ECOBEHAVIORAL DIMENSIONS OF JAYWALKING: JAYWALKER-CAR COLLISIONS AS A FUNCTION OF THE SOCIO-SPATIAL CONTEXT

by

MAURICIO LEANDRO

A dissertation submitted to the Graduate Faculty in Environmental Psychology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, Graduate School and University Center of The City University of New York

2011

This manuscript has been read and accepted for the Graduate Faculty in Psychology in satisfaction of the Dissertation requirements for the degree of Doctor of Philosophy

Dr. Gary Winkel

_____ _____

Date **Chair of Examining Committee**

Dr. Maureen O'Connor

_____ _____

Date **Executive Officer**

Dr. John Seley _____

Dr. Susan Saegert _____

Dr. Stephanie Woolhandler _____

Dr. David Himmelstein _____

Supervisory Committee

ABSTRACT

Ecobehavioral Dimensions of Jaywalking:

Jaywalker-car collisions as a function of the socio-spatial context

by

Mauricio Leandro

A three-level hierarchical model assessed the combined effects of a multilevel approach to the explanation of injury severity in a sample of jaywalker-car collisions that occurred in New Jersey between 2006 and 2009.

First-level units were individual jaywalkers who were involved in the collisions. Second-level units were the road segments (spots) of approximately 0.5 miles radius around the point at which at least one collision occurred. The third-level units were municipalities having had at least one collision.

Results indicate that younger jaywalkers, those who wear light clothes, those who cross the road without running or darting, those who are not under the influence of drugs or medication, and those who collide with drivers not driving in a straight strip of road tend to receive less severe injuries. Along with the individual-level factors, significant interaction of some of the second and third-level predictors was found. When roads were dry, wearing light clothing minimizes the severity of injuries. When jaywalkers were under the influence of drugs or medication, greater sidewalk coverage helped to reduce the injury severity. When fewer cars were parked on the roadside to protect against speeding drivers, wearing clear clothing helped to reduce injury level. No moderation effect was found of macro-level factors on micro-level variables predicting injury level. Nonetheless, environmental features like sidewalk coverage, recreation areas nearby, distance to public transportation, population density, and poverty contributed significantly to explain severity of injuries.

Dedication

To Bridget Driscoll (1852-1896).

A jaywalker…

Acknowledgements

Like every human accomplishment this work is the multiplicative effect of countless individual efforts. It is the sum of the generous, patient and generally positive feedback of countless colleagues, collaborators, critics, reviewers, commentators, and faithful friends. They maintained my hopes high throughout this hasty journey of discovery, while earning for themselves no more than my modest but everlasting gratitude and admiration.

Some had to walk the extra mile side by side with me to accomplish an otherwise unthinkable project. Special recognition has to be given to Gary, John, Susan, Steffie, and David for their meticulous advice and thoughtful support at different points of my doctoral studies. Credit also goes to the New Jersey Department of Transportation and Rutgers' Voorhes Transportation Center for assuming the never-ending task of building a state of the art collision database. Also a very special "gracias" to the Escuela de Psicología and Oficina de Asuntos Internacionales at Universidad de Costa Rica for their faithful support and vision.

To Monica and Carolina who had to grow themselves wiser and happier having a discontinuous father. Overall, my eternal love and admiration to Bea my friend, research associate, nurse, lover, critic, and statistically significant source of happiness…Thank you pezdemar!

Again, any piece of useful thought in this dissertation is a collective effort. The responsibility for any shortcomings, however, is entirely mine.

Table of Contents

Introduction *1*

Chapter 1: Jaywalking in Time *5*
The Afternoon Of August 22nd, 1896 5
From "Street Users" To "Jaywalkers" 10
Walking In Today's America 14

Chapter 2: An Ecobehavioral Approach to Jaywalking *17*
Perception And Walking 17
Affordances: The Building Blocks of Environmental Perception 19
The Street As A Behavior Setting 21
An Ecobehavioral Framework For Jaywalker-Car Collisions 27

Chapter 3: Ecobehavioral Dimensions Of Jaywalker-Car Collisions In New Jersey *31*
Introduction 31
Literature Review 32
Purpose Of The Study 39
Problem Statement 41
Research Question 41
Research Design And Methods 42
- Databases 42
- Database Preparation and Selection of the Outcome Variable 43
- Explanatory Variables 44
- Micro Level (Individual Attributes and Actions) Variables 45
- Meso Level (Proximal Dimension) Variables 47
- Macro Level (Distal Dimension) Variables 54
- Strategy for Data Analysis 57
- Data Exploration 59

Results 67
- Model Building: The Intercepts-Only Model 70
- Model Validation 87
- A More Situated Analysis 89

Discussion 101
Limitations Of The Study 108

General Discussion *112*

Appendixes *119*

References *139*

List of Tables

Table 1. Description of explanatory variables for the micro-level 47
Table 2. Description of explanatory variables for the meso-level 53
Table 3. Description of explanatory variables for the macro-level 57
Table 4. Missing value characteristics for Micro-Level variables 58
Table 5. Plausible interactions between micro level and other levels 66
Table 6a. Descriptive Statistics for severity of injury 68
Table 6b. Levels of severity of injury 68
Table 7a. Statistics for the explanatory variables of the micro-level. Original scores. 69
Table 7b. Statistics for the explanatory variables of the meso-level. Original scores. 69
Table 7c. Statistics for the explanatory variables of the macro-level. Original scores. 70
Table 8. Unconditional means (intercepts-only) model 71
Table 9. Initial MLM for Micro-Level, fixed effects only (n=900) 74
Table 10. Final MLM for Micro-Level including interactions (n=900) 74
Table 11. Information criteria for Micro-Level Model (n=900) 76
Table 12. Initial MLM for Meso-Level predictors (n=900) 78
Table 13. Final MLM for Meso-Level predictors (n=900) 79
Table 14. Initial MLM for Macro-Level predictors (n=900) 80
Table 15. Final MLM for Macro-Level (n=900) 81
Table 16. Initial integrated MLM (n=900) 82
Table 17. Final integrated MLM with interactions (n=900) 83
Table 18. Testing for moderation in the final integrated MLM (n=900) 85
Table 19. Information criteria for the integrated MLM (n=900) 86
Table 20. CONFIRMATORY DATASET. Final integrated MLM (n=900) 88
Table 21. Initial MLM for Micro-Level, fixed effects only (< 30 MPH) 91
Table 22. Final MLM for Micro-Level including interactions (< 30 MPH) 91
Table 23. Initial MLM for Meso-Level predictors (< 30 MPH) 92
Table 24. Final MLM for Meso-Level predictors (< 30 MPH) 93
Table 25. Initial MLM for Macro-Level predictors (< 30 MPH) 93
Table 26. Final MLM for Macro-Level (< 30 MPH) 93
Table 27. Initial integrated MLM (< 30 MPH) 94
Table 28. Final integrated MLM (< 30 MPH) 95
Table 29. Testing for moderation in the final integrated MLM (< 30 MPH) 97
Table 30. Final MLM (< 30 MPH) CONFIRMATORY DATASET $p<0.10$ only 100

Figures, Graphs and Illustrations

Figure 1: Bridget Driscoll (circled), and her family circa 1896 5
Figure 2: Crystal Palace fairgrounds (north view) circa 1854. 8
Figure 3: An Ecobehavioral Framework of Jaywalker-Car Collisions 30
Graph 1: Average number of missing values by year of collision 57
Figure 4: Data layout 67
Figure 5: Main effects and interactions predicting injuries in Jaywalker-Car Collisions in New Jersey (all roads, n=900, exploratory dataset) 87
Figure 6: Main effects and interactions predicting injuries in Jaywalker-Car Collisions in New Jersey (roads < 30 Mph, n=900, exploratory dataset) 98
Figure 7: What protects against severe injuries in Jaywalker-Car Collisions? 107

List of Appendices

Appendix 1. Legend and example sheet of a Straight Line Diagram 119

Appendix 2. Pooled Correlation Estimates and p-values for the initial set of explanatory variables of the micro-level (n = 900) 120

Appendix 3. Pooled Correlation Estimates and p-values for the initial set of explanatory variables of the meso-level (n = 900) 124

Appendix 4. Pooled Correlation Estimates and p-values for the initial set of explanatory variables of the macro-level (n = 900) 129

Appendix 5. Pooled Correlation Estimates and p-values for the initial set of explanatory variables of the integrated MLM (n = 900) 131

Appendix 6. MLM for Municipal Roads only (n = 331).....134

Introduction

"In the day we sweat it out in the streets of a runaway American dream
At night we ride through mansions of glory in suicide machines
Sprung from cages out on Highway 9,
Chrome wheeled, fuel injected
and steppin' out over the line
Baby this town rips the bones from your back
It's a death trap, it's a suicide rap
We gotta get out while we're young
'Cause tramps like us, baby we were born to run

Bruce Springsteen

Pedestrian deaths in United States have declined from 17% of all motor vehicle collision deaths in 1975 to 12% in 2008 (IIHS, 2008). Despite this generally positive downward trend, pedestrian-car collisions remain a serious public health problem (Ewing & Dumbaugh, 2009). In 2009, 4,092 pedestrians were killed and an estimated 59,000 were injured in traffic crashes in the United States. On average, a pedestrian was killed every two hours and injured every nine minutes in traffic crashes (NHTSA, 2009).

Despite the fact that collisions are linked to specific environments, research into the determinants of pedestrian behavior has usually been driven by theoretical positions that emphasize the role of individuals' rational processes in the development of events. From an individualistic perspective, a pedestrian-car collision is primarily explained as a combination of decisions and personal factors pertaining to each participant in the collision. However, it is not always possible to determine what are the motivations, attitudes, and intentions of individuals with respect to crossing a street or driving faster than the posted speed limits. This is particularly true in the case of collisions involving serious injuries, where a large share of participants cannot or do not want to talk about the traumatic event. In the case of pedestrian-car collisions, the environmental conditions associated with the behaviors of the participants are usually recorded as part of administrative procedures. Those contextual

features of the environment could provide valuable information regarding the determinants of those collisions.

It has been previously suggested that the behavioral characteristics of the proximal environment like green spaces for physical activity (Sallis et al., 2006), road infrastructure (Flahaut, 2004; Wang, Quddus& Ison, 2009), population density, levels of poverty (Brownson et al., 2009; Cubbin, LeClere& Smith, 2000), crime (American Academy of Pediatrics, 2009; Giacopassi & Forde), or even less explicit factors like urban sprawl (Ewing, Schieber& Zegeer, 2003; Frumkin, 2002), or environmental racism (Harwood, 2003) could be reasonably considered part of a predictive model of jaywalker-car collisions. It remains unclear what conditions, what mediating circumstances, and what possible moderating factors would be necessary to predict jaywalker-car collisions. It seems clear that research in this area should approach the problem from a broad perspective in order to consider the ecobehavioral complexity of this social phenomenon. Efforts to understand jaywalking and its effects on communities must take into account the interdependence of immediate and more distal environments (Stokols, 1992).

The present research employs an ecobehavioral approach to the study of jaywalker-car collisions, which allows an investigation of how personal and environmental conditions are connected to severity of injury associated with this type of collision. The philosophical, theoretical, and methodological perspective of Ecological Psychology in general and J.J. Gibson and Roger Barker's Ecobehavioral Science standpoint in particular, are used as a framework (Chapter 2). Ecological Psychology's theoretical framework identifies a dynamic liaison of behavioral processes (e.g. jaywalker-car collisions) as embedded in physical, economic, and social contexts. Based on that framework, the present research presumes that mechanisms of jaywalker-car collisions are complex, dynamic, and multileveled. Individual

behavior (the collision itself) is nested in larger ecological units including the street, the neighborhood, and the city.

The broader impacts of this research lie in its potential to incorporate dynamic relationships among different road users, their communities and the urban physical environment, and to link those relationships to inform policies related to collision prevention. The project will benefit society by pointing out gaps in urban, health, and environmental science and policy. These arenas have insufficiently addressed the intersections between the personal characteristics of jaywalkers and environmental conditions.

The intellectual merit of this activity lies in its exploration of interdisciplinary work at the confluence of urban geography, ecological analysis, and traffic safety. Primary methods will include archival data examination with spatial and quantitative analysis. Sources include public data concerned with collision reporting, demographic and housing data from US and state censuses; indexes of sustainable transportation from both public and private institutions; and archival research to document the world's first jaywalker-car collision. Spatial analysis will provide the basis for understanding the spatial patterns of collisions and spatial uses of the urban environment. The ecobehavioral dimensions of collisions in general are a relatively recent focus for researchers and this project will help expand the range of those fields while employing their strengths at interpreting relationships between personal and environmental levels regarding the topic of interest.

Chapter one provides an account of how the term jaywalker was constructed in the United States in the early 20th century. The second chapter will seek to define the street as a behavior-setting according to the perspective of Ecological Psychology. Background ideas from early thinkers like William James and Kurt Lewin are complemented by an exposition of the theoretical foundations of affordances and behavior-settings offered by J.J. Gibson,

Roger Barker, and several others. This topic will be completed with a discussion of theoretical and methodological possibilities for an ecological approach to the study of jaywalker-car collisions.

The last chapter focuses on an empirical study using data from jaywalker-car collisions in New Jersey. Employing a multilevel approach, the research emphasizes the identification of contextual variables in explaining severity of injuries resulting from jaywalker-car collisions. The research process starts with the immediate factors linked to jaywalker-car collisions, assuming that those factors are related to particular configuration of streets and intersections. Moving from there toward neighborhood determinants, a plausible model for ecobehavioral dimensions of jaywalker-car collisions in New Jersey is sought.

Chapter 1: Jaywalking in Time

"The environment exists for the purpose of movement."
Lawrence Halprin

THE AFTERNOON OF AUGUST 22ND, 1896

On a stifling summer's Saturday, Bridget Driscoll, 44, a laborer's wife (See Figure 1) took her 16-year-old daughter, May and a friend for a trip to the Crystal Palace located in south-east London. The group planned to attend a Catholic League of the Cross fete and dance exhibition. Approximately one hour after leaving home, Mrs. Driscoll became the world's first fatal victim of a jaywalker-car collision. Just in front of the Crystal Palace's south entrance, a crowd observing a car exhibition witnessed an imported Roger-Benz car hitting Mrs. Driscoll who, according to witnesses, had hesitated in front of the car and seemed bewildered before being hit (McFarlane, 2010).

Figure 1: Bridget Driscoll (circled), and her family circa 1896

Source: Wikipedia Commons

An account of the inquest procedures compiled by Dauvergne (2005) illustrates the behavioral details of the collision and the moments afterwards:

> "So many legal experts did not seem to create clarity. How fast was the car going? One bystander, the domestic servant Florence Ashmore, testified it was speeding as fast as a fire engine or a good galloping horse. Another witness, William James Wood, who inspected the car afterwards, testified it could not exceed a speed of 4 and a half miles an hour. Edmund Gascoigne,

> the manager of the Anglo-French Motor Car Company, testified it was not even able to exceed 9 miles an hour, although over a year earlier the Birmingham Daily Gazette reported that Gascoigne's cars could average 14–16 miles per hour and could reach speeds of 22 miles per hour. Edsall testified that a lowspeed belt on the car prevented it from exceeding 4 miles an hour—moreover, he wasn't even sure how Mrs. Driscoll was knocked over, claiming the car stopped 2–3 inches from her body. The doctor who examined the body, however, felt the car must have struck her "very severely."
>
> There were other uncertainties as well. Was Edsall reckless, zigzagging, swerving to the right, perhaps racing to pass the two cars just ahead? The daughter, May Driscoll, thought so, testifying that Edsall (who was in his early twenties) did not seem to know how to drive. The passenger in the motor-car, Alice Standing, testified that he swerved to the right. Edsall denied this, claiming he was following a car 20 yards ahead, and not attempting to pass. Did Mrs. Driscoll step into the path of the car, confused, rattled, in the words of the witness Florence Ashmore, by her own efforts at "dodging"? Ashmore thought so. So did Edsall. Did Edsall shout out and ring the car bell? He swore he did. The passenger and the daughter both testified that no bell rang. The daughter, too, did not hear a shout, although the passenger testified Edsall yelled, "Stand back!"
>
> The jury for the inquest, wading through this seemingly contradictory evidence, faced some tough questions. Did Arthur Edsall kill her? Was he at fault? The coroner, Percy Morrison, did not see much ambiguity and instructed the jury that they could "come to no other conclusion than the car was properly driven, straight and slowly." The jury after 6 hours returned a verdict of "accidental death." (Dauvergne, 2005, p. 40)

It is clear that Edsall was going fast, but he somehow managed to swerve. It is also clear that Mrs. Driscoll was on the planned trajectory of the car, apparently was not aware of what was coming and did nothing to avoid being hit. According to McFarlane's description, Mrs. Driscoll could be forgiven for being bewildered by a rare, powerful Roger-Benz car zigzagging while coming towards her at high speed. Bridget Driscoll's death was described as a "fatal accident" at the time and Mr. Edsall was accordingly not prosecuted.

The accounts of by both Dauvergne and McFarlane are particularly appealing not only because of their detailed description of the characteristics of the participants in the collision but also due to the lack of detail on the environmental circumstances that

surrounded the collision. This construction of the very first collision as a combination of individual acts and circumstances has permeated discussions since and has guided most traffic research until relatively recently. A closer view of some environmental factors surrounding Mrs. Driscoll's death sheds light on the explanatory components of her unfortunate Saturday afternoon expedition.

Mrs. Driscoll's party had travelled from Croydon, Surrey which is 3.8 miles southwest of the Crystal Palace's fairgrounds. At the time of the collision, lower and middle class travelers in London could hardly afford the uncomfortable horse buses or the more expensive horse trams operated by private companies. Bicycles were still a novelty in the area, and the party probably had to walk about one hour to the fairgrounds. It was a hot summer afternoon and Mrs. Driscoll was probably wearing her Sunday dress, which increased her discomfort and the need to hurry to the Crystal Palace, a well-ventilated and refreshing place. After the exhausting walk from their neighborhood to the top of Sydenham Hill, the group encountered a rather unfamiliar environment. Shown in Figure 2 is the likely view at their arrival at the main entrance of Crystal Palace, "a huge, modular wood, glass and iron structure (…) in Hyde Park to house The Great Exhibition of 1851" (Hobhouse, 2002, p. 36).

Mrs. Driscoll should have noticed the car exhibition's perceptual clues (crowd, noise, and probably written warning signs and announcements of the event) but she was probably determined to gain access to the big, conspicuous entrance of the building in front of her. For a working class woman, a car exhibition at that time probably meant nothing.

Figure 2: Crystal Palace fairgrounds (north view) circa 1854.

Source: Wikipedia Commons

Just in front of the building depicted in Figure 2, there was a strip of dirt generally used for car and horserace exhibitions. That day, the crowd was an obstacle not only to a clear view of the path but also to the warning cries coming from Mr. Edsall. The Croydon Chronicle quoted one witness as saying "the machines made a great noise". (McFarlane, 2010). According to Edsall's testimony recounted by McFarlane, the young driver did not think the noise would drown out the tinkling of his alarm bell.

The political and economic environment of Victorian London at the time of the collision played a part in Mrs. Driscoll's death. There were fewer than 20 petrol cars in Britain at the time. Car importers were struggling to open the market by creating the necessity for more motor cars. In the preceding years, strict regulations aimed at heavy and noisy steam engines limited the maximum allowable speed in English towns. The Highways and Locomotives Act of 1865, also known as the Red Flag Act, set strict speed limits of 4 mph (6 km/h) in the country and 2 mph (3 km/h) in towns. This law stipulated that self-

propelled vehicles were expected to have a team of three in control; the driver, the fireman - to stoke the engine - and the flagman, whose job was to walk 60 yards in front waving a red flag to warn horse-drawn traffic of the machine's approach. The man with a red flag or lantern enforced a walking pace and warned horse riders and horse drawn traffic about a self-propelled machine approaching.

The limit on maximum speed created a barrier for commercial interests and, as a response, a group of car manufacturers and importers lobbied to repeal the law. They were also organizing car shows to convince the masses of the benefits of petrol engines. Blanks in the specific regulations for the new technology meant that no driver's license was required at the time and no instruction was given to drivers as to which side of the road they should use. Mr. Edsall himself had been driving only three weeks at the time of the collision.

In 1878, an amendment to the Act of 1865 repealed the red flag regulation as a result of political pressure exerted by the aforementioned groups. In the same amendment, the distance of the pedestrian crew member warning about the presence of the vehicle was reduced to 20 yards (18 meters); vehicles were required to stop at the sight of a horse and were forbidden to emit smoke or steam to prevent horses from being alarmed (DOE, 2010).

Pressure from importers and manufactures continued and the popularity of car exhibitions achieved the desired effect. In early 1896, the year of Mrs. Driscoll's death, the Prince of Wales (later the King Edward VII), tried a car from the newly established Daimler Motor Company. He was so impressed with the invention that he agreed to become a patron of the first big motor show in Britain (DaimlerChrysler, 2007). By the end of July, one month before Mrs. Driscoll's death, and after carefully planned political pressure from motor car advocates, the new Locomotives on Highways Act of 1896 exempted light

locomotives (less than three tons) from the restrictions of the 1865 Act. Light locomotives were only required to carry a bell or other instrument "to give audible warning of approach" (DOE, 2010). The speed limit for light locomotives on the public highway was set at 14 mph, while the pedestrian crew member role was abolished altogether (McFarlane, 2010). Mrs Driscoll died barely two weeks after the new Act gained final approval by the House of Commons.

FROM "STREET USERS" TO "JAYWALKERS"

An ecobehavioral approach to the first reported pedestrian-car fatal collision shows that an overly simplistic explanation of events should be avoided. Individual components of collisions need to be integrated into more comprehensive explanatory levels. In technical terms, Bridget Driscoll was jaywalking 30 years before that term was formally coined. Mrs. Driscoll's death was certainly the product of her own decisions and failure to quickly react that afternoon, but it was also the result of a particular road design, and of environmental conditions that facilitated the collision. Legal and political decisions taken years or even days before the collision also facilitated the conditions for the terrible final event.

Although the concept did not exist at the time of her death, Mrs. Driscoll was crossing a road authorized for other uses and therefore she was jaywalking. Most roads in 1896 were authorized for pedestrians, horses, and carriages but not for cars. Road safety was not an issue anywhere. At the turn of the 20th century there were no distracted pedestrians or jaywalkers in London, but only road users negotiating a common space. Traffic in the streets of most cities around the world was basically self-regulated for most of nineteenth century. Earlier attempts to impose order on traffic for safety reasons existed but were scarce. A Paris

ordinance of 1766 stipulated that "pedestrians were allowed on protected side paths (*contre allés*), while horses were permitted at the center of the roadway" (Loukaitou-Sideris & Ehrenfeucht, 2009, p. 16). Sidewalks, if any, were conceived as serving aesthetic, recreational, and hygienic purposes. Years later, sidewalks became an important instrument to segregate pedestrians from public space, using the discourse of safety. At the time of Mrs. Driscoll's death, the road was a spatial frontier where different interests and uses converged.

No traffic regulations were changed as a result of Mrs. Driscoll's death. Pedestrians continued to be considered the rightful main users of the street space. Pedestrians, horse carts, and the new petrol engine cars were increasingly required to share a shrinking space for maneuvering. As newcomers in the public realm, cars were often seen as annoying invaders of a once safer space having to adapt their speed to the reality of a shared space.

In the United States, the idea of cars being unwelcomed members of the old semi-bucolic environment of the street continued well into the first two decades of the 20th century. For most administrators, traffic dynamics were not a serious problem. They were more concerned with larger issues such as sewage treatment, waste management, energy and water distribution, and crime. With the introduction of urban railroads, the rising demand for transportation was satisfied in a relatively cheap and convenient way with gradually bigger transit networks. Even in rapidly growing metropoles, authorities relentlessly avoided addressing issues related to traffic congestion and safe transportation. For example, as of January 1864, rapid transit "was not a question of vital import" to the New York mayor's office (Walker, 1918). By the end of the nineteenth century, most traffic safety problems were addressed by posting policemen in the most crowded or dangerous intersections. By

the turn of the new century, the industrial centers of Europe and United States were reluctantly forced to apply larger scale measures to solve traffic problems.

With the massive invasion of the automobile in America, traffic congestion and pedestrian-car collisions became a major issue in most cities. Public outcry, particularly when victims were children who used to play in the streets before the automobile age, forced varying solutions from banning cars to banning pedestrians. Efforts to police the streets were mostly ineffective and expensive.

Collisions and deaths represented bad publicity for car advocates. Safety boards were formed around the United States in the early 20th century to address the problem as a public safety one. Car users and their advocates had to put much effort into changing public perceptions about what the roads were meant for. Emphasizing the now ubiquitous problem of traffic safety paved the way for regulations which were generally proposed by automobile associations and nearest and their dearest public officials. That change in legislation could not have been possible without first shifting the definition of the very concept of road safety. The first step was a shift in the discourse from the right of use of the public space to one with an exclusive focus on road safety and efficiency.

A key concept in the new order for the road was efficiency. It was then time for engineers to demonstrate their effectiveness in solving urban problems with notorious efficiency (Norton, 2008). Coming from the world of public utilities management, engineers were chosen to devise efficient solutions to the new traffic problems. Engineers visualized the problem of public utilities as one of maximization of throughput. These engineers conceived of roads as a public utility like a sewage collector or a water distribution system. Moving users as rapidly and safely as possible became the principal goal of every city

engineer in the United States during the first 30 years of the 20th century. For the first traffic engineers, the road was not seen as a social place for human interchange, but a dynamic system of controlled movements. In terms of efficiency, the road could not be a shared space any longer. It was certainly a dangerous place, particularly for children who were warned to keep off the streets in most cities. Once the new paradigm of the road as a public utility made its way into the regulatory realm, car users ensured that future definitions of the road would include them as the principle lawful users.

But many pedestrians still used the streets as they always did, decreasing both flow and safety, two of the engineers' most basic concerns. Once the regulatory system was established, pedestrian education was, along with traffic automation, the chosen tools for city officials to prevent pedestrian-car collisions. Education campaigns organized by AAA Clubs around the U.S. with the support of City Safety Commissions and civic organizations like the Boy Scouts emphasized accident reduction by educating pedestrians on the need to use only the confined areas of sidewalks and crosswalks for ambulation. Some pedestrians claimed prior rights, "but motorists' advantage in power tended to make pedestrians relinquish them (…) motorists claimed that old ways no longer suited the new motor age" (Norton, 2008, p. 72). According to Norton, by 1916 the term "jaywalker" was common in the police parlance. It was mainly applied by corner policemen to pedestrians who ignored their directions. To some extent, jaywalking became a way to challenge police power in disputed spaces.

By 1920, specific campaigns aimed at preventing the pedestrians from crossing the street outside of the intersection area were routinely implemented in many cities (Norton, 2008). Most of those campaigns used jaywalking as a synonym of pedestrians who purposefully refused to use the crossings or cut the intersections. Although many of these

campaigns had scant success at actually changing pedestrian behavior, the orchestrated effort by car advocates, police, and safety boards consolidated the concept of jaywalking as an aberrant behavior performed by careless individuals who risked their lives in dangerous streets made for motorized traffic.

WALKING IN TODAY'S AMERICA

The American love affair with the automobile, facilitated by a discourse of traffic safety, not only barred pedestrians (particularly children) from streets, but also spawned a new architectural landscape. In 1929, a critic noted that "the building of drive-in structures to serve a motor-driven population had ushered in a completely new architectural form" (Fishman, 1987, p. 61). The climax of the new car culture vernacular in architecture was the General Motors' *Futurama* exhibition at the World's Fair of 1939, predicting itself into a near future. The effort of GM to actually realize that vision of a world moving by private transportation crystallized in the fifties along with the explosion of private housing development. According to Fishman, between 1950 and 1970, approximately 1.2 million housing units were built annually in the U.S., the vast majority of them as suburban single family dwellings (p.74). This explosion represented an increment of about 50% of new units compared to the existing housing stock in 1950. At the same time, the "white flight" from urban neighborhoods had an impact on the remaining city dwellers. In many cases, sprawl denied or increased the cost of services (such as street maintenance and public health) to inner-city neighborhoods. Transportation budgets were eaten up by a costly network of new freeways built to connect the offices with suburbia, leaving little money to support the urgent investments in pedestrian infrastructure or public transportation services. Building roads is required in areas of rapid suburbanization. Nonetheless, new roads or expansions would never be enough to catch up with the pace of growth in transportation demand. For

example, between 1980 and 1989, if a community's population rose 10 percent, the total vehicle miles driven there typically rose 43.2 percent (Downs, 1992, p. 37).

The environmental and social costs of the construction and expansion of roads have historically been high and unevenly distributed among the population (Jacobs, 1992). In terms of quality of life, during the second part of the 20th century, inner cities in America were converted into active office or commercial hubs for suburbanites during the day, and a collection of deserted and unsafe corridors at night, where pedestrians risked their lives. The new architecture paradigm in suburbia did little for pedestrians who simply had no place in the new landscape of suburbia. Problems associated with a car-dependent culture like obesity, diabetes, long commuting times, and road rage have more recently led to reflections on the design required to promote walkable cities (Duany, Plater-Zyberk& Speck, 2001).

As in the case of Bridget Driscoll, when a pedestrian decides to cross a street out of the crosswalk or against the light in modern America, a complex interrelation of personal and environmental conditions is activated. This activation is perceived as jaywalking by car advocates and police. For the pedestrian it is something else; a reassertion of mobility and accessibility that have been endangered by the process of suburbanization.

How the characteristics of modern roads in America determine the chances of jaywalkers in case of collisions is unclear. What characteristics of the road environment afford protection of the jaywalkers in case of collisions? What characteristics increase their risk? In the case of a collision, it is uncertain what personal and environmental conditions determine variation in the severity of injury sustained by the pedestrians involved in the collision. Before empirically testing the effect of a group of variables on severity of injury in jaywalkers, the next chapter seeks to explain how the personal characteristics of pedestrians can be combined with environmental characteristics to produce affordances for jaywalking that are determined by multiple levels of causation.

Chapter 2: An Ecobehavioral Approach to Jaywalking

> *"I also assume that they are not simply the physical properties of things as now conceived by physical science. Instead, they are ecological, in the sense that they are properties of the environment relative to an animal.*
> *James J. Gibson*

PERCEPTION AND WALKING

For J.J. Gibson, the primary function of perception is "to facilitate interactions between the individual and his or her environment" (Lopez Alonso & Minervino, 2007, p. 231). Those interactions are generally structured as movement in space. Hence walking is a quintessential structuring behavior. As a response to environmental demands, "bipedalism was among the first characteristics to mark the ascent to cognitive life in hominids" (Lovejoy, 1988). In sum, walking is a distinctively human behavior that bridges cognition and movement into a natural mixture of perception, interpretation, and consequent execution of purposeful actions *in the environment* (Gibson, 1979).

Understanding the fundamental, dynamic, and spatial nature of perception involving the walking individual and the environmental structure took a long road in the history of Psychology, itself pervaded by the tradition of mind-body dualism (Heft, 2001). In the dualistic paradigm of perception, a prescient mind oversees how a physical body acquires information from the external environment, which presupposes a discontinuity between experience and the "real" world. Under this paradigm, perception about environmental features is dislocated from the very act of moving in the space, walking, crossing a street, or avoiding an oncoming car. It also presupposes a primarily rational interpretation of information by the individual *before* executing the next sequence of behaviors.

But perception is a kinetic process. It occurs while we move. It has been asserted that crossing a street from a standstill, with a scan of the behavior-setting before crossing entails a larger safety margin for pedestrians (Oudejans et al., 1996). Nonetheless, the most common type of collision involving children is the pedestrian "dart-out" or "dash" in which a child walks or runs into the road either at midblock or at an intersection without a previous scanning of the street (American Academy of Pediatrics, 2009; Preusser et al., 2002).

In his later works, William James refused to accept the mind-body dichotomy and proposed "an ever-differentiating stream of consciousness between the knower and the known, whose relations are direct, that is, not mediated by mind-as-an-entity" (Morris, 2009, p. 282). This monistic, unmediated functional definition of perception allowed experience (e.g. walking) to be defined as a continuous stream of exchanges between individuals and their immediate contexts (James, 1890). Nonetheless, James's radical empiricism left unanswered the question of how agency, considered as the capacity of human beings to make choices and to impose those choices on the world, develops from this process of instantaneous environmental perception. Answering that question for the case of walking means that the mechanisms connecting the constellation of environmental determinants to the "step-by-step" movements of the walking individual have to be convincingly explained.

The continuous stream of exchanges described by James creates a problem of stimuli sequence. In William Holt's words, as the functional relations among stimuli and responses grow complex, prediction of one from another becomes increasingly difficult. Holt then proposed that original stimuli recede in terms of perceptual priority, incorporating more distal features of the environment. According to Holt, psychologists should attempt "to identify the distal features toward which any particular goal-directed actions are directed, and

in so doing to uncover lawful relations between the environment and [individual] action" (Heft, 2001, p. 153). The advice was taken into account by J.J. Gibson among others who, in an analysis of the field of travel expressly mentioned Holt's concept, saying that "the visual field of the driver is a rather special sort of field in several respects. It is selective in that the elements of the field which are pertinent to locomotion stand out or are attended to, while non-pertinent elements, such as 'scenery,' generally recede into the background. The most important part of the terrain included in this pertinent field is the road" (Gibson & Crooks, 1938, p. 454). With the idea of behavioral stages entering and leaving the perceptual foreground, Holt included not only the notions of movement and field in the perceptual equation but also the idea of agency as a dynamically generated process indistinctively linked to perception.

Holt's contribution to the relationship between distal processes and immediate experience created the conditions for Lewin's concept of "life space" as a constellation of factors present in the phenomenal field at a particular time (Heft, 2001, p. 247). This inclusion of psychologically relevant characteristics from the immediate context inside the individual's perceptual space made possible the integration of the individual and the immediate environment into one theoretical and methodological unit of analysis. Movement in space could now be understood as a perceptual process guided by agency created by regularities in the immediate environment that are apprehended in a holistic way with every single step.

AFFORDANCES: THE BUILDING BLOCKS OF ENVIRONMENTAL PERCEPTION

The regularities in perception created as a product of the dynamic relationship of the individual and the environment described by Lewin were coined as "affordances" by J.J.

Gibson as in what "the environment affords behavior" (Morris, 2009, p. 285). One relevant characteristic of affordances is that they can have different valences in Gibson and Lewin's jargon. The multiplicity of meanings (valences) is stressed by Wicker (1992) who talked about the need in every individual to impose a cognitive order on the environment and the process itself being considered a means to build agency making affordances possible for each individual and groups at the same time. Following Wicker's idea, a median barrier on a road could have very different meanings and possibly conflicting uses for diverse road users. To drivers, the median barrier could afford safety, but to pedestrians it could afford *running* and *jumping over*. A hot-dog wagon has "a negative valence with respect to locomotion, but a positive one with respect to appetite" (Gibson & Crooks, 1938, p. 455). Valences (meaning) of the affordances depend on the contextual clues the individual perceives at a particular segment of time-space since the field of safe travel is "a spatial field but it is not fixed in physical space" (Gibson & Crooks, 1938, p. 455). In sum, and following J.J. Gibson's reasoning, walking is a perceptually governed series of behaviors by the pedestrian in order to keep herself in the middle of the field of safe travel. Extending the definition, the field of safe travel changes every second according to updates in the conditions of the immediate context. The field of safe travel is not necessarily confined to the crosswalk, but may include the median, the system of lights and signals, other road users, street furniture, nearby attractions like buildings, transit stops and trees. The pedestrian is a moving perceptual entity constantly evaluating and recalculating the field of safe travel, pondering the options and regulations with every step. For Gibson, once a field of safe travel is established, "the seeing and the doing are merged in the same experience" (Gibson & Crooks, 1938, p. 460).

From J.J. Gibson's ideas, it could be concluded wrongly that walking is a constructivist process that starts *tabula rasa* with every single step. Gibson conceived of movement as a nonlinear, dynamic continuum of information acquisition and behavior. That view contrasts with a *rational man* model of decision making in which the next step is informed by a previous evaluation of all the known alternatives.

Allan Wicker criticized J.J. Gibson's perceptual approach, suggesting that it fails to explain the effect of increasingly larger forces on the behavior of an organism interacting with the social world. For Wicker, "…the language of affordances is simply an operationalized presentation of ethology's fundamental principle: reciprocity between an organism and its environment".

Roger Barker's Ecobehavioral Science complements Gibson's theoretical framework in terms of the extra-individual components of behavior. Gibson's perceptual approach is useful since it identifies contextual opportunities for individual behavior. A straight and level, well-lit, empty roadway could afford an opportunity for jaywalking.

Although in Gibson's view, the point of reference is always the pedestrian herself, the field of safe travel is not a subjective experience. It exists objectively as the combination of previously arranged elements in the environment whether the pedestrian is aware of them or not. Some of those arrangements configure themselves into very predictable sets of environmental affordances as will be explained in the following section.

THE STREET AS A BEHAVIOR SETTING

The field of safe travel is constantly updated perceptually but is essentially composed of regularities. Those regularities are molar behavioral units that allow the individual perceiver to easily grasp the required information from the environment, literally, at a glance.

Those extra-individual behavioral units are linked to particular configurations of spatial arrangements. For example, behaviors of pedestrians in different urban streets show relatively stable patterns. Those regularities are commonly incorporated into street design and guide the behavior of different street users, constituting stable behavioral patterns. Roger Barker and his associates (Barker, 1968) studied several types of behavioral patterns in detail, including behavior on streets. For Barker, people, behavioral objects (sidewalks, traffic signs, cars, benches, storefronts), and circumjacent space are arranged into synomorphic molar units (e.g. a street block) named *behavior-settings*. Behavior settings are the essential units of analysis in Ecobehavioral Science. They are extra-individual as they exist independently of any particular individual perceiving them. Formally defined, behavior-settings are objective, naturally occurring phenomena with a specified time-space locus occurring outside the individual. Barker solves the problem of agency by assuming that "people enter the setting by choice, but once in the setting they usually conform to its constraints. It is the setting itself that directs their molar behavior, not the personal differences of the inhabitants (since) they play their roles as components of the setting, however, not as individuals" (Scott, 2005, pp. 297-298). Individuals act upon affordances, becoming components of the behavior setting. For Barker, it is not possible to make predictions about human behavior without considering the constraints and possibilities of the particular behavior-settings humans inhabit. Barker called that combination of constraints and possibilities of a particular behavior-setting, *the program*. The program addresses the different combinations of the individuals with the environmental characteristics of the spatial and social context in which behavior occurs.

According to Barker, behavior settings like the street have unique self-regulatory and stable characteristics that persist even when current users behave against the established pattern of behavior defined by the program, are replaced by others (Schoggen, 1989), or even when social control agents like the police are not present. Self-regulatory characteristics of the behavior setting are determined by history, design, and policy. They are powerful in determining which behaviors will have a high or low probability of occurrence. For example, adults tend to help small children while crossing the street and cars generally yield or stop for pedestrians at intersections. Those practices are not only determined by regulations but also by the configuration of the particular places. One expected outcome of self-regulation in the behavioral pattern of the street is that a relatively small number of people use the roadway for walking. People generally tend to use the sidewalk. Pedestrians cross the street only at marked crosswalks, with the light, and in the absence of a crosswalk, they look for visual signals indicating a safe crossing point. Experience confirms that pedestrians cross the street wherever they consider it safe to do so. In those cases, the particular configuration of elements in the behavior setting could afford jaywalking behavior independently of the regulations against that practice. Wicker stresses the importance of behavior settings as social constructions since they are, "the result of sense-making and interactive behaviors of participants" (Wicker, 1987, p. 616). Differing from Barker, Wicker considers behavior settings less deterministic than physical entities like magnets or meteorites. In this sense, Wicker is closer to James' and Gibson's position of a dialectic relationship between the individual and the environment. Since they are constituted by multiple combinations of affordance-facilitating features, behavior settings are flexible enough to admit individual (random) variation from their programs. A parsimonious way to look at this deterministic vs.

flexible program conflict is that behavior settings afford what they afford independently of how their program was devised. In the case of a street affording jaywalking, instead of enforcing rules or reeducating pedestrians, it could be more practical for engineers and planners to find out why and how a street program facilitates jaywalking and protects jaywalkers in the event of a collision. This means elucidating those proximal and distal variables that have significant relationships to jaywalking and their effects.

Streets could be considered behavior-settings since they are a combination of several integrated and interdependent standing patterns of behavior (sidewalking, driving, streetcrossing, corner-chatting, jaywalking, biking…) synomorphically attached to particular constellations of circumjacent facilitating elements like buildings, sidewalks, driveways, bike paths, trees, benches, markings, crosswalks, crossing islands, traffic signs, rain, or temperature (See Barker, 1968 Ch.3 ; Schoggen, 1989, pp. 30-36). According to the ecobehavioral approach, synomorphic congruence between particular behaviors (jaywalking) and physical objects of the environment (straight road, good visibility) are governed by a particular program into a behavior-setting known commonly as *the street*.

In summary, events like jaywalker-car collisions could be assumed to be a function of the characteristics of *the street*, a piece of the city where the structure for controlling behaviors is built into a particular configuration of features. The street is, using Barker's terms, a *behavior-setting*, which is "connected to a common world that stands independently of each perceiver" (Heft, 2001, p. 235). In this sense, the street as a behavior-setting is a higher-order, naturally occurring, and socio-cultural structure where particular behaviors can be discerned with quasi-stable physical, temporal, and geographic boundaries. Particular individuals are guided by affordances, but they are not essential for the behavior-setting to

be considered as such (Barker, 1968; Morris, 2009). Behavior-settings exist "independently of any single person's experience of them" (Heft, 2001, p. 254). They are quasi-stable synomorphs (Barker, 1968, p. 19), specifiable, with clear geographical limits, and temporal boundaries which can be modified by specific behaviors.

A Jaywalker-car collision is not only the result of the personal characteristics of participants but also a function of a particular environmental configuration, a radically situated event (Heft, 2001), a mix between the individual's characteristics, the built environment, and the distal features of the social and economic environment.

The Ecobehavioral approach to the systemic study of behavioral events is not unique in Psychology. Urie Bronfenbrenner's Bioecological Systems Theory is also a comprehensive psychological framework. Bioecological Systems Theory starts with the individual child and her development but characterizes that *micro-leveled* relationship as part of a complex contextual system of relationships that determine her environment. This is a fundamental difference from Barker who emphasizes behavior-settings instead of individuals' characteristics as determining agency. Although Bronfenbrenner's theory is more developmentally oriented, its emphasis on *bi-directional influences* between the individual and the environment shows that both entities develop together interacting and transforming themselves as part of a complex system of relations. This bi-directionality in the individual-environment relationship makes Bronfenbrenner's perspective similar to Barker's principle of behavior-milieu synomorphs. Nonetheless, Bioecological Systems Theory gives the environment a decisive influence on behavior and intentions. In that sense, Bonfenbrenner's approach is markedly deterministic on the environment's side. B*ehavior-settings* theory focuses on assigning the same analytical status to each behavior object (trees, traffic signs, humans,

or pavement markings). In Barker and Gibson's view, the emphasis is on regularities in behavior resulting from a particular arrangement of the behavior objects. Therefore, emphasis is not given by Bonfenbrenner to the study of individual components arranged in a particular setting. In a behavior-setting, human and nonhuman components are organized in affordances in such a way that regularly occurring activities can be carried out relatively smoothly (Wicker, 2002).

Although the Ecobehavioral approach has been considered "an enormous step forward in the history of psychology" (Scott, 2005, p. 299), it hasn't been exempt from criticism. Kaminski (1983) argued that Barker underestimated the complexity and variety of everyday life with his schematization of behavior into settings. This criticism is akin to Wicker's (1987) arguments that behavior-settings do not take enough account of individual motives, action plans, personality, and so forth. The Ecobehavioral perspective reflected, in part, a reaction against the then dominant focus in mainstream Psychology on individual behavior rather than the individual in context.

Barker's *extraindividualistic* perspective was unusual only within the context of traditional Psychology. There are some correspondences between behavior-settings and a number of similar concepts developed more or less independently by other social scientists. In sociology for example, F. Stuart Chapin's concept of *activity systems* refers to a tendency for people in a given population to behave in a similar way at certain times and places (Chapin, 1968). For Chapin, the activity systems of urban residents both shape and are shaped by the spatial organization of the metropolitan area. As the life cycle of families progresses, and income and family size constraints are modified, the activity routine changes and, as a result, the mix of accessibilities with respect to the place of residence is modified.

The activity system concept, although similar to behavior-setting, is methodologically focused on the study of aggregations of individual behavior since it relies heavily on self-report and not on objective observation of the behavior-setting in naturalistic fields (Schoggen, 1989). The environment was conceptualized by Chapin as a container for behavior rather than as an active and modifiable component of the setting. Nonetheless, the emphasis Chapin gives to situated action in a specific time and place is fundamental. Also in sociology, Erwin Goffman's Frame Analysis is relatively similar to the concepts of behavior-setting and activity systems. In his seminal work "The Presentation of Self in Everyday Life" (Goffman, 1959), Goffman depicted a dramaturgical method for examining the organization of personal experience and social interactions as perceived by the actors involved. In the book, Goffman proposes that the social actor has agency regarding the selection of a specific costume, stage, and objects used in the performance. The actor's main goal is to adjust to the several settings offered while maintaining coherence. This is done mainly through interaction with other actors in a balance of structure and agency.

From the several avenues of knowledge reviewed so far, it is clear that personal characteristics of the individuals participating in events like collisions need to be framed by contextual elements and influences. A basic framework describing those interrelationships is described next.

AN ECOBEHAVIORAL FRAMEWORK FOR JAYWALKER-CAR COLLISIONS

A unified framework to study jaywalker-car collisions should address the multidimensional and complex nature of the environments in which people jaywalk. Those environments can be described "in terms of their scale or immediacy to individuals and groups (proximal vs. distal). Furthermore, environments can be described as (…) composite

relationships among several features, as exemplified by such constructs as behavior settings" (Stokols, 1992). What are those composite elements and what is the system of relationships constructed upon them?

Following a bio-ecological model (Bronfenbrenner, 1979), a series of nested environmental structures that include but extend beyond the individuals involved in the collision can be distinguished:

The Micro-Level:

This is the most basic level associated with jaywalker-car collisions. The micro-level refers to the personal attributes and actions of the individuals involved in the collision. Activities and past interaction patterns of the pedestrian and driver are included at this level as socio-demographic characteristics. Variables that can be included in this level are comprised of but not limited to: pedestrian/driver age, gender, physical status, pre-collision actions (darting, speeding) and inattention; pedestrian/driver visibility, and the possible influence of substances on behavior. This level comprises the individual factors associated with perceptions of risk characterizing jaywalkers and drivers.

The Meso-Level:

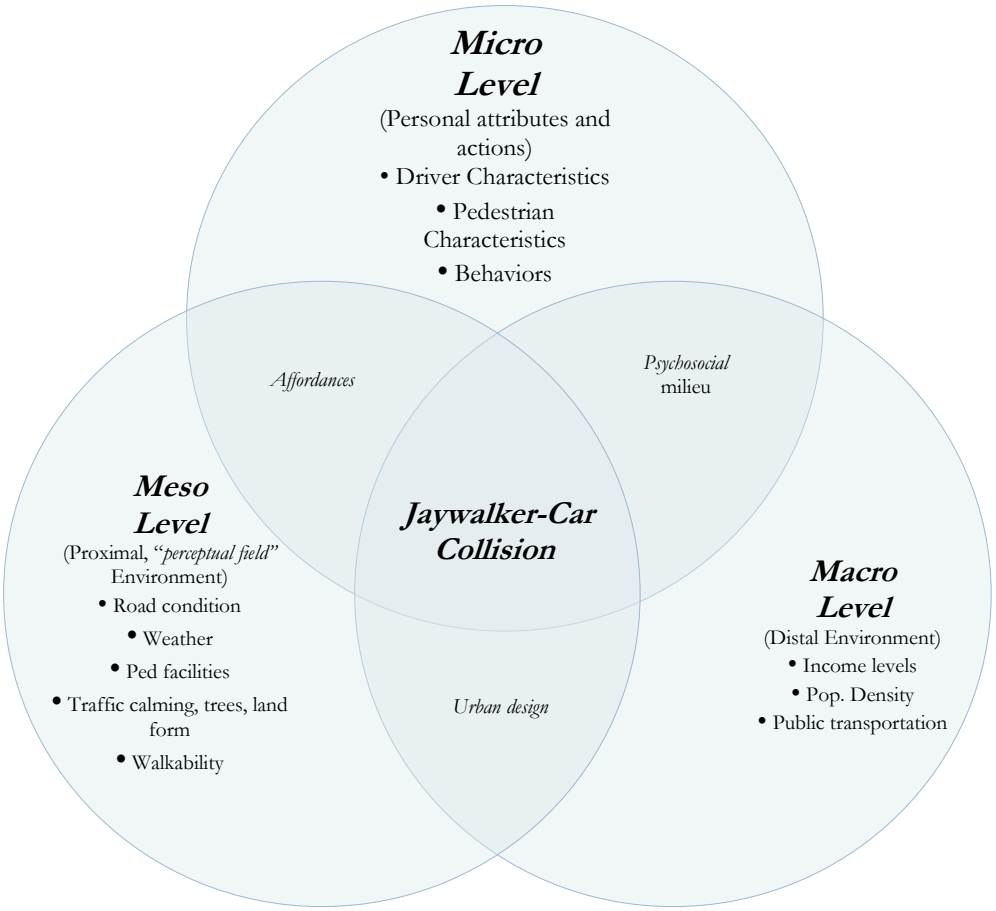
This level is composed of the proximal environmental conditions that affect the pedestrian's perception of risk. It is what Levin called the "perceptual field" and includes physical elements like the immediate road context, weather conditions, traffic signs, lights, markings, median islands, traffic calming measures and street furniture. This level includes the affordances for jaywalking. Variables included in this level are associated with the immediate context of the jaywalker-car collision as, for example, vehicle type and model, roadway characteristics (width, number of lanes, median width, dry/wet, leveled, straight,

markings, signals, divisions, posted speed limit and distance to an intersection), weather conditions as well as traffic volume, sidewalk coverage, street/road furniture and prominent features (benches, planters, light poles, trees).

The Macro-Level:

This level is composed of the distal environmental conditions that indirectly affect individual perceptions of collision risk. Aspects of urban policy and design play a key role in this level. This is the neighborhood level. Examples of macro-level elements affecting the conditions at the collision site are walkability conditions in the neighborhood, transportation costs, population density, and income levels of community members. Possible indicators for this level are housing density, home ownership, recreational area density, walking destinations in the area (stores, pharmacies, libraries, transit stops), public transportation availability, population 65 years and over, average household size, per capita income and sidewalk density.

Figure 3: An Ecobehavioral Framework of Jaywalker-Car Collisions



Chapter 3: Ecobehavioral Dimensions Of Jaywalker-Car Collisions In New Jersey

"The human young must learn to perceive these affordances, in some degree at least, but the young of some animals do not have time to learn the ones that are crucial for survival" James J. Gibson

INTRODUCTION

From a traditional psychological perspective, a jaywalker-car collision can be explained as a combination of individual decisions by each individual involved in the collision. This seems to be particularly true in the case of collisions between cars and jaywalkers, where apparently careless pedestrian decisions lead to injuries, sometimes fatal. However, the literature on pedestrian safety has shown that environmental and socioeconomic factors such as the design of roadways and crossings, nearby amenities, or more distal factors like urban sprawl are significantly associated with pedestrians' severity of injury (Retting, Ferguson& McCartt, 2003). Thus far, no research has addressed possible environmental effects in the case of jaywalker-car collisions.

Ecological Psychology's theoretical framework identifies a dynamic liaison of behavioral processes as embedded in increasingly complex physical, economic, and social contexts. Based on that framework, it can be assumed that the mechanisms of jaywalker-car collisions are complex, dynamic, and multileveled. Individual decisions associated with the collision site are nested in and explained by larger ecological units like the street, neighborhood, and increasingly larger units like cities and regions.

Events like jaywalker-car collisions could be assumed to be a function of the characteristics of *the street*, a piece of the city where the structure for behaviors is built into a particular configuration of influential factors. In the present research, a jaywalker-car collision is assumed to be a function of a particular environmental configuration, a radically situated event (Heft, 2001), a systemic liaison of the personal characteristics, the built

environment, and the distal features of the social and economic environment. Figure 3 shows a diagram summarizing those relationships. Details regarding the categories, labels, and specific relationships among the different levels have already been explained in Chapter 2.

LITERATURE REVIEW

According to the Ecobehavioral Framework for the study of jaywalker-car collisions, personal characteristics of the pedestrians and drivers are significant but insufficient to fully explain these events. In order to maintain methodological consistency, the following review reproduces the categories used by the Ecobehavioral approach:

Research on the effect of personal attributes and actions (Micro-level):

A number of studies have found different degrees of association connecting micro-level variables and injuries. In terms of drivers' ages, Williams & Carsten (1989) reported that the youngest and oldest drivers have the highest relative risk of collision, but the attributable risk is much higher for the youngest age groups because elderly drivers have lower risk exposure (i.e. they drive less). According to the same authors, the elderly driver problem will increase gradually as their share of the population increases but will still remain relatively small. The bulk of the problem will continue to reside among drivers younger than the age of retirement, particularly the youngest drivers. Some researchers report that younger male drivers are more likely to drive and engage in risky behaviors that contribute to the largest share of road accidents (Laberge-Nadeau et al. 1992, Westerman and Haigney 2000, Krahé and Fenske 2002, Vassallo et al. 2007). Massie et al. (1997) found that driver's gender proved highly significant in explaining variations in observed rates of collisions. Men have a consistently higher risk of collision involvement per mile driven than women for all

combinations of collision severity and lighting conditions examined. These findings contrast with female drivers' higher involvement rates in non-fatal collisions as compared to their male counterparts.

In the United States, approximately 70% of pedestrian fatalities are male, a proportion that has remained almost unchanged since 1975. As with adults, approximately 60% to 70% of children killed and injured as pedestrians are males (American Academy of Pediatrics, 2009). According to the same source, male drivers, drivers younger than 40 and those with a record of multiple driving infractions and suspended or revoked licenses are more likely to be involved in a collision with a child pedestrian. Abdel-Aty et al. (2007) found no significant effects of pedestrian gender either on pedestrian/bicyclist collisions involving school-aged children or on the conditions under which these collisions are most likely to occur. Nonetheless, Lee & Abdel-Aty (2005) found that both middle-age male drivers and middle-age male pedestrians tend to be involved in pedestrian collisions significantly more than other age and gender groups. Kim et al. (2008) found no significant effects of gender on pedestrians' severity of injury after controlling for age. Kim, Made & Yamashita (2008) found significant effects for drunk male pedestrians, who were ten times more likely than other groups to be at-fault in pedestrian collisions.

At a general level, drivers seem to be more likely than pedestrians to violate regulations at crosswalks (K. Kim, Brunner& Yamashita, 2008). Around 35% of pedestrian deaths among people aged 60 and older in 2008 occurred at intersections compared to 20% for those younger than 60. In 2005, 82% of pedestrian deaths involving children occurred outside of intersection locations (American Academy of Pediatrics, 2009). The same source mentions that a study of 139 urban children who were struck by automobiles found that in

71% of the cases, children were walking to a specific destination rather than playing in the streets. This finding could imply that children are abandoning the streets as spaces for play and that children, like grownups, need safe routes in order to secure their freedom of movement.

In addition to age, there has been interest in other pedestrian characteristics like the clothing they wear that might account for differences in severity of injury. For example, there are no conclusive data showing that reflective clothing actually decreases collisions or injuries. It has been found that parked cars along a residential street obscure visibility for both drivers and pedestrians, especially children (American Academy of Pediatrics, 2009). The same source asserts that the most common type of collision involving children is the pedestrian "dart-out" or "dash" in which a child walks or runs into the road, either at midblock or at an intersection, often from a position out of view of the motorist. This type of collision accounts for 43% of collisions that involve 5- to 9-year-olds, 30% of collisions that involve 10- to 15-year-olds, and 26% of collisions that involve children younger than 5 years (See also Preusser et al., 2002).

Neyens and Boyle (2008) found that teenage drivers have substantially higher collision risks than other driver age groups. The increased collision risks and frequency of this age group has been attributed to driving ability, increased risk-taking behavior, and distracted driving. Driving while using a cell phone is cause for a number of collisions that involve young drivers. It has been asserted that the opportunity for distractions will increase as drivers adopt more in-vehicle technologies and devices. For drivers and pedestrians, mobile phone use reduces situation awareness and increases unsafe behavior putting them at greater risk for collisions (Nasar, Hecht& Wener, 2008).

Distraction also affects pedestrians. Hyman et al. (2010) investigated the effects of divided attention during walking. Individuals were classified based on whether they were walking while talking on a cell phone, listening to an MP3 player, walking without any electronics, or walking in a pair. In the first study, Hyman and colleagues found that cell phone users walked more slowly, changed direction more frequently, and were less likely to acknowledge other people than participants in the other conditions. In the second study, they found that cell phone users were less likely to notice an unusual activity (a unicycling clown) along their walking route. Cell phone usage may cause inattention blindness even during a simple activity that should require few cognitive resources. Van der Molen (1981) found that a large percentage of jaywalker-car collisions involving children resulted from the child not paying attention to all the traffic and road environmental clues. This problem seems greater for small children since Dunbar, Hill, & Lewis (2001) found that older children tend to show greater ability to appropriately switch focus to important pedestrian tasks.

Chemical intoxication may also increase pedestrian's risk. Around half of pedestrians 16 and older killed in nighttime collisions (9pm - 6am) had blood alcohol concentrations (BACs) at or above 0.08%, compared to 25% during the day, from 6am to 9pm (American Academy of Pediatrics, 2009). According to LaScala, Gerbera, & Gruenewald (2000), research in emergency rooms has suggested that many pedestrians who are injured or killed were under the influence of alcohol to some degree at the time they were struck, but little is known about injuries that do not require admission to emergency rooms. Since pedestrian and drivers have mandatory alcohol tests only when serious injuries or death occurs from the collision, much information is missing from collision reporting systems every year. Profiles

of injured pedestrians compared to other trauma patients at a Regional Medical Center showed that pedestrians represent a sub-population with lower socioeconomic status and a higher incidence of substance abuse (Ryb et al., 2007). According to the authors of the study, injured pedestrians were significantly more likely to be black, unmarried, unemployed, binge drinkers, alcohol dependent, drug dependent, to have blood alcohol concentration > 200 mg/dl, lower incomes, lower educational attainments, younger age, and to lack a driver license. Pedestrians who were under the influence of alcohol also appear to sustain more severe injuries and to experience higher mortality (Dietrich & Eric, 1988; Öström & Eriksson, 2001; Prijon & Ermenc, 2009) than those who are not under the influence. Alcohol use has been difficult to measure due to deficient data collection practices and unclear legislation. Geographical analyses have suggested that the locations of alcohol outlets are associated with alcohol use and alcohol-related collisions (LaScala, Gerber& Gruenewald, 2000).

Research on the effect of the proximal environment (Meso-level):

Tay, Barua, & Kattan (2009) found that a driver leaving the collision scene without reporting it (i.e. hit and run) is associated with increased fatalities. Analysis showed that day of week, time of day, number of vehicles, pedestrian involvement, collision type, route type, median type, types of roadway segment, speed limit, traffic control devices, functioning of traffic control devices, lighting conditions, horizontal alignment, and vertical alignment of the pavement were important determinants of hit-and-run behavior in fatal collisions. This is an interesting example of the interaction among environmental features and the personal characteristics of drivers. The authors recommend enforcement efforts and the installation of cameras at intersections, especially those controlled by stop signs, where the incidents of

hit-and-run are higher. The authors added that, since divided highways are negatively correlated with hit-and-run likelihood, it may be prudent to consider the erection of median separations on roadways where such collisions are relatively common. This is also an interesting example of how researchers assume an established order as normal, recommending the installation of barriers instead of a reduction in maximum speeds. Finally, the authors suggest that transportation engineers should also consider installing street lights at these locations, along with the regular inspection and maintenance of traffic control devices to ensure that they are functioning.

A study by Paulozzi (2005) found that passenger cars and light trucks (vans, pickups, and sport utility vehicles) accounted for about 4 in every 10 pedestrian deaths. The risk of pedestrian fatality is 18% to 29% higher with elevated body vehicles like SUVs, pickup trucks, and vans (American Academy of Pediatrics, 2009).

In 2008, 48% percent of pedestrian deaths occurred in collisions between 6 pm and midnight. The largest proportion of pedestrian deaths in that year occurred in the Friday-Saturday interval (34%) while overall 72% of pedestrian deaths occurred on major roads including interstates and freeways. In urban areas, 54% of pedestrian deaths in 2008 occurred on roads with speed limits of 40 mph or less.

Research on the effect of the distal environment (Macro-level):

Despite a nationwide reduction in collisions, urban areas have accounted for a growing proportion of pedestrian death rates compared to rural areas. In 2008, 72% of pedestrian deaths occurred in urban areas up from 59% in 1975. In New York, 48% of all motor vehicle collisions involved pedestrians compared to 12% nationally (Nicaj, Wilt& Henning, 2006).

Neighborhood socioeconomic conditions seem to be related to jaywalker-car collisions (Chakravarthy et al., 2007; Cubbin, LeClere& Smith, 2000; Graham, Glaister& Anderson, 2005; Graham & Stephens, 2008). Dense, low-income, urban residential neighborhoods with a lack of play areas pose a significantly higher risk for child traffic injuries. For example, a project involving the construction and renovation of playgrounds in Harlem, New York decreased the number of pedestrian injuries involving children by 45% over a 7-year period (Ryb et al., 2007; Winkleby & Cubbin, 2003).

Suburban sprawl (areas with low population density and high automobile use) also seems to predict pedestrian fatalities. Ewing et al. (2003) created a "sprawl index" and found that for every 1% increase in the number of housing units per square mile, pedestrian fatality rates fell by 1.47% to 3.56% ($p<.001$), after adjustment for pedestrian exposure. Those results are supported by Graham & Glaister (2003) who proposed a bimodal relationship between population density and pedestrian collisions meaning that minimally (rural) and highly populated (urban) areas are less prone to having jaywalker-car collisions compared to suburban, sprawling, and medium density areas. In contrast, recent research (Cho, Rodriguez& Khattak, 2009) has established that low density residential land uses increase individual perceptions of collision risk for pedestrians. At the same time, the increased perception of risk seems to reduce actual collision rates as a result of behavioral changes.

In terms of land use, Dissanayake, Aryaija, & Wedagama (2009) concluded that educational sites, junction density, retail in primary streets, and low density residential land use types are associated with child casualties during different periods of the day and week. In the case of educational sites, results showed that the presence of a driveway or a turning bay at the school entrance decreases both collision occurrence and severity. Those results are in

keeping with the work of Clifton et al. (2009) who found that transit access and high pedestrian connectivity (such as central city areas, a high density of sidewalks, paths, amenities, and protected crosswalks) showed a negative correlation with severity of injury. Conversely, the presence of recreational facilities on the school site is positively associated with collision occurrence and also with severity of injury (Clifton, Burnier& Akar, 2009; Clifton & Kreamer-Fults, 2007). A positive correlation between the number of licensed alcohol retail establishments, especially bars and off-premise outlets, and rates of car collisions and injuries was found by Treno, Johnson, Remer, & Gruenewald (2007).

In summary, past research on jaywalker-car collisions in general indicates that those collisions are moderated by a combination of environmental and socioeconomic conditions present at different levels from the actual collision site toward distal conditions defined by characteristics of neighborhoods, cities, and regions. In the present study, it is assumed that, in the case of jaywalker-car collisions, the effect of micro-level conditions on injuries is moderated by meso- and macro-level conditions. That assumption has yet to be established with actual data.

PURPOSE OF THE STUDY

The main goal of the present research is to determine the mechanisms linking the personal characteristics of participants (micro-level), collision site characteristics (meso-level), and distal environmental conditions (macro-level) with the level of injuries sustained by pedestrians involved in jaywalker-car collisions that occurred in New Jersey between 2006 and 2009.

The selection of a specific geography (New Jersey) and time (2006-2009) is based on several circumstances. Pedestrian traffic fatalities increased in ten New Jersey counties

between 1995 and 2003 despite the fact that the numbers of people walking to work decreased in every county. A study conducted by the Surface Transportation Policy Project in 2004 reported that, although pedestrians made up twice the share of total traffic fatalities as they did nationally, New Jersey spent less of its federal transportation funds on pedestrian/bicycle projects than the nation as a whole (Ernst, 2004).

Reacting to the increase in pedestrian fatalities, then Gov. Jon Corzine announced a nearly $74 million pedestrian safety initiative about six months after he took office in 2006. The five-year program would focus on enforcement, education and engineering by cracking down on motorists and pedestrian violations (O'Neill, 2009). The New Jersey Department of Transportation (NJDOT) has made pedestrian safety a top priority. NJDOT implemented a Complete Streets policy to "enable safe access and mobility of pedestrians, bicyclists and transit users of all ages and abilities" (NJDOT, 2010b). The expected immediate effects of the Complete Streets policy are decreasing numbers of pedestrian injuries and fatalities. It is not clear whether those expectations have been met, since there was an increase of 33% in pedestrian fatalities but a decrease of 20% in jaywalker-car collisions from 2008 to 2009. The effect of proximal and distal environmental variables explaining those numbers remains uncertain. In addition, as explained further in this document, a significant improvement in the quality of collision data reporting has occurred since 2006, the year Mr. Corzine's safety initiative took off.

Results from the present research are expected to improve knowledge of causal factors for severity of injury sustained in jaywalker-car collisions. The broader impacts of this research lie in its potential to understand and inform relationships among communities'

characteristics, the urban physical environment, and variables related to the individuals involved in a collision.

PROBLEM STATEMENT

Literature suggests that jaywalker-car collisions are determined not only by personal characteristics but also by proximal and distal environmental effects. Despite the growing interest of traffic safety professionals in understanding environmental effects on pedestrian safety, past research has not systematically examined those effects on jaywalker-car collisions. Moreover, a number of those environmental variables are not currently collected by the collision reporting systems, including New Jersey's. Although much of this additional information is difficult to systematize, it is important to analyze since the inclusion of ecological elements in explanatory models might increase the predictive power of otherwise modestly explanatory models based on limited sets of personal characteristics (Winkel, Saegert& Evans, 2009). This study analyzes how proximal and distal environmental conditions interact with personal characteristics to predict severity of injury derived from jaywalker-car collisions.

RESEARCH QUESTION

Based on the Ecobehavioral Framework of Jaywalker-car collisions depicted in Figure 1 and the literature review on collisions described thus far, a relevant research question is:

> *What is the moderating effect of a set of characteristics from the proximal and distal environment on the predictive power of personal characteristics on severity of injury resulting from jaywalker-car collisions that occurred in New Jersey between 2006 and 2009?*

Following Winkel et al. (2009), this question assumes a modeling of processes by which 1) personal characteristics significantly predict the severity of injury, and 2) the proximal and distal environmental levels moderate those individual effects on injuries.

RESEARCH DESIGN AND METHODS

A quantitative approach with exploratory model building has been devised for the present research. Since relevant explanatory models for jaywalker-car collisions are nonexistent thus far, an exploratory approach to the research question was adopted. Instead of formal hypotheses, a set of motivating questions was therefore proposed. The first motivating question was 1) what personal characteristics can reasonably describe variation in the severity of injury of the jaywalkers? If a basic explanatory model at this level can be established, the next motivating questions to be answered by the research should be 2) what are the characteristics of the proximal environment that might reasonably moderate the effect of personal characteristics contributing to the severity of injury of the jaywalkers?, and 3) is the explanatory power of the model improved when a third set of variables, coming from the distal (macro) level is included?

Databases

A set of jaywalker-car collisions that occurred in New Jersey between 2006 and 2009 was selected as the base data for the study. Data for the micro level were provided by Plan4Safety, an online multi-layered decision support tool created for the New Jersey Department of Transportation (NJDOT) by the Center for Advanced Infrastructure and Transportation (CAIT) at Rutgers University. Plan4Safety updates from NJDOT's release of

collision data every six months. The database has collision data from January 1, 2003 to the current release.

Plan4Safety includes information about the collision (e.g., geographic coordinates, date, and time), the vehicles (including information on driver characteristics), and each person involved (e.g., age, sex, whether hospitalized, severity of injury). These data have been collected mainly from police reports by NJDOT, are frequently updated, checked for consistency, and standardized in cooperation with CAIT (CAIT, 2010), and are available to the research community in geospatial and tabular forms upon request. The Institutional Review Board at the Graduate Center of City University of New York granted an exemption from human subjects review according to National Institutes of Health rules for existing data "if the sources are publicly available".

Database Preparation and Selection of the Outcome Variable

A query of records with recorded date of collision equal to or later than 2006, complete geospatial information (latitude and longitude of the collision site), and positive confirmation that the pedestrian was jaywalking or walking against the light rendered a final set of 1800 records with individualized information of jaywalker-car collisions. These records constituted the base sample for the study.

Severity of injury sustained by the jaywalker was chosen as the outcome variable for several reasons. One reason has to do with policy. Literature shows that there is a lack of association between injury severity and collision frequency, suggesting that "safety programs intended to reduce the number of collisions and those intended to reduce the risk of severe injury and death should use different approaches. The latter should focus on individual factors such as driver or pedestrian actions and behaviors, as well as on road environment

factors such as speed limits and intersection signalization" (Moudon et al., 2011, p. 22). In terms of traffic safety and road design, one of the relevant indicators in decisions about how safe a segment of road seems to be is the number of collisions it sustains over a period of time and, consequently the number of people injured along with the severity of injury. Another reason to use severity of injury is due to methodological and practical reasons since most studies concentrate on the most urgent cases coded as a *KSI* (killed or severely injured) and therefore consider only those cases that result in pedestrians sustaining very severe or mortal injuries. KSI injuries are 16 times less common than less severe injuries (Ewing, Schieber& Zegeer, 2003). Therefore, injuries should be studied due to an important number of collisions with less severe injuries probably affecting different groups of society that are consistently overlooked by the researchers.

The outcome variable of the present study (severity of injury) is extracted from the official collision report currently stored in the Plan4Safety database. It is coded as an ordinal scale ranging from 0 (no injuries reported) to 4 (pedestrian deceased).

Explanatory Variables

The literature review and the availability of data from the Plan4Safety database informed the initial selection of explanatory variables for this study. The Plan4Safety database provided all the information about the micro-level and some of the meso-level variables (See below). For the remainder of the meso-level variables, information was gathered from visual displays of collision sites available online through the commercial software Google Maps and its option Street View (GSV). According to information published on their site, Street Maps provides users 360° horizontal and 290° vertical panoramic street level views. Google collects these images using special cameras and

equipment that capture and match images of a specific location using GPS devices onboard moving vehicles. Once the images are captured, they are "sewn" together to create a 360° panorama. Faces and license plates are blurred before the panorama images are made public in Google Maps. Street View imagery is limited to public streets where most of the collisions included in the present research occurred.

Macro-level variables were extracted from the U.S. Census Bureau's American FactFinder online database. Alternate sources for some of the variables at the macro level are described below.

Micro Level (Individual Attributes and Actions) Variables

A set of personal characteristics of drivers and jaywalkers were extracted from the Plan4Safety dataset. Since most of those potential predictors were originally coded into categorical lists, dichotomous (dummy) variables were created to facilitate the computation and interpretation of results from the analysis. Table 1 shows a summary for each predictor at this level.

Description of explanatory variables for the micro-level

– **Pedestrian's age in years**. Level of measurement is a continuous variable. **CPAGE** is the mean centered version of the variable. Source: Plan4Safety database.

– **Female Pedestrian?** (**PFEM):** Dummy variable with 0=No, 1=Yes. Source: Plan4Safety database.

– **Pedestrian apparently normal? (PNORM):** Indicates whether the pedestrian looked apparently normal and not under the influence of drugs or medication. Not necessarily alcohol related. Dummy variable with 0=No, 1=Yes. Source: Plan4Safety database.

– **Dark clothes? (PDARKC):** Indicates whether the pedestrian was wearing dark clothing. Dummy variable with 0=No, 1=Yes. Source: Plan4Safety database.

– **Pedestrian inattentive? (PINAT):** Indicates whether the pedestrian was inattentive while crossing. Dummy variable with 0=No, 1=Yes. Source: Plan4Safety database.

– **Pedestrian run/dart? (PRUNDAR):** Indicates whether the pedestrian was running or darting from road's edge. Dummy variable with 0=No, 1=Yes. Source: Plan4Safety database.

– **Driver's age in years.** Level of measurement is continuous as an interval between 0 and highest age. **CDAGE** is the mean centered version of the variable. Source: Plan4Safety database.

– **Female driver? (DFEM):** Dummy variable with 0=No, 1=Yes. Source: Plan4Safety database.

– **Driver inattentive? (DINAT):** Indicates whether the driver was inattentive while driving. Dummy variable with 0=No, 1=Yes. Source: Plan4Safety database.

– **Driver speeding? (DSPD):** Indicates whether the driver was speeding. Dummy variable with 0=No, 1=Yes. Source: Plan4Safety database.

– **Vehicle straight? (DSTRAIG):** Indicates whether the vehicle was on a straight trajectory before the collision. Dummy variable with 0=No, 1=Yes. Source: Plan4Safety database.

– **Driver apparently normal? (DNORM):** Indicates whether the driver looked apparently normal and not under the influence of drugs or medication. Not necessarily

alcohol related. No objective test was used. Dummy variable with 0=No, 1=Yes. Source: Plan4Safety database.

In the case of type and year of the car, it was assumed that those characteristics were under the direct control of the driver and were therefore included in this level.

– **SUV? (SUV):** Indicates whether the vehicle type was a Sports Utility. Dummy variable with 0=No, 1=Yes. Source: Plan4Safety database.

– **Vehicle's year:** Vehicle's year of production. Level of measurement is continuous. **CVYEAR** is the mean centered version of the variable. Source: Plan4Safety database.

Table 1. Description of explanatory variables for the micro-level

A Acronym	B Description	C Min Max	D Missing data
cPAGE	Pedestrian's Age in years (MEAN CTD)	0-93	7.5%
PFEM	Female Pedestrian?	0,1	2.1%
PNORM	Pedestrian apparently normal, not under influence?	0,1	26.7%
PDARKC	Pedestrian wearing dark clothing?	0,1	7.3%
PINAT	Pedestrian inattentive?	0,1	7.3%
PRUNDAR	Pedestrian running or darting?	0,1	7.3%
cDAGE	Driver's age in years (MEAN CTD)	16-93	9.1%
DFEM	Female Driver?	0,1	7.6%
DINAT	Driver inattentive?	0,1	2.1%
DSPD	Driver apparently speeding?	0,1	2.1%
DSTRAIG	Vehicle traveling straight ahead?	0,1	0.8%
DNORM	Driver apparently normal, not under influence?	0,1	10.8%
SUV	Was the vehicle type a Sports Utility?	0,1	1.3%
cVYEAR	Vehicle's year of production (MEAN CTD)	1976-2010	8.1%

Meso Level (Proximal Dimension) Variables

This level was defined as the area surrounding every collision. Since information about the route number and precise milepost of the collision were included in the Plan4Safety database, a proximal area of ±0.5 miles was calculated for every occurrence. Collisions that occurred in the same area were nested into units named SPOTS. Using the

latitude and longitude of the collision site as the center of a circumference, it was therefore necessary to define the ratio of that circumference in order to circumscribe the observation of characteristics relative to a specific SPOT. Past research varies in the definition of this ratio. In their study of pedestrian-car collisions in Washington, Moudon and collaborators suggested an airline buffer radius from each collision point of 0.5km or around 1650 feet (Moudon et al., 2011). A close reading of J.J. Gibson's concept of the field of safe travel suggests that the buffer should be smaller to capture the proximal character of the field (Gibson & Crooks, 1938) although no specific distance was given. For the purposes of the present research, it has been considered that the buffer area should be approximately equal to the vision range of a pedestrian as she stands in the center of the circumference in an urban road setting. This vision range has been set to approximately 1300 feet.

As noted earlier, some of the variables included at the meso-level are taken from the Plan4Safety dataset. Some additional meso-level variables are taken from the New Jersey Department of Transportation (NJDOT) 2009 Straight Line Diagrams (SLD). These diagrams are a way to view roadways in a line format (See Appendix 1 for an example). The SLD cover approximately 12,000 miles of State (Interstate, US and NJ numbered roads), National Highway System (NHS), Surface Transportation Program (STP) and all County routes. The remainder of the variables at the meso-level was extracted from pictures available at the Google Street View (GSV) online service.

Table 2 shows a summary for each predictor at this level.

Description of explanatory variables for the meso-level

– **Straight and level segments:** Proportion of segments that are straight and also have a leveled surface within each SPOT. Level of measurement is continuous as an interval

between 0 and 1. **cSTRLVL** is the mean centered version of the variable. Source: Plan4Safety.

– **Lane markings:** Proportion of segments within each SPOT that have clearly defined lane markings making it clearer for both pedestrians and drivers to determine where the different components of the road are located. Level of measurement is continuous as an interval between 0 and 1. **cMARKS** is the mean centered version of the variable. Source: Plan4Safety.

– **Dry surface:** Proportion of segments within each SPOT that had a dry pavement when the collision happened. Level of measurement is continuous as an interval between 0 and 1. **cSDRY** is the mean centered version of the variable. Source: Plan4Safety.

– **Daylight condition:** Proportion of segments within each SPOT that had a collision during daylight hours. Level of measurement is continuous as an interval between 0 and 1. **cDAYLT** is the mean centered version of the variable. Source: Plan4Safety.

– **Weekend:** Proportion of segments within each SPOT that had a collision between Friday, 6pm and Monday, 6am. Level of measurement is continuous as an interval between 0 and 1. **cWKEND** is the mean centered version of the variable. Source: Plan4Safety.

– **Summer:** Proportion of segments within each SPOT that had a collision from June, 22nd. to September, 23rd. Level of measurement is continuous as an interval between 0 and 1. **cSUMMER** is the mean centered version of the variable. Source: Plan4Safety.

– **Green division:** Proportion of segments within each SPOT that have a median division consisting of grass or similar vegetation. Level of measurement is

continuous as an interval between 0 and 1. **cRDGRDIV** is the mean centered version of the variable. Source: Plan4Safety.

– **Posted speed limit:** Mean posted speed limit at crash sites composing the SPOT. Level of measurement is continuous. **cSPEED** is the mean centered version of the variable. Source: NJDOT-SLD.

– **Distance to intersection:** Mean distance in feet from the collision site to the nearest intersection at crash sites composing the SPOT. It is expected that greater distances are associated with more severe injuries. Level of measurement is continuous. Due to high skewness in the original distribution, a transformation into natural logarithm of the original score was computed. **cLNDINT** is the mean centered version of the variable. Source: Google Earth and NJDOT-SLD.

– **Road width:** Mean width in feet of the road segments at crash sites composing the SPOT. Level of measurement is continuous. **cROADW** is the mean centered version of the variable. Source: NJDOT-SLD.

– **Height of road median division:** Mean height in feet of the median division of road segments at crash sites composing the SPOT. Level of measurement is continuous. **cMEDIANH** is the mean centered version of the variable. Source: NJDOT-SLD.

– **Median width:** Mean width in feet of the median division of road segments at crash sites composing the SPOT. Level of measurement is continuous as an interval between 0 and the highest number. **cMEDIANW** is the mean centered version of the variable. Source: NJDOT-SLD.

– **Annual Average Daily Traffic (AADT):** Average volume for all lanes in both directions of road segments at crash sites composing the SPOT. It represents the average of

all days during the year with typical traffic conditions, according to the Traffic Monitoring Guide published by the Federal Highway Administration. Level of measurement is continuous. **cAADT** is the mean centered version of the variable. Source: NJDOT-SLD. Since AADT is calculated for major arterials and highways only, this variable was eliminated from the analysis.

– **Distance to public transportation:** Average distance in statute miles from the collision site to the nearest bus stop at crash sites composing the SPOT. It is expected that greater distances are associated with more severe injuries. Level of measurement is continuous as an interval between 0 and the maximum distance. Due to high skewness and kurtosis in the original distribution, a transformation into natural logarithm of the original score was computed. **cLNDPUB** is the mean centered version of the variable. Source: Google Maps.

– **Cars parked:** Average number of cars parked in both sides of the road at crash sites composing the SPOT. Level of measurement is continuous as an interval between 0 and highest number. **cCPARKED** is the mean centered version of the variable. Source: GSV.

– **Nearby recreation:** Percentage of the total visual range that is covered by a park, playground, or similar recreation area at crash sites composing the SPOT. Level of measurement is continuous as an interval between 0 and 100. **cRECREA** is the mean centered version of the variable. Source: GSV.

– **Street furniture:** Average number of benches, bollards, mailboxes, phone boxes, streetlamps, transit stops, taxi stands, public lavatories, fountains, memorials, and waste bins at crash sites composing the SPOT. Level of measurement is continuous as an

interval between 0 and highest number. **cFURNIT** is the mean centered version of the variable. Source: GSV.

Walkability: An average of a calculated score from two different indicators. The first indicator is the specific *walkscore* from the collision site (For a detailed methodology see Walkscore, 2010). Although information coming from walkscore.com is not directly visible to the jaywalker, it is assumed that amenities in the area shape the proximal characteristics of environmental influences. Walkscore.com is a publicly available online database of amenities for pedestrians in a number of metropolitan areas of the United States. Past research has associated the prediction of whether people walk with the number of nearby amenities in a neighborhood (Ewing & Cervero, 2010; Hoehner et al., 2005). Walkscore measures how easy it is to walk to amenities, not how attractive the area is for walking. According to information on their site, the Walkscore algorithm awards points based on the distance to amenities in each category. If an amenity is within 0.25 miles (0.4 km), the maximum number of points is assigned. The number of points declines as the distance approaches 1 mile (or 1.6 km) and no points are awarded for amenities further than 1 mile. Walkscore also incorporates how many intersections there are in a square mile, how many roads go into each intersection (e.g. a 4-way intersection is more walkable than a 1-way cul-de-sac), and block length as another proxy for pedestrian friendliness. The points are summed and normalized to yield a score from 0-100.

The second variable used in the calculation of walkability is the percentage of the total visual range that is covered by a sidewalk in operable condition at crash sites composing the SPOT. It is assumed that this second variable weights (improves the quality) of the quantitative information included in a particular walkscore by including information regarding the

amount and quality of the sidewalk network in the SPOT. Walkability is calculated from the following formula:

Walkability = (walkscore * sidewalk) / 100

Level of measurement is continuous as an interval between 0 and 100. **cWALK** is the mean centered version of the variable. Source: GSV and Walkscore.com.

Although this variable was originally meant to be aggregated as a macro-level indicator, it was considered that prediction of injuries would be more accurate if specific information on access and use of walking facilities proximate to the collision site was included. For analyses using all available data, the walkability index was used. For the analyses using a subset of roads with posted speed limits less than 30 MPH, only the percentage of the total visual range that is covered by a sidewalk in operable condition at crash sites composing the SPOT was used. The reason for this is that in those settings, the Walkscore variable did not show adequate variation, resulting in a lack of predictive power of the combined variable.

– **Traffic signs:** Average number of barriers, traffic lights, and traffic signs at crash sites composing the SPOT. Level of measurement is continuous. This information was very difficult to gather from GSV photos and therefore it was a high proportion of missing values. **cTSTUFF** is the mean centered version of the variable. Source: GSV. Due to the high proportion of missing data (63.6%), this variable was not included in most analyses.

Table 2. Description of explanatory variables for the meso-level

A Acronym	B Description	C Min Max	D Missing data
cSTRLVL	Road segment straight and level?	0-1	0%
cMARKS	Lane divisions painted?	0-1	3.4%
cSDRY	Road surface dry?	0-1	0%
cDAYLT	Daylight?	0-1	0%
cWKEND	Weekend?	0-1	0%
cSUMMER	Summer?	0-1	0%

cRDGRDIV	Green division?	0-1	0%
cSPEED	Posted speed limit	25-65	3.5%
cLNDINT	Log distance to closest intersection	0-8.57	0%
cROADW	Road width in feet	16-312	0%
cMEDIANH	Height of the median	0-3	0%
cMEDIANW	Width in feet of the median	1-104	0%
cLNDPUB	Log distance to public transportation	0-1	0%
cCPARKED	Number of cars parked	0-1	0.1%
cRECREA	Percentage of view with recreation areas	0-100	0%
cWALK	Walkability	0-100	0%

Macro Level (Distal Dimension) Variables

Information regarding the distal characteristics of environmental influences was gathered at the level of zip codes from the U.S. Census website and two websites: walkscore.com and abogo.org. This level was originally meant to represent the neighborhood level. Nonetheless, socioeconomic information is not disaggregated for several neighborhoods in New Jersey. Due to that technical constraint, the zip code-level information was used as a proxy for neighborhood-level data.

Description of explanatory variables for the macro-level

– **Monthly transportation costs at the zip code of collision:** Level of measurement is continuous as an interval between 0 and the highest amount. **cTRANSPORT** is the mean centered version of the variable. Source: Walkscore.com.

– **Distance from pedestrian zip code to crash site:** An estimate of the average distance in miles to the crash site for an average household based on the pedestrian's zip code. For this research, it is assumed that pedestrians experiencing longer distances might also have increased risk of severe injuries due to exposure to traffic. Level of measurement is continuous. Due to high skewness in the original distribution, a transformation into natural

logarithm of the original score was computed. **cPLNDIST** is the mean centered version of the variable. Source: maps.google.com.

– **Household income (in dollars of 1999) of pedestrian zip code:** An estimate of average income in 1999 dollars for an average household based on the pedestrian's zip code. It is used as a "proxy" for actual pedestrian's income. For this research, it is assumed that pedestrians living in neighborhoods with lower income levels could also have increased risk of severe injuries due to the increased exposure to risk. Level of measurement is continuous. Due to high skewness and kurtosis in the original distribution, a transformation into natural logarithm of the original score was computed. **cLNPINC99** is the mean centered version of the variable. Source: U.S. Census.

– **Monthly transportation costs at zip code of pedestrian:** An estimate of average monthly transportation costs in dollars for an average household at pedestrian's zip code, including commuting, errands, and all other trips around town. It takes into account money spent on car ownership and use as well as public transit use (CTOD, 2006). For this research, it was assumed that pedestrians with lower transportation costs were walking or using public transportation and also could have experienced greater risk of severe injuries due to increased exposure to risk. Level of measurement is continuous. **cPTCOST** is the mean centered version of the variable. Source: abogo.org.

– **Monthly carbon dioxide (CO2) generated from vehicle use at zip code of pedestrian:** An estimate of average monthly carbon dioxide emissions in metric tons per month for an average household at pedestrian's zip code. For this research, it is assumed that pedestrians with lower CO2 emissions generated at their zip codes (meaning lower car

density in the places they live) had to do more walking and therefore could have experienced more severe injuries due to increased risk exposure. Level of measurement is continuous. **cPTCO2** is the mean centered version of the variable. Source: abogo.org.

– **Population density:** Average number of people per square mile at crash sites in SPOTS located at the ZIP CODE level. It is expected that higher densities are associated with less severe injuries due to reduced speeds. Level of measurement is continuous. Due to high skewness and kurtosis in the original distribution, a transformation into natural logarithm of the original score was computed. **cLNDENS** is the mean centered version of the variable. Source: U.S. Census.

– **Poverty level in 1999:** Percentage of people living under the level of poverty in 1999 at crash sites in SPOTS located at the ZIP CODE level. It is assumed that higher percentages are associated with more severe injuries due to increased exposure to road risks. Level of measurement is continuous as an interval between 0 and 100. **cPOV99** is the mean centered version of the variable. Source: U.S. Census.

– **Minorities (Blacks) in 1999:** Percentage of Black population in 1999 in SPOTS located at the ZIP CODE level. It was assumed that higher percentages are associated with more severe injuries due to increased exposure to road risks as a consequence of lack of adequate infrastructure for safe walking. Level of measurement is continuous as an interval between 0 and 100. **cBLACK** is the mean centered version of the variable. Source: U.S. Census.

– **Minorities (Latinos) in 1999:** Percentage of Latino population in 1999 at crash sites in SPOTS located at the ZIP CODE level. It was expected that higher percentages are associated with more severe injuries due to increased exposure to road risks as a

consequence of lack of adequate infrastructure for safe walking. Level of measurement is continuous as an interval between 0 and 100. **cLATIN** is the mean centered version of the variable. Source: U.S. Census.

Indicators for this level are shown in Table 3:

Table 3. Description of explanatory variables for the macro-level

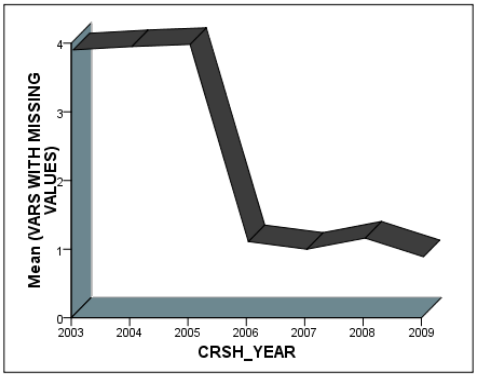
A Acronym	B Description	C Min Max	D Missing data
cTRANSPORT	Monthly transp costs at zip code of collision	237-1102	0%
cPLNDIST	Log distance from ped zip code to crash site	-5.3 – 7.4	4.9%
cPINC99	Log HH income at ped zip code	9.5 – 12.13	5%
cPTCOST	Monthly transp costs at ped zip code	236 – 1157	5.1%
cPTCO2	Monthly tons of transp. CO2 at ped zip code	.17 – 1.31	5.1%
cPOPDENS	Log people per square mile	2.89 – 10.81	0%
cPOV99	% of people under level of poverty in 1999	0 – 33	0%
cBLACK	% of Blacks in 1999	0 – 90	0%
cLATIN	% of Latinos in 1999	0 - 75	0%

Strategy for Data Analysis

Missing Data

Although information from 2003 to 2010 is available in Plan4Safety, only data from 2006 to 2009 were used for analysis due to a significant amount of missing data in the set of years from 2003 to 2005. As shown in Graph 1, there is a substantial decrease in the average number of micro-level variables with missing values in the dataset starting in 2006.

Graph 1: Average number of missing values by year of collision



However, even using data from 2006 to 2009 there still was an important amount of missing data. Approximately 86.6% of cases had at least one missing value among the micro-level variables. A regression analysis using the number of missing values at the micro-level variables to severity of injury was not significant (except for data of year 2008). In order to work with a dataset as complete as possible, a data imputation strategy was used.

A multiple imputation strategy was followed to complete data containing missing values. With multiple imputation, each of the simulated complete datasets is analyzed by standard methods and the results are combined to produce estimates and confidence intervals that incorporate missing-data uncertainty "even under the assumption of high rates of missing information" (Rubin, 1987, p. 114). The number of imputations recommended varies with rate of missing information and sample. Due to the characteristics of the dataset for the present study with fractions of missing information at the micro-level relatively low (< 30%, see Table 4), a total of ten imputation datasets were generated at each level using SAS MI procedure version 9.2.

Table 4. Missing value characteristics for Micro-Level variables

Variable	N	Un-centered Mean	Std. Deviation	Missing	
				Count	Percent
cPAGE	1665	36.15	21.004	135	7.5
cDAGE	1636	43.37	17.463	164	9.1
cVYEAR	1655	2000.39	5.077	145	8.1
PFEM	1762			38	2.1
PNORM	1319			481	26.7
PDARKC	1669			131	7.3
PINAT	1669			131	7.3
PRUNDAR	1669			131	7.3
DFEM	1664			136	7.6
DINAT	1763			37	2.1
DSPD	1763			37	2.1
DSTRAIG	1786			14	0.8
DNORM	1606			194	10.8
SUV	1777			23	1.3

a. Number of cases outside the range (Q1 - 1.5*IQR, Q3 + 1.5*IQR).

Data Exploration

The first step in analysing the data involved data exploration asking the following questions (Zuur, Ieno& Smith, 2007, p. 23): 1. Where are the data centered? How are they spread? Are they symmetric, skewed, bimodal? 2. Are there outliers? 3. Are the variables normally distributed? 4. Are there any relationships between the variables? Are relationships between the variables linear? Which follow-up analysis should be applied? 5. Are transformations needed? 6. Is there any kind of nesting/dependence in the set of explanatory variables?

Violation of the assumptions for Ordinary Least Squares (OLS) was monitored during the analysis phase. Although violation of normality is not a serious problem in

regression, both heteroskedasticity and lack of independence are. The residuals of the models in this study were not assumed as normally distributed with mean 0 and variance σ^2. It was assumed that the data are heteroskedastic and spatially dependent. These assumed characteristics and their consequences are addressed in the Results section.

Model Development:

The performance of a predictive model is overestimated when simply determined using the sample of subjects that was used to construct the model (Steyerberg et al., 2001). In data-splitting, "a random portion of the sample is used for all model development (data transformations, stepwise variable selection, testing interactions, estimating regression coefficients, etc.). That model is 'frozen' and applied to the remaining sample for computing calibration statistics" (Harrell, Lee& Mark, 1996, p. 371). For the current analyses, after the basic exploratory questions were answered and the intercept-only model fixed by using the whole dataset (See Results section below), the dataset was split into two subsets: an exploratory subset (model building) of exactly 900 cases and a confirmatory subset (model validation) of exactly 900 cases. To confirm the randomness of group assignment of cases, INJURY was regressed on group (0=exploratory, 1=confirmatory). Results of the regression were not significant $F(1, 1798) = .111$, $p = .739$).

As per the explanatory model development, the conceptual logic of the multilevel framework introduced in Figure 4 was followed. A hierarchical structure of mixed effects on the outcome variable (individual injuries) was assumed. To study the effects on the outcome variable by variables at different levels, a multilevel linear modeling (MLM) analytical strategy was implemented. In matrix form, the multilevel model can be written as shown in Equation 1:

$$\mathbf{y}_i = \mathbf{X}_i\boldsymbol{\beta} + \mathbf{Z}_i\mathbf{b}_i + \boldsymbol{\varepsilon}_i \qquad \textbf{(Eq.1)}$$
$$\mathbf{b}_i \sim \mathbf{N}_q(\mathbf{0},\boldsymbol{\Psi})$$
$$\boldsymbol{\varepsilon}i \sim \mathbf{N}_{ni}\,(\mathbf{0},\sigma^2\boldsymbol{\Lambda}_i)$$

where group=spot(zip code), and
$\mathbf{y}_i$ is the $n_i \times 1$ severity of injury vector for collisions in the *i*th group.
$\mathbf{X}_i$ is the $n_i \times p$ model matrix for the fixed effects for collisions in the *i*th group.
$\boldsymbol{\beta}$ is the $p \times 1$ vector of fixed-effect coefficients.
$\mathbf{Z}_i$ is the $n_i \times q$ model matrix for the random effects for collisions in the *i*th group.
$\mathbf{b}_i$ is the $q \times 1$ vector of random-effect coefficients for the *i*th group.
$\boldsymbol{\varepsilon}_i$ is the $n_i \times 1$ vector of errors for observations in the *i*th group.
$\boldsymbol{\Psi}$ is the $q \times q$ covariance matrix for the random effects.
$\sigma^2\boldsymbol{\Lambda}_i$ is the $n_i \times n_i$ covariance matrix for the errors in the *i*th group.

Under MLM, the regression intercepts and slopes at the micro level may be treated as random effects of the higher meso, and macro levels. According to Garson (2011), there are three main advantages of MLM over Ordinary Least Squares to study the covariances in a multileveled structure of data:

1. *Random effects*: where the set of values of a categorical predictor variable are seen not as the complete set but rather as a random sample of all values. Through random effects models, it is possible to make inferences over a wider population in MLM than possible with General Linear Modeling (GLM).
2. *Hierarchical effects*: where predictor variables are measured at more than one level (for example, severity of injury explained by jaywalker's age at the micro level and average distance to public transportation at the macro level of cities).
3. *Dependence*: where observations are correlated rather than independent (for example, a number of jaywalker-car collisions are geographically close and therefore they share meso or macro-level characteristics).

For this study, a combination of route number and milepost (rounded to the next integer) were used to define the meso-level grouping variable. In terms of this study, those spots were considered as topographic proxies for what Roger Barker defined as behavior settings. A total of 1325 spots were defined by this method. For the macro-level grouping variable, the zip code category was used. A total of 348 zip codes were identified as having at least one collision in the sample.

In terms of specific analyses, the strategy for multi-level modeling suggested by Hox (1995, reproduced in Garson, 2011) was followed. That strategy recommends the following procedure for multi-level analysis:

1. Compute deviance for the baseline (null) model which includes only the intercept.

The motivation for this basic model was the question on how much spots nested into zip codes (behavior settings) vary in their mean severity of injury. For a detailed explanation, see Singer (1998). Following Hox's procedure, an unconditional means model was fixed as shown in Equation 5 (Based on Hawkley, Preacher& Cacioppo, 2007):

The Level 1 (individual level) submodel is:

$$Y_{ijk} = \pi_{0jk} + \varepsilon_{ijk}, \quad \varepsilon_{ijk} \sim N(0, \sigma_{\varepsilon}^2) \qquad \textbf{Eq.2}$$

where, here Y_{ijk} represents severity of injury at INDIVIDUAL i on SPOT j for ZIPCODE k, π_{0jk} represents the mean severity of injury on SPOT j for ZIPCODE k, and. ε_{ijk} represents the deviation of Y_{ijk} from π_{0jk}. The Level 2 (SPOT-level) model is:

$$\pi_{0jk} = \beta_{00k} + r_{0jk}, \quad r_{0jk} \sim N(0, \tau_{\pi}) \qquad \textbf{Eq.3}$$

where β_{00k} represents the mean severity of injury for ZIPCODE k and r_{0jk} represents the deviation of r_{0jk} from β_{00k}, or the random effect for SPOT j. The Level 3 (ZIPCODE-level) model is:

$$\beta_{00k} = \gamma_{000} + \mu_{00k}, \quad \mu_{00k} \sim N(0, \tau_\beta) \qquad \textbf{Eq.4}$$

where γ_{000} represents the grand mean and μ_{00k} represents the deviation of β_{00k} from γ_{000}. Combining Equations 2, 3 and 4 yields the following composite model equation:

$$Y_{ijk} = \gamma_{000} + \mu_{00k} + r_{0jk} + \varepsilon_{ijk} \qquad \textbf{Eq.5}$$

The unconditional model was used as the base of comparison for subsequent models that included progressively higher levels of information.

2. Compute deviance for the model with the base level independent variables included and the variance components of the slopes constrained to zero (that is, for the fixed model). Regarding the first motivating question (*what personal characteristics can reasonably describe variation in the severity of injury of the jaywalkers?*), a core set of micro-level variables was used to predict severity of injury under the nested effects assumption.

3. Use a chi-square difference test to see if the fixed model has a significantly better fit than the baseline model. If it does, proceed to investigate higher level modifier variables using random effects and/or random coefficients models. Also, assess the relative contribution of the base level independent variables. Drop non-significant base level independents and covariances from the model.

4. Identify which base-level regression slopes have significant variance across upper level groups. Compute -2LL for the model with the variance components of the base-level

slopes constrained to zero only for the slopes which do not have significant variance across upper level groups.

5. Add upper level modifier variables, determining which improve model fit. Drop modifier variables which do not improve model fit.

6. Add cross-level interactions between explanatory modifier variables and base level independent variables that had slope variance (in step 3). Drop interactions which do not improve model fit.

The strategy suggested by Hox, follows the general protocol for model selection recommended by Zuur et al. (2009) that starts with a model that is close to optimal in terms of fixed components. This means a model that contains only the relevant explanatory variables.

Interactions

A necessary step to answer the motivating questions involved an examination of the interactions of the previously defined relevant main effects. According to the review of past research, a number of interactions between the explanatory variables could be reasonably expected in the present dataset. Since the motivating questions for this study were concerned more with inter-level interactions, no intra-level interactions where assumed at levels 2 and 3. At the level-1 model, it is plausible to expect that running or darting from the sidewalk is associated with jaywalkers' age. This kind of collision involves mainly small children (American Academy of Pediatrics, 2009). It is also reasonable to expect that speeding drivers or drivers under the influence of medication and drugs have more trouble detecting jaywalkers who run or dart with enough time to reduce their speed thus resulting in more severe injuries. Finally, in terms of visibility it is expected that pedestrians wearing dark

clothing have an increased risk of injuries when the driver was inattentive, speeding or under the influence (Ryb et al., 2007).

Following the motivating questions and past literature on this topic, a number of interactions were considered plausible between levels 2 - 3, and the level-1 predictors. Those plausible interactions are described in Table 5:

Table 5. Plausible interactions between micro level and other levels

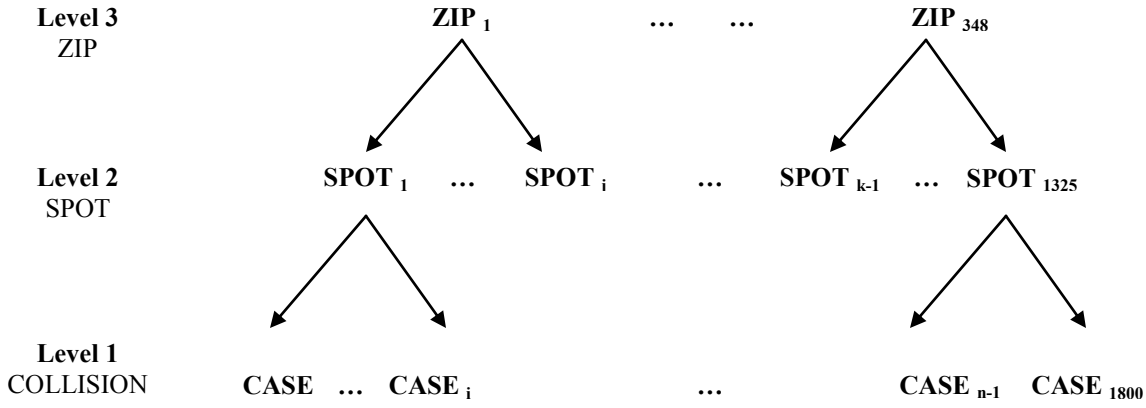
#	Interaction	Description
1	cPAGE* cSDRY	Older jaywalkers sustain more severe injuries when they jaywalk on less dry surfaces
2	cPAGE* cWKEND	Younger jaywalkers sustain more severe injuries on weekends
3	cPAGE* cDAYLT	Younger jaywalkers sustain more severe injuries during the day
4	cPAGE* cSUMMER	Younger jaywalkers sustain more severe injuries on summer days
5	cPAGE* cDINTERS	Younger jaywalkers sustain more severe injuries if away from intersections
6	cPAGE* cLNDPUB	Older jaywalkers sustain more severe injuries if away from public transportation
7	cPAGE* cCPARKED	Younger jaywalkers sustain more severe injuries if a high number of cars are parked on the curbside
8	cPAGE* cRECREA	Younger jaywalkers sustain more severe injuries when close to recreation areas
9	PNORM * cWKEND	Jaywalkers under the influence sustain more severe injuries on weekends
10	PDARKC * cSDRY	Jaywalkers wearing dark clothes sustain more severe injuries when they jaywalk on less dry surfaces
11	PDARKC* cCPARKED	Jaywalkers wearing dark clothes sustain more severe injuries if a high number of cars are parked on the curbside
12	PRUNDAR* cDINTERS	Jaywalkers who run or dart sustain more severe injuries if away from intersections
13	PRUNDAR* cDINTERS	Jaywalkers who run or dart sustain more severe injuries if away from intersections
14	cPAGE* cLNDPUB	Older jaywalkers sustain more severe injuries if away from public transportation
15	cPAGE* cCPARKED	Younger jaywalkers sustain more severe injuries if a high number of cars are parked on the curbside
16	cPAGE* cRECREA	Younger jaywalkers sustain more severe injuries when close to recreation areas

RESULTS

Before beginning with model building, a data exploration process describing the characteristics of the sample studied was followed.

There were 348 zip codes with 1325 data points (Route Number>Milepost) collected from 1800 collisions occurring between 2006 and 2009. This is considered a sufficiently large sample size for MLM and no model convergence difficulties were anticipated. Figure 4 shows the layout for the data arranged as a multilevel structure.

Figure 4: Data layout



Adapted from Tabachnick & Fidell (2006, p. 836)

An inspection of the distributional characteristics of the outcome variable showed that based on skewness (.691) and kurtosis (.189), the outcome variable can be considered normally distributed for this dataset (See Table 6a).

Table 6a. Descriptive Statistics for severity of injury

N	Valid	1800
	Missing	0
Mean		1.64
Median		1.00
Std. Deviation		.970
Skewness		.691
Std. Error of Skewness		.058
Kurtosis		.189
Std. Error of Kurtosis		.115
Minimum		0
Maximum		4

Table 6b. Levels of severity of injury

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	None/Not established	129	7.2	7.2	7.2
	Complaint of Pain	787	43.7	43.7	50.9
	Moderate Injury	591	32.8	32.8	83.7
	Incapacitated	184	10.2	10.2	93.9
	Killed	109	6.1	6.1	100.0
	Total	1800	100.0	100.0	

Frequencies for the nominal levels of severity of injury are shown in Table 6b. Most injuries can be considered minor with approximately 5 out of every 10 jaywalkers not reporting symptoms or reporting pain only. Less than 2 out of every 10 individuals suffered serious or lethal injuries. This result confirms the findings by Ewing and colleagues (2003) who established that KSI injuries in pedestrians are much less common than minor injuries. Including different levels of severity of injuries into the explanatory model improves the variance in the outcome and increases the chances for predictors to be significant.

The next step of the analysis was mean-centering all the continuous predictors to make the results more interpretable. Tables 7a, 7b, and 7c show the original means as a reference for interpretation of the results whenever models are completed.

Table 7a. Statistics for the explanatory variables of the micro-level. Original scores.

		Mean	Std Dev	Max	Min		
cPAGE		36.15	21.00	93	0		
cDAGE		43.37	17.46	93	16	**Cases**	**%**
PFEM	YES					764	43.4%
	NO					998	56.6%
PNORM	NO					239	18.1%
	YES					1080	81.9%
PDARKC	NO					1390	83.3%
	YES					279	16.7%
PINAT	NO					1374	82.3%
	YES					295	17.7%
PRUNDAR	NO					1164	69.7%
	YES					505	30.3%
DFEM	NO					994	59.7%
	YES					670	40.3%
DINAT	NO					1346	76.3%
	YES					417	23.7%
DSPD	NO					1729	98.1%
	YES					34	1.9%
DNORM	NO					24	1.5%
	YES					1582	98.5%
DSTRAIG	NO					425	23.8%
	YES					1361	76.2%

Table 7b. Statistics for the explanatory variables of the meso-level. Original scores.

Variable	N	Minimum	Maximum	Mean	Std. Deviation
cSTRLVL	1800	.00	1.00	.8483	.32490
cMARKS	1738	.00	1.00	.4124	.44710
cSDRY	1800	.00	1.00	.7856	.34697
cDAYLT	1800	.00	1.00	.7911	.34602
cWKEND	1799	.00	1.00	.5106	.43941
cSUMMER	1800	.00	1.00	.3333	.40123
cSTRLVL	1800	.00	1.00	.2322	.36246
cRDGRDIV	1800	.00	1.00	.05	.21
cSPEED	1737	25.0	65.0	31.3	8.5
cLNDINT	1800	.00	8.57	3.9038	1.34158
cROADW	1800	16.0	281.0	47.1	17.2
cMEDIANH	1800	.00	3.00	.2578	.70015
cMEDIANW	1800	.00	104.00	1.9246	6.61647
cLNDPUB	1800	-10.87	2.48	-2.72	1.45
cCPARKED	1799	.00	60.00	7.78	9.82
cRECREA	1800	.00	90.00	4.37	12.09
cWALK	1800	0	100	58	28.5

Table 7c. Statistics for the explanatory variables of the macro-level. Original scores.

Variable	N	Minimum	Maximum	Mean	Std. Deviation
cTRANSPORT	1800	237.0	1102.0	769.6	122.2
cPLNDIST	1711	-5.3	7.4	.8	1.4
cPINC99	1710	9.5	12.1	10.8	.38
cPTCOST	1708	236	1157	796.35	141.957
cPTCO2	1708	.17	1.31	.6199	.25625
cPOPDENS	1800	2.79	10.81	8.5452	1.02780
cPOV99	1800	0	33	9.49	7.826
cBLACK	1800	0	90	22.51	22.791
cLATIN	1800	0	75	17.32	15.474

Initial data exploration focused mainly on the detection of possible influential data points in the level-1 variables and the detection of collinearity in that group of explanatory variables. In order to study possible influential data points at this level, a check of multivariate influential data points through regular OLS regression showed no signs of extreme observations. Regarding possible collinearity, after mean-centering the continuous predictors the correlation matrix for the predictive variables showed low to moderate correlations (See detailed correlation estimates in Appendixes 2 to 5).

Based on the distributional skewness and kurtosis indicators, no further transformations were considered necessary.

Model Building: The Intercepts-Only Model

The limited explanatory power of traditional OLS along with violation of independence implicit in the hierarchical approach motivated a multilevel analytical procedure.

To answer the motivating questions, Hox's (1995, reproduced in Garson, 2011) step one was first followed. Deviance for the baseline model which included only the intercept was computed. Table 8 shows the results of that intercept-only model:

Table 8. Unconditional means (intercepts-only) model

Model Information

Dependent Variable: INJURY
Covariance Structure: Variance Components
Subject Effect: SPOT(ZIP)
Estimation Method: ML
Fixed Effects SE Method: Empirical
Degrees of Freedom Method: Containment
Columns in X: 1
Columns in Z Per Subject: 1
Subjects: 1381
Max Obs Per Subject: 14
Number of Observations Used: 1800
Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Subject	Estimate	Std Error	Z Value	Pr > Z	Lower	Upper
Intercept	SPOT(ZIP)	0.2549	0.04914	5.19	<.0001	0.1806	0.3871
Residual		0.6925	0.0467	14.83	<.0001	0.6093	0.794

Fit Statistics
-2 Log Likelihood: 4968.2
AIC (smaller is better): 4974.2
AICC (smaller is better): 4974.3
BIC (smaller is better): 4989.9
CAIC (smaller is better): 4992.9

Solution for Fixed Effects

Effect	Estimate	Std Error	DF	t Value	Pr > |t|
Intercept	1.6636	0.0245	1380	67.90	<.0001

Empirical Covariance Matrix for Fixed Effects

Row	Effect	Col1
1	Intercept	0.0006

As explained in the Methods section, the motivation for this null model was the question of whether behavior settings vary in their mean severity of injury. As shown in Table 8, there are significant differences across the different behavior settings on the intercept for severity of injury (Estimate 0.2549; Z = 5.19; $\alpha \leq .0001$). Nonetheless, the residual variance in severity of injury not explained by the effect between behavior settings (0.6925) represents significant variation within the set of individual characteristics of the different collisions. Due to the large amount of unexplained variance, a test of whether hierarchical linear modeling was needed became necessary. The intraclass-correlation (ICC) was used to determine empirical suitability of a hierarchical modeling approach. The ICC is the between-groups effect divided by the total effect for the null model, meaning that differences between the groups which form the higher levels are reflected in the index. In other words, the lower the ICC, the less difference MLM could make in predicting the severity of injury of jaywalkers compared to traditional regression techniques. In this case the computed ICC was 0.2549 / (0.2549 + 0.6925) = 0.269. That is, almost 27% of the variance in jaywalker's severity of injury is associated with the specific behavior setting (zip code>route>milepost) where the collision occurred. As this is a significant estimate ($\alpha < 0.0001$), multilevel linear modeling was considered appropriate for these data.

Beyond the ICC calculation, the intercept-only model gives information criteria to be used as a base of comparison for the suitability of the different models to be calculated later.

Modeling micro level influences:

As detailed in the Methods section, in order to answer the first motivating question, *what personal characteristics can reasonably describe variation in the severity of injury of the jaywalkers?,* a MLM procedure was followed. The purpose of this step of the modeling process was to

understand which micro-level explanatory variables explained severity of injury. A model composed of significant and marginally significant parameters and interaction terms was subsequently determined.

The aim of this first model was to evaluate the relationship between jaywalker's severity of injury (INJURY) and the group of explanatory variables at the micro-level while considering the combined random effects of the collision site route/milepost (SPOT) and zip code (ZIP). For purposes of model building, a subset of 900 cases (exploratory dataset) was used from this point on.

Although interactions were intuitively expected due to the conceptual questions that were posed, the simplest way to start the modeling process was to formulate a very simple model without interactions (See Eq.3).

(Eq.3)

$$\textbf{OUTCOME} = \beta_0 + \beta_1 PED_AGE + \beta_2 PED_FEMALE + \beta_3 PED_APPAR_NORMAL + \beta_4 PED_DARK_CLOTH + \beta_5 PED_INATTENTIVE + \beta_6 PED_RUNNG_DARTING + \beta_7 DVR_AGE + \beta_8 DVR_FEMALE + \beta_9 DVR_INATTENTIVE + \beta_{10} DVR_SPEED + \beta_{11} VEH_PRECRSH_STRAIGHT + \beta_{12} DVR_APPAR_NORMAL + \varepsilon$$

$$\textbf{with } \varepsilon \sim N(0,\sigma^2)$$

If the model was validated and there were patterns in the residuals, interactions could be added to improve the overall model fit. It was assumed that the coefficients for each of the predictors at this level would not vary significantly across behavior settings and therefore they were treated as fixed effects only. Results from this first run of fixed effects MLM are summarized in Table 9. This table shows several non-significant parameters along with some others that are significant. In order to develop a parsimonious model with significant parameters only, a backward elimination of non-significant parameters was employed by first eliminating those parameters with the lowest levels of significance. Results for the final

iteration of this evaluation of fixed effects plus interaction effects of the MLM at level 1 are shown in Table 10.

Table 9. Initial MLM for Micro-Level, fixed effects only (n=900)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H0: Parameter=0	Pr > |t|
Intercept	2.559	0.296	1.977	3.141	788.720	2.494	2.663	8.64	<.0001
cPAGE	0.007	0.002	0.004	0.011	395.600	0.007	0.008	4.16	<.0001
PFEM	-0.048	0.063	-0.171	0.075	637.590	-0.076	-0.033	-0.77	0.443
PNORM	0.215	0.106	0.007	0.424	866.860	0.202	0.231	2.03	0.043
PDARKC	-0.485	0.098	-0.677	-0.293	837.930	-0.504	-0.464	-4.96	<.0001
PINAT	0.039	0.077	-0.112	0.191	452.530	0.008	0.076	0.51	0.610
PRUNDAR	-0.324	0.071	-0.464	-0.185	596.510	-0.347	-0.293	-4.56	<.0001
cDAGE	-0.001	0.002	-0.004	0.003	648.980	-0.001	0.000	-0.39	0.699
DFEM	0.074	0.065	-0.053	0.201	600.200	0.050	0.091	1.15	0.251
DINAT	0.100	0.074	-0.045	0.246	746.390	0.081	0.124	1.35	0.177
DSPD	-0.299	0.261	-0.812	0.213	842.920	-0.379	-0.266	-1.15	0.252
DNORM	0.269	0.310	-0.339	0.877	872.590	0.228	0.315	0.87	0.386
DSTRAIG	-0.354	0.063	-0.478	-0.229	853.600	-0.366	-0.343	-5.59	<.0001
SUV	-0.120	0.080	-0.277	0.038	845.590	-0.141	-0.108	-1.49	0.137
cVYEAR	0.000	0.006	-0.013	0.012	694.180	-0.002	0.001	-0.06	0.953

Table 10. Final MLM for Micro-Level including interactions (n=900)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
Intercept	1.478	0.215	1.055	1.901	305.64	1.426	1.525	6.870	<.0001
cPAGE	0.006	0.003	0.000	0.011	215.30	0.004	0.007	2.030	0.043
PDARKC	0.373	0.168	0.042	0.704	175.60	0.278	0.440	2.230	0.027
PRUNDAR	0.259	0.115	0.032	0.487	137.46	0.189	0.320	2.260	0.026
DSPD	0.146	0.349	-0.541	0.834	289.69	0.059	0.255	0.420	0.676
DSTRAIG	0.227	0.088	0.055	0.400	305.25	0.213	0.260	2.590	0.010
PDARKC*DSPD	1.585	0.576	0.439	2.730	87.20	1.270	2.130	2.750	0.007

In terms of the personal characteristics that can reasonably describe variation in the severity of jaywalker injuries, it can be said that there is a significant detrimental effect involving the pedestrian's age, (see Table 10) with older jaywalkers suffering more severe injuries. In addition to pedestrian age, wearing dark clothing showed a very significant relationship with injuries. More serious injuries were more frequent among jaywalkers wearing dark clothing. This result is consistent with the results reported by Ryb and colleagues (2007) who described pedestrians wearing dark clothing as having an increased risk of injuries when the driver was inattentive, speeding, or under the influence of substances. Another finding is that drivers who were driving straight forward before the impact caused significantly more serious injuries to jaywalkers compared to those who were not driving on a straight stretch of road.

There was a significant effect of reduced cognitive ability in jaywalkers' level of injuries. Those jaywalkers with impaired attention capacity (due to drugs or medication) suffered more severe injuries than people who were apparently normal. No significant interaction was found between jaywalkers who were apparently not normal and who also tended to dart or run into the street. No significant effect was found on the level of injuries caused by drivers who were apparently not normal and who also collided with jaywalkers who darted or ran into the street. The assumption that there was a significant interaction between running or darting from the sidewalk and jaywalkers' age was not confirmed.

Inattentive drivers were not more likely to cause serious injuries to jaywalkers if those jaywalkers were wearing dark clothing.

No significant differences were found between speeding drivers and non-speeding drivers in terms of the seriousness of injuries of the jaywalkers.

Once the micro level model included only significant parameters, information criteria were calculated to be used as a base reference for model assessment. Information criteria regarding the studied level are shown in Table 11. These criteria represent model fit for each of the ten missing data imputed data sets described earlier.

Table 11. Information criteria for Micro-Level Model (n=900)

Imputation	Neg2LogLike	Parms	AIC	AICC	HQIC	BIC	CAIC
1	2362.8	8	2378.8	2379	2393.2	2416	2424
2	2356.5	8	2372.5	2372.7	2386.8	2409.7	2417.7
3	2364	8	2380	2380.1	2394.3	2417.2	2425.2
4	2358.7	8	2374.7	2374.8	2389	2411.9	2419.9
5	2358.5	8	2374.5	2374.7	2388.8	2411.7	2419.7
6	2368.6	8	2384.6	2384.8	2398.9	2421.8	2429.8
7	2350.7	8	2366.7	2366.8	2381	2403.9	2411.9
8	2362	8	2378	2378.1	2392.3	2415.2	2423.2
9	2362.2	8	2378.2	2378.3	2392.5	2415.4	2423.4
10	2365.3	8	2381.3	2381.5	2395.6	2418.5	2426.5
Averaged	**2360.93**	**8**	**2376.93**	**2377.08**	**2391.24**	**2414.1**	**2422.1**

The idea behind assessing the micro-level model was to answer whether this set of variables predict INJURY beyond what would be predicted by an intercepts-only model. In order to test for differences between the two models (intercepts-only vs. micro-level), a chi-square likelihood-ratio test (χ^2) was used as long as all the effects of the simpler model are in the more complex model and a full Maximum Likelihood (not Restricted Maximum

Likelihood) method was used to generate both models. The formula to calculate χ^2 under the aforementioned conditions is:

$$\chi^2 = [(-2 * \text{log-likelihood for intercepts-only model}) - (-2 * \text{log-likelihood for expanded model})] \quad \textbf{(Eq.4)}$$

The degrees of freedom are the difference between the degrees of freedom for the larger and smaller models. In this case, the intercepts-only model has 3 parameters (one intercept and two random parameters, ZIP and SPOT). The micro-level model has 8 parameters (one intercept, five fixed predictors, and two random parameters, ZIP and SPOT). Therefore the calculation for the chi-square LL ratio is:

$$\chi^2 = 4968.2 - 2360.93 = 2607.27$$

with 8-3 = 5 degrees of freedom, $p < 0.0000$ indicating highly significant enhancement to prediction of INJURY by individual characteristics of the participants in the collision.

Modeling meso level influences:

To answer the second motivating question, *what are the characteristics of the proximal (meso) environment that might reasonably moderate the effect of personal characteristics contributing to the severity of injury of the jaywalkers?,* a new MLM procedure was followed. The aim of this second model was to evaluate the relationship between severity of injury (INJURY) and the group of explanatory variables of the level-2 predictors which are detailed in Table 2. Before examining the interactions, main effects were tested. Second, tests for moderation were performed according to the expectations shown in Table 5.

Results from a first run of fixed effects MLM are summarized in Table 12. That table shows several non-significant parameters along with others that are significant. Following the reasoning used for the first level variables, in order to develop a parsimonious model without non-significant parameters, a backward elimination of non-significant parameters was applied by eliminating first those parameters with the lowest levels of significance. Results for the final iteration of this evaluation of fixed effects of the MLM at level 2 are shown in Table 13.

Table 12. Initial MLM for Meso-Level predictors (n=900)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
Intercept	1.610	0.029	1.552	1.667	879.640	1.609	1.610	54.67	<.0001
cSTRLVL	-0.009	0.098	-0.202	0.183	879.620	-0.012	-0.006	-0.1	0.924
cMARKS	0.188	0.075	0.042	0.335	860.690	0.173	0.200	2.52	0.012
cSDRY	-0.152	0.083	-0.315	0.011	879.240	-0.157	-0.149	-1.83	0.068
cDAYLT	-0.231	0.075	-0.379	-0.083	873.570	-0.239	-0.221	-3.07	0.002
cWKEND	0.209	0.081	0.051	0.367	879.170	0.205	0.213	2.59	0.010
cSUMMER	0.204	0.089	0.031	0.378	879.610	0.202	0.208	2.31	0.021
cSPEED	0.014	0.006	0.002	0.026	849.800	0.013	0.015	2.29	0.023
cDINTERS	0.027	0.024	-0.020	0.074	877.550	0.025	0.029	1.14	0.253
cLANES	0.043	0.045	-0.046	0.131	879.110	0.040	0.044	0.95	0.342
cROADW	-0.004	0.003	-0.010	0.002	879.670	-0.004	-0.004	-1.18	0.238
cMEDIANH	0.156	0.065	0.028	0.284	879.410	0.153	0.158	2.38	0.017
cLNDPUB	0.041	0.024	-0.007	0.088	879.090	0.039	0.042	1.69	0.092
cCPARKED	0.000	0.003	-0.006	0.006	878.000	0.000	0.000	0.03	0.978
cGRDIV	0.223	0.192	-0.154	0.601	879.280	0.215	0.234	1.16	0.246
cRECREA	0.005	0.003	0.000	0.010	879.430	0.005	0.005	1.88	0.060
cFURNIT	-0.005	0.004	-0.013	0.004	757.480	-0.007	-0.004	-1.1	0.272
cWALK	-0.002	0.002	-0.005	0.001	874.800	-0.002	-0.002	-1.48	0.140

Table 13. Final MLM for Meso-Level predictors (n=900)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
Intercept	1.610	0.030	1.552	1.669	885.560	1.610	1.611	54.2	<.0001
cMARKS	0.203	0.072	0.061	0.345	870.710	0.189	0.213	2.8	0.005
cSDRY	-0.159	0.084	-0.324	0.006	885.230	-0.164	-0.157	-1.9	0.058
cDAYLT	-0.225	0.075	-0.373	-0.078	877.020	-0.234	-0.214	-2.99	0.003
cWKEND	0.204	0.081	0.046	0.362	884.930	0.200	0.209	2.53	0.012
cSUMMER	0.199	0.088	0.026	0.372	885.820	0.197	0.201	2.26	0.024
cSPEED	0.016	0.005	0.005	0.027	872.110	0.015	0.017	2.87	0.004
cMEDIANH	0.148	0.056	0.038	0.259	884.630	0.145	0.151	2.64	0.009
cLNDPUB	0.044	0.024	-0.004	0.091	885.530	0.043	0.045	1.81	0.071
cRECREA	0.005	0.003	0.000	0.010	885.390	0.005	0.005	1.85	0.065
cWALK	-0.003	0.001	-0.006	0.000	882.370	-0.003	-0.003	-2.05	0.041

In terms of the SPOT level characteristics that describe variation in the severity of injury of the jaywalkers, it was found that several characteristics of the proximal environment contribute in the prediction of that variation: segments with more lane markings (e.g. highways), less daylight, weekends, higher speed limits, and raised median divisions are strongly associated with more severe injuries. There are marginally significant associations of more serious injuries with summer days, longer distances to intersections, longer distances to public transportation, higher percentages of recreation areas on sight, and less walkability in the proximal areas to collisions.

Modeling macro level influences:

The last motivating question, *what are the characteristics of the distal (macro) environment that might reasonably moderate the effect of personal characteristics contributing to the severity of injury of the*

jaywalkers? was answered using MLM once again. The aim of the third model was to evaluate the relationship between severity of injury (INJURY) and the group of macro-level explanatory variables detailed in Table 3.

Results from the first run of fixed effects MLM are summarized in Table 14. That table shows several non-significant parameters along with some that are significant. As noted in the first and second level models, a parsimonious model without non-significant parameters was pursued following the backward elimination of non-significant parameters. Results for the final iteration of this evaluation of fixed effects of the MLM at level 3 are shown in Table 15.

Table 14. Initial MLM for Macro-Level predictors (n=900)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
Intercept	1.608	0.032	1.546	1.670	887.710	1.607	1.609	50.74	<.0001
cTRANSPORT	0.001	0.000	0.000	0.002	856.270	0.001	0.001	1.66	0.098
cPLNDIST	-0.021	0.024	-0.069	0.027	644.240	-0.028	-0.012	-0.85	0.395
cPINC99	-0.098	0.122	-0.338	0.143	859.950	-0.123	-0.082	-0.8	0.425
cPTCOST	-0.001	0.001	-0.002	0.000	666.830	-0.001	0.000	-1.16	0.247
cPTCO2	0.574	0.292	0.001	1.147	649.280	0.476	0.654	1.97	0.050
cLNDENS	-0.150	0.057	-0.260	-0.039	872.110	-0.158	-0.143	-2.65	0.008
cPOV99	0.007	0.008	-0.008	0.022	884.000	0.006	0.007	0.88	0.379
cBLACK	-0.002	0.002	-0.006	0.002	886.910	-0.002	-0.002	-1.06	0.290
cLATIN	-0.002	0.003	-0.008	0.005	887.470	-0.002	-0.002	-0.52	0.600

Table 15. Final MLM for Macro-Level (n=900)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H0: Parameter=0	Pr > |t|
Intercept	1.613	0.032	1.551	1.675	894.870	1.613	1.614	50.96	<.0001
cPTCO2	0.291	0.166	-0.034	0.616	688.070	0.248	0.357	1.76	0.079
cLNDENS	-0.205	0.045	-0.294	-0.117	851.430	-0.212	-0.194	-4.56	<.0001

As shown in Table 15, collisions occurring in areas with higher monthly CO2 emissions due to automobile use in the pedestrian zip code were associated with higher injury levels. This was a marginally significant relationship. It was also found that greater injury severity was strongly related to lower densities of population.

The integrated multilevel model:

Once significant parameters predicting INJURY were identified at each level, an integrated model was tested. The first step of this new analysis involved the evaluation of the relationship among injury severity (INJURY) and the combined group of explanatory variables. Results of that analysis are summarized in Table 16. A parsimonious model without non-significant main-effects parameters is shown in Table 17.

Table 16. Initial integrated MLM (n=900)

Parameter	Estimate	Std Error	95% Conf. Limits		DF	Min	Max	t for H_0: Param=0	Pr > |t|
Intercept	1.374	0.108	1.162	1.585	662.180	1.345	1.408	12.8	<.0001
cPAGE	0.005	0.002	0.002	0.008	399.190	0.004	0.006	3.11	0.002
PNORM	-0.115	0.101	-0.314	0.084	642.560	-0.161	-0.087	-1.13	0.258
PDARKC	0.341	0.098	0.149	0.533	706.200	0.298	0.359	3.48	0.001
PRUNDAR	0.228	0.065	0.101	0.356	863.550	0.219	0.237	3.51	0.001
DSTRAIG	0.280	0.064	0.155	0.406	867.140	0.269	0.287	4.38	<.0001
cMARKS	0.110	0.072	-0.031	0.252	840.870	0.092	0.129	1.53	0.127
cSDRY	-0.122	0.082	-0.283	0.038	872.180	-0.133	-0.110	-1.49	0.136
cDAYLT	-0.078	0.075	-0.225	0.069	863.000	-0.088	-0.062	-1.04	0.298
cWKEND	0.172	0.078	0.019	0.325	873.830	0.164	0.182	2.21	0.027
cSUMMER	0.197	0.088	0.024	0.370	881.440	0.191	0.204	2.24	0.025
cSPEED	0.012	0.006	0.001	0.023	848.760	0.011	0.013	2.06	0.039
cMEDIANH	0.164	0.056	0.054	0.274	867.090	0.157	0.173	2.92	0.004
cLNDPUB	0.037	0.024	-0.010	0.085	881.000	0.036	0.039	1.55	0.121
cRECREA	0.004	0.002	-0.001	0.008	881.230	0.003	0.004	1.44	0.152
cWALK	-0.002	0.001	-0.005	0.001	880.830	-0.002	-0.002	-1.27	0.205
cPTCO2	0.109	0.156	-0.199	0.416	719.390	0.072	0.173	0.69	0.488
cLNDENS	-0.030	0.046	-0.120	0.060	866.720	-0.035	-0.022	-0.65	0.515

Table 17. Final integrated MLM with interactions (n=900)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
Intercept	1.207	0.056	1.097	1.317	830.65	1.196	1.221	21.53	<.0001
cPAGE	0.006	0.002	0.002	0.009	415.16	0.005	0.006	3.52	0.001
PDARKC	0.399	0.090	0.222	0.577	756.15	0.370	0.421	4.43	<.0001
PRUNDAR	0.249	0.065	0.122	0.376	857.80	0.237	0.259	3.85	0.000
DSTRAIG	0.324	0.065	0.197	0.451	858.25	0.314	0.335	5	<.0001
cWKEND	0.191	0.076	0.042	0.340	853.88	0.176	0.202	2.52	0.012
cSUMMER	0.184	0.086	0.015	0.352	869.19	0.172	0.197	2.14	0.033
cSPEED	0.013	0.005	0.002	0.023	846.29	0.012	0.014	2.37	0.018
cMEDIANH	0.166	0.053	0.063	0.270	876.48	0.160	0.170	3.15	0.002
cLNDPUB	0.008	0.024	-0.039	0.055	863.93	0.006	0.013	0.33	0.740
cWALK	0.002	0.002	-0.003	0.007	825.39	0.001	0.002	0.78	0.435
cDINTERS	0.038	0.022	-0.005	0.081	871.91	0.035	0.041	1.72	0.086
cPAGE*cDINTERS	0.003	0.001	0.001	0.005	745.28	0.003	0.003	2.71	0.007
cPAGE*cWKEND	0.007	0.004	0.000	0.015	427.59	0.006	0.009	2.04	0.042
DSTRAIG*cWALK	-0.006	0.002	-0.011	-0.002	837.10	-0.007	-0.006	-2.59	0.010
PDARKC*cLNDPUB	0.169	0.054	0.063	0.274	791.10	0.150	0.180	3.14	0.002
cPAGE*cMEDIANH	-0.006	0.003	-0.011	-0.001	201.09	-0.007	-0.005	-2.29	0.023

Using a multilevel approach, it was found that older pedestrians, those wearing dark clothing, those who ran or darted from the sidewalk, along with the condition of drivers driving on a straight stretch of the road are associated with higher injury severity. The characteristics of the places associated with more severe injuries comprise roads with higher posted speed limits, taller street median divisions (associated with higher speed roads), summer seasons, and weekends. Intersections seem to be a marginally safer option to avoid severe injuries as shown by the marginally significant relationship between cDINTERS and INJURY (Table 17).

In terms of the interactions between higher levels of explanation and the individual characteristics associated with severity of injuries, Table 18 shows that in spite of what was anticipated (Table 5), those who sustain more severe injuries when further away from the intersection tend to be older pedestrians. The association between age and severity of injuries becomes non-significant in areas proximal to the intersection. One possible reason for this moderating effect is that younger pedestrians are less likely to put themselves at risk by crossing the road further away from intersections. A related finding is that older jaywalkers suffer significantly more severe injuries only in settings with a lower than average median division height. This kind of low-profile median barrier appears to afford less difficulty in crossing the street for adults and senior jaywalkers.

Collisions in which the driver was driving straightforward down the road (opposed to maneuvering) produced significantly more severe injuries only if the level of walkability in that SPOT was low. For areas with high walkability, the relationship between the way the driver drove and the severity of injuries was only marginally significant.

Also in relation to moderation, one of the strongest predictors of injury severity was whether the jaywalker was wearing dark clothes or not (See Table 17). Nonetheless, that association was significant only when the distance to public transportation was long.

In terms of the moderating effect of weekends, Table 18 shows that places with a higher number of collisions happening during weekends tend to magnify the association between pedestrian age and severity of injuries. On weekends, older jaywalkers suffered significantly more severe injuries. That relationship was not significant during the rest of the

week. An explanation for this moderation effect might be that children spend more time at home or traveling with parents during weekends.

Table 18. Testing for moderation in the final integrated MLM (n=900)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
cPAGE with cDINTERS=1 Std.Dev. ABOVE the mean	0.010	0.002	0.005	0.014	500	0.009	0.010	4.2	<.0001
cPAGE with cDINTERS=1 Std.Dev. BELOW the mean	0.002	0.002	-0.002	0.006	497	0.001	0.003	1.01	0.311
cPAGE with cWKEND=1 Std.Dev. ABOVE the mean	0.009	0.002	0.004	0.013	338	0.007	0.009	3.83	0.000
cPAGE with cWKEND =1 Std.Dev. BELOW the mean	0.003	0.002	-0.001	0.007	460	0.002	0.004	1.51	0.131
cPAGE with cMEDIANH=1 Std.Dev. ABOVE the mean	0.002	0.002	-0.003	0.007	302	0.001	0.003	0.81	0.417
cPAGE with cMEDIANH =1 Std.Dev. BELOW the mean	0.010	0.002	0.005	0.014	532	0.009	0.011	4.44	<.0001
DSTRAIG with cWALK=1 Std.Dev. ABOVE the mean	0.137	0.074	-0.009	0.283	859	0.127	0.148	1.84	0.066
DSTRAIG with cWALK=1 Std.Dev. BELOW the mean	0.517	0.113	0.295	0.740	850	0.502	0.539	4.57	<.0001
PDARKC with cLNDPUB=1 Std.Dev. ABOVE the mean	0.638	0.121	0.401	0.875	828	0.608	0.655	5.28	<.0001
PDARKC with cLNDPUB=1 Std.Dev. BELOW the mean	0.167	0.118	-0.065	0.399	831	0.139	0.187	1.41	0.158

Two of the motivating questions of the present research asked about the improvement in explanatory characteristics of the meso and macro levels compared to the amount of variance in INJURY explained by the micro-level alone. To that extent, once the integrated model included only significant parameters, information criteria were calculated to compare the micro-level model alone versus the integrated model. . Information criteria for the 10 missing data imputed data sets are shown in Table 19.

Table 19. Information criteria for the integrated MLM (n=900)

Imputation	Neg2LogLike	Parms	AIC	AICC	HQIC	BIC	CAIC
1	2258.8	15	2288.8	2289.3	2315.6	2358.5	2373.5
2	2253.5	15	2283.5	2284.1	2310.4	2353.3	2368.3
3	2261.7	15	2291.7	2292.2	2318.5	2361.4	2376.4
4	2257.0	15	2287.0	2287.5	2313.8	2356.7	2371.7
5	2256.6	15	2286.6	2287.1	2313.4	2356.3	2371.3
6	2265.0	15	2295.0	2295.6	2321.9	2364.8	2379.8
7	2255.3	15	2285.3	2285.8	2312.1	2355.1	2370.1
8	2259.3	15	2289.3	2289.8	2316.1	2359.0	2374.0
9	2258.1	15	2288.1	2288.7	2315.0	2357.9	2372.9
10	2262.9	15	2292.9	2293.4	2319.7	2362.6	2377.6
Averaged	**2258.8**	**15**	**2288.8**	**2289.4**	**2315.7**	**2358.6**	**2373.6**

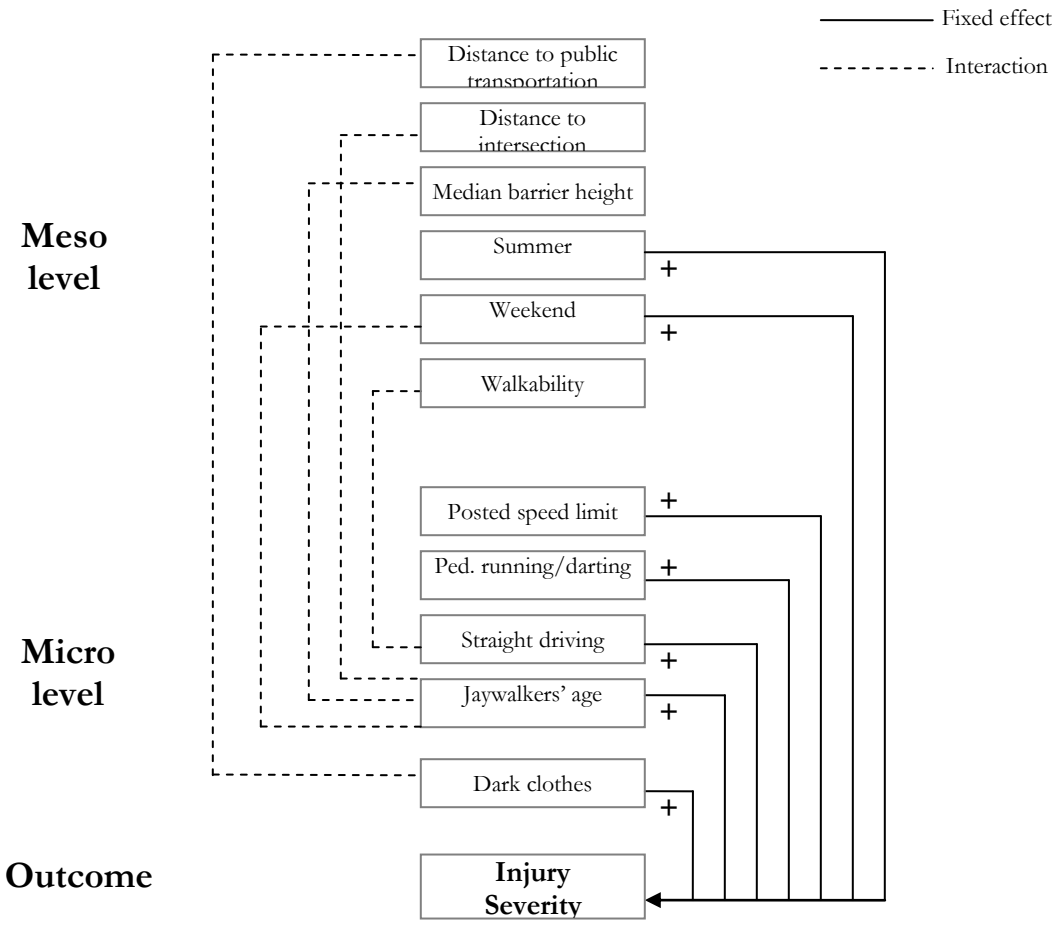
The chi-square likelihood-ratio test (χ^2) was used to test for differences between the two models using the difference of the two negative log-likelihoods and the difference of parameter number as degrees of freedom. In this case, the micro-level model has 8 parameters (one intercept, five fixed predictors, and two random parameters, ZIP and SPOT). The integrated model has 15 parameters (one intercept, 12 fixed predictors, and the

same two random parameters). Following Equation 2, the calculation for the chi-square LL ratio is:

$$\chi^2 = 2360.93 - 2258.8 = 102.13$$

with 15-8 = 7 degrees of freedom, a p <.0001 indicating a highly significant enhancement by a model that incorporates environmental influences (main effects and interactions) to the individual characteristics of the participants in the collision to predict INJURY.

Figure 5: Main effects and interactions predicting injuries in Jaywalker-Car Collisions in New Jersey (all roads, n=900, exploratory dataset)



Model Validation

As originally planned, the exploratory random portion of the sample (50%) was used for model development (data transformations, stepwise variable selection, testing interactions, estimating regression coefficients, etc.). Once the integrated model was stable, the confirmatory dataset was used to run that model for validation purposes. Results shown in Table 20 indicate that most of the significant main effects included in the integrated model using the exploratory dataset were also shared by the confirmatory dataset. The one exception to that result was cSUMMER. No statistical comparison (χ^2) between the two final models (exploratory vs. confirmatory datasets) is possible due to data coming from two theoretically different samples.

Table 20. CONFIRMATORY DATASET. Final integrated MLM (n=900)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
Intercept	1.387	0.058	1.274	1.501	813	1.373	1.398	24.05	<.0001
cPAGE	0.009	0.002	0.005	0.012	78	0.007	0.010	4.8	<.0001
PDARKC	0.358	0.102	0.159	0.558	428	0.318	0.413	3.53	0.001
PRUNDAR	0.169	0.074	0.023	0.316	404	0.125	0.209	2.28	0.023
DSTRAIG	0.235	0.066	0.105	0.366	822	0.219	0.249	3.54	0.000
cWKEND	0.207	0.079	0.052	0.361	842	0.191	0.223	2.62	0.009
cSPEED	0.015	0.007	0.002	0.027	863	0.014	0.016	2.24	0.026
cMEDIANH	0.000	0.057	-0.112	0.112	871	-0.012	0.008	0	0.999
cLNDPUB	0.053	0.021	0.011	0.095	884	0.052	0.055	2.49	0.013
cWALK	-0.004	0.002	-0.008	-0.001	855	-0.004	-0.004	-2.41	0.016
cDINTERS	0.042	0.025	-0.007	0.090	864	0.038	0.047	1.7	0.090
cPAGE*cMEDIANH	0.006	0.003	0.001	0.011	444	0.005	0.007	2.34	0.020

A More Situated Analysis

In Chapter 2, walking was conceptualized as a structuring interaction that runs continuously between the individual and the environment sustained by kinetic perception. In other words, human beings apprehend a behavior setting's program while moving within that behavior setting. From an Ecobehavioral perspective, that structuring interaction does not assume a preeminence of any level in particular. In other words, walking is structured by equal contributions of individual and environmental influences. It is a dynamic arrangement of equally important perceptual and contextual components. The field of safe walking, a combination of individual and contextual characteristics, responds to changes in each of those levels. The dynamic liaison of those characteristics is reevaluated with every step.

Results so far show that changes in the speed of travel of pedestrians and vehicles determine how serious the injuries resulting from a collision would be. There is a chief role of posted speed limits on the moderation of injuries. Spots with higher posted limits are strongly associated with more severe injuries.

It seems clear that reducing the current posted speed limits alone would result in a significant reduction of injuries. Although that conclusion is interesting in terms of policymaking, it does not say anything about the effect of the other possible environmental determinants on injuries. This result leads to the question of whether the role that environmental determinants play in injury severity would be clearer if the effect of speed on injuries is controlled. In other words, what if a subsample of roads with homogeneous posted speeds became the analytic focus of analysis? At a certain point in the analysis, it was assumed that, once the posted speed limit was controlled, a different set of main effects and interactions might be found. To address that question, a subsample of records containing

information about municipal roads only was selected. It was reasoned that municipal roads were uniformly associated with lower posted speeds. Nonetheless, the analysis of this subsample revealed few differences when compared to the original sample. The wide range of posted speeds on municipal roads made it difficult to explain the variance between SPOTS associated with other predictors of interest. Results for the analysis using municipal roads only (n=331) are included as a reference in Appendix 6.

In order to avoid meaningless labels defining type of roads, a decision was made to select a group of records comprising the lowest posted speeds. An arbitrary criterion (percentile 50 or approximately 30 miles per hour) was defined as the cut point to select cases for the new subsample. After the selection was made, a total of 499 out of the original 900 records were included in the new working dataset.

The analytical process for this new subsample followed the same approach used for the original sample. Results for this process are shown in Tables 21 to 28.

Table 21. Initial MLM for Micro-Level, fixed effects only (< 30 MPH)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H0: Parameter=0	Pr > |t|
Intercept	1.919	0.336	1.257	2.580	348.770	1.739	2.047	5.71	<.0001
cPAGE	0.005	0.002	0.001	0.010	181.670	0.004	0.007	2.48	0.014
PFEM	-0.064	0.071	-0.204	0.076	389.610	-0.103	-0.045	-0.9	0.367
PNORM	-0.145	0.151	-0.442	0.152	311.580	-0.200	-0.085	-0.96	0.338
PDARKC	0.445	0.131	0.186	0.704	294.680	0.372	0.500	3.38	0.001
PINAT	0.049	0.087	-0.122	0.220	307.480	-0.001	0.076	0.57	0.571
PRUNDAR	0.198	0.089	0.021	0.375	118.500	0.132	0.256	2.22	0.028
cDAGE	-0.001	0.002	-0.006	0.003	450.370	-0.002	-0.001	-0.53	0.593
DFEM	-0.137	0.068	-0.271	-0.003	447.640	-0.149	-0.119	-2.01	0.045
DINAT	0.002	0.078	-0.152	0.156	448.170	-0.018	0.020	0.02	0.981
DNORM	-0.602	0.337	-1.265	0.062	371.440	-0.715	-0.453	-1.78	0.075
DSTRAIG	0.232	0.070	0.094	0.371	422.820	0.215	0.258	3.3	0.001
SUV	0.019	0.088	-0.155	0.193	471.360	0.006	0.030	0.22	0.830
cVYEAR	-0.001	0.007	-0.014	0.012	377.140	-0.003	0.002	-0.18	0.860

Table 22. Final MLM for Micro-Level including interactions (< 30 MPH)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
Intercept	1.865	0.331	1.214	2.517	317.410	1.684	2.017	5.63	<.0001
cPAGE	0.005	0.002	0.001	0.010	176.980	0.004	0.007	2.52	0.013
PDARKC	0.448	0.131	0.190	0.705	290.940	0.369	0.501	3.42	0.001
PRUNDAR	0.200	0.090	0.022	0.377	114.190	0.133	0.261	2.23	0.028
DFEM	-0.137	0.068	-0.270	-0.004	438.800	-0.152	-0.117	-2.03	0.043
DNORM	-0.709	0.326	-1.350	-0.067	291.640	-0.863	-0.518	-2.18	0.030
DSTRAIG	0.247	0.071	0.108	0.386	419.110	0.228	0.269	3.49	0.001

A difference between the set of main effects shown in Table 22 and those using the complete sample of 900 records (Table 17) is related to DFEM and DNORM emerging as

significant parameters. When exclusively individual characteristics are taken into account to predict injury severity in settings with posted speeds below 30 Mph, collisions involving male drivers or pedestrians under the influence of drugs or medicines were associated with more severe injuries.

Table 23. Initial MLM for Meso-Level predictors (< 30 MPH)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
Intercept	1.441	0.053	1.336	1.545	456	1.432	1.459	27.1	<.0001
cSTRLVL	0.054	0.109	-0.160	0.268	464	0.022	0.075	0.500	0.620
cMARKS	0.175	0.096	-0.013	0.363	436	0.133	0.198	1.830	0.068
cSDRY	-0.069	0.104	-0.274	0.136	478	-0.080	-0.057	-0.660	0.511
cDAYLT	-0.174	0.094	-0.359	0.011	457	-0.201	-0.158	-1.850	0.065
cWKEND	0.219	0.105	0.014	0.425	478	0.204	0.228	2.100	0.036
cSUMMER	0.209	0.111	-0.009	0.426	479	0.198	0.215	1.880	0.060
cDINTERS	0.026	0.033	-0.039	0.090	477	0.022	0.030	0.790	0.431
cLANES	-0.011	0.057	-0.124	0.102	478	-0.016	-0.005	-0.2	0.843
cROADW	-0.001	0.004	-0.010	0.008	472	-0.002	0.000	-0.200	0.840
cLNDPUB	0.037	0.031	-0.023	0.098	480	0.036	0.040	1.220	0.225
cCPARKED	-0.005	0.004	-0.012	0.003	470	-0.005	-0.004	-1.280	0.200
cRECREA	0.004	0.003	-0.002	0.011	479	0.004	0.005	1.290	0.198
cFURNIT	-0.003	0.005	-0.013	0.006	370	-0.005	-0.002	-0.690	0.488
cSDWLK	0.001	0.003	-0.004	0.006	443	0.000	0.002	0.420	0.673
cWSCORE	0.000	0.003	-0.006	0.005	479	-0.001	0.000	-0.150	0.879

Table 24. Final MLM for Meso-Level predictors (< 30 MPH)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
Intercept	1.488	0.047	1.396	1.579	396	1.471	1.512	31.97	<.0001
cMARKS	0.185	0.093	0.002	0.367	449	0.151	0.207	1.99	0.047
cWKEND	0.142	0.107	-0.067	0.352	469	0.110	0.163	1.34	0.182
cCPARKED	-0.006	0.003	-0.012	0.000	479	-0.007	-0.006	-1.98	0.048
cRECREA	0.001	0.003	-0.006	0.007	484	0.000	0.001	0.17	0.867
cSDWLK	-0.003	0.002	-0.007	0.001	326	-0.004	-0.002	-1.44	0.150
cWKEND*cSDWLK	0.009	0.004	0.001	0.017	385	0.008	0.011	2.23	0.026
cRECREA*cSDWLK	0.000	0.000	0.000	0.001	484	0.000	0.000	2.61	0.009

Table 25. Initial MLM for Macro-Level predictors (< 30 MPH)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
Intercept	1.433	0.044	1.346	1.520	482	1.429	1.442	32.37	<.0001
cTRANSPORT	0.000	0.001	-0.001	0.002	450	0.000	0.001	0.88	0.380
cPLNDIST	-0.027	0.032	-0.089	0.036	227	-0.037	0.000	-0.84	0.403
cPINC99	0.074	0.157	-0.234	0.383	265	-0.024	0.134	0.47	0.635
cPTCOST	0.000	0.001	-0.001	0.001	362	0.000	0.000	-0.23	0.816
cPTCO2	0.145	0.382	-0.607	0.896	375	-0.024	0.290	0.38	0.705
cLNDENS	-0.083	0.080	-0.239	0.073	465	-0.093	-0.056	-1.04	0.297
cPOV99	0.012	0.009	-0.006	0.030	416	0.009	0.016	1.32	0.189
cBLACK	-0.001	0.003	-0.006	0.004	484	-0.002	-0.001	-0.57	0.570
cLATIN	0.000	0.004	-0.008	0.008	483	0.000	0.001	0.05	0.957

Table 26. Final MLM for Macro-Level (< 30 MPH)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
Intercept	1.440	0.044	1.354	1.527	487	1.437	1.451	32.75	<.0001
cLNDENS	-0.107	0.047	-0.200	-0.014	492	-0.115	-0.103	-2.260	0.024

Table 27. Initial integrated MLM (< 30 MPH)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
Intercept	1.366	0.158	1.054	1.677	357	1.307	1.436	8.62	<.0001
cPAGE	0.006	0.002	0.001	0.010	172	0.004	0.007	2.500	0.013
PDARKC	0.449	0.133	0.188	0.710	265	0.373	0.511	3.38	0.001
PRUNDAR	0.185	0.092	0.003	0.366	157	0.123	0.244	2.01	0.047
DFEM	-0.112	0.066	-0.243	0.018	430	-0.125	-0.092	-1.69	0.091
PNORM	-0.178	0.151	-0.475	0.118	225	-0.266	-0.097	-1.18	0.238
DSTRAIG	0.199	0.071	0.059	0.340	441	0.182	0.217	2.79	0.006
cSTRLVL	0.046	0.104	-0.157	0.250	456	0.031	0.064	0.45	0.654
cMARKS	0.089	0.097	-0.103	0.280	407	0.054	0.110	0.91	0.363
cSDRY	0.016	0.100	-0.181	0.213	454	-0.010	0.030	0.16	0.875
cDAYLT	0.004	0.095	-0.183	0.192	387	-0.036	0.029	0.04	0.964
cWKEND	0.183	0.098	-0.010	0.375	446	0.166	0.207	1.86	0.063
cSUMMER	0.181	0.111	-0.036	0.399	455	0.155	0.198	1.64	0.102
cDINTERS	0.034	0.032	-0.030	0.097	460	0.029	0.038	1.04	0.300
cLANES	-0.027	0.058	-0.142	0.087	454	-0.035	-0.015	-0.47	0.637
cROADW	0.000	0.005	-0.009	0.009	438	-0.001	0.001	0.04	0.971
cLNDPUB	0.028	0.031	-0.034	0.089	453	0.020	0.033	0.89	0.375
cCPARKED	-0.004	0.004	-0.011	0.004	447	-0.005	-0.003	-1.02	0.310
cRECREA	0.004	0.003	-0.002	0.009	462	0.003	0.004	1.22	0.221
cFURNIT	-0.004	0.005	-0.013	0.006	325	-0.006	-0.002	-0.76	0.446
cSDWLK	0.002	0.002	-0.003	0.007	388	0.001	0.003	0.78	0.434
cWSCORE	0.001	0.003	-0.005	0.007	457	0.001	0.002	0.37	0.709
cTRANSPORT	0.000	0.001	-0.001	0.001	405	0.000	0.000	0.36	0.721
cPLNDIST	-0.033	0.029	-0.091	0.024	227	-0.043	-0.010	-1.15	0.252
cPINC99	0.066	0.161	-0.251	0.382	219	-0.027	0.139	0.41	0.684
cPTCOST	0.000	0.001	-0.001	0.001	366	0.000	0.000	0.03	0.973
cPTCO2	0.012	0.379	-0.734	0.758	368	-0.180	0.133	0.03	0.975
cLNDENS	-0.065	0.083	-0.229	0.098	442	-0.084	-0.038	-0.79	0.432
cPOV99	0.013	0.009	-0.005	0.032	377	0.011	0.018	1.4	0.161
cBLACK	-0.001	0.002	-0.006	0.003	458	-0.002	-0.001	-0.54	0.586
cLATIN	0.000	0.004	-0.007	0.008	454	0.000	0.001	0.09	0.925

Table 28. Final integrated MLM (< 30 MPH)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter= 0	Pr > |t|
Intercept	1.190	0.135	0.925	1.456	330	1.139	1.248	8.83	<.0001
cPAGE	0.007	0.002	0.002	0.011	211	0.005	0.008	3.06	0.003
PDARKC	0.550	0.136	0.283	0.818	228	0.480	0.626	4.05	<.0001
PRUNDAR	0.159	0.088	-0.015	0.334	130	0.095	0.229	1.81	0.073
PNORM	0.027	0.134	-0.236	0.290	242	-0.049	0.095	0.2	0.841
DSTRAIG	0.204	0.070	0.067	0.341	451	0.188	0.222	2.93	0.004
cSDRY	-0.077	0.097	-0.266	0.113	455	-0.093	-0.048	-0.79	0.429
cDAYLT	0.008	0.091	-0.171	0.187	347	-0.036	0.044	0.09	0.930
cWKEND	0.193	0.094	0.009	0.378	452	0.175	0.218	2.06	0.040
cSUMMER	0.217	0.107	0.007	0.427	465	0.202	0.234	2.03	0.043
cCPARKED	0.000	0.003	-0.007	0.006	438	-0.001	0.000	-0.15	0.882
cRECREA	-0.002	0.003	-0.007	0.003	468	-0.002	-0.001	-0.68	0.498
cSDWLK	0.013	0.003	0.006	0.019	332	0.011	0.014	3.97	<.0001
cLNDENS	-0.134	0.055	-0.241	-0.026	453	-0.143	-0.120	-2.44	0.015
cPOV99	0.00	0.004	0.002	0.018	466	0.010	0.011	2.48	0.014
cRECREA*cSDWLK	0.000	0.000	0.000	0.001	442	0.000	0.000	4.74	<.0001
PDARKC*cSDRY	0.583	0.291	0.010	1.156	335	0.456	0.726	2	0.05
PNORM*cSDWLK	-0.015	0.004	-0.023	-0.008	378	-0.017	-0.013	-4.13	<.0001
cPAGE*cDAYLT	-0.010	0.005	-0.020	-0.001	330	-0.012	-0.008	-2.17	0.031
PDARKC*cCPARKED	-0.025	0.011	-0.046	-0.004	250	-0.030	-0.018	-2.34	0.020

Tables 23 to 27 represent intermediate steps in the calculation of a final integrated MLM model using a subsample of SPOTS with posted speed limits under 30 Mph. The integrated model is shown in Table 28. The first difference between the set of main effects from settings with a full range of posted speeds and those below 30 Mph is that running/darting was less likely to be significant as a predictor of injuries in the latter roads. This finding suggests that decreasing posted speeds has a protective effect on jaywalkers. In

addition, weekends and summertime maintain their predictive power in terms of more severe injuries.

In terms of main effects, three new predictors appeared in the final model and were significantly associated with injuries: greater amounts of sidewalk coverage and lower population density in the SPOT along with higher poverty in the ZIP CODE predicted significantly more severe injuries.

Finally, moderation was evaluated. As shown in Table 29, the more recreation areas in sight were significantly associated with more severe injuries when sidewalk coverage was above the mean. This result could be due to the possibility that greater sidewalk coverage affords opportunities to walk alongside the road. On the other hand, the more recreation areas in sight were significantly associated with less severe injuries when sidewalk coverage was below the mean.

Under low daylight conditions, older jaywalkers sustained significantly more severe injuries. Related to road conditions, wearing dark clothes was associated with more severe injuries especially when the roads were drier. Wearing dark clothes was also associated with more severe injuries when the number of cars parked on the roads composing the setting was lower.

When sidewalk coverage was above the mean, jaywalkers under the influence of drugs or medicines sustained less severe injuries. Conversely, when sidewalk coverage was below the mean, jaywalkers under the influence of drugs or medicines sustained significantly more severe injuries.

Table 29. Testing for moderation in the final integrated MLM (< 30 MPH)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
cRECREA with cSIDEWALK=1 Std.Dev. ABOVE the mean	0.013	0.004	0.006	0.020	465	0.012	0.014	3.59	0.000
cRECREA with cSIDEWALK=1 Std.Dev. BELOW the mean	-0.016	0.004	-0.025	-0.008	446	-0.017	-0.015	-3.76	0.000
PDARKC with cSDRY =1 Std.Dev. ABOVE the mean	0.752	0.186	0.386	1.119	180	0.638	0.878	4.050	<.0001
PDARKC with cSDRY =1 Std.Dev. BELOW the mean	0.348	0.151	0.051	0.644	430	0.308	0.383	2.310	0.022
PNORM with cSIDEWALK =1 Std.Dev. ABOVE the mean	-0.489	0.182	-0.848	-0.131	197	-0.566	-0.364	-2.690	0.008
PNORM with cSIDEWALK =1 Std.Dev. BELOW the mean	0.543	0.184	0.181	0.904	427	0.467	0.595	2.950	0.003
cPAGE with cDAYLT =1 Std.Dev. ABOVE the mean	0.002	0.002	-0.003	0.007	183	0.001	0.003	0.900	0.371
cPAGE with cDAYLT =1 Std.Dev. BELOW the mean	0.011	0.004	0.004	0.018	308	0.009	0.013	3.150	0.002
PDARKC with cPARKED=1 Std.Dev. ABOVE the mean	0.307	0.147	0.015	0.599	125	0.207	0.419	2.080	0.039
PDARKC with cPARKED=1 Std.Dev. BELOW the mean	0.793	0.192	0.416	1.170	345	0.717	0.872	4.140	<.0001

Figure 6: Main effects and interactions predicting injuries in Jaywalker-Car Collisions in New Jersey (roads < 30 Mph, n=499, exploratory dataset)

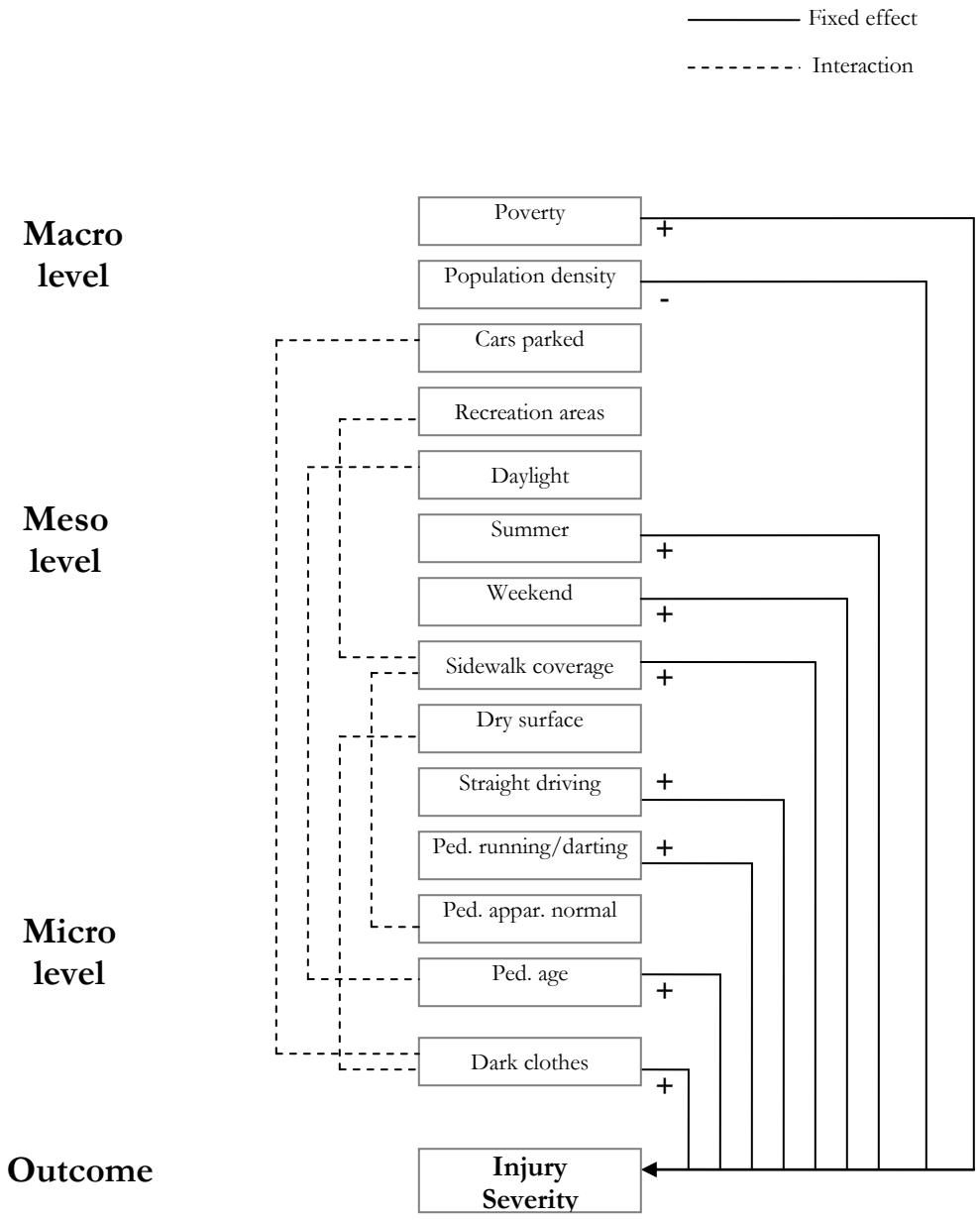


Figure 6 shows that, when a more situated analysis controlling for posted speeds was assumed, a different set of predictors became significant in the explanation of injury levels. It is possible that when the effect of highways, arterials, and connector roads with high posted speeds was eliminated, differences between urban and suburban settings were more apparent. Beyond the interactions described above, it was found that the percentage of people living under the level of poverty in 1999 at crash sites in SPOTS located at the ZIP CODE level significantly explained the injury levels in jaywalkers. In other words, people living in poorer communities experienced more severe injuries. At the same time, when the average number of people per square mile at crash sites in SPOTS located at the ZIP CODE level was higher, collisions were associated with less severe injuries. Consistent with the literature, higher density protects against severe injuries even those involving jaywalkers. It can be assumed that speeding behavior can be controlled not only by norms about speeding but also by the design of the built environment (Leandro, 2010b).

The confirmatory dataset was used to run the new integrated model for validation purposes. Results shown in Table 30 indicate that several of the significant main effects included in the integrated model using the exploratory dataset were also shared by the confirmatory dataset. However, none of the moderation effects could be replicated using the confirmatory dataset.

Table 30. Final MLM (< 30 MPH) CONFIRMATORY DATASET p<0.10 only

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
Intercept	1.362	0.068	1.229	1.495	488	1.349	1.372	20.12	<.0001
cPAGE	0.006	0.002	0.002	0.010	185	0.005	0.007	3.05	0.003
PRUNDAR	0.184	0.087	0.013	0.356	403	0.154	0.211	2.11	0.035
DSTRAIG	0.194	0.076	0.044	0.344	451	0.171	0.214	2.54	0.011
cSDRY	0.249	0.104	0.044	0.454	467	0.226	0.279	2.38	0.018
cDAYLT	-0.378	0.085	-0.545	-0.210	487	-0.389	-0.359	-4.43	<.0001
cLNDPUB	0.057	0.028	0.002	0.111	481	0.051	0.063	2.04	0.042
cLNDENS	-0.084	0.047	-0.175	0.008	453	-0.098	-0.074	-1.8	0.073

DISCUSSION

Using data involving car/pedestrian collisions in New Jersey, three guiding questions were addressed. The first involved personal characteristics of the jaywalkers that could reasonably describe variation in the severity of injuries these individuals suffered. This question was satisfactorily answered. Using the general sample (n=900) of all roads, it was determined that the most serious injuries were sustained significantly more often by older jaywalkers, jaywalkers who wore dark clothes, or those who ran or darted from the sidewalk. It was also determined within that sample that jaywalkers who collided with drivers who were driving in a straight stretch of road or speeding-up when collision happened also sustained more severe injuries. Those are the personal characteristics that significantly defined the probability of receiving more severe injuries by jaywalkers. Those characteristics remained significant when the subsample of SPOTS with posted speeds lower than 30 Mph (n=499) were examined. These consistent results emphasize the importance of individual characteristics as predictors of injuries. A highly significant proportion of the variation in injuries associated with jaywalking is explained by personal characteristics of both the jaywalkers and the drivers involved in accidents.

The two other motivating questions for this study were related to the role of environmental characteristics as moderators of accident severity. When a set of these higher-level predictors was added to the equations for both the general sample (n=900) and the subsample of roads below 30 Mph (n=499), most parameters relative to pedestrian characteristics remained significant as they were when only micro-level characteristics were included in the models.

A number of environmental main effects explaining variation in injury severity were found. Weekends and summertime are significant predictors of more severe injuries both in the general sample (n=900) and the below 30 Mph subsample (n=499). More people on the streets during summer or weekends do not necessarily result in a reduction in actual speed for drivers. The combination of more people and the same speeds increases the probability of more severe injuries. Main effects for median barrier height and distance to an intersection were significant only for the general sample but not for the subsample of roads having posted speed limits below 30 Mph. This makes sense since roads with lower posted speed limits generally lack median barriers and have shorter distances to intersections. Interestingly, new main effects appeared when the posted speed limit was controlled at below 30 Mph: More severe injuries occurred in SPOTS with larger sidewalk coverage and in ZIP CODES that were less densely populated or poorer. The somewhat counterintuitive main effect for sidewalk coverage is explained by its interaction with recreation areas (see below). Nonetheless, the difference in the significant parameters in the subsample of SPOTS with speeds below 30 Mph compared to the general sample show a different configuration in the behavioral program as a result of different action patterns on roads with posted speed limits of 30Mph. (Schoggen, 1989, p. 108).

Beyond the main effects, the characteristics of the proximal environment that could moderate the effect of individual characteristics on injuries also yielded some significant interaction effects. For the general sample, one interesting moderating effect was the effect of walkability on drivers who were driving on a straight stretch of road. The latter predictor produced significantly more injuries only in SPOTS where walkability was low. It appears that when affordances for walking increase, an inhibitory effect on drivers' speed is created.

This means that when the environment affords less walkability, the straighter the road segment, the more severe are jaywalkers' injuries. The combination of straight road segments with the reduced availability of walkable access could increase the opportunities for drivers to drive in a more relaxed manner paying less attention to environmental stimuli (e.g. jaywalkers crossing). Comfortable (straight) road segments for drivers are not necessarily safer for jaywalkers if walkability is low. The opposite concept (safer pedestrians in less straight segments with more alert drivers) has been the basis for the movement in street design named Shared Space (Hamilton-Baillie, 2008; Lutz, 2009; Shared_Space_Project, 2005). Shared Space proponents use risk homeostasis theory to support the idea that "drivers are believed to continuously adjust their behavior to accommodate situational fluctuations in the amount of risk they experience" (Jackson & Blackman, 1994, p. 950). That way, road segments perceived as riskier would motivate a decrease in driving speed or more attentive driving. Shared Space exploits this assumption via a redesign of the road segment geometry without using traditional safety prompts like signalized crossings, barriers, curbs, or even traffic lights. Shared Space represents a "deliberate effort to reassert the place status of streets while maintaining their link status. It aims to achieve this by minimizing the paraphernalia associated with vehicle movement and may introduce features such as seating, public art etc. to influence the behavior of street users and thereby enhance amenity and facilitate place-based activity" (Reid, Kocak& Hunt, 2009 p. 7). By decreasing drivers' perceptions of the safety associated with any road segment the perceived safety in drivers and at the same time increasing the preeminence of social contact for all road users, shared spaces' main goal is to increase the overall actual safety record of the road segment.

Like drivers, jaywalkers regulate their behavior to accommodate fluctuations in the amount of risk they perceive. The counterintuitive main effect found in the subsample of roads below 30 Mph linking more sidewalks with more severe injuries can be explained in terms of the perceived safety sidewalks give to pedestrians in general. More sidewalks do not necessarily mean safer crossings. Under the assumption of risk homeostasis, it can also be explained reasonably well why the more recreation areas in sight were significantly associated with more severe injuries when sidewalk coverage was above the mean. For the pedestrian, a sidewalk is perceived as an affordance for safe walking which is not necessarily true. This conceptualization of affordance is different from J.J. Gibson's. For Gibson, an affordance is "an action possibility available in the environment to an individual, independent of the individual's ability to perceive this possibility" (McGrenere & Ho, 2000) but, for some authors, it is possible to deal with "perceived affordances" (Norman, 1988) or even "false affordances" (Gaver, 1991). False affordances are associated with no real action possibility but with at least a piece of information that specifies it is an affordance. For example, "one will perceive that one can walk forward when one sees a solid, opaque surface that extends under one's feet. The affordance is walkability and the information that specifies walkability is a perceived invariant combination of a solid, opaque surface of a certain size relative to oneself" (McGrenere & Ho, 2000, p. 2). Nonetheless, a sidewalk without safe crossings connecting with other affordances is as false as a chair that looks well-built but made of cardboard. Affordances mean more than the quality of the immediate surface; they imply connectivity between the different elements of the spatial carte du jour.

In relation to connectivity, another moderating effect that was found using the general sample of road segments (n=900) involves the role of wearing dark clothing in the

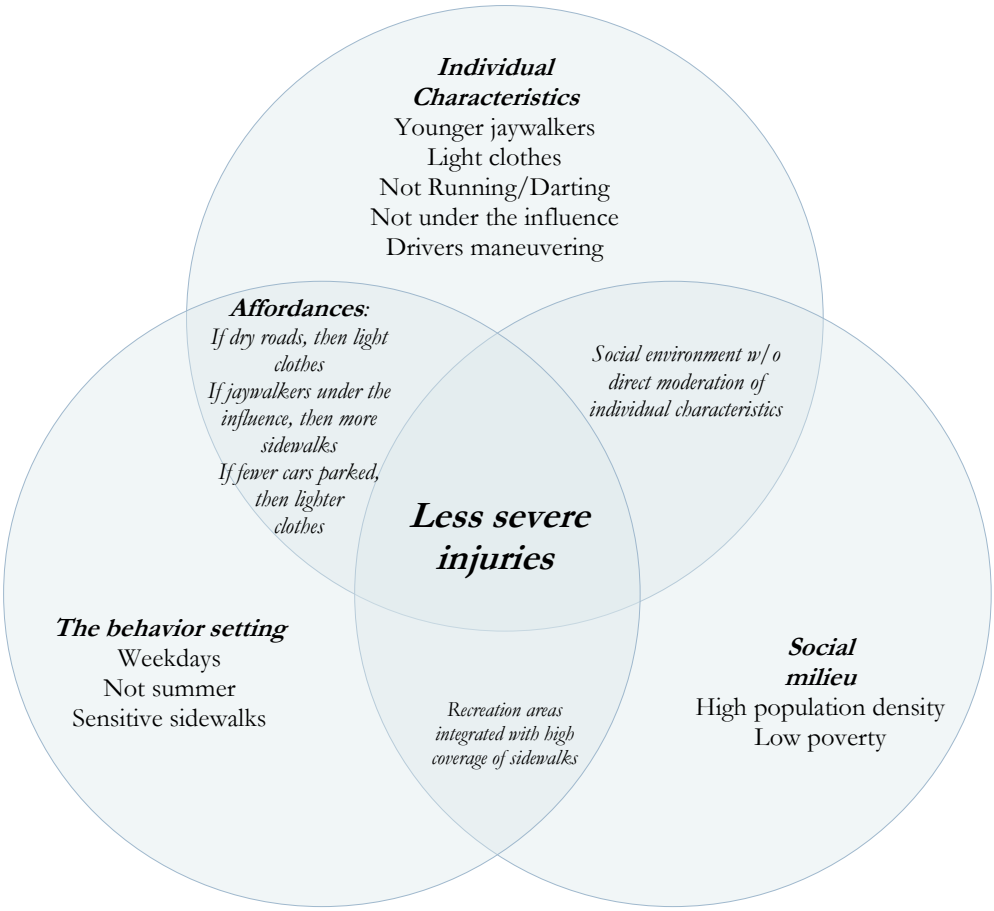
context of distance to public transportation. Wearing dark clothes increases the chance of receiving more severe injuries when the distance to public transportation is greater than average (at least one standard deviation above). One plausible explanation for this phenomenon is that, when jaywalkers have to walk longer distances, they face the possibility of having to cross roads where speeds are higher and they therefore have a greater risk of suffering severe injuries. One argument in favor of this rather speculative explanation is that the interaction between dark clothing and distance to public transportation became non-significant whenever the maximum posted speed was explicitly controlled (roads with less than 30 Mph). This outcome seems to be characteristic of less urban areas where access to public transportation is of inferior quality. An accessible transit network seems to protect jaywalkers who are wearing dark clothes from suffering severe injuries in case of collisions. This is a policy issue for New Jersey since, during nights and weekends, public transportation becomes less regular particularly in semi-urban and rural areas. The current state government and planning priorities have led the transit authorities to reduce service frequency and the number of routes. In SPOTS where the roads have posted speeds of less than 30 Mph, public transportation did not significantly moderate the effect of dark clothes on severe injuries. Most of those SPOTS were located in areas well served by public transportation. Personal choices (e.g. clothing) have impacts on injuries that are moderated by connectivity and accessibility to places by public transportation or by foot.

Further on connectivity, it was found that, as age increased, jaywalkers also sustained more severe injuries when crossing the road at points further away from an intersection. This moderating effect poses interesting questions regarding the type of trips and their environmental determinants: do older jaywalkers develop more complex routes compared to

younger jaywalkers? Are urban streets and roads (with shorter distances between intersections) more heavily used by younger people? Also, in relation to age, older jaywalkers suffer significantly more severe injuries in settings having a lower-than-average median division height. These low-profile dividers seem to afford crossing the street with less difficulty. The most obvious solution would be to raise the median division in places where jaywalkers cross frequently creating negative affordances for crossing. Higher barriers better protect against severe injuries. Although effective in terms of reducing jaywalking, that safety measure also creates what is called the "severance effect". This effect is associated with the lack of access and the resulting distress that vehicle mobility imposes on pedestrians and other road users (VTPI, 2009). Without an opportunity to cross the streets where they want, pedestrians have to walk increasingly longer distances in order to reach their destinations. According to VTPI, the barrier effect "imposes indirect costs by reducing the viability of non-motorized travel, which reduces accessibility for non-drivers…" (p5.13-2). Severance also produces inequality since disadvantaged groups have to bear a larger part of those costs as they depend on public transportation and walking.

Based on the results considered so far, a revised conceptual model is shown in Figure 7. It contextualizes the general conceptual model depicted in Figure 3. In order to keep the results contextualized, the revised model involves results only for SPOTS where maximum posted speed was less than 30 Mph.

Figure 7: What protects against severe injuries in Jaywalker-Car Collisions?



The analyses performed in the present study showed that there are important predictors and moderators of effects systematically ignored by current information system policies. In terms of the policy implications of this empirical study, it is recommended that, at least, the most significant predictors from the meso and macro levels found in this study could be routinely included in the collision reporting information system. It is a tradeoff in terms of resources and information but a required step in the prevention of injuries on New Jersey's roads.

In addition, alcohol tests should be applied to both the driver and the pedestrian involved in every single collision reported to the police, independent of the outcome of the collision. The geographical information system administered by Rutgers University should also include data regarding detailed sidewalk coverage at the crash site, proximity to recreation areas, and distance to public transportation with a code for quality of access to this transportation mode.

LIMITATIONS OF THE STUDY

The research questions have been so far addressed but additional complexities still require an appropriate answer in this study. The first limitation is related to the variables used to address the research questions. Have all the possibly relevant variables been taken into account when addressing the motivating questions prompting the explanatory models? Literature indicates that most of them have but the empirical results show that there is still an important amount of unexplained variance in injury severity. One variable that is definitely missing is related to alcohol consumption. It has been estimated that alcohol involvement — either for the driver or for the pedestrian — is present in 48 percent of the

collisions that resulted in pedestrian fatalities in the United States (NHTSA, 2009). The reasons for excluding this variable go beyond the matter of pure statistics. They have to do with the way minor injuries are considered by authorities, regulators, and the general public. Unless every collision report includes information regarding alcohol consumption both by the pedestrian and the driver, the real effect of this variable will remain underestimated. The explanatory power of the whole model could change depending on the availability of this variable.

One further caveat is that the results were not replicated in their entirety in the confirmatory dataset. This means that additional, confirmatory research with different samples should be performed. In addition, partitioning the sample meant a reduction in sample size by half. A consequent reduction in statistical power to reject the null was a consequence of this decision. The researcher considers that the exploratory/confirmatory approach rendered more valid results despite the cost in terms of power.

There are also some possible conceptual limitations. For example, for this research, a fixed criterion for the definition of the physical dimensions of the different SPOTS was used. Each SPOT was defined by an airline buffer radius from each collision point of around 1300 feet, approximately equal to the vision range of a pedestrian as she stands in the center of the circumference in an urban road setting. It is reasonable to argue with this criterion and more research on the measurement aspects of the SPOT concept is required (particularly the circumference around the crash site).

DIRECTIONS FOR FURTHER RESEARCH

The aforementioned limitations reveal at least three important gaps in current knowledge about injuries in pedestrians. First, there is a need for more detailed research on the conceptualization and practical definitions of behavior settings. An interesting study could aim to define and test different types of SPOTs (e.g. 250 ft.; 500 ft.; 750 ft., etc.), evaluating the particular change in the explanatory contribution of each predictor. The logic behind the study proposed is that a study based on large samples like the present research can overlook fine grain details on the everyday dynamics of behavior settings. A study that takes into account the ecology of urban walking should focus on specific spatio-temporal niches to elucidate the temporal depth and homogeneity of particular behavior settings.

The second gap in knowledge addresses the relationship between injury levels and pedestrian connectivity. The relationship between connectivity and injuries has been found in the present research but the mechanisms linking both factors are still unclear. Further research should define pedestrian connectivity not only in terms of the extension of sidewalks (as defined in the present research) but also as a function of route directness (Randall & Baetz, 2001), quality of surface, and safety. Further research should also determine the amount of pedestrian connectivity required to prevent serious injuries or deaths in pedestrians.

Third, the effect of implementing Complete Streets programs on injury levels is unknown. A Complete Street is defined as "means to provide safe access for all users by designing and operating a comprehensive, integrated, connected multi-modal network of transportation options" (NJDOT, 2010a). A Complete Street improves safety for "pedestrians, bicyclists, children, older citizens, non-drivers and the mobility challenged as

well as those that cannot afford a car or choose to live car free" (NJDOT, 2010a, p. 1). This improved mobility incorporates sidewalks, bike lanes, safe crossings, and transit amenities into the initial design of a project. As of December, 2010 more than 210 US jurisdictions (including the State of New Jersey) had adopted Complete Streets as a compulsory policy. Data associated with changes in injuries since the implementation of those policies have not been reported so far.

Research in this area is therefore required. Such a study should cover other types of related strategies like Transit-Oriented Developments and their effect on injury dynamics. A Transit-Oriented Development (TOD) is "a mixed-use community within an average 2,000-foot walking distance of a transit stop and core commercial area. TODs mix residential, retail, office, open space, and public uses in a walkable environment, making it convenient for residents and employees to travel by transit, bicycle, foot, or car" (Calthorpe, 1993, p. 56). Although there are more than twenty declared Transit Villages (an alternative name for TODs) with some of them older than 15 years, it is still unclear what effect, if any, they have on pedestrian injuries.

General Discussion

> *"Urban transport is a political and not a technical issue. The technical aspects are very simple. The difficult decisions relate to who is going to benefit from the models adopted"*
> *Enrique Peñalosa, Mayor of Bogota (1998-2001)*

Affordances are determined by perceptual information. But affordances can also depend on experience, knowledge, and the individual's culture. Affordances are historically determined. Bridget Driscoll did not see a car coming because, among other reasons, the car was not supposed to be there that afternoon in 1896. Or was it? She did not perceive the negative affordances in the form of environmental cues that might have prevented her from crossing the road strip in front of Crystal Palace because of an historical bias. Her perceptual system was not configured to cope with a new dangerous environmental condition. Bridget Driscoll was a jaywalker before the term existed. Mrs. Driscoll was a jaywalker in the sense that she was looking for fair mobility and accessibility without following the norms created to favor motorized traffic. The area she crossed was actually configured for motorized traffic that day. But, as a pedestrian in 1896, she felt entitled to walk confidently on what she assumed was an otherwise safe and walkable place.

The Crystal Palace's fairgrounds changed qualitatively that day of August, becoming a potentially unhealthy place. Those fairgrounds were transformed into the kind of unhealthy places for jaywalkers that a majority of roads now are. Roads in New Jersey are a good example of standardized and predictable places where space is constructed as a function of motorized traffic.

The road environment is highly regulated and, according to regulation advocates, it has to be that way to prevent chaos on roads. The issue behind regulation of the road space is that standardization is necessary to speed up motorized traffic at the expense of other

types of road users. Cars own public space and jaywalkers are unwelcome users, a nuisance. The road space is unequally divided among those who are and those who are not car oriented. Speed rather than connectedness defines the program of roads as behavior settings in today's New Jersey. Different action patterns of the road environment are organized into programs to speed up motorized traffic.

Previous studies of jaywalker-car collisions can be characterized by two relevant conceptual characteristics. The first is related to the type of outcome studied. Most studies use the probability of the pedestrian being killed or sustaining major injuries as the outcome. Due to the nature of the outcome of interest, many of those studies tend to focus on roads and intersections like arterials and collector roads where posted speeds exceed 30 Mph. The present research has demonstrated that a small variation in the posted speed limits leads to a different model of main effects and interactions that needs to be studied in detail. In that sense, including less severe injuries as part of the outcome variable made it possible to discover effects otherwise concealed by the effect of posted speed limits. The present research makes a contribution to the rather scarce literature on the environmental determinants of injuries. At the same time, the findings stress the importance of a careful calculation of the posted speed limits on roads where the presence of different types of users is expected (Fitzpatrick et al., 2003). Some of the current methodologies used to calculate posted speed limits have been criticized elsewhere (Leandro, 2010a).

The second aspect emphasized in the published literature is the conceptualization of jaywalking as an illegal behavior that is relatively isolated from its context, the road environment. Rather than attempting an explanation of the determinants of the socio-spatial context in which jaywalking occurs, most studies simply overlook jaywalking as a valid

research topic. The lack of studies on the topic is somewhat surprising since jaywalking is a daily practice of many people around the world and deserves to be studied. The present research adds some valuable insights for the study of the environmental dynamics of a common behavior like jaywalking.

While having disproportionate access to space, jaywalkers and drivers share the same goals. They all want to get to their destinations as quickly as possible by using the most direct route, with the minimum cost, and within reasonable safety boundaries. Lower speeds would benefit pedestrians the most. It has been asserted that an average reduction of as little as 1 to 3 Mph in posted speeds could lead to a reduction ranging from 10% up to at least 30% in crash related injuries (Molin & Brookhuis, 2007). The safest places are those where posted speeds are lower. But speed reduction is difficult to attain when high speeds are promoted by design. As asserted by Kunstler "some drive faster than the limit…It is easy to do. The scale of the street is so immense that, at twenty-five, a motorist hardly feels he is moving" (1993, p. 116). That is particularly true in low and medium density geographies like many of the areas studied in New Jersey. Improving pedestrian connectivity by harmonizing the different components of the road environment necessarily implies a reduction in the posted speed limits.

In summary, based upon both the general sample (n=900) and the subsample of roads under 30 Mph (n=499), it can be said that 1) personal characteristics significantly predict the injury severity and 2) some of the proximal and distal environmental characteristics moderate some of those individual effects on injuries. Moreover, results from the subsample of roads under 30 Mph (n=449) show that places having high population densities, low poverty, and high walkability effectively protect jaywalkers from injuries.

Nonetheless, retrofitting places to make them more walkable should take into account the needs of the different road users in order to guarantee a minimum degree of environmental justice and effective risk reduction. The presence of sidewalks does not make walking safer due to the effect of risk homeostasis. The structure of a particular visual field is not deterministic. The structure implies possibilities for action –affordances- based on the valences of objects present in the visual path of the walker. Those valences are defined by the particular experience of every individual. Differences found in injury levels based upon the distance to an intersection depending on pedestrian's age make sense if evaluated as the product of individualized experience and structure. Some parents walk their children to school crossing the streets only at intersections. The same parents jaywalk on their way to work. From an affordance perspective, this apparent behavioral incoherency makes perfect sense. Perception of risk depends on individual experience structured by particular arrangements of visual objects. At the same time, navigation among environmental features is organized based upon risk perception. A sidewalk is perceived in different ways by different individuals. The use a majority gives to that sidewalk determines its particular program. A sidewalk is associated not only with ambulatory behavior but also with ecological practices like play, safe travel, social interaction, and the fulfillment of basic needs like recreation and sustenance.

The network for transportation on foot should be at least as complete as the network for transportation by car. The results of this study show that the coexistence of recreation areas and high sidewalk coverage that generates severe injuries is, most probably, due to poor planning in terms of equitable access to those recreation areas. Many of those recreation areas are characterized by high posted speeds limits on neighboring roads. Places

with pedestrian access facilities that lack connectivity and safe crossings are more dangerous than those without access at all. Incomplete streets falsely afford safe walking where, in fact, the opposite result can be expected. Building sidewalks into neighborhoods without a plan for completing the streets seems to make things worse for jaywalkers. Complete streets provide safe access for all users by designing and operating a comprehensive, integrated, connected multi - modal network of transportation options. As users of the road, jaywalkers should be included in a Complete Streets design and policy in order to make the road environment a sensible one. Increasing the number of midblock intersections could address this problem but it would also slow down traffic. The decision to make streets more human is political not technical.

It has been found that, while federal funding for non-motorized modes has clearly increased bike/pedestrian projects across the United States, "results show that the share of funding spent on such projects, the programs from which they are funded, and the types of projects funded vary widely from region to region depending on state, regional, and local factors" (Handy & McCann, 2011, p. 12). New Jersey's Department of Transportation in fact has had a "Complete Streets Policy" since 1989 with a revision in 2009 (NJDOT Policy No. 703). But current actions necessary to implement the policy seem to be unequally distributed over the State's geography. Many of the actions taken are circumscribed to very small and localized projects. For example, none of the grants approved for New Jersey as part of the Transportation Investment Generating Economic Recovery (TIGER) programs I and II involved the creation of regional pedestrian areas or complete streets.

One meritorious exception (submitted by Pennsylvania) is the Philadelphia Area Pedestrian & Bicycle Network, a project with a cost of $54,800,000 that involves the

improvement of the primary commuter routes closest to downtown in some of the communities hardest hit by the recession including Southwest Philadelphia and Camden, New Jersey. According to the grant application, a 128-mile bicycle and pedestrian regional network is being created to connect people from those areas to communities that provide employment opportunities including Philadelphia and Cherry Hill, NJ. The main reason for the creation of this project was that it will provide improved commuting options with "significant livability benefits, enhancing access to green space and alternative modes of transportation that offer public health benefits" (USDOT, 2010). It is expected that posted speed limits in the areas surrounding the project intervention will be adjusted according to the project's goals.

But New Jersey's actual support for the Complete Streets Program needs to be more conspicuous. The State still openly favors programs to benefit car owners. For example, a heavily funded project in New Jersey, the Meadowlands adaptive signal system, will use Tiger II dollars to modernize and coordinate traffic signals at 128 intersections along the Meadowlands corridor. The goal of the project is "to achieve the maximum roadway capacity, improve operating efficiency, and avoid unnecessary roadway widening". For proponents, the system "will benefit the thousands who use personal vehicles…to get around the region and into New York City".

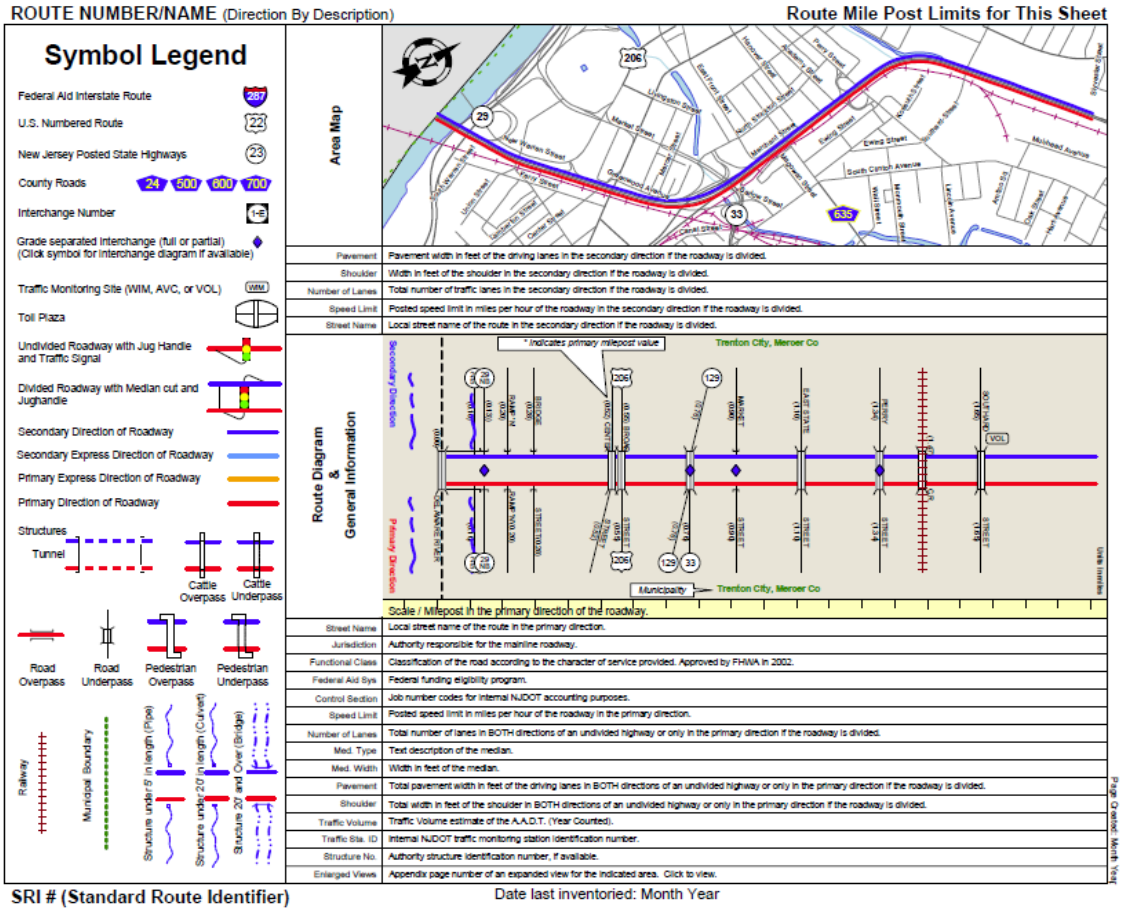
New Jersey's Policy 703 clearly states that "where needs or opportunities are identified….bikeways, walkways or other facilities intended to encourage or support travel by bicycle or walking should be designed and constructed". In a recent revised version of the policy (2009), it says that "if there is evidence of heavy pedestrian usage then sidewalks shall be considered in the project". How could a road environment have heavy pedestrian usage if

there are no pedestrian facilities on it? As any behavior, the act of walking has to be intertwined with the physical structures that potentiate that behavior (perceivable action potentials) without conflicting messages from the physical, social, and political environment. After all, that is what Gibson defined as affordances.

Appendices

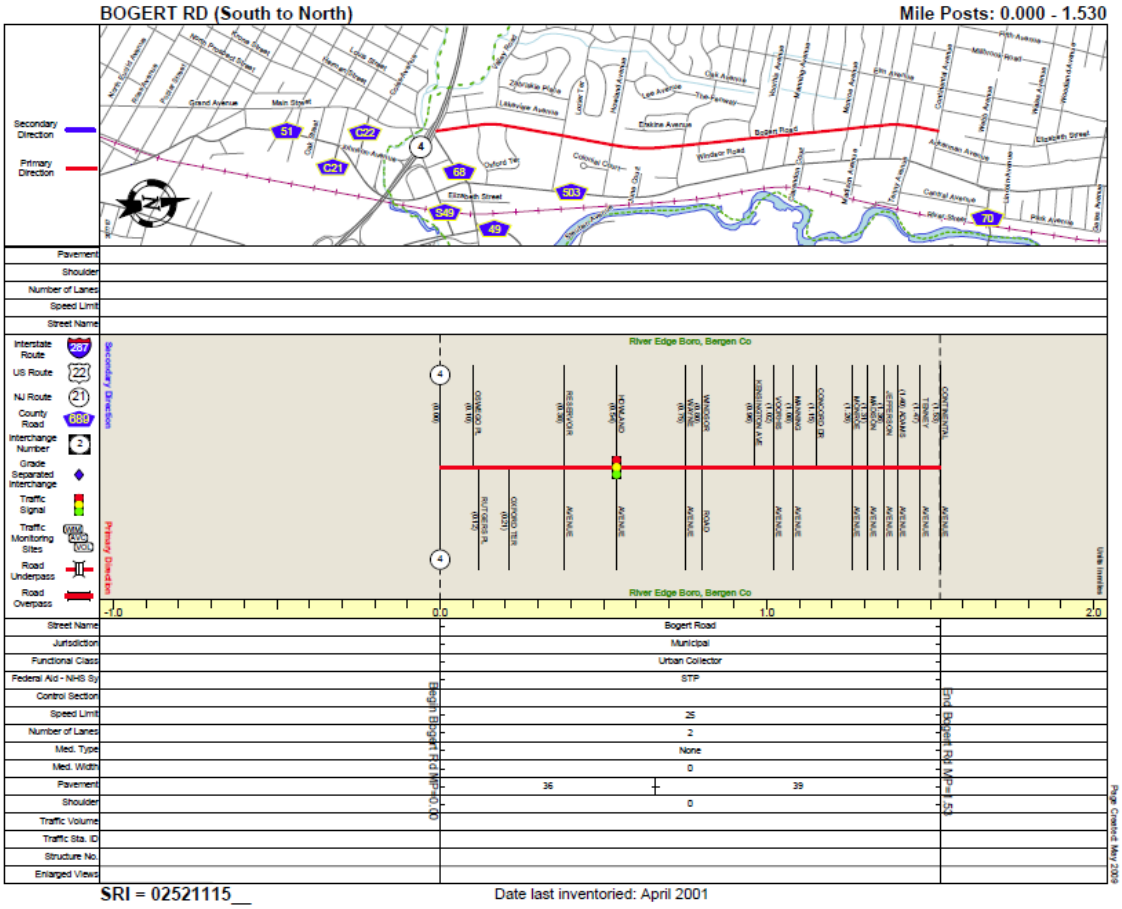
Appendix 1. Legend and example sheet of a Straight Line Diagram

Legend



Appendix 1. (continued…)

Example sheet



Appendix 2. Pooled Correlation Estimates and p-values for the initial set of explanatory variables of the micro-level (n = 900)

Pair	r	StdErr	Fishersz	Probt
DFEM DINAT	0.02396	0.035448	0.023969	0.4991
DFEM DNORM	-0.04843	0.03767	-0.04847	0.1997
DFEM DSPD	-0.06065	0.042443	-0.060729	0.1575

DFEM DSTRAIG	-0.00269	0.033905	-0.002693	0.9367
DFEM SUV	0.07288	0.034998	0.073005	0.0372
DFEM cVYEAR	0.12162	0.034222	0.122228	0.0004
DINAT DNORM	-0.10808	0.037935	-0.108502	0.0047
DINAT DSPD	0.16042	0.033552	0.161818	<.0001
DINAT DSTRAIG	-0.13075	0.033599	-0.1315	<.0001
DINAT SUV	-0.05608	0.033752	-0.056141	0.0963
DINAT cVYEAR	0.03198	0.034908	0.031989	0.3596
DNORM DSTRAIG	-0.04664	0.033708	-0.046671	0.1662
DNORM SUV	-0.0387	0.035174	-0.038719	0.2713
DNORM cVYEAR	-0.01317	0.037263	-0.013175	0.724
DSPD DNORM	-0.15606	0.042599	-0.157345	0.0005
DSPD DSTRAIG	0.02971	0.033635	0.029717	0.377
DSPD SUV	-0.01485	0.033431	-0.014853	0.6568
DSPD cVYEAR	-0.01853	0.03938	-0.018533	0.6388
DSTRAIG SUV	0.01604	0.03385	0.016037	0.6357
DSTRAIG cVYEAR	-0.08486	0.033842	-0.085061	0.012
PDARKC DFEM	-0.03203	0.034433	-0.032037	0.3522
PDARKC DINAT	0.03851	0.034284	0.038527	0.2612
PDARKC DNORM	-0.03064	0.034251	-0.030651	0.3709
PDARKC DSPD	0.00452	0.033978	0.004515	0.8943
PDARKC DSTRAIG	0.02353	0.03568	0.02353	0.5099
PDARKC PINATT	-0.11759	0.034588	-0.118137	0.0006
PDARKC PRUNDAR	-0.14588	0.033917	-0.146929	<.0001
PDARKC SUV	0.06244	0.033755	0.062518	0.064
PDARKC cDAGE	0.0277	0.036499	0.027711	0.4483
PDARKC cVYEAR	-0.04521	0.034623	-0.045245	0.1914
PFEM DFEM	0.01809	0.034945	0.018093	0.6047
PFEM DINAT	0.04927	0.034171	0.049312	0.1491
PFEM DNORM	0.0433	0.034258	0.043323	0.2061
PFEM DSPD	0.0448	0.033489	0.044828	0.1807
PFEM DSTRAIG	-0.0785	0.034406	-0.078661	0.0223
PFEM PDARKC	0.01207	0.033993	0.012072	0.7225
PFEM PINATT	-0.05261	0.034652	-0.052663	0.1287
PFEM PNORM	0.17995	0.03444	0.18193	<.0001
PFEM PRUNDAR	-0.09871	0.033914	-0.099037	0.0035

PFEM SUV	-0.01711	0.033743	-0.017113	0.6121
PFEM cDAGE	0.02632	0.035612	0.02633	0.46
PFEM cVYEAR	-0.02714	0.034692	-0.027145	0.4341
PINATT DFEM	-0.02327	0.035077	-0.023275	0.5071
PINATT DINAT	0.03501	0.034369	0.035028	0.3082
PINATT DNORM	0.03343	0.035225	0.033447	0.3426
PINATT DSPD	-0.00133	0.035204	-0.001328	0.9699
PINATT DSTRAIG	-0.00462	0.035251	-0.004617	0.8958
PINATT PRUNDAR	-0.11128	0.035215	-0.111745	0.0016
PINATT SUV	-0.01423	0.034188	-0.014226	0.6773
PINATT cDAGE	0.02635	0.036104	0.02636	0.4657
PINATT cVYEAR	-0.00298	0.035026	-0.002978	0.9323
PNORM DFEM	0.02111	0.037346	0.021114	0.5724
PNORM DINAT	0.09284	0.035226	0.093109	0.0084
PNORM DNORM	0.24143	0.036998	0.246291	<.0001
PNORM DSPD	0.00991	0.033872	0.009915	0.7698
PNORM DSTRAIG	-0.10033	0.033992	-0.100668	0.0031
PNORM PDARKC	-0.03669	0.034248	-0.036706	0.2839
PNORM PINATT	-0.03549	0.033831	-0.035507	0.2939
PNORM PRUNDAR	0.02206	0.034307	0.022061	0.5202
PNORM SUV	-0.02172	0.033799	-0.021719	0.5205
PNORM cDAGE	-0.00621	0.036669	-0.006207	0.8657
PNORM cVYEAR	-0.00731	0.034459	-0.007314	0.8319
PRUNDAR DFEM	-0.00947	0.034309	-0.009466	0.7826
PRUNDAR DINAT	-0.25168	0.034006	-0.257207	<.0001
PRUNDAR DNORM	0.06715	0.034578	0.067255	0.0519
PRUNDAR DSPD	-0.07472	0.034559	-0.074855	0.0304
PRUNDAR DSTRAIG	0.23052	0.035202	0.234735	<.0001
PRUNDAR SUV	-0.02725	0.034024	-0.027253	0.4232
PRUNDAR cDAGE	-0.03501	0.035033	-0.035029	0.3176
PRUNDAR cVYEAR	-0.06812	0.03596	-0.06823	0.0584
SUV cVYEAR	0.02577	0.035414	0.025774	0.467
cDAGE DFEM	-0.00766	0.035501	-0.007663	0.8292
cDAGE DINAT	0.00104	0.037671	0.001042	0.978
cDAGE DNORM	0.01705	0.035323	0.017052	0.6294
cDAGE DSPD	-0.09352	0.049173	-0.093792	0.0658

cDAGE DSTRAIG	-0.00486	0.034064	-0.004859	0.8866
cDAGE SUV	-0.00264	0.036202	-0.002643	0.9418
cDAGE cVYEAR	0.01368	0.034902	0.013681	0.6951
cPAGE DFEM	-0.03817	0.037137	-0.038192	0.3048
cPAGE DINAT	0.16686	0.03485	0.168438	<.0001
cPAGE DNORM	-0.01488	0.037999	-0.014884	0.6958
cPAGE DSPD	-0.00104	0.034254	-0.001043	0.9757
cPAGE DSTRAIG	-0.1941	0.035072	-0.196599	<.0001
cPAGE PDARKC	0.13057	0.034535	0.131317	0.0001
cPAGE PFEM	-0.02835	0.034895	-0.028357	0.4166
cPAGE PINATT	0.01186	0.035533	0.011862	0.7386
cPAGE PNORM	-0.11542	0.036268	-0.115941	0.0015
cPAGE PRUNDAR	-0.31077	0.034645	-0.321403	<.0001
cPAGE SUV	0.0299	0.034393	0.029912	0.3845
cPAGE cDAGE	0.05797	0.035755	0.05804	0.1051
cPAGE cVYEAR	0.04529	0.035827	0.045318	0.2065

Appendix 3. Pooled Correlation Estimates and p-values for the initial set of explanatory variables of the meso-level (n = 900)

Pair	r	StdErr	Fishersz	Probt
cAADT cCPARKED	-0.1185	0.03953	-0.11906	0.0032
cAADT cDPUBTR	0.00577	0.035041	0.00577	0.8692
cAADT cFURNIT	0.09918	0.040008	0.099504	0.0146
cAADT cRECREA	-0.04706	0.04556	-0.047099	0.3072
cAADT cTRSTUFF	-0.04112	0.044292	-0.041142	0.3576
cAADT cWALK	-0.30433	0.044255	-0.314288	<.0001
cCPARKED cFURNIT	0.24088	0.033572	0.245712	<.0001
cCPARKED cRECREA	-0.04023	0.033391	-0.040255	0.228
cCPARKED cTRSTUFF	0.11465	0.034769	0.115157	0.0009
cCPARKED cWALK	0.5217	0.033432	0.578674	<.0001
cDAYLT cAADT	-0.09016	0.041433	-0.090408	0.0323
cDAYLT cCPARKED	0.23154	0.033428	0.235816	<.0001
cDAYLT cDINTERS	-0.07778	0.033389	-0.077941	0.0196
cDAYLT cDPUBTR	-0.07077	0.03339	-0.070891	0.0337
cDAYLT cFURNIT	0.03109	0.033826	0.031103	0.3579
cDAYLT cMEDIANH	-0.15512	0.033395	-0.156381	<.0001
cDAYLT cMEDIANW	-0.11502	0.033454	-0.11553	0.0006
cDAYLT cRDGRDIV	-0.07832	0.0335	-0.078485	0.0191
cDAYLT cRECREA	0.08403	0.03339	0.084226	0.0117
cDAYLT cROADW	-0.13567	0.033401	-0.136515	<.0001
cDAYLT cSPEED	-0.27132	0.033618	-0.278288	<.0001
cDAYLT cSUMMER	0.15089	0.033391	0.15205	<.0001
cDAYLT cTRSTUFF	0.05587	0.043825	0.055931	0.2076
cDAYLT cWALK	0.22009	0.033393	0.223751	<.0001
cDAYLT cWKEND	-0.2041	0.033407	-0.207009	<.0001
cDINTERS cAADT	0.23571	0.038015	0.240224	<.0001
cDINTERS cCPARKED	-0.22166	0.033389	-0.225404	<.0001
cDINTERS cDPUBTR	0.15293	0.033389	0.154139	.
cDINTERS cFURNIT	-0.19051	0.033545	-0.192871	<.0001
cDINTERS cMEDIANH	0.22705	0.033389	0.23108	.
cDINTERS cMEDIANW	0.37557	0.033389	0.394898	.
cDINTERS cRECREA	0.01864	0.033389	0.018645	.
cDINTERS cROADW	0.24319	0.033389	0.248166	.

cDINTERS cTRSTUFF	-0.36417	0.061701	-0.381681	<.0001
cDINTERS cWALK	-0.36903	0.033389	-0.387301	.
cDPUBTR cCPARKED	-0.14815	0.033389	-0.149252	<.0001
cDPUBTR cFURNIT	-0.071	0.03358	-0.071117	0.0342
cDPUBTR cRECREA	0.00816	0.033389	0.008164	.
cDPUBTR cTRSTUFF	-0.05513	0.041344	-0.055185	0.186
cDPUBTR cWALK	-0.2519	0.033389	-0.257439	.
cFURNIT cTRSTUFF	0.33715	0.05938	0.350869	<.0001
cFURNIT cWALK	0.25389	0.033914	0.259564	<.0001
cMARKS cAADT	0.18105	0.039525	0.183067	<.0001
cMARKS cCPARKED	-0.31042	0.033835	-0.321009	<.0001
cMARKS cDAYLT	-0.21281	0.034739	-0.216114	<.0001
cMARKS cDINTERS	0.1633	0.033452	0.164773	<.0001
cMARKS cDPUBTR	0.13973	0.033422	0.140654	<.0001
cMARKS cFURNIT	0.00783	0.034026	0.007834	0.8179
cMARKS cMEDIANH	0.18708	0.034819	0.189307	<.0001
cMARKS cMEDIANW	0.16381	0.033435	0.165301	<.0001
cMARKS cRDGRDIV	0.17727	0.033584	0.179167	<.0001
cMARKS cRECREA	-0.0468	0.033467	-0.046838	0.1617
cMARKS cROADW	0.18637	0.034037	0.18857	<.0001
cMARKS cSDRY	0.03926	0.033761	0.039275	0.2447
cMARKS cSPEED	0.34126	0.033655	0.355517	<.0001
cMARKS cSUMMER	0.01395	0.034005	0.013949	0.6817
cMARKS cTRSTUFF	-0.06534	0.040554	-0.065434	0.1103
cMARKS cWALK	-0.29647	0.033683	-0.305643	<.0001
cMARKS cWKEND	0.05758	0.034577	0.057646	0.0956
cMEDIANH cAADT	0.54716	0.036016	0.614323	<.0001
cMEDIANH cCPARKED	-0.25919	0.033398	-0.265235	<.0001
cMEDIANH cDPUBTR	0.04447	0.033389	0.044504	.
cMEDIANH cFURNIT	-0.06198	0.033864	-0.062062	0.0669
cMEDIANH cMEDIANW	0.53242	0.033389	0.593511	.
cMEDIANH cRECREA	-0.05597	0.033389	-0.056031	.
cMEDIANH cTRSTUFF	-0.09644	0.04306	-0.096736	0.0286
cMEDIANH cWALK	-0.47863	0.033389	-0.521203	.
cMEDIANW cAADT	0.37194	0.034096	0.390671	<.0001
cMEDIANW cCPARKED	-0.20258	0.033394	-0.205426	<.0001

cMEDIANW cDPUBTR	0.14272	0.033389	0.143697	.
cMEDIANW cFURNIT	-0.04853	0.033421	-0.04857	0.1462
cMEDIANW cRECREA	-0.00617	0.033389	-0.006173	.
cMEDIANW cTRSTUFF	-0.33572	0.090854	-0.349259	0.0023
cMEDIANW cWALK	-0.39773	0.033389	-0.420948	.
cRDGRDIV cAADT	0.35744	0.03632	0.373946	<.0001
cRDGRDIV cCPARKED	-0.17207	0.033393	-0.173798	<.0001
cRDGRDIV cDINTERS	0.22528	0.033389	0.229209	.
cRDGRDIV cDPUBTR	0.03284	0.033389	0.032857	.
cRDGRDIV cFURNIT	-0.01107	0.033413	-0.011074	0.7403
cRDGRDIV cMEDIANH	0.39841	0.033389	0.421762	.
cRDGRDIV cMEDIANW	0.53543	0.033389	0.597722	.
cRDGRDIV cRECREA	-0.00856	0.033389	-0.008562	.
cRDGRDIV cROADW	0.35571	0.033389	0.37197	.
cRDGRDIV cSPEED	0.39831	0.033413	0.421641	<.0001
cRDGRDIV cTRSTUFF	0.00044	0.042215	0.000436	0.9918
cRDGRDIV cWALK	-0.27455	0.033389	-0.281779	.
cRECREA cFURNIT	-0.0037	0.034009	-0.003701	0.9134
cRECREA cTRSTUFF	0.05146	0.038523	0.051507	0.1833
cRECREA cWALK	0.03445	0.033389	0.034468	.
cROADW cAADT	0.49993	0.035664	0.549214	<.0001
cROADW cCPARKED	-0.11603	0.033393	-0.11655	0.0005
cROADW cDPUBTR	0.02124	0.033389	0.021248	.
cROADW cFURNIT	0.12427	0.033724	0.124911	0.0002
cROADW cMEDIANH	0.58778	0.033389	0.67426	.
cROADW cMEDIANW	0.61294	0.033389	0.713613	.
cROADW cRECREA	-0.01997	0.033389	-0.019968	.
cROADW cTRSTUFF	-0.05412	0.081117	-0.054173	0.5159
cROADW cWALK	-0.31738	0.033389	-0.328727	.
cSDRY cAADT	-0.02314	0.039031	-0.023143	0.5543
cSDRY cCPARKED	0.02766	0.033395	0.027666	0.4074
cSDRY cDAYLT	0.1752	0.033421	0.177031	<.0001
cSDRY cDINTERS	-0.03913	0.033389	-0.039152	.
cSDRY cDPUBTR	0.02356	0.033389	0.023568	.
cSDRY cFURNIT	-0.04716	0.034167	-0.04719	0.1673
cSDRY cMEDIANH	0.0085	0.033389	0.008497	.

cSDRY cMEDIANW	0.02723	0.033389	0.027232	.
cSDRY cRDGRDIV	0.03153	0.033389	0.03154	.
cSDRY cRECREA	0.03037	0.033389	0.03038	.
cSDRY cROADW	0.01029	0.033389	0.010289	.
cSDRY cSPEED	0.00773	0.033528	0.007727	0.8177
cSDRY cSUMMER	0.11943	0.033389	0.12	.
cSDRY cTRSTUFF	-0.05309	0.042007	-0.053135	0.2103
cSDRY cWALK	-0.04338	0.033389	-0.04341	.
cSDRY cWKEND	-0.00265	0.033389	-0.002646	.
cSPEED cAADT	0.49381	0.036574	0.541087	<.0001
cSPEED cCPARKED	-0.44624	0.033585	-0.48	<.0001
cSPEED cDINTERS	0.36482	0.033461	0.382431	<.0001
cSPEED cDPUBTR	0.2278	0.033415	0.231868	<.0001
cSPEED cFURNIT	-0.07199	0.034088	-0.072119	0.0344
cSPEED cMEDIANH	0.53942	0.033478	0.603332	<.0001
cSPEED cMEDIANW	0.51705	0.033694	0.572305	<.0001
cSPEED cRECREA	-0.07525	0.033607	-0.075397	0.0249
cSPEED cROADW	0.53529	0.033811	0.597535	<.0001
cSPEED cTRSTUFF	-0.22505	0.04858	-0.228971	<.0001
cSPEED cWALK	-0.6584	0.034016	-0.789985	<.0001
cSTRLVL cAADT	-0.07826	0.036546	-0.078416	0.0326
cSTRLVL cCPARKED	0.1343	0.033464	0.135116	<.0001
cSTRLVL cDAYLT	0.05039	0.033391	0.050436	0.1309
cSTRLVL cDINTERS	-0.01692	0.033389	-0.016923	.
cSTRLVL cDPUBTR	0.00836	0.033389	0.008361	.
cSTRLVL cFURNIT	0.00825	0.033706	0.008255	0.8065
cSTRLVL cMARKS	-0.10412	0.034286	-0.104495	0.0023
cSTRLVL cMEDIANH	-0.09632	0.033389	-0.096618	.
cSTRLVL cMEDIANW	-0.02616	0.033389	-0.026164	.
cSTRLVL cRDGRDIV	-0.06098	0.033389	-0.061061	.
cSTRLVL cRECREA	0.05483	0.033389	0.054887	.
cSTRLVL cROADW	-0.07792	0.033389	-0.078079	.
cSTRLVL cSDRY	-0.03193	0.033389	-0.031938	.
cSTRLVL cSPEED	-0.05479	0.033436	-0.054842	0.101
cSTRLVL cSUMMER	-0.01239	0.033389	-0.012387	.
cSTRLVL cTRSTUFF	0.01552	0.043096	0.015517	0.7201

cSTRLVL cWALK	0.09482	0.033389	0.095106	.
cSTRLVL cWKEND	-0.04126	0.033389	-0.041284	.
cSUMMER cAADT	0.00552	0.041126	0.005523	0.8935
cSUMMER cCPARKED	0.05253	0.033393	0.05258	0.1154
cSUMMER cDINTERS	0.0269	0.033389	0.026911	.
cSUMMER cDPUBTR	-0.02475	0.033389	-0.024755	.
cSUMMER cFURNIT	0.05725	0.034586	0.057313	0.0977
cSUMMER cMEDIANH	-0.03398	0.033389	-0.03399	.
cSUMMER cMEDIANW	-0.05148	0.033389	-0.051526	.
cSUMMER cRDGRDIV	-0.04857	0.033389	-0.04861	.
cSUMMER cRECREA	-0.01728	0.033389	-0.017277	.
cSUMMER cROADW	-0.02175	0.033389	-0.021749	.
cSUMMER cSPEED	-0.04936	0.033581	-0.049403	0.1413
cSUMMER cTRSTUFF	0.02163	0.037438	0.021629	0.564
cSUMMER cWALK	0.02767	0.033389	0.027679	.
cWALK cTRSTUFF	0.29502	0.038234	0.304051	<.0001
cWKEND cAADT	0.02079	0.040941	0.020797	0.6129
cWKEND cCPARKED	-0.03417	0.033399	-0.034185	0.3061
cWKEND cDINTERS	-0.03104	0.033389	-0.031045	.
cWKEND cDPUBTR	0.06553	0.033389	0.065623	.
cWKEND cFURNIT	-0.01663	0.033925	-0.016631	0.624
cWKEND cMEDIANH	0.04037	0.033389	0.04039	.
cWKEND cMEDIANW	-0.01302	0.033389	-0.01302	.
cWKEND cRDGRDIV	-0.01533	0.033389	-0.015329	.
cWKEND cRECREA	-0.03608	0.033389	-0.036095	.
cWKEND cROADW	0.0279	0.033389	0.027905	.
cWKEND cSPEED	-0.00484	0.033493	-0.004842	0.8851
cWKEND cSUMMER	0.01475	0.033389	0.014753	.
cWKEND cTRSTUFF	-0.01867	0.0373	-0.018675	0.6171
cWKEND cWALK	0.00457	0.033389	0.004567	.

Appendix 4. Pooled Correlation Estimates and p-values for the initial set of explanatory variables of the macro-level (n = 900)

Pair	r	StdErr	Fishersz	Probt
cBLACK cLATIN	0.20551	0.033389	0.20848	.
cBLACK cT2WORK	-0.01045	0.033389	-0.010449	.
cLATIN cT2WORK	-0.25699	0.033389	-0.262883	.
cPINC99 cBLACK	-0.38291	0.033808	-0.403463	<.0001
cPINC99 cLATIN	-0.36661	0.034423	-0.384496	<.0001
cPINC99 cPOPDENS	-0.26899	0.034477	-0.275777	<.0001
cPINC99 cPOV99	-0.56087	0.033776	-0.634097	<.0001
cPINC99 cPTCO2	0.4651	0.034187	0.503799	<.0001
cPINC99 cPTCOST	0.42454	0.034177	0.453219	<.0001
cPINC99 cT2WORK	0.24478	0.033705	0.249854	<.0001
cPLNDIST cBLACK	-0.13547	0.033903	-0.136309	<.0001
cPLNDIST cLATIN	-0.07043	0.034808	-0.070548	0.0429
cPLNDIST cPINC99	0.04351	0.034116	0.04354	0.2019
cPLNDIST cPOPDENS	-0.19098	0.035113	-0.193352	<.0001
cPLNDIST cPOV99	-0.08094	0.033849	-0.081118	0.0166
cPLNDIST cPTCO2	0.2215	0.034342	0.225234	<.0001
cPLNDIST cPTCOST	0.14348	0.034301	0.144481	<.0001
cPLNDIST cT2WORK	-0.0493	0.03381	-0.049336	0.1445
cPOPDENS cBLACK	0.32355	0.033389	0.335604	.
cPOPDENS cLATIN	0.59794	0.033389	0.689937	.
cPOPDENS cPOV99	0.41447	0.033389	0.441	.
cPOPDENS cT2WORK	0.16109	0.033389	0.16251	.
cPOV99 cBLACK	0.67542	0.033389	0.820638	.
cPOV99 cLATIN	0.63742	0.033389	0.753811	.
cPOV99 cT2WORK	-0.24236	0.033389	-0.247276	.
cPTCO2 cBLACK	-0.31298	0.034175	-0.323846	<.0001
cPTCO2 cLATIN	-0.39245	0.0352	-0.414687	<.0001
cPTCO2 cPOPDENS	-0.56136	0.036443	-0.634817	<.0001
cPTCO2 cPOV99	-0.3538	0.033548	-0.369777	<.0001
cPTCO2 cT2WORK	-0.04829	0.033734	-0.048328	0.152
cPTCOST cBLACK	-0.22355	0.033985	-0.227395	<.0001
cPTCOST cLATIN	-0.39586	0.034488	-0.418727	<.0001

cPTCOST cPOPDENS	-0.5966	0.035299	-0.687846	<.0001
cPTCOST cPOV99	-0.33421	0.033499	-0.347558	<.0001
cPTCOST cPTCO2	0.86904	0.034327	1.329164	<.0001
cPTCOST cT2WORK	-0.155	0.033604	-0.156258	<.0001
cTRANSPORT cBLACK	-0.33957	0.033389	-0.35361	.
cTRANSPORT cLATIN	-0.55087	0.033389	-0.619635	.
cTRANSPORT cPINC99	0.36136	0.034355	0.378446	<.0001
cTRANSPORT cPLNDIST	0.13384	0.03479	0.134643	0.0001
cTRANSPORT cPOPDENS	-0.70612	0.033389	-0.879409	.
cTRANSPORT cPOV99	-0.5139	0.033389	-0.568012	.
cTRANSPORT cPTCO2	0.58014	0.034299	0.662669	<.0001
cTRANSPORT cPTCOST	0.67512	0.033709	0.820087	<.0001
cTRANSPORT cT2WORK	-0.03143	0.033389	-0.03144	.

Appendix 5. Pooled Correlation Estimates and p-values for the initial set of explanatory variables of the integrated MLM (n = 900)

Pair	r	StdErr	Fishersz	Probt
VEH_PRECRSH_STRAIGHT PED_RUNNG_DARTING	0.232	0.034	0.236	<.0001
VEH_PRECRSH_STRAIGHT DVR_INATTENTIVE	-0.133	0.034	-0.134	<.0001
VEH_PRECRSH_STRAIGHT DVR_APPAR_NORMAL	-0.041	0.035	-0.041	0.244
VEH_PRECRSH_STRAIGHT csspeed	0.116	0.033	0.116	0.001
VEH_PRECRSH_STRAIGHT csrecreatio	0.102	0.044	0.102	0.025
VEH_PRECRSH_STRAIGHT cslanes	0.049	0.033	0.049	0.140
VEH_PRECRSH_STRAIGHT csdistpubtr	0.027	0.033	0.027	0.419
VEH_PRECRSH_STRAIGHT cped_tcosts	0.101	0.034	0.102	0.002
VEH_PRECRSH_STRAIGHT cmwalkabili	-0.091	0.033	-0.091	0.006
VEH_PRECRSH_STRAIGHT cmspeed	0.109	0.033	0.110	0.001
VEH_PRECRSH_STRAIGHT cmdistpubtr	0.027	0.033	0.027	0.419
PED_RUNNG_DARTING DVR_INATTENTIVE	-0.251	0.034	-0.256	<.0001
PED_RUNNG_DARTING DVR_APPAR_NORMAL	0.066	0.035	0.066	0.060
PED_RUNNG_DARTING csspeed	0.069	0.034	0.069	0.043
PED_RUNNG_DARTING csrecreatio	0.065	0.043	0.065	0.137
PED_RUNNG_DARTING cslanes	0.013	0.034	0.013	0.693
PED_RUNNG_DARTING csdistpubtr	0.014	0.033	0.014	0.684
PED_RUNNG_DARTING cmwalkabili	-0.043	0.035	-0.043	0.216
PED_RUNNG_DARTING cmspeed	0.034	0.035	0.034	0.332
PED_RUNNG_DARTING cmdistpubtr	0.042	0.033	0.042	0.209
PED_DARK_CLOTH VEH_PRECRSH_STRAIGHT	0.021	0.035	0.021	0.542
PED_DARK_CLOTH PED_RUNNG_DARTING	-0.148	0.035	-0.149	<.0001
PED_DARK_CLOTH DVR_INATTENTIVE	0.035	0.034	0.035	0.297
PED_DARK_CLOTH DVR_APPAR_NORMAL	-0.038	0.034	-0.038	0.264
PED_DARK_CLOTH csspeed	0.156	0.034	0.158	<.0001
PED_DARK_CLOTH csrecreatio	0.027	0.052	0.027	0.611
PED_DARK_CLOTH cslanes	0.043	0.034	0.043	0.204
PED_DARK_CLOTH csdistpubtr	0.125	0.033	0.125	0.000
PED_DARK_CLOTH cped_tcosts	0.094	0.035	0.094	0.008
PED_DARK_CLOTH cmwalkabili	-0.169	0.034	-0.171	<.0001
PED_DARK_CLOTH cmspeed	0.179	0.034	0.181	<.0001
PED_DARK_CLOTH cmdistpubtr	0.117	0.034	0.118	0.000
PED_APPAR_NORMAL VEH_PRECRSH_STRAIGHT	-0.100	0.034	-0.100	0.003

PED_APPAR_NORMAL PED_RUNNG_DARTING	0.024	0.035	0.024	0.497
PED_APPAR_NORMAL PED_DARK_CLOTH	-0.035	0.036	-0.035	0.334
PED_APPAR_NORMAL DVR_INATTENTIVE	0.083	0.035	0.084	0.019
PED_APPAR_NORMAL DVR_APPAR_NORMAL	0.231	0.035	0.236	<.0001
PED_APPAR_NORMAL csspeed	-0.146	0.034	-0.148	<.0001
PED_APPAR_NORMAL csrecreatio	-0.043	0.043	-0.043	0.324
PED_APPAR_NORMAL cslanes	-0.121	0.036	-0.122	0.001
PED_APPAR_NORMAL csdistpubtr	-0.035	0.036	-0.035	0.328
PED_APPAR_NORMAL cped_tcosts	-0.106	0.034	-0.106	0.002
PED_APPAR_NORMAL cmwalkabili	0.115	0.034	0.115	0.001
PED_APPAR_NORMAL cmspeed	-0.138	0.034	-0.138	<.0001
PED_APPAR_NORMAL cmdistpubtr	-0.057	0.034	-0.057	0.101
DVR_INATTENTIVE DVR_APPAR_NORMAL	-0.114	0.037	-0.114	0.002
DVR_INATTENTIVE csspeed	-0.100	0.034	-0.100	0.003
DVR_INATTENTIVE csrecreatio	-0.026	0.038	-0.026	0.495
DVR_INATTENTIVE cslanes	-0.046	0.034	-0.046	0.167
DVR_INATTENTIVE csdistpubtr	-0.062	0.034	-0.062	0.065
DVR_INATTENTIVE cmwalkabili	0.063	0.034	0.063	0.063
DVR_INATTENTIVE cmspeed	-0.079	0.034	-0.079	0.020
DVR_INATTENTIVE cmdistpubtr	-0.069	0.034	-0.069	0.040
DVR_APPAR_NORMAL csspeed	-0.077	0.034	-0.077	0.025
DVR_APPAR_NORMAL csrecreatio	0.040	0.054	0.040	0.466
DVR_APPAR_NORMAL cslanes	-0.004	0.037	-0.004	0.916
DVR_APPAR_NORMAL csdistpubtr	-0.039	0.034	-0.039	0.257
DVR_APPAR_NORMAL cmwalkabili	0.066	0.034	0.067	0.052
DVR_APPAR_NORMAL cmspeed	-0.085	0.035	-0.085	0.014
DVR_APPAR_NORMAL cmdistpubtr	-0.020	0.034	-0.020	0.561
csspeed cmwalkabili	-0.671	0.034	-0.813	<.0001
csspeed cmspeed	0.819	0.034	1.154	<.0001
csspeed cmdistpubtr	0.239	0.033	0.243	<.0001
csrecreatio csspeed	-0.057	0.037	-0.057	0.121
csrecreatio cmwalkabili	-0.186	0.039	-0.188	<.0001
csrecreatio cmspeed	0.042	0.037	0.042	0.253
csrecreatio cmdistpubtr	0.080	0.041	0.080	0.057
cslanes csspeed	0.505	0.033	0.556	<.0001
cslanes csrecreatio	-0.088	0.042	-0.088	0.039

cslanes cmwalkabili	-0.260	0.033	-0.266	<.0001
cslanes cmspeed	0.340	0.033	0.354	.
cslanes cmdistpubtr	0.045	0.033	0.045	.
csdistpubtr csspeed	0.249	0.033	0.255	<.0001
csdistpubtr csrecreatio	0.088	0.042	0.089	0.036
csdistpubtr cslanes	0.022	0.033	0.022	0.504
csdistpubtr cmwalkabili	-0.301	0.034	-0.311	<.0001
csdistpubtr cmspeed	0.304	0.033	0.314	<.0001
csdistpubtr cmdistpubtr	0.823	0.033	1.166	<.0001
cped_tcosts PED_RUNNG_DARTING	0.030	0.036	0.030	0.404
cped_tcosts DVR_INATTENTIVE	-0.078	0.034	-0.078	0.020
cped_tcosts DVR_APPAR_NORMAL	-0.069	0.034	-0.070	0.040
cped_tcosts csspeed	0.358	0.034	0.374	<.0001
cped_tcosts csrecreatio	0.161	0.048	0.162	0.002
cped_tcosts cslanes	0.049	0.033	0.049	0.141
cped_tcosts csdistpubtr	0.239	0.033	0.243	<.0001
cped_tcosts cmwalkabili	-0.428	0.034	-0.458	<.0001
cped_tcosts cmspeed	0.437	0.033	0.468	<.0001
cped_tcosts cmdistpubtr	0.243	0.033	0.248	<.0001
cped_age VEH_PRECRSH_STRAIGHT	-0.200	0.035	-0.202	<.0001
cped_age PED_RUNNG_DARTING	-0.307	0.035	-0.317	<.0001
cped_age PED_DARK_CLOTH	0.128	0.035	0.129	0.000
cped_age PED_APPAR_NORMAL	-0.106	0.034	-0.106	0.002
cped_age DVR_INATTENTIVE	0.172	0.034	0.174	<.0001
cped_age DVR_APPAR_NORMAL	-0.019	0.034	-0.019	0.568
cped_age csspeed	0.092	0.034	0.093	0.007
cped_age csrecreatio	-0.083	0.043	-0.083	0.059
cped_age cslanes	0.089	0.034	0.089	0.008
cped_age csdistpubtr	-0.011	0.033	-0.011	0.744
cped_age cped_tcosts	0.015	0.034	0.015	0.654
cped_age cmwalkabili	-0.036	0.034	-0.036	0.290
cped_age cmspeed	0.065	0.034	0.065	0.057
cped_age cmdistpubtr	-0.026	0.033	-0.026	0.441
cmspeed cmwalkabili	-0.815	0.034	-1.141	<.0001
cmdistpubtr cmwalkabili	-0.283	0.034	-0.290	<.0001
cmdistpubtr cmspeed	0.292	0.033	0.300	.

Appendix 6. MLM for Municipal Roads only (n = 331)

Initial MLM for Micro-Level, fixed effects only (municipal roads)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H0: Parameter=0	Pr > |t|
Intercept	1.919	0.458	1.018	2.819	351.030	1.691	2.132	4.19	<.0001
cPAGE	0.006	0.003	0.001	0.011	691.880	0.005	0.007	2.32	0.021
PFEM	-0.166	0.091	-0.344	0.013	397.050	-0.211	-0.124	-1.82	0.069
PNORM	-0.299	0.210	-0.713	0.114	688.330	-0.362	-0.215	-1.42	0.155
PDARKC	0.402	0.164	0.081	0.724	491.860	0.328	0.467	2.46	0.014
PINAT	-0.027	0.106	-0.236	0.181	467.800	-0.071	0.022	-0.26	0.795
PRUNDAR	0.229	0.108	0.016	0.442	472.040	0.186	0.272	2.11	0.035
cDAGE	0.005	0.003	0.000	0.011	737.320	0.004	0.006	1.79	0.073
DFEM	0.055	0.089	-0.120	0.230	566.060	0.015	0.087	0.62	0.534
DINAT	-0.047	0.101	-0.245	0.150	661.700	-0.084	-0.018	-0.47	0.638
DSPD	0.317	0.373	-0.415	1.049	839.850	0.225	0.369	0.85	0.396
DNORM	-0.437	0.441	-1.305	0.430	257.970	-0.675	-0.201	-0.99	0.322
DSTRAIG	0.218	0.088	0.046	0.391	701.890	0.196	0.246	2.48	0.013
SUV	0.028	0.113	-0.194	0.249	867.440	0.011	0.048	0.24	0.807
cVYEAR	-0.009	0.009	-0.027	0.009	467.230	-0.012	-0.004	-1	0.320

Final MLM for Micro-Level including interactions (municipal roads)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
Intercept	1.466	0.215	1.044	1.889	773.64	1.396	1.526	6.81	<.0001
cPAGE	0.006	0.003	0.000	0.011	444.29	0.004	0.007	2.14	0.0332
PNORM	-0.376	0.212	-0.791	0.039	738.42	-0.438	-0.307	-1.78	0.0759
PDARKC	0.413	0.167	0.086	0.741	354.40	0.324	0.475	2.48	0.0136
PRUNDAR	0.249	0.115	0.021	0.476	221.12	0.182	0.313	2.16	0.0322
DSTRAIG	0.241	0.089	0.067	0.415	816.00	0.223	0.273	2.710	0.007

Initial MLM for Meso-Level predictors (municipal roads)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
Intercept	1.631	0.086	1.461	1.801	274.230	1.601	1.652	18.91	<.0001
cSTRLVL	-0.004	0.149	-0.297	0.289	309.490	-0.012	0.008	-0.03	0.977
cMARKS	0.121	0.130	-0.135	0.378	299.060	0.097	0.163	0.93	0.3532
cSDRY	-0.002	0.126	-0.251	0.246	308.710	-0.014	0.010	-0.02	0.9869
cDAYLT	-0.193	0.117	-0.424	0.038	309.060	-0.201	-0.182	-1.65	0.1007
cWKEND	0.130	0.123	-0.111	0.372	309.090	0.119	0.138	1.06	0.2892
cSUMMER	0.208	0.130	-0.047	0.464	309.310	0.196	0.217	1.6	0.1096
cSPEED	0.030	0.014	0.003	0.057	137.740	0.022	0.037	2.18	0.0313
cDINTERS	0.017	0.039	-0.061	0.094	309.720	0.014	0.018	0.42	0.6718
cLANES	0.056	0.074	-0.090	0.202	308.520	0.051	0.066	0.75	0.4534
cROADW	-0.001	0.007	-0.014	0.012	308.060	-0.002	0.000	-0.16	0.8738
cMEDIANH	0.254	0.274	-0.284	0.793	308.240	0.228	0.282	0.93	0.3533
cMEDIANW	-0.055	0.061	-0.176	0.066	308.700	-0.061	-0.050	-0.89	0.3751
cLNDPUB	0.003	0.036	-0.069	0.074	308.990	0.000	0.007	0.07	0.9441
cCPARKED	-0.006	0.004	-0.015	0.002	307.760	-0.007	-0.006	-1.4	0.1615
cGRDIV	0.176	0.698	-1.197	1.548	308.140	0.124	0.260	0.25	0.8015
cRECREA	0.005	0.004	-0.003	0.013	308.890	0.005	0.005	1.23	0.2186
cFURNIT	-0.007	0.006	-0.018	0.004	236.860	-0.009	-0.004	-1.23	0.2217
cWALK	0.000	0.002	-0.005	0.004	291.050	-0.001	0.000	-0.19	0.8524

Final MLM for Meso-Level predictors (municipal roads)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
Intercept	1.618	0.081	1.458	1.777	259.010	1.586	1.641	19.94	<.0001
cSPEED	0.033	0.012	0.009	0.058	179.640	0.027	0.039	2.68	0.008
cCPARKED	-0.010	0.004	-0.017	-0.003	322.340	-0.011	-0.010	-2.89	0.004

Initial MLM for Macro-Level predictors (municipal roads)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
Intercept	1.473	0.059	1.358	1.589	318.860	1.471	1.476	25.14	<.0001
cTRANSPORT	0.001	0.001	0.000	0.002	311.600	0.001	0.001	1.30	0.195
cPLNDIST	-0.028	0.038	-0.103	0.047	270.270	-0.042	-0.010	-0.74	0.462
cPINC99	0.020	0.181	-0.335	0.376	247.640	-0.050	0.099	0.11	0.910
cPTCOST	0.000	0.001	-0.002	0.001	274.630	-0.001	0.000	-0.71	0.479
cPTCO2	0.306	0.419	-0.519	1.130	300.070	0.179	0.423	0.73	0.466
cLNDENS	-0.111	0.104	-0.315	0.093	309.070	-0.129	-0.082	-1.07	0.286
cPOV99	0.016	0.012	-0.008	0.039	312.450	0.014	0.018	1.33	0.185
cBLACK	-0.002	0.003	-0.009	0.005	318.530	-0.002	-0.002	-0.63	0.532
cLATIN	-0.002	0.005	-0.013	0.009	318.740	-0.002	-0.002	-0.36	0.721

Final MLM for Macro-Level (municipal roads)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
Intercept	1.485	0.0575			285			25.79	<.0001
cLNDENS	-0.171	0.0608			44			-2.81	0.007

Initial integrated MLM (municipal roads)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
Intercept	2.049	0.264	1.524	2.575	83.28	1.911	2.355	7.76	<.0001
cPAGE	0.010	0.004	0.002	0.017	136.19	0.007	0.012	2.58	0.011
PNORM	-0.749	0.218	-1.183	-0.316	82.89	-0.942	-0.625	-3.44	0.001
PDARKC	0.410	0.189	0.038	0.783	231.80	0.324	0.477	2.17	0.031
PRUNDAR	0.281	0.149	-0.014	0.575	239.38	0.217	0.338	1.88	0.062
DSTRAIG	0.130	0.178	-0.222	0.481	109.70	0.020	0.206	0.73	0.467
cSPEED	0.090	0.047	-0.002	0.183	101.63	0.067	0.141	1.93	0.056
cCPARKED	0.040	0.022	-0.004	0.084	224.06	0.032	0.052	1.79	0.075
cLNDENS	-0.616	0.301	-1.209	-0.023	252.15	-0.746	-0.508	-2.05	0.042
cPAGE*cSPEED	0.000	0.001	-0.001	0.002	104.56	0.000	0.001	0.67	0.507
cPAGE*cCPARKED	0.000	0.000	-0.001	0.000	162.62	0.000	0.000	-1.20	0.232
cPAGE*cLNDENS	-0.001	0.004	-0.008	0.007	194.15	-0.003	0.001	-0.20	0.844
PNORM*cSPEED	-0.072	0.038	-0.148	0.003	105.33	-0.105	-0.050	-1.90	0.061
PNORM*cCPARKED	-0.039	0.022	-0.083	0.004	197.01	-0.052	-0.031	-1.78	0.077
PNORM*cLNDENS	0.441	0.300	-0.151	1.032	225.15	0.307	0.571	1.47	0.144
PDARKC*cSPEED	0.020	0.035	-0.050	0.090	235.55	0.000	0.034	0.57	0.571
PDARKC*cCPARKED	-0.009	0.014	-0.036	0.018	195.09	-0.015	-0.002	-0.63	0.528
PDARKC*cLNDENS	0.106	0.177	-0.243	0.454	269.65	0.030	0.158	0.60	0.551
PRUNDAR*cSPEED	0.023	0.028	-0.033	0.079	110.16	0.002	0.041	0.81	0.419
PRUNDAR*cCPARKED	-0.013	0.010	-0.033	0.007	182.27	-0.019	-0.009	-1.30	0.196
PRUNDAR*cLNDENS	0.270	0.151	-0.026	0.567	238.86	0.199	0.328	1.80	0.074
DSTRAIG*cSPEED	-0.012	0.030	-0.071	0.047	71.94	-0.034	0.006	-0.42	0.676
DSTRAIG*cCPARKED	-0.006	0.007	-0.021	0.008	268.66	-0.009	-0.004	-0.89	0.373
DSTRAIG*cLNDENS	0.090	0.140	-0.184	0.365	259.70	0.044	0.133	0.65	0.518

Final integrated MLM (municipal roads)

Parameter	Estimate	Std Error	95% Confidence Limits		DF	Minimum	Maximum	t for H_0: Parameter=0	Pr > |t|
Intercept	2.075	0.261	1.553	2.597	64.963	1.865	2.268	7.94	<.0001
cPAGE	0.006	0.003	0.001	0.011	218.610	0.004	0.007	2.170	0.031
PNORM	-0.830	0.248	-1.325	-0.336	67.584	-1.001	-0.631	-3.350	0.001
PDARKC	0.335	0.163	0.014	0.655	201.710	0.239	0.392	2.060	0.041
PRUNDAR	0.236	0.113	0.012	0.461	126.980	0.154	0.302	2.090	0.039
DSTRAIG	0.213	0.088	0.039	0.386	307.580	0.200	0.240	2.410	0.016
cSPEED	0.115	0.039	0.038	0.193	54.680	0.080	0.142	2.980	0.004
cCPARKED	-0.007	0.003	-0.014	0.000	315.050	-0.008	-0.007	-2.090	0.038
PNORM*cSPEED	-0.097	0.038	-0.173	-0.022	71.605	-0.121	-0.065	-2.570	0.012

References

Abdel-Aty, M., Chundi, S. S. & Lee, C. (2007). Geo-spatial and log-linear analysis of pedestrian and bicyclist crashes involving school-aged children. *Journal of Safety Research, 38*(5), 571-579.

American Academy of Pediatrics. (2009). Pedestrian safety: American academy of pediatrics' committee on injury, violence, and poison prevention. *Pediatrics, 124*(2), 802-812. doi: 10.1542/peds.2009-1143

Barker, R. G. (1968). *Ecological psychology: Concepts and methods for studying the environment of human behavior*. Palo Alto, CA: Stanford University Press.

Bronfenbrenner, U. (1979). Theoretical models of human development. In H. U. Press (Ed.), *The ecology of human development* (pp. 993-1028). New York: Wiley.

Brownson, R. C., et al. (2009). Measuring the built environment for physical activity: State of the science. *American Journal of Preventive Medicine, 36*(4, Supplement 1), S99-S123.e112.

CAIT. (2010). Plan4safety frequently asked questions. Retrieved 2010/10/06, from http://cait.rutgers.edu/cait/P4S-FAQs

Calthorpe, P. (1993). *The next american metropolis: Ecology, community and the american dream.* New York: Princeton Architectural Press.

Chakravarthy, B., et al. (2007). Disparities in pedestrian crashes using geographic information system (gis) data in a large southern california county. *Annals of Emergency Medicine, 50*(3, Supplement 1), S99-S100.

Chapin, F. S. (1968). Activity systems and urban structure: A working schema. *Journal of the American Institute of Planners, 34*(1), 11-18.

Cho, G., Rodriguez, D. A. & Khattak, A. J. (2009). The role of the built environment in explaining relationships between perceived and actual pedestrian and bicyclist safety. *Accident Analysis & Prevention, 41*(4), 692-702.

Clifton, K. J., Burnier, C. V. & Akar, G. (2009). Severity of injury resulting from pedestrian-vehicle crashes: What can we learn from examining the built environment? *Transportation Research Part D: Transport and Environment, 14*(6), 425-436.

Clifton, K. J. & Kreamer-Fults, K. (2007). An examination of the environmental attributes associated with pedestrian-vehicular crashes near public schools. *Accident Analysis & Prevention, 39*(4), 708-715.

CTOD. (2006). The affordability index: A new tool for measuring the true affordability of a housing choice. *Center for Transit-Oriented Development and the Center for Neighborhood Technology Brookings Institute*. Retrieved from www.brookings.edu/metro/umi/20060127_affindex.pdf

Cubbin, C., LeClere, F. & Smith, G. (2000). Socioeconomic status and injury mortality: Individual and neighbourhood determinants. *Journal of Epidemiology and Community Health, 54*, 517-524.

DaimlerChrysler. (2007). The early years of the automobile in britain. Retrieved October, 29th., 2010

Dauvergne, P. (2005). Dying of consumption: Accidents or sacrifices of global morality? *Global Environmental Politics, 5*(3), 35-47.

Dietrich, J. & Eric, C. (1988). Effect of alcohol consumption on outcome of pedestrian victims. *Annals of Emergency Medicine, 17*(9), 953-956.

Dissanayake, D., Aryaija, J. & Wedagama, D. M. P. (2009). Modelling the effects of land use and temporal factors on child pedestrian casualties. *Accident Analysis & Prevention, 41*(5), 1016-1024.

DOE. (2010). A summary of important legislation. Retrieved October, 21st., 2010, from http://www.roadsafetyni.gov.uk/index/road_safety_education/teacherzone-home/teacherzone-mvrus/mvrus-legislation.htm

Downs, A. (1992). *Stuck in traffic: Coping with peak-hour traffic congestion*. Washington D.C.: The Brookings Institution.

Duany, A., Plater-Zyberk, E. & Speck, J. (2001). *Suburban nation: The rise of sprawl and the decline of the american dream*. New York: North Point Press.

Dunbar, G., Hill, R. & Lewis, V. (2001). Children's attentional skills and road behavior. *Journal of Experimental Psychology: Applied, 7*(3), 227-234.

Ernst, M. (2004). Mean streets: Surface Transportation Policy Project.

Ewing, R. & Cervero, R. (2010). Travel and the built environment -- a meta-analysis. *Journal of the American Planning Association, 76*(3), 265 - 294.

Ewing, R. & Dumbaugh, E. (2009). The built environment and traffic safety: A review of empirical evidence. *Journal of Planning Literature, 23*(4), 347-367. doi: 10.1177/0885412209335553

Ewing, R., Schieber, R. A. & Zegeer, C. V. (2003). Urban sprawl as a risk factor in motor vehicle occupant and pedestrian fatalities. *Am J Public Health, 93*(9), 1541-1545. doi: 10.2105/ajph.93.9.1541

Fishman, R. (1987). Beyond suburbia: The rise of the technoburb. In R. LeGates & F. Stout (Eds.), *The city reader (2007)* (4th. ed., pp. 69-77). New York: Routledge.

Fitzpatrick, K., et al. (2003). Nchrp report 504: Design speed, operating speed, and posted speed practices. In T. R. BOARD (Ed.). Washington D.C.

Flahaut, B. (2004). Impact of infrastructure and local environment on road unsafety: Logistic modeling with spatial autocorrelation. *Accident Analysis & Prevention, 36*(6), 1055-1066.

Frumkin, H. (2002). Urban sprawl and public health. *Public Health Reports, 117*, 201-217.

Garson, G. D. (2011, 01/10/2011). Linear mixed models. *Statnotes: Topics in Multivariate Analysis*. from http://faculty.chass.ncsu.edu/garson/pa765/statnote.htm

Gaver, W. W. (1991). *Technology affordances*. Paper presented at the ACM CHI 91 Human Factors in Computing Systems Conference April 28 - June 5, 1991, New Orleans, Louisiana.

Giacopassi, D. & Forde, D. R. (2000). Broken windows, crumpled fenders, and crime. *Journal of Criminal Justice, 28*(5), 397-405.

Gibson, J. & Crooks, L. (1938). A theoretical field analysis of automobile-driving. *American Journal of Psychology, 51*, 453-471.

Goffman, E. (1959). *The presentation of self in everyday life*: Anchor.

Graham, D. & Glaister, S. (2003). Spatial variation in road pedestrian casualties: The role of urban scale, density and land-use mix. *Urban Studies (Routledge), 40*(8), 1591.

Graham, D., Glaister, S. & Anderson, R. (2005). The effects of area deprivation on the incidence of child and adult pedestrian casualties in england. *Accident Analysis & Prevention, 37*(1), 125-135.

Graham, D. & Stephens, D. (2008). Decomposing the impact of deprivation on child pedestrian casualties in england. *Accident Analysis & Prevention, 40*(4), 1351-1364.

Hamilton-Baillie, B. (2008). Towards shared space. *Urban Design International, 13*, 130-138.

Handy, S. & McCann, B. (2011). The regional response to federal funding for bicycle and pedestrian projects. *Journal of the American Planning Association, 77*(1), 23-38.

Harrell, F. E., Lee, K. L. & Mark, D. B. (1996). Multivariable prognostic models: Issues in developing models, evaluating assumptions and adequacy, and measuring and reducing errors. *Statistics in Medicine, 15*(4), 361-387. doi: 10.1002/(sici)1097-0258(19960229)15:4<361::aid-sim168>3.0.co;2-4

Harwood, S. A. (2003). Environmental justice on the streets: Advocacy planning as a tool to contest environmental racism. *Journal of Planning Education and Research, 23*(1), 24-38. doi: 10.1177/0739456x03255431

Hawkley, L. C., Preacher, K. J. & Cacioppo, J. T. (2007). Multilevel modeling of social interactions and mood in lonely and socially connected individuals. In A. D. O. M. H. M. v. Dulmen (Ed.), *Oxford handbook of methods in positive psychology the macarthur social neuroscience studies* (pp. 559-575). New York: Oxford University Press.

Heft, H. (2001). *Ecological psychology in context*. Mahwah, New Jersey: Lawrence Erlbaum Associates.

Hobhouse, H. (2002). *The crystal palace and the great exhibition of the works of industry of all nations*. London: Athlone.

Hoehner, C., et al. (2005). Perceived and objective environmental measures and physical activity among urban adults. *American Journal of Preventive Medicine, 28*(2), 105-116.

Hox, J. J. (1995). Applied multi-level analysis. Amsterdam: TT-Publikaties.

Hyman, I. E., et al. (2010). Did you see the unicycling clown? Inattentional blindness while walking and talking on a cell phone. *Applied Cognitive Psychology, 24*(5), 597-607. doi: 10.1002/acp.1638

IIHS. (2008). Pedestrians. *Fatality Facts 2008*. Retrieved 2010-03-29, from http://www.iihs.org/research/fatality_facts_2008/pedestrians.html#sec5

Jackson, J. S. H. & Blackman, R. (1994). A driving-simulator test of wilde's risk homeostasis theory. *Journal of Applied Psychology, 79*(6), 950-958.

Jacobs, J. (1992). *The death and life of great american cities*. New York: Vintage Books.

James, W. (1890). The principles of psychology Vol. 1. C. Green (Ed.) *Classics in the History of Psychology* Retrieved from http://psychclassics.asu.edu/James/Principles/index.htm

Kaminski, G. (1983). The enigma of ecological psychology. *Journal of Environmental Psychology, 3*(1), 85-94.

Kim, J., et al. (2008). Age and pedestrian injury severity in motor-vehicle crashes: A heteroskedastic logit analysis. *Accident Analysis & Prevention, 40*(5), 1695-1702.

Kim, K., Brunner, I. M. & Yamashita, E. (2008). Modeling fault among accident--involved pedestrians and motorists in hawaii. *Accident Analysis & Prevention, 40*(6), 2043-2049.

Kim, K., Made, I. & Yamashita, E. (2008). Modeling violation of hawaii's crosswalk law. *Accident Analysis & Prevention, 40*(3), 894-904.

Kunstler, J. H. (1993). *The geography of nowhere*. New York: Touchstone.

LaScala, E. A., Gerber, D. & Gruenewald, P. J. (2000). Demographic and environmental correlates of pedestrian injury collisions: A spatial analysis. *Accident Analysis & Prevention, 32*(5), 651-658.

Leandro, M. (2010a). Límites de velocidad: Una mirada desde la ecología conductual. *Ambientales, 39*, 9-14.

Leandro, M. (2010b). *Young drivers and speed selection: A model guided by the theory of planned behavior*.

Lee, C. & Abdel-Aty, M. (2005). Comprehensive analysis of vehicle-pedestrian crashes at intersections in florida. *Accident Analysis & Prevention, 37*(4), 775-786.

Lopez Alonso, A. O. & Minervino, R. (2007). The need for an ecological approach within the study and comprehension of cognitive processes. *Interdisciplinaria: Revista de Psicologia y Ciencias Afines, 24*(2), 229-237.

Loukaitou-Sideris, A. & Ehrenfeucht, R. (2009). *Sidewalks: Conflict and negotiation over public space*: The MIT Press.

Lovejoy, C. O. (1988). Evolution of human walking. *Scientific American, 259* (5), 82-89.

Lutz, S. (2009). Shared space - final evaluation: Institute for Shared Space.

Massie, D. L., Green, P. E. & Campbell, K. L. (1997). Crash involvement rates by driver gender and the role of average annual mileage. *Accident Analysis and Prevention, 29*(5), 675-685.

McFarlane, A. (2010, 17 August). How the uk's first fatal car accident unfolded, *BBC News Magazine*. Retrieved from http://www.bbc.co.uk/news/magazine-10987606

McGrenere, J. & Ho, W. (2000). *Affordances: Clarifying and evolving a concept.* Paper presented at the Proceedings of Graphics Interface 2000, Montreal, Canada.

Molin, E. J. E. & Brookhuis, K. A. (2007). Modelling acceptability of the intelligent speed adapter. *Transportation Research Part F: Traffic Psychology and Behaviour, 10*(2), 99-108.

Morris, E. (2009). Behavior analysis and ecological psychology: Past, present, and future. A review of harry heft's ecological psychology in context. *Journal of the Experimental Analysis of Behavior, 92*(2), 275.

Moudon, A. V., et al. (2011). The risk of pedestrian injury and fatality in collisions with motor vehicles, a social ecological study of state routes and city streets in king county, washington. *Accident Analysis & Prevention, 43*(1), 11-24.

Nasar, J., Hecht, P. & Wener, R. (2008). Mobile telephones, distracted attention, and pedestrian safety. *Accident Analysis & Prevention, 40*(1), 69-75.

Neyens, D. M. & Boyle, L. N. (2008). The influence of driver distraction on the severity of injuries sustained by teenage drivers and their passengers. *Accident Analysis & Prevention, 40*(1), 254-259.

NHTSA. (2009, 2011-02-22). Traffic safety facts: 2009 data pedestrians. DOT HS 811 394, from http://www-nrd.nhtsa.dot.gov/Pubs/811394.pdf

Nicaj, L., Wilt, S. & Henning, K. (2006). Motor vehicle crash pedestrian deaths in new york city: The plight of the older pedestrian. *Injury Prevention, 12*(6), 414-416.

NJDOT. (2010a). *Complete streets policy*. (No.703). Trenton: Retrieved from http://www.completestreets.org/webdocs/policy/cs-nj-dotpolicy.pdf.

NJDOT. (2010b). Pedestrian safety. Retrieved 2010/10/06, from http://www.state.nj.us/transportation/commuter/pedsafety/

Norman, D. A. (1988). *The psychology of everyday things*: Basic Books.

Norton, P. (2008). *Fighting traffic: The dawn of the motor age in the american city*. Cambridge: MIT Press.

O'Neill, E. (2009, October 13). N.J. Pedestrian deaths jump after years of decline, *The Star-Ledger*. Retrieved from http://www.nj.com/news/local/index.ssf/2009/10/nj_pedestrian_deaths_spike_aft.html

Öström, M. & Eriksson, A. (2001). Pedestrian fatalities and alcohol. *Accident Analysis & Prevention, 33*(2), 173-180.

Oudejans, R. u. R., et al. (1996). To cross or not to cross: The effect of locomotion on street-crossing behavior. *Ecological Psychology, 8*(3), 259.

Paulozzi, L. J. (2005). United states pedestrian fatality rates by vehicle type. *Injury Prevention, 11*(4), 232-236. doi: 10.1136/ip.2005.008284

Preusser, D. F., et al. (2002). Pedestrian crashes in washington, dc and baltimore. *Accident Analysis & Prevention, 34*(5), 703-710.

Prijon, T. & Ermenc, B. (2009). Influence of alcohol intoxication of pedestrians on injuries in fatal road accidents. *Forensic Science International Supplement Series, 1*(1), 33-34.

Reid, S., Kocak, N. & Hunt, L. (2009). Dft shared space project stage 1: Appraisal of shared space mva consultants.

Retting, R. A., Ferguson, S. A. & McCartt, A. T. (2003). A review of evidence-based traffic engineering measures designed to reduce pedestrian--motor vehicle crashes. *American Journal of Public Health, 93*(9), 1456-1463.

Rubin, D. (1987). *Multiple imputation for nonresponse in surveys*. New York: John Wiley & Sons.

Ryb, G. E., et al. (2007). Social, behavioral and driving characteristics of injured pedestrians: A comparison with other unintentional trauma patients. *Accident Analysis & Prevention, 39*(2), 313-318.

Sallis, J. F., et al. (2006). An ecological approach to creating active living communities. *Annual Review of Public Health, 27*(1), 297-322. doi: doi:10.1146/annurev.publhealth.27.021405.102100

Schoggen, P. (1989). *Behavior settings: A revision and extension of roger g. Barker's ecological psychology*. Stanford, CA: Stanford University Press.

Scott, M. M. (2005). A powerful theory and a paradox: Ecological psychologists after barker. *Environment and Behavior, 37*(3), 295-329.

Shared_Space_Project. (2005). Shared space: Room for everyone: A new vision for public spaces. In Shared_Space_Institute (Ed.). Fryslan Province, PO Box 20120, 8900 HM Leeuwarden,The Netherlands.

Singer, J. D. (1998). Using sas proc mixed to fit multilevel models hierarchical models and individual growth models. *Journal of Educational and Behavioral Statistics, 23*(4), 323-355.

Steyerberg, E. W., et al. (2001). Internal validation of predictive models: Efficiency of some procedures for logistic regression analysis. *Journal of Clinical Epidemiology, 54*(8), 774-781.

Stokols, D. (1992). Establishing and maintaining healthy environments: Toward a social ecology of health promotion. *American Psychologist, 47*(1), 6-22.

Tabachnick, B. G. & Fidell, L. S. (2006). *Using multivariate statistics (5th edition)*. Needham Heights, MA, USA. : Allyn & Bacon, Inc.

Tay, R., Barua, U. & Kattan, L. (2009). Factors contributing to hit-and-run in fatal crashes. *Accident Analysis & Prevention, 41*(2), 227-233.

Treno, A. J., et al. (2007). The impact of outlet densities on alcohol-related crashes: A spatial panel approach. *Accident Analysis & Prevention, 39*(5), 894-901.

USDOT. (2010). Transportation investment generating economic recovery(tiger) grants *U.S. Department of Transportation*. Washington D.C.

Van der Molen, H. (1981). Child pedestrian's exposure, accidents and behavior. *Accident Analysis & Prevention, 13*(3), 193-224.

VTPI. (2009). Transportation cost and benefit analysis techniques, estimates and implications T. Litman & E. Doherty (Eds.), *Victoria Transport Policy Institute* Retrieved from http://www.vtpi.org/tca/

Walker, J. B. (1918). *Fifty years of rapid transit 1864-1917*: Law Printing Company.

Walkscore. (2010). *Walkscore methodology*. Front Seat. Seattle, WA. Retrieved from http://blog.walkscore.com/wp-content/uploads/2010/12/WalkScoreMethodology.pdf

Wang, C., Quddus, M. & Ison, S. (2009). The effects of area-wide road speed and curvature on traffic casualties in england. *Journal of Transport Geography, 17*(5), 385-395.

Wicker, A. (1987). Behavior settings reconsidered: Temporal stages, resources, internal dynamics, context. In D. Stokols & I. Altman (Eds.), *Handbook of environmental psychology* (pp. 613-648). New York: Wiley.

Wicker, A. (1992). Making sense of environments. In W. B. Walsh, K. H. Clark & R. H. Price (Eds.), *Person-environment psychology: Models and perspectives* (pp. 158-191). Hillsdale, NJ: Lawrence Erlbaum Associates.

Wicker, A. (2002). Ecological psychology: Historical contexts, current conception, prospective directions. In R. Bechtel & A. Churchman (Eds.), *Handbook of environmental psychology* (pp. 114-126). New York: Wiley.

Williams, A. F. & Carsten, O. (1989). Driver age and crash involvement. *American Journal of Public Health, 79*(3), 326-327.

Winkel, G., Saegert, S. & Evans, G. W. (2009). An ecological perspective on theory, methods, and analysis in environmental psychology: Advances and challenges. *Journal of Environmental Psychology, 29*(3), 318-328.

Winkleby, M. A. & Cubbin, C. (2003). Influence of individual and neighbourhood socioeconomic status on mortality among black, mexican-american, and white women and men in the united states. *Journal of Epidemiology and Community Health, 57*, 444-452.

Zuur, A., Ieno, E. & Smith, G. (2007). *Analysing ecological data*. New York: Springer.

Zuur, A., et al. (2009). *Mixed effects models and extensions in ecology with r*. New York: Springer.