-star scoring system will increase or change with information the user inputs regarding the existing conditions of the selected crossing. The scores will also change when users select a countermeasure for the crossing. To learn more about the My Street Avatars and the scoring system, please review the My Street Technical Appendix. Once users have filled in all the questions, they will be asked to click the "Complete Review" button.

## Countermeasure Selection

Users will see a before rendering representing the facility being reviewed. Users should now see the countermeasures that are applicable for this crossing. The countermeasures will be listed with the updated rendering showing the updated improvements.

Users should see the updated rendering now showing the countermeasure selected. Above the updated rendering, users can now see the avatars' star scoring system has either increased or decreased, dependent on what countermeasure was selected. Once users have decided upon their preferred countermeasure selection, click the "Apply Countermeasures" button. Users should see a summary of the site and the selected countermeasures. Users can now decide to push either "Add Site to Report" or "Discard Site" button.

*Reminder: Click **either** of the buttons to decide what to do with a location and continue to review up to ten sites. If users select the "Discard" button, they will be brought back to their original grid site* review to select another site.

If users choose to add a site to their final report, they will see two new buttons labeled, "Review Next Site" or "View Report". If there are no more sites to review or add, click "View Report" to go to the draft pedestrian safety action plan download page.

*Pro Tip: If users desire to further review additional sites, they should go back to the populated grid with selections and click on the plus icon located next to one of the selections. Users will repeat the steps from "Exploring the Results Page" to "Further Review Results Selection for Final Report" until they are done reviewing sites and select the "View Report" in the Countermeasure selection of their last site.*

### Congratulations

The Congratulations page shows the initial pedestrian safety action plan which includes: the reviewed sites with before and after countermeasure renderings, the cost range of improvements, and their benefits. Users are also allowed to download the action plan as a PDF.

## Key Terms in My Street

**Avatars:** The My Street avatars serve as visual representatives of pedestrians with varying abilities. There are four avatars that start off with unique baseline scores, which are determined by their age, gender, national pedestrian fatality crash risk data, and other socio-economic characteristics impacting their mobility. Each avatar has a 1 to 5 star scoring underneath their thumbnail image with less stars indicating decreased pedestrian safety and more stars indicating increased pedestrian safety.

My Street allows the user to select countermeasure options for each priority site and test how each avatar may respond to the countermeasure. The stars will fill as the score of the avatar changes in response to the selected safety improvements.

**Avatar Scoring**: My Street uses socioeconomic data in two ways, first, to inform and prioritize the user's pedestrian crash locations for review and countermeasure recommendations and second, as a component of the avatar scoring formula. Each avatar inherits a score based on the socioeconomic conditions of the area surrounding the site being reviewed, and the national prevalence of pedestrian fatalities per each socioeconomic variable.

My Street developers assessed the correlation of 19 socio-economic and employment variables with fatal pedestrian crashes to inform a composite crash factor metric for site prioritization. This analysis used geolocated fatal pedestrian crashes obtained from the National Highway Traffic Safety Administration's (NHTSA's) Fatality Analysis Reporting System (FARS) for the years between 2017 and 2019. To learn more about this process please review the Technical Appendix section "Further Understanding the Equity Index Scoring for the My Street Avatars"

**Countermeasure:** My Street displays engineering treatments, or countermeasures - physical roadway design treatments – generally appropriate to reduce the risk for severe injury or fatal pedestrian crashes. All locations reviewed by My Street are at unsignalized intersections or midblock crossings, and countermeasures include a variety of physical improvements that increase pedestrian safety by improving visibility, reducing vehicle speeds, improving separation from traffic, increasing yielding, and/or reducing crashes at crossing locations.

**Crash Modification Factor (CMF):** A numerical factor used to calculate the expected number of crashes expected after implementing a countermeasure or combination of countermeasures at a crossing location. My Street calculates a CMF for each package of countermeasures considered, based on selected CMF identified in the CMF Clearinghouse and Federal Highway Administration's (FHWA) Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations. Where a CMF is not available for a countermeasure included in the package, the designers of My Street consulted State DOT CMFs and included a factor based on best practices and experience.

**Crash Reduction Factor (CRF):** A crash reduction factor (CRF) is the percentage crash reduction that might be expected after implementing a given countermeasure at a specific site. In some cases, the CRF is negative, i.e. the implementation of a countermeasure is expected to lead to a percentage increase in crashes.

**Facility Type:** A category of roadway defined by posted speed limit, number of lanes, presence of a median, and Annual Average Daily Traffic (AADT) volumes.

"**KABCO" Injury Scale:** The "KABCO" injury scale is used by law enforcement and traffic safety officials for classifying injuries and also for establishing crash costs. KABCO stands for the following terms as defined in the Model Minimum Uniform Crash Criteria (MMUCC) Guideline 5th Edition:

- **K – Fatal Injury -** A fatal injury is any injury that results in death within 30 days after the motor vehicle crash in which the injury occurred. If the person did not die at the scene but died within 30 days of the motor vehicle crash in which the injury occurred, the injury classification should be changed from the attribute previously assigned to the attribute "Fatal Injury."
- **A – Suspected Serious Injury -** A suspected serious injury is any injury other than fatal which results in one or more of the following:
  - Severe laceration resulting in exposure of underlying tissues/muscle/organs or resulting in significant loss of blood
  - Broken or distorted extremity (arm or leg)
  - Crush injuries ~ Suspected skull, chest or abdominal injury other than bruises or minor lacerations
  - Significant burns (second and third degree burns over 10% or more of the body) ~ Unconsciousness when taken from the crash scene
  - Paralysis
- **B – Suspected Minor injury** - A suspected minor injury is any injury that is evident at the scene of the crash, other than fatal or serious injuries. Examples include lump on the head, abrasions, bruises, minor lacerations (cuts on the skin surface with minimal bleeding and no exposure of deeper tissue/muscle).
- **C – Possible Injury -** A possible injury is any injury reported or claimed, which is not a fatal, suspected serious or suspected minor injury. Examples include momentary loss of consciousness, claim of injury, limping, or complaint of pain or nausea. Possible injuries are those which are reported by the person or are indicated by his/her behavior, but no wounds or injuries are readily evident.
- **O – Property Damage-Only –** Property damage only is a situation where there is no reason to believe that the person(s) received any bodily harm from the motor vehicle crash.

**Milepost:** This references the mile markers used in the Highway Performance Monitoring System (HPMS) data utilized by My Street to identify the point of origin and end point for any given section of road.

**Pedestrian Safety Action Plan (PSAP):** My Street produces a summary report – a PSAP – listing the sites reviewed and countermeasure packages selected by the user. The My Street PSAP is an initial assessment of sites reviewed based on available data. An agency should conduct additional site review and data analysis with traffic safety officials to identify policies and infrastructure improvements that respond to pedestrian safety problems.

**Systemic Analysis:** Systemic analysis uses historic crash data, roadway characteristics, existing conditions, and socio-economic data to identify, prioritize, and determine appropriate pedestrian countermeasures for locations with a high risk of pedestrian-related crashes, even when crash occurrence data are sparse. My Street's socio-economic data incorporate eight American Community Survey (ACS) and Longitudinal Employer-Household Dynamics (LEHD) five-year estimates published by the United States Census Bureau at the Census tract-level:

- Employment density.
- Proportion of the population living under the poverty line.
- Median household income.
- Proportion of non-motorized commuters (walk, bicycle, and public transit).
- Proportion of the population that is non-white or two or more races.
- Proportion of the civilian labor force that is unemployed.
- Proportion of households with zero motor vehicles.
- Proportion of households classified as limited English proficiency.

These inputs have shown documented correlation with increased pedestrian crashes in national safety studies. One case study example is the 2019 review of the City of Seattle's entire street network focusing on midblock crossings. Researchers developed safety performance functions for two types of collision between motor vehicles and pedestrians. These predictive models were used, with identified risk factors and countermeasures effectiveness data, to develop a systemic screening tool to identify mid-block sites that may benefit from treatment. The research also provided a framework to identify and prioritize locations within a jurisdiction that are risky for pedestrians and to identify and implement effective, appropriate treatments at many such locations.

# My Street Technical Appendix

## Data

This section describes how My Street processes user provided crash data and incorporates roadway and socio-economic data to generate web maps and conduct analyses.

### My Street Data Sources

The My Street application combines data from three national sources to produce pedestrian risk maps and generate statistics for local communities. The pedestrian risk map created in My Street is supported by Environmental Systems Research Institute, Inc. (ESRI), a geographic information system (GIS) online mapping software. The layers of the GIS map include data from the following sources: 1) FHWA's Highway Performance Monitoring System (HPMS), 2) U.S. Census Bureau's TIGER lines, and 3) the U.S. Census Bureau's ACS.

#### HPMS

The HPMS program allows FHWA to monitor performance on the nation's roads and supports strategic planning initiatives. States submit HPMS data (as of 2018), a mix of complete population and sample data, in geographic information systems (GIS) format on an annual basis. My Street incorporates centerline spatial geometry, as well as several attribute inputs from HPMS to support the application's screening functions:

- Route Number.
- Alternate Route Name.
- Facility Type.
- Access Control.
- Through Lanes.
- Functional System.
- Speed Limit.
- AADT.

However, it is important to note that My Street only includes HPMS data located within Urbanized Areas as defined by the US Census in 2021. Users will not be able to analyze pedestrian crashes and review related countermeasures for rural areas with My Street.

#### TIGER

The U.S. Census Bureau manages linear data for transportation features in the United States. This includes roadway centerlines. TIGER files are stored by county and include overlapping routes. In other words, roads with more than one concurrent route, such as U.S.-, State-, and locally signed names, all have overlapping lines. My Street uses TIGER lines (as of 2021) for two primary purposes: 1) provide additional alternate route names that are missing in HPMS (e.g., Main Street) and 2) provide additional centerline geometry and road locations also missing in HPMS. My Street's database appended names to existing HPMS centerlines where possible, and it incorporates centerline geometry from TIGER where applicable (i.e., centerline is missing in HPMS).

#### ACS/LEHD

The U.S. Census Bureau also manages a national survey of population and socioeconomic characteristics by place of residence (ACS), as well as employment by place of work and by place of residence (LEHD). My Street aggregates these characteristics at the Census tract-level. My Street currently uses the ACS's 5-Year Estimates (as of 2015-2019 estimates), as well as the LEHD Origin-Destination Employment Statistics (LODES) Workplace Area Characteristics. My Street assumes that the Census tract that covers the majority of the segment is the applicable data source, and the application does not blend data for roads that fall on tract boundaries.

## Data Structure

In addition to user-provided crash point data (see *Crash Data*), My Street references one linear and two polygon files in its database:

- Centerlines (linear) published by State.
- Centerline buffers (polygon) published by State.
- Census tracts (polygon) published as a single national dataset. The following sections document My Street's data model and schema.

## Crash Data

Crash data is supplied by the user and My Street applies the locations of crashes and severity of crashes to identify roadway types that had the highest rate of severe crashes.

### *Requirements and Limitations*

Crash data must:

- be a shapefile
- have a point geometry in web mercator (EPSG:3857, WGS 84) projection
- have a crash severity field
- only contain pedestrian related crashes, and
- NOT include any personal identifier information.

### *Attributes*

My Street users provide crash data in the form of a zipped point shapefile (SHP); in other words, this is a GIS-compatible file of individual mapped points and associated attributes (e.g., crash severity). My Street ingests this point SHP and reads tabular fields (i.e., attributes) associated with these points. For analysis purposes, My Street requires the user to identify the field containing crash severity designations and delineate the attribute values describing fatal and suspected serious injury crashes. This allows My Street's analytical capabilities to prioritize more severe pedestrian crashes by determining two key metrics:

1. **Crash Severity Weighting:** Weighted crash cost based on the distribution of fatal and suspected serious injury crashes in an agency's jurisdiction.
2. **Road Facility Prioritization:** High priority road facility types based on the value of weighted crashes associated with that facility type.

### *Crash Severity Weighting*

Equivalent Property Damage Only (EPDO) analysis is a network screening method documented in the First Edition of the Highway Safety Manual, published by the American Association of State Highway and Transportation Officials (AASHTO). This method derives a crash severity weight based on the ratio of the cost of a fatal or other injury crash relative to a property damage only (PDO) crash (Figure 1. Example of an EPDO Calculation).

$$Fatal\ Crash\ Weighting\ Factor = \frac{Fatality\ Crash\ Cost}{PDO\ Crash\ Cost}$$

$$Fatal\ Crash\ Weighting\ Factor = \frac{\$4{,}008{,}900}{\$7{,}400}$$

$$Fatal\ Crash\ Weighting\ Factor = 541.7$$

*Figure 1. Example of an EPDO Calculation.*

My Street adapts this methodology to account for two key variations across jurisdictions in the United States. The first variation is in the frequency of severe crash reporting, particularly with respect to suspected serious injuries. Although the Model Minimum Uniform Crash Criteria (MMUCC) guidelines intends to harmonize crash reporting, variations will occur between crash responder observations and State training policies. The second variation is in the specific crash costs by agency and crash type (e.g., bicycle, pedestrian, or motorist).

My Street calculates the distribution of fatal and suspected serious injury crashes in the uploaded SHP. The tool uses the sum of fatal and suspected serious injuries respectively to develop the weighted EPDO value. My Street then addresses the crash cost of the EPDO value, by applying crash costs based on FHWA's *Crash Costs for Highway Safety Analysis* guide. Below is a national estimate of crash costs by severity (Table 1).

| Severity Comprehensive Crash Unit Costs | Severity Comprehensive Crash Unit Costs (2016 $) |
|---|---|
| K | $11,295,400 |
| A | $655,000 |
| B | $198,500 |
| C | $125,600 |
| O | $11,900 |

*Table 1. Recommended national KABCO comprehensive crash unit costs for the FHWA BCA Guide and Tool.*

Although the specific dollar value will vary by locality and is affected by inflation over time, the methodology recommended by the guide creates a simplified assumption that assumes proportional change across the country. In other words, the EPDO ratio between a fatal or injury crash and a PDO crash will be consistent across jurisdictions. My Street calculates a single weighted EPDO crash value for fatal and suspected serious injury crashes according to the equation in Figure 2 (below); the tool assigns all other crash severity types a value of 1.

$$Average\ Pedestrian\ KA\ Crash\ Crash\ Cost = \frac{(Total\ K\ Crashes * \$11{,}295{,}400) + (Total\ A\ Crashes * \$655{,}000)}{Total\ K\ Crashes + Total\ A\ Crashes}$$

$$Weighted\ Pedestrian\ KA\ Crash\ EDPO\ Value = \frac{Average\ Pedestrian\ KA\ Crash\ Crash\ Cost}{\$11{,}900}$$

*Figure 2. Weighted Pedestrian KA Crash EDPO Value Calculation Used in My Street.*

*Roadway Data*

My Street incorporates linear centerlines in a GIS format for the purposes of crash analysis and site development. This methodology incorporates three components:

1. Facility type development.
2. Crash data integration.
3. Site development.

My Street ingests centerline data from HPMS and stratifies each segment to develop facility types. Facility types represent key thresholds for pedestrian safety countermeasures according to FHWA's *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations.* These thresholds incorporate three roadway characteristics for analysis: 1) posted speed limit in miles per hour (mph), 2) number of through lanes, and 3) AADT. My Street currently considers 18 facility types (Table 2).

| Facility Type Number | Posted Speed Limit | Number of Through Lanes | AADT |
|---|---|---|---|
| 1 | Under 40 mph | 2 | Less than 9,000 |
| 2 | Under 40 mph | 2 | Between 9,000 and 15,000 |
| 3 | Under 40 mph | 2 | 15,000 or more |
| 4 | Under 40 mph | 3 | Less than 9,000 |
| 5 | Under 40 mph | 3 | Between 9,000 and 15,000 |
| 6 | Under 40 mph | 3 | 15,000 or more |
| 7 | Under 40 mph | 4+ | Less than 9,000 |
| 8 | Under 40 mph | 4+ | Between 9,000 and 15,000 |
| 9 | Under 40 mph | 4+ | 15,000 or more |
| 10 | 40 mph and Over | 2 | Less than 9,000 |
| 11 | 40 mph and Over | 2 | Between 9,000 and 15,000 |
| 12 | 40 mph and Over | 2 | 15,000 or more |
| 13 | 40 mph and Over | 3 | Less than 9,000 |
| 14 | 40 mph and Over | 3 | Between 9,000 and 15,000 |
| 15 | 40 mph and Over | 3 | 15,000 or more |
| 16 | 40 mph and Over | 4+ | Less than 9,000 |
| 17 | 40 mph and Over | 4+ | Between 9,000 and 15,000 |
| 18 | 40 mph and Over | 4+ | 15,000 or more |

*Table 2. Facility Types in My Street.*

## Equity Data / Pedestrian Fatality Data

My Street uses socioeconomic ("equity") data in two ways, first, to inform and prioritize the user's pedestrian crash locations for review and countermeasure recommendations. Second, as a component of the avatar scoring formula. Each avatar inherits a score based on the socioeconomic conditions of the area surrounding the site being reviewed, and the national prevalence of pedestrian fatalities per each socioeconomic variable.

My Street developers assessed the correlation of 19 socio-economic and employment variables with fatal pedestrian crashes to inform a composite crash factor metric for site prioritization. This analysis used geolocated fatal pedestrian crashes obtained from the National Highway Traffic Safety Administration's (NHTSA's) Fatality Analysis Reporting System (FARS) for the years between 2017 and 2019.

### Data Integration

My Street integrates crash points with linear facility types based on 75-foot polygon buffers of road centerlines. All centerlines that represent a single facility type form a single comprehensive buffer; this produces 18 such buffers representing the entire jurisdiction's network. Where roads (and therefore, buffers) intersect and overlap, My Street grants priority to buffers representing wider, faster, and higher traffic facilities. These are based on the increasing robustness and cost of countermeasures recommended in Table 1 of FHWA's *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations.*

Table 3 (below) organizes facility types according to crash data integration priority. For example, if a crash occurs within the buffer area covered by a road representing facility type of 1 and another representing a facility type of 5, My Street assigns the crash to the facility type 5 road.

| Priority | Facility Types |
|---|---|
| 1 (Lowest) | 1, 4, 10, 13 |
| 2 | 7, 16 |
| 3 | 2, 5 |
| 4 | 11, 14 |
| 5 | 3, 6, 8, 9 |
| 6 (Highest) | 12, 15, 17, 18 |

*Table 3. Facility Type Priority for Crash Data Integration Purposes.*

## In-Depth Avatar Scoring & Additional Information

### Further Understanding the Equity Index Scoring for the My Street Avatars

My Street developers assessed the correlation of 19 socio-economic and employment variables with fatal pedestrian crashes to inform a composite crash factor metric for site prioritization. This analysis used geolocated fatal pedestrian crashes obtained from the National Highway Traffic Safety Administration's (NHTSA's) Fatality Analysis Reporting System (FARS) for the years between 2017 and 2019. Developers aggregated fatal crashes at the Census tract-level and compared the distribution of fatal crashes with the residential population across tracts. Table 4 (below) illustrates how median household income is negatively correlated with fatal crashes in the United States (i.e., lower income tracts experience more pedestrian fatal crashes relative to the proportion of residential population).

| Census Tracts - Median Household Income | % of Total Population | % of Fatal Pedestrian Crashes (2017-2019) | Difference in Percentages |
|---|---|---|---|
| **Lowest 10%** | 6.6% | 13.6% | 7.0% |
| **10-20%** | 8.8% | 14.0% | 5.2% |
| **20-30%** | 9.3% | 12.3% | 3.0% |
| **30-40%** | 9.7% | 11.0% | 1.3% |
| **40-50%** | 9.9% | 10.0% | 0.1% |
| **50-60%** | 10.4% | 9.6% | -0.8% |
| **60-70%** | 10.7% | 8.7% | -1.9% |
| **70-80%** | 11.3% | 8.1% | -3.2% |
| **80-90%** | 11.8% | 6.9% | -4.9% |
| **Highest 10%** | 11.3% | 5.4% | -6.0% |

*Table 4. Sample Comparison of Fatal Pedestrian Crashes and Median Household Income in the United States.*

After selecting priority facility types, My Street sorts applicable sites based on socioeconomic factors for sites within each facility type category. This "risk score" is based on tract-specific values combining eight socio-economic characteristics prioritized as a result of the FARS/ACS/LEHD data comparison:

- Employment density.
- Proportion of the population living under the poverty line.
- Median household income.
- Proportion of non-motorized commuters (walk, bicycle, and public transit).
- Proportion of the population that is non-white or two or more races.
- Proportion of the civilian labor force that is unemployed.
- Proportion of households with zero motor vehicles.
- Proportion of households classified as limited English proficiency.

My Street normalizes these socio-economic values according to State-specific Z-scores. Z-scores measure the number of standard deviations an individual observation (i.e., a Census tract's value) is from the sample mean (i.e., the mean statewide value for all tracts). Figure 3 (below) illustrates a sample Z-score calculation for employment density.

$$Z = \frac{x - \mu}{\sigma}$$

*Figure 3. Z-Score Calculation.*

Where,
Z = the Z-score for employment density in Census tract
x = the employment density in Census tract A.
μ = the mean Census tract-level employment density in State B.
σ = the standard deviation of Census tract-level employment density in State B.

Values greater than one indicate a Census tract is above the average value for the State, and values less than one indicate a Census tract value below the average value for the State. My Street averages the Z-scores for all eight factors to derive a raw crash factor where higher values indicate greater pedestrian crash risk (Referenced in Figure 4 below).

$$Crash\ Factor = \frac{(x_1 * x_2 * (-1 * x_3) * x_4 * x_5 * x_6 * x_7 * x_8)}{8}$$

*Figure 4. Crash Factor Calculation.*

Where,
$X_1$ = Z-score of employment density.
$X_2$ = Z-score of proportion of the population living under the poverty line.
$X_3$ = Z-score of median household income.
$X_4$ = Z-score of proportion of non-motorized commuters (walk, bicycle, and public transit).
$X_5$ = Z-score of proportion of the population that is non-white or two or more races.
$X_6$ = Z-score of proportion of the civilian labor force that is unemployed.
$X_7$ = Z-score of proportion of households with zero motor vehicles.
$X_8$ = Z-score of proportion of households classified as limited English proficiency.

Like the crash factor, the second component of the avatar baseline score is a composite average of Z-scores by socio-economic characteristic (Referenced in Figure 5 below).

$$Avatar\ Community\ Score = \frac{((x_1 * 2) * x_2 * x_3 * x_4 * x_5)}{6}$$

*Figure 5. Avatar Community Score Calculation.*

Where,
$X_1$= Z-score of proportion of the population with a physical disability.
$X_2$ = Z-score of proportion of the population living under the poverty line.
$X_3$ = Z-score of proportion of the population aged 18 and younger.
$X_4$ = Z-score of proportion of the population aged 65 and older.
$X_5$ = Z-score of proportion of the population that is non-white or two or more races.

This score identifies Census tracts with a greater share of minority or vulnerable populations that may be disadvantaged compared to other tracts; higher scores indicate greater share of vulnerable populations. My Street allocates all Census tracts in a State into four categories. These Census Tract categories each have an associated community multiplier or "score" that is included in the overall avatar scoring formula. An avatar's "Community Score" is multiplied by the avatar's FARS score to create the "baseline" score for each avatar. This portion of the score indicates the avatar's pedestrian safety levels before they engage with roadway mid-block crossing. The avatar scoring system is detailed in Table 5 below.

| Census Tract Category | Avatar Community Score |
|---|---|
| Highest 25% of Census Tract Avatar Score values in a State (75-100%) | 0.75 |
| 50-75% | 1.00 |
| 25-50% | 1.25 |
| Lowest 25% of Census Tract Avatar Score values in a State (0-25%) | 1.50 |

*Table 5. Multiplier Associated with Avatar Community Scores.*

### How is the "Avatar Coefficient" (which includes an average weighted score and the unique vulnerability score) applied to avatar scores?

The avatars have a baseline score based on national FARS data which is then multiplied by an Equity Index data score. The next component added is a weighted score produced by answering five existing conditions questions after selecting a site. Each avatar will have its own set of averaged weighted scores which are created by averaging unique vulnerability scores.

Weighted scores are based on a literature scan and expert interviews focusing on pedestrian safety, gender, age, and speed. Vulnerability scores reflect the individual impacts to safety, comfort, and access for each avatar with higher scores indicating positive impacts and lower scores indicating negative impacts. All scores are considered subjective.

### How do the countermeasures impact the avatar scores?

The final component added to the avatar score occurs once a user has selected the countermeasure for the selected site. Each avatar will see an increase in score, though the increase may vary. The combined medium or high Crash Reduction Factor (CRF) scores, depending on what countermeasure package is selected, will be added to each avatar's existing score to show how the avatars benefit from these pedestrian safety improvements. To ensure consistency in the avatars' 5-star scoring system, the combined medium and high CRF scores received an addition of 1 to their score to produce a scoring range between 1.3 and 1.9.

## Countermeasure Selection, Package Creation, and Scoring

### Resources Used for Determining Countermeasures for Each Package

In the process of creating each countermeasure package, *My Street* consulted the U.S Department of Transportation Federal Highway Administration (FHWA) STEP Studio tools, specifically Tables 1 -3 on best pedestrian safety countermeasure selection based on Roadway Features, Safety Features, and Implementation and Operations Considerations.

Each roadway configuration is evaluated based on: 1) number of lanes (2,3,4+ lanes with or without a median), 2) potential posted speed limits (equal to or less than 30 MPH, 35 MPH, and greater than or equal to 40 MPH), and 3) Annual Average Daily Traffic (less than 9,000, 9,000 – 15,000, and greater than 15,000). Each configuration then had a baseline, medium, and high countermeasure package created from FHWA STEP Studio recommendations. It is important to note, that these packages are recommendations and not the only possible countermeasure solutions.

### Countermeasure Package Creation

Every roadway segment being reviewed for countermeasures will receive the same "baseline" countermeasure package of high visibility crosswalks, curb ramps, W-11 warning signs, and improved pedestrian lighting. These countermeasures were selected as essential and cost- effective elements and would allow for the addition of medium and high countermeasure packages.

Each countermeasure package can include one or several countermeasures to further improve safety for pedestrians based on the current roadway and safety conditions given. When creating the scoring for each countermeasure package, which will be the final addition to each avatars' score, *My Street* selected the countermeasure with the lowest Crash Modification Factor (CMF), which would yield the highest Crash Reduction Factor (CRF) score.

For the purposes of creating a consistent medium and high countermeasure package score, the combined effect of multiple countermeasures is estimated based on research completed under NCHRP Project 17-63, *Guidance for the Development and Application of Crash Modification Factors*, and presented in FHWA's training video, Applying a Method to Analyze Multiple CMFs. First, the CMFs for the two most effective countermeasures are combined. Since the CMFs for the individual countermeasures are less than 1.0, the dominant effect and dominant common residual methods are both applied. The combined effect is based on the method that produces the greatest crash reduction. Next, there is a need to confirm the combined effect does not exceed 100 percent. If so, the maximum combined effect is set to 100 percent. The same process is used to estimate the combined effect of the third countermeasure, starting with the combined effect of the first two countermeasures.

### Where and How Does the Final Combined CRF Scores Get Used?

The combined medium or high CRF scores (depending on what countermeasure package is selected) will be added to each avatar's score to illustrate how the avatars benefit from these pedestrian safety improvements. To ensure consistency in the avatars' 5-star scoring system, the combined medium and high CRF scores received an addition of 1 to their score to produce a scoring range between 1.3 and 1.9.

## Further Description of the Avatar Scoring System

VHB's *My Street* pedestrian safety tool has four avatars which help to represent the variety of vulnerable users crossing dangerous or inaccessible roads. The avatars have a five-star scoring system created by VHB to show an initial baseline score of pedestrian vulnerability. This is based on multiplying National FARS and site-specific Census data, this is followed by adding a subjective weighted score created from the user selecting existing conditions at each site, and then this combined score is finally added to a Crash Reduction Factor (CRF) score created by selecting a countermeasure package to create a final score, shown through the 5-star scoring system, for each avatar.

The following preliminary research was done specifically to support the individual weighted scores created for the existing conditions questions to be added to each avatar's baseline score. Further research will be needed to support the assumptions made for creating the weighted averages. The existing conditions score is created by how the user answer five questions regarding each site which have drop down options on the *My Street* portal. Each response has a hard coded score for that response and is then multiplied by the avatar's unique weighted score to show how some pedestrians (and avatars) have more vulnerable conditions when crossing a street than others. These weighted scores are considered subjective and have a conservative multiplier of 1 to 3 to create the weighted score. This produces a scoring range between 0 to 4 depending on the avatar. This specific component of the avatar scoring formula will be called the "avatar coefficient" moving forward in this document.

## Questions & Weighted Averages Creating the "Avatar Coefficient" Score

The five questions users must answer to create the avatar coefficient score focus on their selected site's existing conditions. Each of the four avatars provided can have various levels of safety, comfort, and access impacted when crossing a road. To show the variation per roadway user (or avatar) in the scoring, the following pedestrian vulnerabilities were researched to support the weighted scoring created. These vulnerabilities include level of mobility, disability status, age, and gender.

The weighted scoring also helps point to different mobility needs for each avatar – where some pedestrians may require more time to cross the road and a safe place to stop mid-way, others may need improved sight lines or clearer or additional signage or signal lighting.

*Existing Conditions Questions for My Street Users:*

1. Are there medians within the corridor?
   Drop down - Yes or No
2. What is the posted speed of the corridor?
   Drop down - Equal to or less than 30mph, 35 mph, 40 or greater mph
3. Is there on street parking along the corridor?
   Drop down - Yes – Parking on both sides, No
4. Is there existing transit route along the corridor?
   Drop down – Route – No stops, Route – Stops, Route – High Frequency - Stops
5. Is the corridor within a 5–10-minute walk of a K-12 school or public/private university or college?
   Drop down - Yes or No

## Avatar Vulnerability Score

Each *My Street* avatar has a unique scoring range for their answers to the existing condition questions; this scoring is called the "Vulnerability Score". These scores reflect the individual impacts to safety, comfort, and access for each avatar with higher scores indicating positive impacts and lower scores indicating negative impacts. The five selected vulnerability scores are then averaged out and converted into weighted averages (explained in the *"Assumptions Made from Research to Weighted Scores"* section).

Steve, the 45–54-year-old male, has a vulnerability scoring range of 4, 3, and 0.5. This was the highest vulnerability score range given since Steve had the greatest mobility level and access while crossing a street. Alice, the 65+ year old active female, has a vulnerability scoring range of 3.5, 2, and 0.5. This was the second highest vulnerability score range given since Alice, despite having an increased need for more time and places to pause while crossing, is an active older adult. Mia, the under 14-year-old girl, will also have a vulnerability scoring range of 3.5, 2, and 0.5 since she needs help understanding crossing conditions and requires more time and space to safely cross. Michael, the 35–44-year-old male using an assisted mobility device, has a vulnerability scoring range of 3, 1.5, and 0. This was the lowest vulnerability score range given since Michael needs at least the baseline pedestrian improvements recommended – sidewalk, curb ramps, and improved lighting to be able to cross the street. Also, for the "Are median present" question Michael's scores were 0 for "no" and 3 for "yes" to highlight his lack of access to the street in comparison to the other avatars. Table 6 below provides an example of the vulnerability scoring for Mia.

| **Speed Responses** | **Medians Responses** | **Parking Responses** | **Transit Responses** | **Schools Responses** |
|---|---|---|---|---|
| <= 30 mph | Yes | Yes | No | Yes |
| 35 mph | No | No | Yes - Route | No |
| >= 40 mph | - | - | Yes - Major Route w/Stops | - |
| **Vulnerability Score Ranking** | | | | |
| 3.5 | 3.5 | 0.5 | 3.5 | 0.5 |
| 2 | 0.5 | 3.5 | 2 | 3.5 |
| 0.5 | - | - | 0.5 | - |

*Table 6. Example of Vulnerability Scoring for Mia, the "Under 14-Year-Old Girl" Avatar*

## Assumptions Made from Research for Weighted Scores

### Speed

Speed was identified as a safety and crash risk for all avatars – regardless of age, gender, or ability. Numerous studies examined the impact of speed on pedestrian fatalities, and all found similar relationships. As motor vehicle impact speeds increase, the risk of pedestrian death increases. One study estimated that the risk of a pedestrian dying from a collision with a motor vehicle increases from 8% at about 31 mph to 50% at about 47 mph (Brookshire, K et al., 2016 & Rosén, E., & Sander, U. 2009). Based on the research, each avatar's response to the question regarding posted speed limit for the user's selected site will be multiplied by 3, which is the highest weight used to indicate increased pedestrian vulnerability.

### Proximity to Transit & Schools

Land uses generating pedestrian traffic (such as schools, commercial facilities, multifamily housing) are frequently found to be linked to high collision rates. For example, an analysis of crashes in Honolulu showed that the number of schools (and bars) in a block group predicted the number of pedestrian crashes, along with the population and employment variables (Levine, Kim, and Nitz 1995b). Similarly, studies have found associations to exist between pedestrian collision rates and concentrations of retail establishments along arterials and transit corridors (Miles-Doan and Thompson, 1999; Hess, Moudon, and |Matlick 2004).

Based on this research, considering the increased pedestrian traffic and high collision rates, the avatar responses to the questions regarding proximity to transit route and educational institutions will be multiplied by 2 or 3 to indicate increased pedestrian vulnerability. Mia, the under 14-year-old girl, and Michael, the 35–44-year-old male using an assisted mobility device, will be multiplied by 3 due to their increased pedestrian vulnerability, while Alice, the 65+ year old active female, and Steve, the 45–54-year-old male, will be multiplied by 2.

### Medians

Avatar coefficient scoring regarding medians being present or not will be addressed within the following other attributes contributing to increased pedestrian vulnerability.

## Avatar Attributes to Consider for Scoring

### Gender

Studies generally show that women were more likely than men to have no mode of personal transportation available and walk more out of necessity. Women were shown to be more dependent on public transportation than men (Granié, 2020). Another study indicates the location of bus stops, or how well-lit streets are, can also greatly affect women's' movement (Brown D, et al., 2014).

Additionally, in a case study by Gendered Innovation in Transportation which surveyed 15 countries (EU countries, Spain, etc.), research noted women performed an average of 32 minutes of childcare per day, and men performed an average of 12 minutes (United States Bureau of Labor Statistics, 2011). The conclusion indicated women spend significantly more time than men performing caring work and rely more on public transportation for this purpose. (Sánchez de Madariaga, 2013; Sánchez de Madariaga, 2009)

Last, more women than men make multiple-stop trips (trip chaining) when traveling between their homes and workplaces. Women make more short stops on the way to or from work than do men to perform household-sustaining activities, such as shopping and family errands, and working women in two-worker families were twice as likely as men in two-worker families to pick up and drop off school-age children at school during their commute. Other demographic variables interact with gender in predicting trip chaining. For example, having a child under age 5 increases trip chaining by 54% for working women and 19% for working men (McGukin et al., 2005a; cited in Sánchez de Madariaga, 2013; Sánchez de Madariaga, 2009).

Based on this research, due to increased vulnerability caused by longer exposure to traffic, trip chaining, need for pausing safely will crossing a street, and frequent use of transit, responses for Mia and Alice's questions regarding presence of medians and parking would each be multiplied by 3. Again, this is the highest weight used to indicate increased pedestrian vulnerability when crossing a street.

## Age: Older Adults

Looking at the National Highway Traffic Safety Administration's (NHTSA) Traffic Safety Facts for 2019, fatalities of 65-and-older pedestrians increased by 55% overall (NHTSA & NCSA, "Older Adults", 2021). In a Federal Highway Administration (FHWA) review of 2015 pedestrian fatalities for the United States, 5,376 pedestrians died with 19% of those killed being adults 65 years and older, including 302 pedestrians 80 years and above (Richard, C. M., 2018).

Furthermore, at signalized and unsignalized intersections, senior pedestrians (80 years and older) are associated with higher probability of severe injuries compared to other age groups, mainly due to their physical conditions. This result is consistent with the findings in other studies, e.g., Tarko and Azam (2011) and Sarkar et al. (2011). However, senior pedestrians experience a greater severity risk at signalized intersections compared to unsignalized intersections. The crossing time provided by the pedestrian signal may not have been sufficient for the slow walking speed of older pedestrians, especially at wider intersections, making them more vulnerable to severe injuries (Haleem K, 2015).

Finally, according to a FHWA Bicycle and Pedestrian Transportation course (2006), older pedestrians are more likely than younger pedestrians to be involved in crashes due to problems in information processing, judgment, and physical constraints. The following is a list of vulnerable characteristics of older pedestrians:

- Vision is affected in older people by decreased acuity and visual field, loss of contrast sensitivity, and slower horizontal eye movement.They often have difficulty with balance and postural stability, resulting in slower walking speeds and increased chances for tripping.
- Selective attention mechanisms and multitasking skills become less effective with age, so older people may have difficulty locating task-relevant information in a complex environment.
- They have difficulty in selecting safe crossing situations in continuously changing complex traffic situations, likely due to deficits in perception and cognitive abilities, as well as ineffectual visual scanning, limitations in time-sharing, and an inability to ignore irrelevant stimuli
- They have difficulty in assessing the speed of approaching vehicles, thus misjudging when it is safe to cross the road.
- They have slower reaction times and decision-making skills.
- Those with arthritis may have restricted head and neck mobility as well as difficulty walking.
- There is reduced agility for those who use canes or crutches for assistance.

Based on this research, due to decreased mobility, need for more time and places to pause safely while crossing the street, Alice, the older female avatar, receives a weighted average of 3 to multiply scores for responses to questions on: posted speed, medians, and parking.

## Age: Children (14 years old and under)

In a FHWA review of 2015 pedestrian fatalities for the United States, 5,376 pedestrians died and among children, pedestrians aged 10-14 had the highest number of fatalities and injuries, while children under 5 and 5-9 had the highest percentage of pedestrian fatalities. Children 14 years and younger accounted for 4% of the pedestrian fatalities and an estimated 11% of all pedestrians injured in traffic crashes(Richard, C. M., 2018).

Looking at NHTSA's Traffic Safety Facts for 2019 of the 6,205 pedestrian traffic fatalities, 181 (3%) were children. 67% (121) of the child pedestrian fatalities occurred at non-intersection locations as compared to 20% (36) at intersections and 13% (23) at other locations (NCSA, "Children", 2021). A 2012 study reviewing children's pedestrian injuries specifically at the ages of 4 through 12, indicated most pedestrian injuries occur in mid-block areas, where children enter the middle of the street and are struck by moving vehicles, or at intersections (Schwebel DC, 2012 - Cited - Agran PF et al. 1994, DiMaggio C, et al., 2002, and Lightstone AS, et al., 2001).

Based on this research, due to reduced judgement in identifying safe crossing situations and understanding traffic calming or intersection geometry and signage, the Mia avatar, a female child, received a weighted average score of 3 to multiply the following responses by: proximity to schools if parking and transit was present.

## Mobility Impaired Pedestrians

As defined by the FHWA, mobility-impaired pedestrians include those with wheelchairs, crutches, canes, walkers, guide dogs, prosthetic limbs, orthotics, or other assistive devices. Some may not require these devices but still have a disability that limits their range or speed of motion. As expected, the walking speeds for pedestrians with disabilities are lower than the average walking speed assumed for the design of pedestrian facilities (FHWA, 2006 and Dewar, R., 2002). Table 7 below reviews mean walking speeds for disabled pedestrians and users of various assistive devices.

| Disability or Assistive Device | Mean Walking Speed, m/s (ft/s) |
|---|---|
| Cane or crutch | 0.8 (2.62) |
| Walker | 0.6 (2.07) |
| Wheelchair | 1.1 (3.55) |
| Immobilized knee | 1.1 (3.50) |
| Below-knee amputee | 0.7 (2.46) |
| Above-knee amputee | 0.6 (1.97) |
| Hip arthritis | 0.7 to 1.1 (2.24 to 3.66) |
| Rheumatoid arthritis (knee) | 0.7 (2.46) |

*Table 7. Mean walking speeds for disabled pedestrians and users of various assistive devices*
*Source: Human Factors in Traffic Safety(3)*

A 2015 Georgetown University study also suggests that pedestrian wheelchair users are a third more likely to be killed in a road crash than those that do not use a wheelchair. The study also found that in more than 75 % of crashes that involve a wheelchair user, no "crash avoidance maneuver" by the driver—like breaking or steering—was recorded (Poon, 2015).

Based on this research, if a My Street User selected Michael's avatar, which utilizes an assisted mobility device, each of their responses to the questions about medians being present, parking being available, and being in proximity to transit and schools would be multiplied by three to indicate increased pedestrian vulnerability.

## Full Avatar Scoring Example

Below is an example of the weighted and unique vulnerability scores for Mia, the Under 14-Year-Old Girl Avatar Mia's weighted scores are in Table 8 below, in the second row, and are all registering as a "3"; Mia's vulnerability scores are under each score header and range from 0.5 to 3.

| **Mia's Weighted Scores*** | | | | | | |
|---|---|---|---|---|---|---|
| 3* | 3* | 3* | 3* | 3* | | |
| ***Speed Vulnerability Score*** | ***Medians Vulnerability Score*** | ***Parking Vulnerability Score*** | ***Transit Vulnerability Score*** | ***Schools Vulnerability Score*** | **Average Of Vulnerability Scores** | ***Mia's Weighted Average of Vulnerability Scores*** |
| 3.5 | 3.5 | 0.5 | 3.5 | 0.5 | 2.3 | 2.300 |
| 2 | 3.5 | 0.5 | 3.5 | 0.5 | 2 | 2.000 |
| 0.5 | 3.5 | 0.5 | 3.5 | 0.5 | 1.7 | 1.700 |
| 3.5 | 0.5 | 0.5 | 3.5 | 0.5 | 1.7 | 1.700 |
| 2 | 0.5 | 0.5 | 3.5 | 0.5 | 1.4 | 1.400 |

*Table 8. Example of the Avatar Mia's Weighted Scores.*

## Citation for Avatar Coefficient Scoring Section

Brookshire, K., Sandt, L., Sundstrom, C., Thomas, L., & Blomberg, R. (2016, April). Advancing pedestrian and bicyclist safety: A primer for highway safety professionals (Report No. DOT HS 812 258). Washington, DC: National Highway Traffic Safety Administration.

Brown, D., McGranahan, G., & Dodman, D. (2014). *Urban informality and building a more inclusive, resilient and green economy*. International Institute for Environment and Development. http://www.jstor.org/stable/resrep01305

Carmel S. (2019). Health and Well-Being in Late Life: Gender Differences Worldwide. *Frontiers in medicine*. https://doi.org/10.3389/fmed.2019.00218

Haleem, K., Alluri, P., & Gan, A. (2015). Analyzing pedestrian crash injury severity at signalized and non-signalized locations. Accident; analysis and prevention. https://doi.org/10.1016/j.aap.2015.04.025.

Loukaitou-Sideris, A., Liggett, R., & Sung, H.-G. (2007). Death on the Crosswalk: A Study of Pedestrian-Automobile Collisions in Los Angeles. Journal of Planning Education and Research. https://doi.org/10.1177/0739456X06297008.

Marie-Axelle Granié. Gender & Mobility: differences & risk factors. Global Alliance of NGO for Road Safety. Gender & Mobilities. Alliance Live Session, Jun 2020, SUISSE, Switzerland. ffhal-03094366f.

McGuckin, N., & Nakamoto, Y. (2005a). Differences in Trip Chaining by Men and Women. In United States National Research Council, Research on Women's Issues in Transportation Report of a Conference, Vol. II: Technical Papers. Washington, D.C.: Government Publishing Office (GPO).

National Center for Statistics and Analysis. (2021, May). *Older population: 2019 data. Traffic Safety Facts.* Report No. DOT HS 813 121). National Highway Traffic Safety Administration.

National Center for Statistics and Analysis. (2021, May). *Children: 2019 data. Traffic Safety Facts.* Report No. DOT HS 813 122). National Highway Traffic Safety Administration.

Poon, L. (2015, November 19). *Study: Pedestrians in wheelchairs are a third more likely to be killed in road accidents*. Bloomberg.com. Retrieved November 2, 2022, from https://www.bloomberg.com/news/articles/2015-11-19/study-pedestrians-in-wheelchairs-are-a-third-more-likely-to-be-killed-in-road-accidents

Richard, C. M., Magee, K., Bacon-Abdelmoteleb, P., & Brown, J. L. (2018, April). Countermeasures that work: A highway safety countermeasure guide for State Highway Safety Offices, Ninth edition (Report No. DOT HS 812 478). Washington, DC: National Highway Traffic Safety Administration.

Rosén, E., & Sander, U. (2009). Pedestrian fatality risk as a function of car impact speed. *Accident; analysis and prevention*, *41*(3). https://doi.org/10.1016/j.aap.2009.02.002

Rothman L, Buliung R, Macarthur C, et al. Walking and child pedestrian injury: a systematic review of built environment correlates of safe walking. Injury Prevention 2014.

Sánchez de Madariaga, I. (2013). The Mobility of Care: A new Concept in Urban Transportation. In Sánchez de Madariaga, I., & Roberts, M. (Eds.), Fair Share Cities: The Impact of Gender Planning in Europe. London: Ashgate.

Sánchez de Madariaga, I. (2009). Vivienda, Movilidad, y Urbanismo para la Igualdad en la Diversidad: Ciudades, Género, y Dependencia. Ciudad y Territorio Estudios Territoriales, XLI.

Schwebel DC, Davis AL, O'Neal EE. Child Pedestrian Injury: A Review of Behavioral Risks and Preventive Strategies. *Am J Lifestyle Med*. 2012;6(4). doi:10.1177/0885066611404876

United States Bureau of Labor Statistics. (2011). American Time Use Survey—2010 Results. Washington, D.C.: United States Department of Labor.

United States Department of Transportation. Federal Highway Administration "University Course on Bicycle and Pedestrian Transportation". FHWA-HRT-05-099. July 2006.