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PEDESTRIAN SAFETY

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PEDESTRIAN SAFETY

I. Introduction

A. Background

In the year 2000, Florida's 500 pedestrian traffic fatalities accounted for over 10 percent of the national total of 4,843.[1] Its pedestrian fatality rate of 3.13 per 100,000 residents was the highest of all fifty states (although it was topped by the District of Columbia), and it exceeded the national average by 82 percent. Table 1 ranks the five states with the highest and lowest pedestrian fatality rates.

Table 1
Ranking of States by Pedestrian Fatality Rate, 2000[2]

State or District	Pedestrian Fatalities	Resident Population	Fatalities per 100,000 Residents
The five states with the highest fatality rates			
District of Columbia	18	572,059	3.15
Florida[3]	500	15,982,378	3.13
Delaware	22	783,600	2.81
New Mexico	48	1,819,046	2.64
Arizona	135	5,130,632	2.63
Hawaii	31	1,211,537	2.56
The five states with the lowest fatality rates			
North Dakota	5	642,200	0.78
Kansas	19	2,688,418	0.71
Rhode Island	6	1,048,319	0.57
New Hampshire	7	1,235,786	0.57
Idaho	6	1,293,953	0.46
United States	4,843	281,421,906	1.72

Source: Pedestrian fatalities from Fatal Accident Reporting System (FARS), National Highway Traffic Safety Administration, U.S. Department of Transportation.

Although the number of pedestrian fatalities in Florida decreased slightly in 2001 (to 494 from 500 in 2000), as the data in Table 2 illustrate, Florida's share has averaged 10

[1] A *pedestrian traffic fatality* is defined as the death of a pedestrian directly resulting from a traffic crash within 30 days of the crash. In the FARS database we counted person types 5 and 8 as pedestrians.
[2] See: http://www-fars.nhtsa.dot.gov/main.cfm. Population data are available from Census of Population 2000 (Census 2000), maintained by the Census Bureau, U.S. Department of Commerce; see the American FactFinder: http://www.census.gov/main/www/cen2000.html. For a ranking of all 50 states, see Attachment 1.
[3] Note that the Florida Department of Highway Safety and Motor Vehicles' number for pedestrian fatalities differs slightly from the numbers used in this report. The Department cites 506 pedestrian fatalities and a rate of approximately 3.2 fatalities in 2000. See Florida Department of Transportation, *The 2002 Short-Range Component: the Department's Plan for Implementing the 2020 Florida Transportation Plan*, February 5, 2002, at p. 35, available at: http://www.fladot.com/planning/policy/pdfs/src.pdf.

percent from 1997 to 2001, confirming that Florida's ranking in 2000 was not an anomaly. Over this same period, national reductions in pedestrian fatalities have been matched by similar reductions in Florida.

Table 2
Annual Pedestrian Fatalities, 1982-2001

Year	Florida	Other States	U.S.	Florida as a Share of U.S.
1982	672	6,684	7,356	0.091
1984	635	6,432	7,067	0.090
1986	598	6,239	6,837	0.087
1988	633	6,315	6,948	0.091
1990	584	5,953	6,537	0.089
1992	486	5,113	5,599	0.087
1994	532	5,012	5,544	0.096
1996	543	4,973	5,516	0.098
1997	538	4,868	5,406	0.100
1998	536	4,765	5,301	0.101
1999	496	4,524	5,020	0.099
2000	500	4,343	4,843	0.103
2001	494	4,461	4,955	0.100

Source: Computations by the Bureau of Economic and Business Research (BEBR) using FARS data.

Tables 1 and 2 appear to support the findings of the highly publicized *Mean Streets 2002* report. Using a "Pedestrian Danger Index" that measured the yearly pedestrian fatalities per capita (for years 2000 and 2001), the report ranked five large metro areas in Florida – Orlando, Tampa-St. Petersburg-Clearwater, West Palm Beach-Boca Raton, Miami-Ft. Lauderdale, and Jacksonville – among the six most dangerous metro areas for pedestrians in the nation.[4]

Obviously these high rates raise the question of what policy actions Florida and its local governments can take to reduce them. But that question is not the focus of our effort in this report. Instead, we address the related question of *why* Florida's cities have such high pedestrian fatality rates. Our work is exploratory and is based on statistical analysis of 276 metropolitan areas across the country. Confirmation and perhaps modification of the results could be obtained by applying our model to data for individuals, an effort beyond the scope of this report.

[4] Memphis was the only non-Florida metro area in this illustrious group. See Michelle Ernst and Barbara McCann, *Mean Streets 2002*, Surface Transportation Policy Project, available at: http://www.transact.org.

B. Project Organization

This report uses economic analyses and presents relevant information to help policymakers determine why pedestrian fatality rates in Florida exceed those in the rest of the country.

Section II summarizes several federal and state laws and policies that have directly affected the Florida Department of Transportation's funding decisions on pedestrian safety measures.

Section III briefly critiques and ultimately rejects the pedestrian exposure measure used in *Mean Streets 2002*, with an eye to preparing the reader for both the theoretical model of Section IV and the empirical analysis of Section V.

Section IV sets forth a theoretical model of public investment in pedestrian-safety capital, a model relating pedestrian fatalities to safety capital; risk factors such as climate, sunlight and age; pedestrian exposure; and the value of a statistical life. This model guides the next section's exploration of the available data on fatalities.

Section V is an empirical analysis of pedestrian fatalities. Using multivariate regression, we examine six factors that could plausibly explain Florida's higher pedestrian fatality rate. The following factors are indicators of exposure, the conditions under which pedestrians and drivers interact, and the characteristics of individual pedestrians: the average low January temperature, hours of sunlight, an age index, interstate highway lane miles per resident, land area per resident, and the poverty rate.

Section VI presents and interprets tables containing data useful for explaining differences in pedestrian fatality rates. Most of the tabulated data are drawn from the Fatal Accident Reporting System (FARS) and cover topics ranging from road type to time of accident and are intended to complement our model and regression analysis.

Section VII briefly discusses the implications of our findings and suggests possibilities for further research.

C. Major Results

Our chief finding is that over half of the excess fatality rate in Florida's metropolitan areas relative to the nation's comes from more exposure per resident. Because of Florida's relatively warm winters and the natural timing of summer and winter sunlight, Floridians probably walk more often in places that are exposed to traffic than do typical U.S. residents, especially during the critical hours around dusk. Moreover, Florida is visited by millions of tourists each year, and even though they are not counted as residents, their deaths while walking register as pedestrian fatalities.

Additionally elderly residents, less agile and less likely to survive being struck by a vehicle, have higher fatality rates than other age groups, and we therefore find that Florida's age-structure accounts for about ten percent of the state's excess fatalities. Also evident is that the state's shortfall of metropolitan interstate lane miles—resulting in greater use of more dangerous high-speed arterials—accounts for another four percent. Finally, Florida's poverty rate slightly exceeds the nation's, a fact that accounts for two percent of the excess pedestrian fatalities.

In a statistical sense, the combination of exposure, sunlight timing, elderly residents, the interstate shortfall, and poverty explain over 70 percent of Florida's excess fatalities, leaving less than 30% unexplained by these variables. We emphasize that we are not presenting the ability to "explain" 70% of Florida's excess as a justification for relaxing ongoing vigorous efforts to reduce it. We simply intend for our interpretation, if confirmed, to provide an additional perspective for guiding those efforts.

We find that our model fails to explain large excess fatality rates in four Florida metropolitan areas. The areas are Tampa-St. Petersburg, Fort Myers, Daytona Beach, and Ocala. It might be that intensive study of especially dangerous corridors, such as U.S. 19 in the Tampa area, and more thorough analysis of individual events in these areas would yield a high return in guiding policy and safety investments. Orlando and Jacksonville, after allowing for the effects of the variables we analyze, especially proxies for exposure, are also more dangerous than expected, but not in a statistically significant way. In a statistical sense, Tampa-St. Petersburg, Fort Myers, Daytona Beach and Ocala are the only metro areas in Florida that significantly exceed national fatality rates once the effects of exposure, daylight timing, and age are accounted for. On the other side, only Punta Gorda's fatality rate is significantly below its predicted value, after controlling for these variables.

II. Federal and State Programs and Policies

A. Federal Programs

Pedestrian safety measures receive funding from various sources. However, four federal programs authorized under the Transportation Equity Act for the 21st Century (TEA-21) have been particularly significant sources for such funding: Hazard Elimination Program, Programs under Sections 402 and 163 of TEA-21, the Transportation Enhancement Program, and the Congestion Mitigation and Air Quality (CMAQ) Improvement Program.[5]

Hazard Elimination Program.[6] This federal program requires states to monitor all public roads for and to "identify problems at hazardous locations and sections, and elements…which may constitute a danger to motorists, pedestrians, and bicyclists."[7] The Secretary of Transportation is authorized to approve as a project under this section any safety improvement project described above, and to fund (1) any public road; (2) any public surface transportation facility or any publicly owned bicycle or pedestrian pathway or trail; or

[5] State and local matching requirements may apply depending on the particular program's formula.
[6] The Hazard Elimination Program is itself an element of the Highway Safety Infrastructure Program, which also comprises Rail/Highway Crossings Program, Operation Lifesaver, and the Railway-Highway Crossing Hazard Elimination in High-Speed Rail Corridors, all of which are specifically designed "to eliminate hazards at rail/highway grade crossings." See http://www.fhwa.dot.gov/tea21/factsheets/isfty.htm.
[7] See 23USC152(a)

(3) any traffic calming measure.[8] The federal government funds 90 percent of the costs of projects approved under this program.[9] Florida's apportionment for Hazard Elimination in FY 2003 was nearly $6.25 million.

Section 402 Programs. Section 402 of TEA-21 requires each state to "have a highway safety program approved by the Secretary [of Transportation], designed to reduce traffic accidents and deaths, injuries, and property damage resulting therefrom." State programs must conform to uniform guidelines promulgated by the Secretary. The minimum criteria are outlined in federal law; two pertinent criteria for purposes of this report are: "to improve pedestrian performance and bicycle safety" and "to reduce deaths and injuries resulting from accidents involving motor vehicles and motorcycles."[10] The Highway Safety Grant Program Section of the Florida Department of Transportation uses federal funding authorized under Section 402 for grants to state and local agencies for projects that demonstrate, improve, or evaluate measures that counter safety-related problems identified by a local or state agency.[11] Certain conditions limit the application of Section 402 funds. Funds may not be used for highway construction, maintenance, or design activities. However, they may be used to develop and implement systems and procedures for carrying out safety construction and operation improvements.[12] These grants are used to "seed" new safety programs or enhance existing programs. Recent examples of pedestrian safety projects include funding to Florida Atlantic University for the establishment of the Pedestrian Safety Resources Center and funding to provide pedestrian and bicycle safety curricula for schoolteachers. In FY 2003, over $7.4 million was authorized for Florida under the Section 402 formula, although only a portion of that funding has been expended specifically for pedestrian and bicycle safety programs.[13]

Section 163 Programs. Section 163 authorizes funding for traffic safety incentive projects. The Highway Safety Grant Program Section of the Florida Department of Transportation administers funds received under Section 163 in essentially the same manner as Section 402 funds.[14] To be eligible for Section 163 funds, states had to pass and enforce a law that designates as a "per se offense" the operation of a motor vehicle by an intoxicated person. A person is intoxicated if he or she has a blood alcohol concentration of at least .08 percent or greater.[15] As Florida has enacted such legislation,[16] the state has received annual funding for this program.

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[8] See 23USC152(c)

[9] See 23USC152(c)

[10] See 23USC402, State and Community Highway Safety Grant Program. An overview of the program is available at: http://www11.myflorida.com/safety/HighwaySafetyGrantProgram/hsgp/hsgp.htm.

[11] The Florida Department of Transportation's annual grant selection process is described in: http://www11.myflorida.com/safety/HighwaySafetyGrantProgram/hsgp/HSGPselect.htm.

[12] See Uniform Guidelines for State Highway Safety Programs, Guideline 21, Roadway Safety, available at: http://www.nhtsa.dot.gov/nhtsa/whatsup/tea21/tea21programs/402Guide.html#g21.

[13] See http://www.nhtsa.dot.gov/nhtsa/whatsup/tea21/tea21programs/TEA21HwyFY03.htm for a list of federal funding by state for FY 2003, in accordance with the Section 402 formula. The formula is: 75 percent based on the state's population in the latest federal census relative to the total population in all states, and 25 percent based on its share of the nation's public road miles. See http://www.nhtsa.dot.gov/nhtsa/whatsup/tea21/tea21programs/Factshee.402.html.

[14] See http://www11.myflorida.com/safety/HighwaySafetyGrantProgram/hsgp/hsgp.htm.

[15] See 23 USC163; Safety Incentives to Prevent Operation of Motor Vehicles by Intoxicated Persons.

Transportation Enhancement Program. Safety projects, under the rubric of "transportation enhancement activities," also may be funded from a federal set-aside (10 percent of apportionments to states of the Surface Transportation Program authorized under TEA-21). "Transportation enhancement activities" include, among others, "provision of facilities for pedestrians and bicycles and provision of safety and educational activities for pedestrians and bicyclists."[17] A recent example of a pedestrian safety-related project is the construction of sidewalks leading to a school in Columbia County, Florida. For FY 2002, the apportionment of Enhancement Program set-aside funds to Florida exceeded $40 million.[18]

Surface Transportation Program set-aside funds may also be used without meeting requirements for highway safety improvements when a Community Traffic Safety Team identifies a documented safety problem approved by the District Safety Engineer. The expected benefits and documented needs of the Team determine the priority for program improvements.[19]

CMAQ Program. The CMAQ program has provided funding for projects that both contribute to improvements in air quality and reduce congestion. Eligible projects (many of which have safety-related implications for pedestrians) include transit programs, traffic flow programs, Intelligent Transportation Systems, shared ride programs, and travel demand management.[20] Eligible programs specifically related to pedestrians include: "programs to limit portions of road surfaces or certain sections of the metropolitan area to use of non-motorized vehicles or pedestrian use, both as to time and place" and "programs for new construction and major reconstructions of paths, tracks or areas solely for use by pedestrian or other non-motorized means of transportation when economically feasible and in the public interest."[21] The Metropolitan Planning Organizations (MPOs) in Florida administer those funds. The MPOs are required to address in their long-range transportation plans, among many other items, congestion management strategies which may include

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[16] See 2002 Florida Statutes 316.1934 (2)(c).
[17] See 23USC101 (a) (35).
[18] See http://www.fhwa.dot.gov/tea21/fy2002/tbl2p5.htm.

[19] See Florida Department of Transportation, "Work Program Instructions: Tentative Work Program – FY 03/04-07/08, September 17, 2002, at Section 6.5.1; available at: http://www.myflorida.com/programdevelopmentoffice/work%20program20instructions.htm.
[20] The 1990 Clean Air Act Amendments require areas to meet certain quality standards. Areas that have been identified as "areas of nonattainment" have failed to meet the National Ambient Air Quality Standards. These areas must reduce the amount of pollutants in the air and, therefore, are under pressure to reduce emissions. In the first six years of the CMAQ program, pedestrian/bike projects accounted for only 3 percent or $137 million of all funding for projects nationwide. Total funding from FY 1992-1997 was $4.6 billion. See U.S. Department of Transportation, *The Congestion Mitigation and Air Quality Improvement Program*, available at http://www.fhwa.dot.gov/environment/cmaq/cmaqbroc.pdf.
[21] See The Congestion Mitigation and Air Quality Improvement (CMAQ) Program under the Transportation Equity Act for the 21st Century (TEA-21); Program Guidance, April 1999, available at: http://www.fta.dot.gov/library/planning/enviro/cmaq.htm.

pedestrian and bicycle facilities.[22] Florida received an apportionment of over $54.8 million in FY 2002 for CMAQ projects in non-attainment areas.[23]

B. State Policy and Legislation

Safety is central to the Florida Department of Transportation's mission, which is "to provide a *safe* statewide transportation system that ensures the *mobility of people* and goods, enhances economic prosperity, and preserves the quality of our environment and communities."[24]

State Transportation Planning Process. The goals and objectives that provide policy direction for realizing the statutory mission of the Florida Department of Transportation are set forth in Florida's transportation plan, which has a 20-year horizon but must be revised every five years.[25] The Short Range Component of the plan must be updated annually. This plan serves as the policy framework for the Department's work programs that itemize its proposed commitments and planned expenditures for transportation projects.[26] In the work program planning process, the Department is required to consider projects and strategies that, among other activities, will "increase the *safety* and security of the transportation system of motorized and *nonmotorized users*." (emphasis added)[27] The first long-range objective listed in the Department's most recent 20-year plan is the reduction of rates of motor vehicle, bicycle, and pedestrian fatalities.[28] The Department also identifies strategic goals and short-range objectives on an annual basis as part of the planning process. One of its four strategic goals in 2002 is to "enhance Florida's economic competitiveness, quality of life, and transportation safety." Four short-range objectives supporting that goal address the reduction of fatalities. One objective specifically calls for reducing the pedestrian fatality rate to or below 2.35 fatalities per 100,000 residents by 2011.[29]

Florida Laws Concerning Bicycle and Pedestrian Paths. The Florida Pedestrian Plan (February 1992) includes recommended measures that should be implemented by FDOT, local agencies and private developers to accommodate pedestrians.[30] In addition,

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22 See *Metropolitan Planning Organization Program Management Handbook*, Chapter 4, December 24, 2002, at pp.4-6 - 4-7, available at: http://www11.myflorida.com/planning/policy/mpohandbook/mpo_ch4.pdf. Many other types of projects, also listed in the Handbook, are eligible for CMAQ funding.

23 See http://www.fhwa.dot.gov/legsregs/directives/notices/n4510479/n4510479a15.htm.

24 See 2002 Florida Statutes 334.046 (2). Emphasis added.

25 See 2002 Florida Statutes 334.046 (3) and 339.155 (1).

26 See 2002 Florida Statutes 339.135 (3)(a). A good explanation of the process for developing the work program is available at: http://www11.myflorida.com/programdevelopmentoffice/. Projects under Section 163 and Section 402 are not subject to the work program planning process but are subject to another selection process. See http://www11.myflorida.com/safety/HighwaySafetyGrantProgram/hsgp/HSGPselect.htm for a summary of the grant selection process.

27 See 2002 Florida Statutes 339.155 (2) (b).

28 See Florida Department of Transportation, *2020 Florida Transportation Plan*, December 2000, at p. 2, available at: www.fladot.com/planning/2020ftp.

29 See Florida Department of Transportation, *The 2002 Short-Range Component: the Department's Plan for Implementing the 2020 Florida Transportation Plan*, February 5, 2002, at p. 35, available at: http://www.fladot.com/planning/policy/pdfs/src.pdf.

30 See Florida Department of Transportation, *Work Program Instructions: Tentative Work Program – FY 03/04-07/08*, September 17, 2002, Revised December 13, 2002, at Section 6.5.1.2; available at:

two Florida statutes in particular deserve some comment as they pertain to the establishment of bicycle and pedestrian ways. State law requires that the planning process for the construction, reconstruction, or other changes to transportation facilities include bicycle and pedestrian accommodations. However, these plans need not proceed if the projected investment fails to meet specified conditions.[31] A law passed in 2002 establishes the Safe Paths to Schools Program with the intent of providing "safe transportation for children from neighborhoods to schools, parks, and the state's greenways and trails systems." [32] The Florida Department of Transportation is authorized to establish a grant program for local, regional, and state projects. Although the Legislature did not expressly earmark funding for this program, transportation districts in Florida were not precluded from using available funds. For example, District 4 proceeded with a GIS sidewalk assessment program and high-priority sidewalk projects under the auspices of this program.[33]

III. Critique of the *Mean Streets 2002* Pedestrian Danger Index

With respect to the controversial issue of per-resident exposure, we have chosen to use variables representing climate, daylight hours, tourism, age, and poverty. This stands in sharp contrast to the use of walking to work as the sole indicator of exposure in *Mean Streets 2002*, which adjusts the simple pedestrian fatality rate (fatalities per 100,000 persons) by the share of workers commuting to work on foot and calls the result a "pedestrian danger index."[34] This index is faulty for at least two reasons. First, it implies the pedestrians most at risk are those walking to or from work. Second, it implies that the pedestrians most at risk are those walking (for whatever purpose) during the day (since most people work daytime shifts). Tables 3 and 4 illustrate part of our reason for thinking that indicator seriously flawed, using data from FARS and from the National Household Travel Survey.

Table 3
Pedestrian Fatalities per 100,000 Residents by Hour of Day, 2001

Hours of Day	Florida	Other States	Florida relative to Other States
Midnight to 6 a.m.	0.64	0.30	2.13
6 a.m. to noon	0.33	0.25	1.32
Noon to 6 p.m.	0.43	0.36	1.19
6 p.m. to midnight	1.62	0.75	2.16
All Hours	3.02	1.66	1.82

Source: Computations by BEBR using FARS data.

http://www.myflorida.com/programdevelopmentoffice/work%20program20instructions.htm. That section also explicitly states that "[b]icycle and pedestrian projects are eligible for NHS, STP, CMAQ, Federal Lands, Scenic Byways, and Recreational Trail program funds."

[31] See 2002 Florida Statutes 335.065. Specifically, Section 1(b) provides that bicycle and pedestrian ways are not required to be established: "1. Where their establishment would be contrary to public safety; 2. When the cost would be excessively disproportionate to the need and probable use; and 3. Where other available means or factors indicate an absence of need."

[32] See 2002 Florida Statutes 335.066.

[33] Electronic communication from Linda Crider, Program Director, Florida Traffic and Bicycle Education Program. Received March 24, 2003. A total of $6.2 million ($5.2 million of discretionary state funds and $1 million of federal funds) was designated for the sidewalk projects in FY 2004-2008.

[34] *Mean Streets 2002*, p.8.

In fact, Table 3 demonstrates that 53 percent of pedestrian fatalities in Florida and 45 percent in other states occurred during the hours of 6 p.m. to midnight. Table 4 further shows that walking at this time is more likely to be recreational: only 29 percent of walks from work to home occurred during 6 p.m. to midnight – the peak hours for pedestrian fatalities. The peak hours for walking home from work were earlier – from 3 p.m. to 6 p.m. Approximately 40 percent of walks from work to home occurred during those three hours.

Table 4
Time of Day of Walking Trips to Return Home and Purpose of Previous Trips by Percentage, United States, 2001

Hours of Day	Work	School	Medical, dental	Shop-ping	Social, recre-ational	Other, family personal	Transport someone else	Meals social events	Other
Midnight to 6 a.m.	3.96	0.05	0.00	0.87	3.23	0.86	1.49	2.51	1.11
6 a.m. to noon	7.69	9.21	40.20	24.95	10.88	23.81	41.18	15.20	21.50
Noon to 6 p.m.	58.97	80.63	42.97	48.18	40.48	40.00	45.79	41.08	70.88
6 p.m. to midnight	29.37	10.10	16.84	26.00	45.43	35.33	11.53	41.21	6.50
All Hours	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Computations by BEBR using NHTS data

Far more walks classified as social or recreational (45 percent) occurred during the time period of 6 p.m. to midnight, which suggests that recreational walkers may be particularly vulnerable to fatal motor-vehicle accidents. The reasons for their vulnerability may include vision difficulties, effects of aging on elderly walkers, and lower attentiveness at the end of the day.

In contrast to *Mean Street*'s emphasis on urban form, our regression analysis in Section V will show that the interaction between climate and the timing of sunset accounted for much of the geographical variation in fatality rates. In Table 3, we present a tabulation of fatalities by time of day—in 2001 only 13-14% occurred between 6 and 10 a.m. while 45-53% occurred between 6 p.m. and midnight, showing that relatively few pedestrian fatalities in 2001 occurred in the morning when many people are traveling to work.

For these reasons we believe that the "pedestrian danger index" is a faulty statistic. It takes into account only commuting to work on foot, one of the many possible types of walking trips, and a form generally safer than the trips taken for social or recreational purposes after dark.

IV. A Micro-Location Model of Public Investment in Pedestrian Safety

As the earlier discussion of pedestrian paths illustrates, one question confronting policymakers is how to allocate funds for location-specific capital investment to improve pedestrian safety. Specific investment decisions are made for micro-locations—the actual places where fatalities occur.

We construct a micro-location based model to explore the relationship of public spending on safety capital to exposure, natural conditions and urban form. We chose this approach because most public funds spent on pedestrian safety capital improvements, such as sidewalks, lights, and signals are site-specific. This is, to our knowledge, the first economic model of pedestrian safety to focus on public investment. Most models address regulatory controls—such as drinking-and-driving laws—rather than investment.

A. Factors Affecting Pedestrian Safety – Our Example

To set the proper context for our analysis, we need to understand the factors affecting pedestrian safety. Pedestrian safety involves the interaction of pedestrians and drivers in specific locations, such as at an intersection or a crosswalk. Whether a particular interaction between a pedestrian and a driver has a good outcome in terms of fatal accidents depends on luck, the pedestrian, the driver, ambient conditions, and characteristics of the specific location. Pedestrians and drivers might be young or old, aggressive or cautious, drunk or sober. The weather might be rainy or dry; it might be day or night. A stretch of road used by both pedestrians and vehicles might have a speed limit that is high or low and is enforced loosely or rigorously. The location might not have a sidewalk, lights, crossing signals, or speed bumps.

Previous analyses of pedestrian fatalities have not been based on explicit models of government behavior. What we want is a model that describes how a city or other unit will allocate its scarce resources in order to reduce fatalities. Our purpose is to provide a framework for estimating how fatalities relate to exposure and other variables.

The spirit of our model is this: as exposure rises, there are two offsetting effects on fatalities. Rising exposure increases the potential interactions between pedestrians and vehicles, thus increasing fatalities. However, as exposure rises, communities take advantage of economies of scale in safety capital. A given length of sidewalk costs the same whether ten people or a thousand people use it. Whether, for a given number of people, fatalities rise or fall with exposure depends on the relative strengths of these offsetting influences. In the following model we have a particularly simple expression for the effectiveness of investment in pedestrian safety. It is intended to be illustrative and mathematically tractable rather than realistic. In ongoing research, we are studying the technical literature on pedestrian safety capital with a view toward building a more realistic model.

In this first model, we assume there are only fatalities but no injuries. Begin by supposing only one pedestrian and one vehicle use the stretch of road each day at random times. A fatality is extremely unlikely, occurring only if the pedestrian and vehicle happen to use the road at the same time and if either of them also makes a serious mistake. Perhaps the chance of such an occurrence is one in ten trillion. If we increase the daily traffic to one pedestrian and two vehicles, we also increase the chance of a fatal interaction to two in ten trillion. If traffic increases so that there are two pedestrians and two vehicles and if each pedestrian could be struck by either of the two vehicles, the chance of a fatality rises to four in ten trillion. We assume that the chance of a fatality is proportional to the number of pedestrians multiplied by the number of vehicles. That is, of course, a crude approximation, but we want to keep our model simple.

If we stop here, our example has a highly unrealistic implication. If along a stretch of road, the number of pedestrians increases from 100 to 1000, and the number of vehicles also increases from 100 to 1000, the likelihood of a fatality rises a hundred-fold. In reality, we would expect a community faced with a large number of fatalities to intervene by investing in safety measures, such as sidewalks, lights, and traffic signals. Depending on the effectiveness of those investments, the full effect of heavier traffic could even be fewer fatalities.[35]

B. A Simple Model of Safety Capital and Exposure.

To formalize the ideas in our example, we hypothesize that in deciding how much to invest in safety measures along the stretch of road, the community minimizes the total expected cost of pedestrian fatalities and spending on safety capital:

(1) $\min C(k) = Z\lambda + k$

Equation (1) finds the value of k which minimizes the cost function, where k is the annualized cost of pedestrian safety capital, Z is the value of a statistical life (lost when a fatality occurs), and λ is the expected number of pedestrian fatalities per year at that micro location.[36] The actual (as opposed to the expected) number of deaths, d, is assumed to follow a Poisson distribution: [37]

(2) $P(d) = \lambda^{d} e^{-\lambda}/d!$

In Equation (2), $P(d)$ is the probability that d deaths are observed, e is the natural exponent, and ! denotes a factorial. Consistent with our example, the expected number of deaths, λ, is proportional to the product of the number of pedestrians and the number of vehicles; is affected by a vector, X of other influences such as climate and characteristics of pedestrians and drivers; and varies inversely with spending on safety capital. A formula that expresses these expectations is Equation (3):

(3) $\lambda = WVf(X)e^{-bk^{a}}$

where we assume $0 < a \leq 1$ in order to capture the effects of diminishing marginal returns to a factor (safety capital in this instance): the lower the value of a, the more strongly

[35] As a further, and probably important, complication, if the community makes the stretch of road safer, more pedestrians may decide to use it. For simplicity, we omit that induced effect.

[36] Ideally, □□ and Z would also represent the expected number of pedestrian *injuries* and the expected cost thereof, in addition to fatalities. For simplicity's sake, however, we concentrate on fatalities.

[37] A Poisson distribution is used to describe a situation with the following characteristics: (a) there are a large number of "trials" (in our example, pedestrians crossing streets); (b) in each trial, there is a very small probability that a trial leads to a given outcome (in our example, being fatally struck by a vehicle); (c) the chance that an outcome occurs in a small time interval does not depend on the history of the site or its current state. Equation (2) gives the probability that d = 0,1,2… where d is the outcome.

diminishing the returns to safety capital. The larger the value of *b*, the more effective is a dollar of investment. *W* denotes the number of pedestrians (walkers) per day, *V* the number of vehicles per day, and *f(X)* indicates a function of *X*, a vector of characteristics of pedestrians, drivers, and natural conditions. The number of fatalities is assumed to be proportional to the number of random contacts between motorists and pedestrians (the multiple *WV*, with *f(X)* describing the mortality rate per contact when $k = 0$; i.e., there is no expenditure of safety capital). Equation (3) assumes that annual spending on safety capital exhibits diminishing returns: each extra dollar spent on safety capital reduces the expected number of deaths from its current level by abk^{a-1} percent. With additional investments, both the percentage reduction and the absolute reduction become smaller and smaller, indicating diminishing returns. We assume that the safety investment is a pure public good in that the percentage reduction in expected fatalities is the same regardless of the numbers of pedestrians and vehicles.

From minimization of Equation (1) subject to Equation (3), the optimal spending on safety capital, *K*, is defined implicitly by:

$$(4)\quad bK^{a} = (a-1)\ln K + \ln\left[abZWVf(X)\right],$$

where *K* is the optimal value of *k*. In the limiting case in which $a = 1$, each additional dollar of spending reduces expected fatalities by *b* percent, and equation (4) reduces to:

$$(5)\quad K = \frac{1}{b}\ln\left[bZWVf(X)\right]$$

Clearly the optimal safety capital depends upon the number of pedestrians. More capital is required where pedestrian density is greater. For Equation (4) to represent a minimum, the second derivative of cost with respect to capital must be positive:

$$(6)\quad C''(k) = (1 - a + bak^{a})abk^{a-2}ZWVf(X)e^{-bk^{a}} > 0$$

which is the case. The effect of an increase in the value of a statistical life is shown by

$$(7)\quad \frac{d\lambda}{dZ} = -bak^{a}WVf(X)e^{-bk^{a}}Z^{-1}(1 - a + bak^{a})^{-1} < 0\,.$$

Not surprisingly, placing a higher value on a statistical life boosts investment in safety, thus reducing the expected casualties. Thus as a community's income rises, so will its investment in safety capital.

By total differentiation of the equilibrium condition (4) and substitution into (3), we obtain the effect on the expected number of fatalities at the location as the number of pedestrians rises (assuming capital is adjusted instantaneously to its optimal level):

$$(8)\quad \frac{d\lambda}{dW} = Vf(X)e^{-bk^{a}}[1 - bak^{a}(1 - a + bak^{a})^{-1}] \geq 0$$

with equality holding when $a = 1$. Equation (8) states that, except for under equality, an increase in the number of pedestrians will increase expected fatalities. If there is no corresponding increase in vehicle travel, it can be shown that the increase is less than proportional. That is to say that the expected fatality rate declines because of the induced investment in safety.

Finally, the effect of an increase in *f(X)*, among other things the inherent danger of a site, is:

$$(9)\quad \frac{d\lambda}{df(X)} = WVe^{-bk^a}[1 - bak^a(1 - a + bak^a)^{-1}] \geq 0,$$

where equality holds when $a = 1$. An increase in danger induces more investment but not by enough to prevent expected fatalities from rising, except in the case of weakly diminishing returns to safety capital.

In summary, this model of optimal investment in pedestrian safety yields the testable implications that fatality rates will be higher where:

- For a given total amount of walking in an urban area, pedestrian density is lower in that area relative to another.
- income is lower, and thus poverty rates are higher, and
- the inherent danger is higher.

IV. Empirical Analysis

A. Data

We proceed to specify the variables used in the empirical analysis. From a technological perspective, designing a safer road network and installing pedestrian infrastructure such as sidewalks can increase the supply of safe walking trips. The supply can also be increased by actions taken by the walkers themselves: wearing reflective clothing, carrying flashlights at night, and crossing streets at intersections with traffic signals rather than jaywalking. Similarly, more careful and sober driving by motorists can increase the supply of safe walking trips.

For this report, we have taken the view that metropolitan statistical areas (denoted as MSAs or metropolitan areas) are useful units for analyzing pedestrian fatalities. The Orlando MSA, for example, includes four counties: Orange, Lake, Seminole, and Osceola. Orlando serves that area as the major employer, to which workers commute from all four counties, as well as the chief shopping and cultural center. With respect to the transportation network, the set of four counties functions to a large extent as a unit. Considering each county separately would lose that unity. At another extreme, considering the entire state of Florida would form too large a unit. Naturally there is travel between, say, Orange and Duval counties, but it is far less than that between Orange and its surrounding counties.

With this in mind, we analyze data for 276 of the nation's metropolitan statistical areas, those for which we could secure adequate data, including all of the twenty in Florida. In selecting variables, we focused on those that are (1) defined consistently across MSAs, which as a practical matter means available from federal sources; and (2) likely to be relevant to explaining the difference between fatality rates in Florida and those in non-Florida urban areas.

These criteria result in omitting a few factors that figure strongly in earlier studies of pedestrian fatalities. The most striking omission is that we include no measure of alcohol consumption. The relevant consumption, binge drinking followed by driving or by walking exposed to traffic, is difficult to measure at the metropolitan level, and we have no reason to believe Florida's residents differ strongly from those in the rest of the nation in that regard. Using proxies such as the percentage of accidents involving drinking risks circular reasoning.

In our view, the most important potential explanation of Florida's excess pedestrian fatality rate is exposure per resident. In its simplest form, exposure is how much people walk near traffic. We prefer a slightly more complicated concept that combines exposure with the degree of risk caused by lighting conditions. As the sky darkens, pedestrians become less visible to drivers. But having started walking when there was more daylight, pedestrians may be poorly prepared, wearing dark clothing and lacking flashlights. Perhaps for that reason, and perhaps because there is more recreational walking in the evening, twilight is an especially dangerous time. In 2001 Florida's evening hours (6 p.m. to midnight) were each, on average, 4.4 times as deadly as each daylight hour (6 a.m. to 6 p.m.). In the rest of the country, evening hours averaged 2.5 times as deadly as daylight hours. Looking at it another way: whereas, per resident, Florida's daylight hours were only 25 percent more dangerous than the same hour in the rest of the country, each night hour in Florida was more than twice as dangerous as in other states (see Table 3).

From this comparison, we hypothesize that a large share of Florida's higher pedestrian fatality rate comes from having more pedestrians, per resident, when it is twilight or dark. The reasons for increased walking in the evening vary by season. During the summer, both southerners and northerners are likely to take an evening stroll. But in the North, where the summer sun sets late, that stroll is less likely than in the South to extend into the twilight or dark. During the winter, it is warm enough and the day lingers long enough to entice southerners to take walks just as the sun is setting. In the North, both frigid weather and early darkness discourage walking. The combination of day length and climate encourages southerners, and especially Floridians, to walk during the more dangerous twilight and night hours year-round.

We use two variables to represent this hypothesis. The first is the 30-year mean low January temperature, JANLOW, obtained from the 1994 edition of the *City and County Data Book*,[38] which provides county-level data. We calculated population-weighted averages for metropolitan statistical areas. In a regression in which the pedestrian fatality rate is the dependent variable, we expect the coefficient of JANLOW to be positive, indicating that people are more likely to take evening walks during the winter in MSAs with relatively warm winters.

[38] See http://fisher.lib.virginia.edu.

The second variable, DAYLIGHT, is the hours from sunrise to sunset on December 21, 2000—the winter solstice, the shortest day of the year (in terms of daylight hours).[39] We calculated this variable by means of formulas using population-weighted latitude and longitude for each MSA.[40] County time zones were obtained from the *National Atlas of the United States* published by the U.S. Geological Survey, Department of the Interior.[41] The South's longer winter days and shorter summer days are expected to induce more walking there relative to the North, thus the coefficient of DAYLIGHT is expected to be positive.

As a proxy for TOURISM, another component of exposure, we use per capita sales in thousands of dollars at establishments classified in NAICS sector 72 (accommodation and food services), obtained from the 1997 Economic Census. We normalized the variable to have a weighted average across MSAs of one. The coefficient of TOURISM is expected to be positive, since the presence of tourists adds to the number of pedestrians at risk, but is excluded from the denominator when calculating fatality rates.

Another variable, AGE, is included to represent the greater pedestrian fatality rates of elderly residents. It is calculated by weighted age-specific mortality rates for the 17 five-year age groups from birth through 84, plus the group 85 and older. That is, the national mortality rate for the age group birth to four years was multiplied times the metropolitan area's population in that age group. A similar multiplication was performed for each of the 17 other age groups and the results added. This sum was then divided by the metropolitan area's total population. The coefficient of AGE is expected to be positive. In fact, by the construction of the variable its coefficient is expected to be close to one. The age-specific population numbers are from the *2000 Census* and the age-specific fatality rates were calculated by us for that year from the Fatal Accident Reporting System data and Census population figures.

Chosen from many possibilities as an indicator of the resources available to the population for taking safety precautions, both individually and collectively, we use POVERTY, the percentage of families in the area with incomes below the poverty line in 1999, from the *2000 Census*. The coefficient of POVERTY is expected to be positive, that is, poorer MSAs can direct fewer resources to safety improvements in general, increasing the likelihood of pedestrian fatalities. Further strengthening the expectation of a positive coefficient is the fact that POVERTY also measures exposure: since poorer residents are less likely to have access to motor transportation, they are more likely to walk than the average resident.[42]

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[39] A similar variable could be constructed for the summer solstice, the longest day of the year in terms of daylight hours, but it would be too highly collinear to the current DAYLIGHT to be useful. That is, locations with short winter days also have long summer days. The relation between the two is so tight that their separate effects cannot be disentangled with our regression approach.

[40] For methodology of computing times of sunrise and sunset, please see Sinnott, R. W. Astronomical Computing. *Sky and Telescope*, Vol. 89, March 1995, pp.84-86.

[41] See http://www.nationalatlas.gov.

[42] Muramaki and Young in *Daily Travel by Persons with Low Income* (1997) use the 1995 Nationwide Personal Transportation Survey (NPTS) to demonstrate that the "biggest difference in travel mode is in the proportion of walking trips. People in low income households are nearly twice as likely to walk as people in other income groups" (p. 1).

We use AREA—defined equivalently as the inverse of population density or land area per capita—as a simple measure of urban form. AREA is obtained from the *2000 Census of Population*, Summary File 3, Geographic File, and normalized to one. We expect the coefficient of AREA to be positive, because of the public good aspect of safety capital.

INTERSTATE measures interstate lane miles per resident, normalized to one. Interstate lane miles were obtained from the *2000 National Transportation Atlas Database* (CD ROM), published by the Bureau of Transportation Statistics, U.S. Department of Transportation. Cities with abundant controlled-access highways need to rely less on high-speed arterials, which are particularly dangerous for pedestrians. The coefficient of INTERSTATE is expected to be negative.

The dependent variable, PFRATE, is the annual pedestrian fatality rate per 100,000 residents averaged across the years 1999, 2000, and 2001, using FARS data. The three-year average is used to reduce noise. Summary statistics for all variables are reported in Table 5.

Table 5
Population-Weighted Summary Statistics

Variable	U.S. Mean	Florida Mean	U.S. Standard Deviation
PFRATE	1.80	3.08	0.67
JANLOW	28.75	52.74	13.10
DAYLIGHT	9.56	10.41	0.74
TOURISM	1.00	1.91	1.16
AGE	1.75	1.86	0.07
POVERTY	0.09	0.10	0.03
AREA	1.00	0.49	1.17
INTERSTATE	1.00	0.61	0.84

Variable Definitions—Sources:
PFRATE: Average annual pedestrian fatality rate per 100,000 residents for 1999, 2000,and 2001—FARS;
JANLOW: 30-year mean January low temperature—*City and County Databook*;
DAYLIGHT: Hours of daylight on December 21, 2000—*National Atlas of the United States*, BEBR calculations;
TOURISM: Per capita sales in thousands of dollars at accommodation and food establishments—*1997 Economic Census*;
AGE: Average weighted age-specific mortality rate—*2000 Census*, FARS, and BEBR calculations;
POVERTY: Percentage of families in 1999 living under the poverty line—*2002 Census*;
AREA: Land area per capita, the inverse of population density—*2002 Census*;
INTERSTATE: Interstate miles per resident, normalized to 1—*2000 National Transportation Atlas Database*.

B. Estimation and Results

The most important results from the regression—reported in Table 6—for our hypothesis are the significantly positive coefficients of JANLOW and DAYLIGHT, which confirm that Florida's higher pedestrian fatality rate stems in large part from an interaction between climate and the timing of sunsets. These coefficients are consistent with the idea that people walk more in warmer climates, even though winter days are shorter than those in summer, and that people walk less where winters are cold and dark. Since DAYLIGHT represents daylight hours in December, low values imply long daylight hours in summer. In the summer, people everywhere walk in the evening, but those walks are safer in the North, which has longer summer days.

The coefficient on TOURISM suggests that a doubling of tourism above the national average raises the pedestrian fatality rate by 0.10 per 100,000. When thinking of the effect of tourism as an explanation of why fatality rates are higher in Florida, we cannot simply consider how many tourists come to Florida. It has to be how many compared to the national average. With that in mind, the only metropolitan area for which TOURISM matters much is Orlando.

The coefficient on AGE was expected to be one, and our results show it to be very close to that value, at 0.98. Other things the same, pedestrian fatality rates are higher where there are more elderly residents. The coefficient on POVERTY suggests that residents living in households below the poverty threshold are three times as likely to suffer pedestrian fatalities as are more financially secure residents. Among other reasons why this might be, they are less likely to have cars, and they are more likely to live on poorly lit and otherwise unsafe streets. This finding might be of use to the State as a consideration in the Florida DOT's Efficient Transportation Decision Making Process.

The positive coefficient on AREA indicates that less dense areas have higher fatality rates. Sprawl may in fact be associated with higher fatality rates, though the relation between urban form and pedestrian fatalities requires more analysis than this single coefficient allows. The negative coefficient on INTERSTATE suggests that having more interstate lane miles reduces reliance on high-speed arterials, which are especially dangerous for pedestrians.

Table 6
Regression of Metropolitan Areas' Pedestrian Fatality Rates

		Coefficient	t-statistic
Constant		-3.86	-3.35
JANLOW		0.02	4.96
DAYLIGHT		0.32	3.27
TOURISM		0.10	1.72
AGE		0.98	2.21
POVERTY		3.15	2.75
AREA		0.09	2.83
INTERSTATE		-0.14	-3.41
$\overline{R}^2$	0.52		
Observations (MSAs)	276		

Source: Regression of PFRATE. For description of variables, see Table 3.

When the regression is run separately for interstate and non-interstate fatalities, the results are reasonable. Interstate pedestrian fatalities are associated chiefly with vehicle breakdowns or accidents, not people taking an evening stroll, paying a social visit, or shopping. January temperature is irrelevant, as is the per capita area of the MSA. The elderly, who tend to avoid interstates, and the poor, less likely to own cars, are less likely than other residents to suffer pedestrian fatalities on interstates. Unsurprisingly, an increase in interstate lane miles is associated with more pedestrian fatalities. When the dependent variable is the non-interstate pedestrian fatality rate, the results are similar to those for all pedestrian fatalities. The interstate pedestrian fatality rates are almost identical in Florida and the rest of the country, 0.19 per hundred thousand residents in Florida compared to 0.18 in the rest of the country. The non-interstate pedestrian fatality rate, in contrast, is 90% higher in Florida than elsewhere. Whatever the cause for Florida's excess rate of pedestrian fatalities overall, it seems not to apply to the state's interstate fatalities.

Our estimates of the causes of the excess pedestrian mortality rate compared to the U.S. average are presented in Table 7 for each of Florida's metropolitan areas. Consider, for example, Miami, the state's largest metropolitan area. Miami's annual pedestrian fatality rate averaged 3.04 per 100,000 residents over the years 1999, 2000, and 2001. This exceeds the national average of 1.80 deaths per 100,000 by 1.24. The combination of climate and weather explain three-fourths of this 1.24, (that is to say, 0.49 from JANLOW and 0.44 from DAYLIGHT). Together, Miami's tourism, somewhat older population, higher-than-average poverty rate, and shortage of interstate lane miles largely explain the remaining 25 percent. But Miami also has less area per resident than the national average among metropolitan areas, which also should reduce its fatality rate. That leaves only 4 percent of Miami's excess pedestrian fatality rate unexplained (that is to say 0.05 deaths per 100,000 residents remain unexplained). Though we cannot be complacent about Miami's high fatality rate, we do have a plausible explanation for it that uses seven variables to fit Miami into its place among 276 metropolitan areas in the United States.

The model "over-explains" some cities, like Punta Gorda, to take the extreme example. Punta Gorda has a fatality rate of only 0.94, which is 0.86 lower than the national average, whereas, because of its climate and sunlight pattern and its older population, our equation expects a fatality rate of 2.82, which is 1.02 higher than the national average. Ft. Pierce, Ft. Walton Beach, Gainesville, Naples, Sarasota, and West Palm Beach also are safer than our equation predicts. Offsetting that, some cities are substantially more dangerous than expected. The chief examples are Daytona Beach, Ft. Myers, Ocala, and Tampa-St. Petersburg. Orlando and Panama City are also more dangerous than expected, even after allowing for the relatively strong effects of tourism in those two metropolitan areas.

Our analysis and the overall impression from Table 7 suggest that by far the most important source of Florida's excess fatality rate comes from the interactions of sunlight and climate. The second most important variable is age. Tourism is important for Orlando, Naples, and Daytona Beach and a few other areas to a lesser degree. Poverty, interstate lane miles, and area per resident all play minor roles in explaining Florida's high fatality rate relative to the nation's.

Table 7
Estimated Sources of Differences in Florida MSA and National Pedestrian Fatality Rates

MSA	MSA PFRATE	Difference in MSA and US PFRATE	JAN-LOW	DAY-LIGHT	TOUR-ISM	AGE	POV-ERTY	AREA	INTER-STATE	Unexplained Difference
Daytona Beach	3.38	1.58	0.30	0.33	0.08	0.21	-0.04	-0.03	-0.10	0.81
Ft Lauderdale	3.04	1.24	0.49	0.44	0.05	0.07	0.10	-0.06	0.10	0.04
Ft Myers	4.23	2.43	0.41	0.42	0.10	0.24	-0.07	-0.06	0.04	1.35
Ft Pierce	2.40	0.60	0.38	0.39	-0.07	0.23	-0.03	0.00	-0.07	-0.25
Ft Walton Beach	1.76	-0.04	0.21	0.28	0.05	-0.01	-0.08	0.00	-0.04	-0.46
Gainesville	2.29	0.49	0.23	0.31	-0.03	0.00	0.11	-0.03	-0.06	-0.04
Jacksonville	2.64	0.84	0.20	0.30	0.01	-0.02	-0.03	-0.04	-0.02	0.43
Lakeland	2.89	1.09	0.36	0.37	-0.02	0.09	0.02	-0.03	0.06	0.23
Melbourne	2.17	0.37	0.35	0.36	-0.01	0.15	-0.07	-0.06	-0.05	-0.32
Miami	3.04	1.24	0.49	0.44	0.05	0.07	0.10	-0.07	0.10	0.05
Naples	2.39	0.59	0.41	0.43	0.24	0.20	-0.08	0.04	-0.18	-0.49
Ocala	4.12	2.32	0.27	0.33	-0.03	0.20	0.01	0.01	-0.05	1.57
Orlando	3.28	1.48	0.35	0.35	0.39	0.00	-0.04	-0.03	0.10	0.34
Panama City	3.15	1.35	0.17	0.30	0.18	0.02	0.03	-0.01	0.14	0.51
Pensacola	2.59	0.79	0.21	0.29	-0.03	0.01	0.07	0.00	-0.01	0.24
Punta Gorda	0.94	-0.86	0.42	0.40	-0.05	0.41	-0.12	-0.01	-0.06	-1.88
Sarasota	2.54	0.74	0.38	0.39	0.03	0.33	-0.10	-0.03	-0.02	-0.27
Tallahassee	2.23	0.43	0.16	0.29	-0.02	-0.02	0.05	-0.01	-0.10	0.08
Tampa	3.95	2.15	0.36	0.37	0.01	0.16	-0.04	-0.05	0.06	1.26
West Palm Beach	2.83	1.03	0.46	0.42	0.06	0.24	-0.07	-0.06	0.09	-0.12
FLORIDA	3.08	1.28	0.38	0.38	0.07	0.11	0.00	-0.04	0.04	0.34

Source: BEBR computations from the regression in Table 5. The row FLORIDA is the population-weighted average of the metropolitan areas. For description of variables, see Table 3.

In summary, the regression analysis fully supports the theoretical model and the hypothesis that much of Florida's high pedestrian fatality rate results from greater exposure when the sun is setting or the sky is dark. The State's role as a destination for both retirees and tourists explains a smaller part of the excess fatality rate. Although our results confirm the hypothesis that urban form plays a role in explaining the difference in fatality rates, further study is required to determine how urban form should be measured and how it relates to other variables influencing pedestrian fatalities.

VI. Data Relevant to Understanding Pedestrian Fatalities

A. Road Type and Speed Limits

If one cause of Florida's higher fatality rate is a shortage of interstate highways to provide access to central business districts, we would expect that the interstate share of Florida's total fatalities to be relatively low. That should be offset, however, by more fatalities on U.S. and state highways, because of the heavy demand placed on them as substitute arterials. Table 8 confirms both expectations: In Florida, state and U.S. highway pedestrian fatalities account for 58 percent of all such fatalities, as opposed to 36 percent in the rest of the country. Similarly, about 6 percent of Florida's pedestrian fatalities occur on interstate highways, against 11 percent in the rest of the country.

Table 8
Pedestrian Fatality Percentages by Road Signing – 1987-2000

Route Signing	Florida (%)	Other States (%)
Interstate	6.44	10.68
U.S. Highway	27.98	13.41
State Highway	29.94	22.77
County Road	6.07	11.95
Township	0.52	5.47
Municipality	24.40	31.50
Frontage Road	0.03	0.33
Other	4.56	3.25
Unknown	0.05	0.65
Total	100.00	100.00

Source: Computations by BEBR using FARS data.

Table 9 suggests that perhaps Florida could reduce pedestrian fatalities significantly on these arterials by constructing median strips with traffic barriers. If Florida's higher rate of pedestrian fatalities can be attributed to conditions of urban sprawl, we would expect roads to be wide and speeds to be high. Indeed our findings suggest that fatalities are proportionately higher on that type of road.

Table 9
Pedestrian Fatality Percentages by Road Type, 2001

Traffic Flow	Florida (%)	Other States (%)
Not Physically Divided (Two Way Traffic)	39.88	53.58
Divided Highway, Median Strip (Without Traffic Barrier)	58.91	23.90
Divided Highway, Median Strip (With Traffic Barrier)	1.01	12.24
One Way Traffic	0.20	2.17
Divided Highway, Median Strip (2-way cont. Left-turn lane)	0.00	4.95
Unknown	0.00	3.16
Total	100.00	100.00

Source: Computations by BEBR using FARS data.

Table 10 provides additional confirmation that dangerous, high-speed arterial corridors substitute for interstates: In Florida, 51 percent of pedestrian fatalities occur on roads with speed limits ranging from 40 to 50 miles per hour, compared with only 25 percent in other states. Our analysis of speed limits in Florida and other states lends support to our finding that Florida has a higher pedestrian fatality rate than other states on U.S. and state highways. For example, the road with the most fatalities in the nation is U.S. 19 in the Tampa MSA.[43]

Table 10
Percentage of Pedestrian Fatalities by Speed Limit, 2001

Speed Limit	Florida (%)	Other States (%)
0	0.00	0.16
5	0.20	0.00
10	0.40	0.00
15	0.20	0.29
20	0.20	0.47
25	1.62	9.68
30	10.32	11.72
35	11.54	18.29
40	13.16	9.41
45	33.40	11.84
50	4.86	3.95
55	10.73	15.80
60	1.82	2.69
65	3.64	7.29
70	4.45	2.11
75	0.00	0.58
99	3.44	5.72
Total	100.00	100.00

Source: Computations by BEBR using FARS data.

B. Seniors

Additionally, 18 percent of Florida's residents are age 65 and older, compared to 12 percent nationally. Due to their reduced visual acuity, impaired hearing and balance, and compromised agility, seniors are more likely to be struck by a vehicle while walking. Moreover, once injured, they are less likely to survive.[44] These observations are supported by Table 11, which presents national data of pedestrian fatality rates by age. This table shows a greater number of fatalities per billion miles walked for seniors than for their younger cohorts.[45]

[43] U.S. 19 is a principal arterial road of 6 to 8 lanes with a speed limit of 45 miles per hour. See *Mean Streets 2002*, at p. 5.

[44] See*,* Charles V. Zegeer, Cara Seiderman, Peter Lagerwey, Mike Cynecki, Michael Ronkin, and Robert Schneider, *Pedestrian Facilities Users Guide -- Providing Safety and Mobility*, U.S. Department of Transportation, Federal Highway Administration, March 2002, at p. 12, available at: http://www.walkinginfo.org/pdf/peduserguide/peduserguide.pdf.

[45] See Michael Baltes, *A Study of Fatal Pedestrian Crashes in Florida*, Center for Urban Transportation Research, University of South Florida, 1995, at p. 3. Note that the measure -- per million miles walked --may be somewhat imprecise given the much higher number (5.12) for the age cohort 65-74 than for surrounding cohorts.

Table 11
Pedestrian Fatalities and Miles Walked, by Age, U.S., 2001

Pedestrian Age Group	Age Group PFRATE	Age Group Population	Pedestrian Fatalities	U.S. Miles Walked	Fatalities per Billion Miles Walked
Less than 5	0.67	19,175,798	128	1,153,598,881	111
5-9	0.74	20,549,505	153	1,575,725,177	97
10-14	0.93	20,528,072	190	2,378,037,800	80
15-19	1.35	20,219,890	272	1,887,060,616	144
20-24	1.83	18,964,001	347	1,265,478,891	274
25-29	1.43	19,381,336	277	1,934,691,763	143
30-34	1.44	20,510,388	295	2,133,253,973	138
35-39	1.96	22,706,664	445	1,833,338,296	243
40-44	2.1	22,441,863	471	2,367,584,027	199
45-49	2.15	20,092,404	432	1,773,844,712	244
50-54	2.07	17,585,548	364	2,748,289,471	132
55-59	1.92	13,469,237	258	1,331,062,263	194
60-64	1.88	10,805,447	203	1,253,973,090	162
65-69	1.91	9,533,545	182	987,343,962	184
70-74	2.52	8,857,441	223	736,470,843	303
75-79	3.06	7,415,813	227	492,477,633	461
80-84	5.06	4,945,367	250	252,220,944	991
85+	5.61	4,239,587	238	97,249,521	2,447
Total	1.76	281,421,906	4,955	26,201,701,863	189

Source: Computations by BEBR using FARS, NHTS and *2000 Census* data.

In support of this observation, nationwide, the PFRATE of persons ages 85 years or older is about three times the national average. However, since people in that age cohort walk far less than the average person, the number of fatalities per mile walked is nearly 13 times the national average. Notice that both the PFRATE and the Fatalities per Billion Miles Walked rise sharply beginning with the cohort of seniors aged 65-69. In other words, although seniors walk less than other age groups, each mile walked is much more dangerous for them than for younger Americans.

Finally, we might ask how Florida compares to other states with respect to pedestrian fatalities of senior citizens. Table 12 suggests that pedestrians ages 15 through 59 are at much greater risk of dying from being stuck in Florida than in other states. The relative risk is less pronounced for children under 14 and residents sixty or more years old. One topic for consideration of future study is the relation between the relative risks for pedestrians stuck in Florida versus those struck in other states.

Table 12
Pedestrian Fatalities and Miles Walked in Florida and Other States, 2001

	Florida			Other States			Ratio of FL and Other States PFRATE by Age
Pedestrian Age Group	Share of Population (%)	Number of Fatalities	PFRATE of Age Group	Share of Population (%)	Number of Fatalities	PFRATE of Age Group	
Less than 5	6.03	7	0.71	6.85	121	0.66	1.08
5-9	6.33	9	0.87	7.13	144	0.75	1.16
10-14	6.55	8	0.75	7.38	182	0.92	0.81
15-19	6.42	28	2.67	7.16	244	1.27	2.11
20-24	5.96	34	3.49	6.97	313	1.67	2.08
25-29	6.15	23	2.29	6.68	254	1.42	1.62
30-34	6.62	24	2.22	7.30	271	1.38	1.61
35-39	7.57	51	4.14	7.82	394	1.88	2.20
40-44	7.64	42	3.37	8.02	429	1.99	1.69
45-49	6.91	59	5.23	7.32	373	1.90	2.75
50-54	6.25	39	3.82	6.48	325	1.87	2.04
55-59	5.35	34	3.89	4.96	224	1.67	2.32
60-64	4.76	17	2.19	3.85	186	1.80	1.22
65-69	4.55	18	2.42	3.27	164	1.87	1.30
70-74	4.44	16	2.21	3.00	207	2.57	0.86
75-79	3.82	34	5.45	2.53	193	2.84	1.92
80-84	2.60	26	6.13	1.76	224	4.74	1.29
85+	2.07	25	7.40	1.51	213	5.23	1.41
Total	100.00	494	3.08	100.00	4461	1.80	1.71

Source: Same as Table 11.

A policy issue in the news concerns seniors as drivers. Are they more likely than other populations to have accidents involving pedestrian fatalities? If they are more likely to do so, when do such accidents occur? Table 13 below suggests that seniors age 65-84 have a higher rate of such accidents than their counterparts in other states. The numbers increase dramatically for seniors aged 85 and older, both in Florida and the nation as a whole. Seniors in that age group drive only one-third as much as seniors age 80-84; they are, however, nine times more likely to be in accidents involving pedestrian fatalities.

Table 13
Ages of All Drivers in Accidents with a Pedestrian Fatality, 2001

Pedestrian Age Group	Florida (%)	Other States (%)	Number All States	Million Miles Driven	Fatalities per Billion Miles Driven
15-19	9.22	9.50	514	143,477	3.582
20-24	13.20	11.67	642	233,416	2.750
25-29	11.93	10.17	562	273,308	2.056
30-34	8.32	11.02	583	344,548	1.692
35-39	6.69	9.52	501	343,453	1.459
40-44	11.75	8.82	495	374,635	1.321
45-49	9.22	7.98	440	288,101	1.527
50-54	4.16	6.03	317	278,174	1.140
55-59	3.62	4.51	240	187,987	1.277
60-64	2.53	2.65	143	161,297	0.887
65-69	3.80	1.95	116	118,984	0.975
70-74	2.17	1.74	97	83,905	1.156
75-79	1.63	1.48	81	55,612	1.457
80-84	1.45	1.23	68	23,918	2.843
85+	10.31	11.69	627	7,984	78.531
Frequency	553	4,875	5,428	2,918,793	1.860

Source: Computations by BEBR using FARS and NHTS data.

Table 14 indicates that fatal accidents of seniors age 85 and older, as drivers, occur disproportionately at night. This finding suggests that, in many cases, vision impairment might be a significant contributory factor to those fatalities. Furthermore, these results lend support to the Florida Department of Transportation's recently modified policy of providing streetlights.

Table 14
Time of Fatal Accidents, Florida and Other States

Light Condition	2001 Ages 85 and over Florida (%)	2001 Ages 85 and over Other States (%)	1982-2000 Nationwide 85+ (%)	1982-2000 Nationwide <85 (%)
Daylight	24.29	32.59	13.71	34.16
Dark	38.87	30.11	36.94	32.92
Dark but Lighted	31.17	32.29	44.67	29.00
Dawn	3.04	1.59	1.59	1.42
Dusk	2.63	2.22	1.56	2.36
Unknown	0.00	1.10	1.54	0.15
Total	100.00	100.00	100.00	100.00

Source: Computations by BEBR using FARS data.

C. Tourism

Are tourists, as drivers, more likely than resident drivers to be involved in accidents with pedestrian fatalities? We would expect a higher level of tourism to account for a greater share of pedestrian accidents in Florida than in other states with a less significant tourism presence. Nonresident drivers are less likely to be familiar with road signs and road conditions. To test this hypothesis, Table 15 combines data for 1987-2001, the years for which interstate routes are coded. Tourists comprise a larger proportion of drivers in accidents with pedestrian fatalities on interstates.[46] In Florida, by this measure, almost 28 percent of drivers in fatal pedestrian accidents were tourists, in contrast to only 22 percent of drivers in other states. In contrast, on other routes in both Florida and other states, only 21 percent of such drivers were tourists.

[46] We can make this inference if we treat nonresident driver licenses as a proxy for tourists, although it is an imperfect measure since some states have large numbers of out-of-state commuters. Florida, on the contrary, is a center of international tourism, and is contiguous to only three other states (Georgia, Alabama, and Mississippi). We feel that these mitigating factors warrant our treatment of "nonresident" as a proxy for TOURISM in this section. We acknowledge, however, that these characteristics are exceptional and do not warrant a generalization to all of the MSAs in our regression.

Table 15
Percentage Distribution of Drivers by Residency Status, 1987-2001

	All routes		Interstates		Other Routes	
	Florida (%)	Rest of U.S. (%)	Florida (%)	Rest of U.S. (%)	Florida (%)	Rest of U.S. (%)
Residency distinguished by vehicle registration						
Resident	82.39	78.54	76.85	77.79	81.82	78.42
Nonresident	17.61	21.46	23.15	22.21	18.18	21.58
Total	100.00	100.00	100.00	100.00	100.00	100.00
Frequency	8,976	85,221	1,335	9,983	7,861	74,298
Residency distinguished by driver license						
Resident	79.10	79.04	72.43	77.88	78.57	78.94
Nonresident	20.90	20.96	27.57	22.12	21.43	21.06
Total	100.00	100.00	100.00	100.00	100.00	100.00
Frequency	8,976	85,221	1,335	9,983	7,861	74,298

Source: Computations by BEBR using FARS data.

Nonresident drivers were more likely in Florida than in other states to be involved in pedestrian fatalities on the interstate. However, as Table 16 illustrates, resident drivers were involved in more accidents of this type in Florida (86 percent, 82 percent) than were residents in other states (79 percent). Interestingly, the opposite was true in 1982, when more pedestrian fatalities were caused by nonresident drivers in Florida (22 percent, 23 percent) than by their counterparts in other states (20 percent, 21 percent).

Table 16
Percentage Pedestrian Fatalities by Residency Status, 2001 and 1982

	2001		1982	
	Florida (%)	Other states (%)	Florida (%)	Other states (%)
Residency distinguished by vehicle registration				
Resident	85.74	79.29	78.31	79.62
Nonresident	14.26	20.71	21.69	20.38
Total	100.00	100.00	100.00	100.00
Residency distinguished by driver license				
Resident	82.13	79.02	76.66	78.69
Nonresident	17.87	20.98	23.34	21.31
Total	100.00	100.00	100.00	100.00

Source: Computations by BEBR using FARS data

D. Daylight and Daylight Saving

And, along the lines of our hypothesis about the importance of the variation by season of sunlight, what are the possible effects on pedestrian safety of daylight savings time (DST), which begins on the first Sunday of April and reverts to standard time on the last Sunday of October? Is there a possible relationship between a sharp transition from more to less light at peak driving times? Do drivers and pedestrians have problems adjusting to new behaviors when confronted with dramatic changes to daylight that affect visibility? The data in Table 19 suggest that a greater number of pedestrian fatalities occur during those periods of transition in the Spring and Fall.

As the numbers in Table 17 reveal, a disproportionate share of pedestrian fatalities in 1982-2001 occurred between 6 p.m. and 7 p.m. (8.25 percent), although a large number also occurred from 7 to 9 p.m. (8.06-8.13 percent). The smallest share of fatalities occurred between 4 a.m. and 5 a.m. (1.90 percent) and very few occurred between 8 a.m. and 10 a.m. (3.93 percent).

At the end of DST, the number of pedestrian fatalities jumped from 562 to 1571 between 5 p.m. and 6 p.m., and from 882 to 1710 between 6 p.m. and 7 p.m. At the beginning of DST, the number fell from 838 to 370 between 6 p.m. and 7 p.m., and from 1278 to 654 between 7 p.m. and 8 p.m. However, the changes in fatality incidents in the morning were much smaller. At the end of DST, the number of pedestrian fatalities fell from 586 to 321 between 6 a.m. and 7 a.m., and from 380 to 252 between 7 a.m. and 8 a.m. At the beginning of DST, the number increased from 165 to 180 between 6 a.m. and 7 a.m., but fell from 5 a.m. to 7 a.m. Our findings correspond to those in earlier research into the effects of daylight on pedestrian safety, but are novel in bringing to bear the effects of the *interaction* between daylight and climate.[47] We are confident of our results, but we acknowledge that there are some lingering concerns, such as asymmetry in the shifts in pedestrian fatalities occurring in the evening and morning. Further research into these issues might help resolve such concerns.

[47] See Dorothy Robinson, "Pedestrian Fatalities and Daylight Saving Time," available at: http://agbu.une.au/~drobinso/DSTacc.html.

Table 17
Number of Pedestrian Fatalities by Hour of Day and Month, U.S., 1982-2001

Hour	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
0	359	298	389	414	445	516	549	542	495	516	414	364	5,301
1	402	296	342	357	415	472	493	497	491	472	352	365	4,954
2	364	310	329	342	425	401	494	524	504	398	334	336	4,761
3	170	139	181	218	258	273	355	306	295	277	189	213	2,874
4	151	110	153	156	201	231	257	286	222	200	169	150	2,286
5	191	196	195	172	177	171	233	298	301	307	272	256	2,769
6	519	317	165	180	139	127	157	268	444	586	321	484	3,707
7	375	226	218	168	207	164	158	204	331	380	252	321	3,004
8	224	159	163	168	176	188	166	204	203	256	229	247	2,383
9	192	165	175	173	175	221	228	202	217	203	198	202	2,351
10	177	183	189	214	185	235	250	223	238	204	217	199	2,514
11	209	201	223	208	242	233	282	265	249	251	242	201	2,806
12	233	209	214	220	262	289	256	279	265	257	219	248	2,951
13	223	198	253	259	263	296	315	297	291	259	248	253	3,155
14	302	288	291	277	301	304	314	296	301	348	352	342	3,714
15	414	357	427	411	462	380	310	347	377	444	429	422	4,780
16	339	320	362	371	393	383	329	348	409	392	454	436	4,563
17	819	371	386	373	352	371	317	359	335	562	1,571	1,558	7,374
18	1,453	1,151	838	370	370	355	316	363	429	882	1,710	1,695	9,932
19	932	1,028	1,278	654	329	316	304	403	807	1,493	1,073	1,093	9,710
20	675	710	864	975	755	518	580	961	1,142	1,018	769	774	9,741
21	548	580	686	857	1,038	964	114	1,101	863	792	598	647	9,788
22	465	478	590	612	763	830	939	902	711	707	555	614	8,166
23	442	391	480	534	669	667	766	677	569	599	512	548	6,854
Total	10,178	8,681	9,391	8,683	9,002	8,905	9,482	10,152	10,489	11,803	11,677	11,995	12,0438
Missing	794												

Source: Computations by BEBR using FARS data.

The impact of natural light conditions on pedestrian safety warrants further comment. With respect to dawn and dusk, pedestrian fatality shares were higher in 2001 in Florida (3.04 percent and 2.63 percent, respectively) than in the nation as a whole (1.59 percent and 2.22 percent, respectively). We also computed the hours of daylight in Florida and the other states, using counties as our unit of analysis.[48] In this computation, we define "daylight" as the hours between sunrise and sunset. From Table 18, we can observe that the average amount of daylight from 5a.m. to 7 a.m. and from 8 p.m. to 10 p.m. is less in Florida than in the rest of the nation. Averaged over a year, those are periods of time when, due to natural light conditions, pedestrians may be less visible to drivers in Florida than they would be to the same drivers in other parts of the country.

Table 18
Average Yearly Amount of Daylight in Minutes, by Selected Hour, 2000[49]

Hour	Florida	Other States
5:00 to 5:59 a.m.	191	1,093
6:00 to 6:59 a.m.	5,072	8,211
7:00 to 7:59 a.m.	19,520	18,451
Noon to 12:59 p.m.	21,960	21,960
7:00 to 7:59 p.m.	9,285	9,259
8:00 to 8:59 p.m.	2,052	3,537
9:00 to 9:59 p.m.	0	155

Source: Internal computations by BEBR. See preceding discussion for methodology.
Other States excludes Alaska and Hawaii.

E. Alcohol Consumption and Pedestrian Fatalities

Is alcoholism more of a contributing factor to pedestrian fatalities in Florida than in other states? As we might expect, intoxicated pedestrians are at greater risk than their sober counterparts for motor-vehicle injuries and deaths in Florida and elsewhere because alcohol impairs attention, judgment, perception, vision, and coordination. Alcohol is implicated in almost one-third of all reported pedestrian fatalities.[50] Moreover, susceptibility to fatalities appears to be greater at night; 53 percent of pedestrians age 16 and older who were killed at night in 2001 had blood alcohol concentrations of at least 0.08 percent.[51]

[48] See *supra* at note 36.
[49] The number of daylight hours was computed for each county in Florida and the rest of the continental United States. The purpose of this table is to illustrate exactly how much, due to the Earth's axis of rotation, the Sunshine State differs from its peers in the amount of daylight it receives in the morning and evening hours.
[50] Although that is still a high percentage, it represents an improvement from the 1980s, when 41 percent of pedestrian fatalities were attributed to alcohol. See Insurance Institute for Highway Safety, "Little Steps, Bigger Ones to Protect Pedestrians," *Status Report*, Vol. 34, No.3, March 13, 1999, at p. 2. The report compared pedestrians (age 16 and older) in 1980 and 1997 with blood alcohol concentrations of .10 percent.
[51] See "Fatality Facts: Pedestrians as of November 2002," available at: http://www.iihs.org/safety_facts/fatality_facts/peds.htm.

These facts notwithstanding, characteristics of intoxicated pedestrians involved in fatal and nonfatal accidents have not been well defined.[52] Table 19 seems to corroborate that point, since, in a high percentage of accident reports in Florida (52 percent compared to 20 percent in other states), alcohol as a contributory factor to a fatal accident is either not reported or is unknown. The results in Table 19 also suggest that we might not be able to determine with any certainty whether alcohol is more of a cause of pedestrian fatalities in Florida than in other states. However, when alcohol usage or non-usage is reported, alcohol usage seems to be less prevalent in Florida than in other states.

Table 19
Percentage of Pedestrian Drinking in Florida and Other States – Fatal Accident Reports

Pedestrian Drinking	Florida (%)	Other States (%)
No Alcohol	32.39	31.18
Yes Alcohol	8.30	15.31
Not Reported	6.88	33.92
Unknown	52.43	19.59
Total	100.00	100.00

Source: Computations by BEBR using FARS data.

Even if they are not drinking, pedestrians in Florida seem to have become less attentive to personal safety over the past four years. A recent survey of Floridians found that from 1998 to 2002, a greater percentage of respondents indicated they crossed at intersections with or without lights, walked along roads without sidewalks, and crossed the street in the middle of the block.[53] This survey also found that pedestrians' exposure to traffic (measured by pedestrian trip rates) increased by 16 percent in that time interval.[54] The findings suggest that this increased exposure may partly explain the slight increase in pedestrian fatalities in Florida since 1999.[55]

VII. Discussion and Conclusion

It is natural to wonder why, year after year, Florida's pedestrian fatality rate exceeds the national average by such a large margin. Not surprisingly, various interpretations of this problem have emerged. One school of thought, typified by *Mean Streets 2002*, emphasizes

[52] See "Motor-Vehicle-Related Deaths Involving Intoxicated Pedestrians – United States, 1982-1992," *MMWR Weekly*, Vol. 43, No. 14, April 15, 1994, 249-253, available at: http://www.cdc.gov/epo/mmwr/preview/mmwrhtml/00030694.htm.

[53] See Florida Department of Transportation, *2002 Bicycle and Pedestrian Survey: Final Report*, at p. 40. A survey was conducted of 963 residents in Tampa, Orlando, Miami, and Jacksonville. Survey responses from 2002 were compared to those received from a similar survey conducted in December 1998. The primary objective in both surveys was "to determine if trip frequencies and trip lengths are increasing or decreasing, and determine if exposure to crashes is increasing or decreasing and to what degree"

[54] *Id*, at p. x.

[55] *Id.*

urban sprawl and lack of investment in safety: Low-density automobile-centered cities generate high-speed traffic on arterials that are a nightmare for walkers. Money that should be spent on enhancing safety is devoted instead to building more dangerous roads, leading people to live still farther from where they work. Such a policy, goes the line of thought, not only creates a greater danger to those who walk, but such spending and its attendant sprawl raise overall death rates even more by discouraging walking, an otherwise beneficial form of exercise. In this view, the compact cities in the North benefit their citizens by encouraging them to walk because of their convenience and safety.

An alternative view emphasizes exposure: Floridians, as others in the South, are more likely to be involved as pedestrians in vehicular accidents because they walk more. The warmer climate invites more walking, the amount of which is poorly measured by surveys and other data, and which certainly is inadequately represented by the percentage of the labor force walking to work, the indicator used in *Mean Streets*. Moreover, the resident population inadequately measures exposure, especially in Florida, on account of the tourists and "part-time" residents (e.g. snowbirds), who are not included in census counts. Add to that the greater susceptibility of older residents, and Florida's high fatality rate is easily understood, though it of course remains a serious concern.

The seemingly straightforward view of exposure in the South being increased by a milder climate encounters a serious difficulty: by this interpretation, the ratio of the fatality rate in the South to that in the North should be much higher in the winter than in the summer. A glance at the numbers, however, shows that the ratio remains fairly constant throughout the year. Even though it seems eminently plausible that the South's warm winters should encourage more walking and thus place more pedestrians at risk, the numbers fail to support this straightforward interpretation.

Our own view is that exposure is indeed a large part of the explanation of Florida's high pedestrian fatality rate, but that the exposure interpretation must be modified to emphasize the interaction between climate and length of day. It is well known that the darker hours are considerably more dangerous to pedestrians. Drivers are simply less able to see them. It is also highly plausible that people are less likely to take evening walks when it is freezing and dark. Moreover, compared to the South, days in the North are long in the summer and short in the winter.

These statements suggest the following hypothesis: In the summer, people in both the South and the North take evening walks and (to a lesser extent) morning walks. Compared to the South, those walks are safer in the North because the sun sets very late. In the winter, people in the North are less likely to take evening walks because it is cold and dark. If they do walk, they will stay away from streets, especially poorly lit streets with significant amounts of traffic. In the South, however, walking is pleasant even in January, and the walk can start just in time to enjoy a beautiful sunset and end in the dark. Consequently, the seasonality of pedestrian fatalities is similar in North and South, but the level is higher in the South year-round.

There is a simple way to check this hypothesis: compare fatality rates in Florida and in the rest of the country in the daylight hours and at night. From six in the morning until six in the evening, Florida's pedestrian fatality rate exceeds the nation's by approximately twenty-five percent. That excess can be explained by tourism and age. In the night hours, from 6 p.m. to 6 a.m., however, Florida's rate is more than double the nation's, far too large a difference to be explained by tourists and retirees alone. But the night/daylight comparison fits easily into the hypothesis that the *interaction* between climate and the seasonality of sunrise and sunset explains a great deal of the difference between Florida and other states, with tourism, age, with a few other variables accounting for a significant share of the remainder.

As a more formal test of the climate-length of day interaction hypothesis, we regressed pedestrian fatality rates on January temperature, length of December days, and other variables (see Table 5). The results of the regression support the hypothesis. While we admit that our results are not definitive, we think they are sufficiently strong to warrant careful consideration by those responsible for designing and executing pedestrian safety policy. The appropriate test to obtain such definitive results would be to analyze individual fatalities from reports for several years with respect to time of day, weather, and light conditions, using data from the Fatal Accident Reporting System. Because of its relevance to the nation, not just to Florida, such a study could be funded by a national source. Considering the scope and complexity of the problem, we recommend that it be undertaken by a scholar or institution with an established, national reputation in transportation safety.

There are a number of ways our results could be extended. One would be to change the unit of observation from metropolitan statistical areas to arterial corridors. While this would complicate the definition of the relevant populations used to calculate the fatality rates, it would enable the analysis of how the interaction of climate and daylight influence fatalities on arterial roads. Are they more dangerous during evening rush hours, or afterwards? Is there a particularly dangerous combination of climate, evening rush hours, and time of sunset? Another possible extension would be to combine engineering and cost data with studies of the effects of specific types of investments to refine the specification of our safety capital equation. Of particular interest would be to examine how rapidly the returns to additional safety investments decline.

An important omission in our model is the potential exposure induced by extra safety investment considered in two senses: First, making one micro-location safer induces pedestrians to walk there instead of elsewhere. Second, additional safety investment increases total walking and thus exposure. Ignoring this fact could make the returns to safety investment appear smaller than they are.

Information could be gained from panel studies, and the time-series could then be combined with our own cross-sectional analysis. The attempt to explain both the large spatial and temporal variations in pedestrian fatalities with the same model would sharpen our understanding of what causes them.

More generally, our approach suggests that information about pedestrian fatalities for allocating scarce safety resources could be organized into three categories:

(1) Measuring exposure as a function not only of population but also of climate, tourism, and other variables;
(2) Characteristics of both individuals and of locations influencing inherent dangers and risks;

(3) The function relating safety to investment.

More precise knowledge of each of these categories of information will enhance our ability to combine them into models that provide additional perspective on such issues as the relation of pedestrian safety to urban form, to regulation and education, to population characteristics, and to public safety investment.

Appendix A
Ranking of States by Pedestrian Fatality Rate, 2000

Rank	State or District	Pedestrian Fatalities	Resident Population	PFRATE
1	District of Columbia	18	572,059	3.15
2	Florida	500	15,982,378	3.13
3	Delaware	22	783,600	2.81
4	New Mexico	48	1,819,046	2.64
5	Arizona	135	5,130,632	2.63
6	Hawaii	31	1,211,537	2.56
7	Wyoming	12	493,782	2.43
8	Nevada	46	1,998,257	2.30
9	Louisiana	101	4,468,976	2.26
10	Mississippi	64	2,844,658	2.25
11	South Carolina	82	4,012,012	2.04
12	California	691	33,871,648	2.04
13	Texas	420	20,851,820	2.01
14	North Carolina	159	8,049,313	1.98
15	Colorado	80	4,301,261	1.86
16	Tennessee	102	5,689,283	1.79
17	New York	337	18,976,457	1.78
18	New Jersey	148	8,414,350	1.76
19	Alaska	11	626,932	1.75
20	Maryland	92	5,296,486	1.74
21	Georgia	141	8,186,453	1.72
22	South Dakota	13	754,844	1.72
23	Michigan	170	9,938,444	1.71
24	Missouri	88	5,595,211	1.57
25	Illinois	191	12,419,293	1.54
26	Oregon	52	3,421,399	1.52
27	Utah	33	2,233,169	1.48
28	West Virginia	26	1,808,344	1.44
29	Arkansas	38	2,673,400	1.42
30	Connecticut	48	3,405,565	1.41
31	Alabama	62	4,447,100	1.39
32	Pennsylvania	171	12,281,054	1.39
33	Kentucky	54	4,041,769	1.34
34	Maine	17	1,274,923	1.33
35	Montana	12	902,195	1.33
36	Virginia	92	7,078,515	1.30
37	Massachusetts	82	6,349,097	1.29
38	Oklahoma	43	3,450,654	1.25
39	Nebraska	21	1,711,263	1.23
40	Washington	68	5,894,121	1.15
41	Vermont	7	608,827	1.15
42	Wisconsin	52	5,363,675	0.97
43	Indiana	56	6,080,485	0.92
44	Ohio	98	11,353,140	0.86
45	Iowa	25	2,926,324	0.85
46	Minnesota	41	4,919,479	0.83
47	North Dakota	5	642,200	0.78
48	Kansas	19	2,688,418	0.71
49	Rhode Island	6	1,048,319	0.57
50	New Hampshire	7	1,235,786	0.57
51	Idaho	6	1,293,953	0.46
	U.S. Total	4,843	281,421,906	1.72

Source: Pedestrian fatalities from FARS