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ABSTRACT
A leading cause of death and injury to children is being struck by a motor vehicle. A disproportionate number of injured child pedestrians are of low socioeconomic status. The relationship between socioeconomic status and pedestrian injury is poorly understood. The existing literature is limited by the lack of pedestrian exposure data, a common measure of risk, and a clear conceptual framework for the interaction between socioeconomic status and pedestrian injury. Another issue is the limited availability of injury data. This paper proposes a model for understanding child pedestrian exposure and risk and its relationship to socioeconomic status. The analysis also identifies the need for additional data and research, and makes specific policy proposals.

INTRODUCTION

It has been suggested that pedestrian injury risk is particularly high for persons of low income or socioeconomic status (SES) (*1-4)* and for children (*5-8*). However, the ability to develop reliable estimates of injury risk is constrained by limited data on walking rates among specific demographic subgroups, incomplete records of pedestrian injuries, and the lack of a consistent risk measurement tool. While SES has an apparent influence on travel behavior, SES is rarely considered in transportation research, and our understanding of the influence of SES on pedestrian injury risk is limited. Children's travel patterns and needs are similarly neglected within transportation research.

This paper proposes a model for understanding the relationship between SES and risk for injury among child pedestrians, and it uses this model to consider the limitations of current data as well as to outline directions for future research and policy to help understand and reduce childhood pedestrian injury.

Using this conceptual model, this article interprets a review of the literature on childhood pedestrian injury helps to explain the mechanisms outlined in the model below. A variety of sources were used, including searches of online journals, the TRIS Online database, general internet web search engines, annotated bibliographies, referrals from researchers, and personal files. A total of 49 articles on a range of subjects including childhood pedestrian injury, pedestrian safety, childhood injury, poverty and health, and income and transportation were located and reviewed. Of these, nine studies that focus on the relationship between SES and childhood pedestrian injury were selected for more in-depth review and discussion. Other articles served as background material.

Through the review of the literature, various limitations and policy implications become apparent through the framework of the model. This article concludes with a summary of limitations on current pedestrian data and suggestions for future research agendas and intervention efforts in pedestrian safety.

Walkable Communities

In recent years transportation planners and sustainable development advocates have increasingly promoted alternatives to the use of private vehicles for transportation, including public transit, bicycling, and in particular, walking. This interest stems from a variety of sources, including the damaging effects of auto-based transportation on the environment, the spread of auto-oriented sprawl and subsequent loss of farmland and open space, and the damaging effects of long auto commutes and multiple vehicle trips on families and personal lives.

At the same time, public health professionals have begun to encourage the integration of walking into everyday life in response to growing concerns about lack of physical activity, obesity and other associated health risks. An emerging consensus is that the physical environment shapes how we move, and that changes in the way we design cities and neighborhoods can have profound effects on transportation and physical activity. Based on this shared interest in walking, transportation planners and public health professionals are integrating their efforts to encourage "active environments" that support walking. However, for walking to be a safe and healthy activity, we must understand and address the risk of pedestrian injury.

Children and Walking

The renewed emphasis on walking is particularly relevant for children, especially children from low-income households, for several reasons. Low-income children are especially likely to walk,

because low-income households generally have fewer vehicles than higher-income households. This includes children who are too young to drive and children living in households with few or no cars. Low-income children also tend to use public transit more often, which usually includes a walk trip both to and from the transit stop. In California, children in households with annual incomes under $25,000 per year were almost three times more likely to walk or bike than children in households with annual incomes over $75,000 (10). Similarly, children in households with annual incomes under $25,000 per year were almost twelve times more likely to take public transit than children in households with annual incomes over $75,000 (10).

However, rates of walking among children in general have declined dramatically over the past several decades. This is consistent with a large decrease in walking trips among the overall population. For example, the percentage of people walking to work dropped more than 30 percent from 1990 to 2000 (*8*), while the number of vehicle miles traveled increased two-fold from 1970 to 2000 (*9*). The percentage of children walking or bicycling to school has decreased from over 66 percent in the 1970s to about 10 percent today (*8*). Currently, at least 70 percent of children's trips are by private vehicle (*2*). Historical data on child walking rates by household income are limited, so it is unclear whether these changes also apply to low-income children. Given the concentration of low-income families in urban areas that tend to have better transit services, it is likely that walking rates for low-income children have dropped by less than for higher income children.

Children's Pedestrian Injury Risk

While walking can contribute to the health and mobility of children, pedestrian injury from being struck by a motor vehicle is a serious concern. It has been estimated that between 700 and 1100 children under the age of 14 in the United States die each year from pedestrian injury, and an additional 30,000 to 47,000 child pedestrians suffer non-fatal injuries (*5-7*). The greatest risk for pedestrian injury is to children ages 5 to 9 years of age in their own neighborhoods (*8*). Pedestrian injuries account for more childhood disabilities and deaths than all other causes of childhood illness (*4*). This is particularly of concern given the disparate prevalence of injury among vulnerable populations such as low-income children. Understanding the extent of these disparities in risk and why these disparities exist is crucial to planners and public health professionals. With this knowledge, planners and health professionals are equipped to address injury risks and encourage walking while ensuring that increased walking is not exposing people to increased injury risk.

Children's disparate risk of pedestrian injury can be explained by several factors. They may have higher exposure to traffic because they tend to play on streets and sidewalks. They may also be more likely to enter conflicts with vehicles due to their less developed cognitive, perceptual and motor skills and lack of awareness about road safety. Children generally do not understand a driver's perspective and have a hard time anticipating how drivers will behave. Smaller children are often less visible in traffic due to their size, and they are therefore more likely to be hit. Their narrower field of vision also makes it more difficult for them to see oncoming vehicles. Finally, children are more likely than adults to be injured if a collision occurs due to their smaller size and lighter weight relative to vehicles.

While the disparate rate of pedestrian injury among children compared to other age groups is fairly well understood, the relationship between SES and pedestrian injury is less clear. Pedestrian injury seems to be higher in low SES groups than in high SES groups. This is at least partly related to lower vehicle ownership rates and higher rates of walking among low-income

persons. For example, it has been shown that lack of access to a car increases pedestrian injury risk two-fold (*4*). However, many other factors may also be involved. To begin to understand the relationship between SES and pedestrian injury, it is helpful to consider the more general relationships between low-income status and health, and low-income status and injury.

SES Public Health Issues

SES and Health

The relationship between low SES and poor health is present across a variety of geographic areas and health measures. For example, rates of cancer, obesity, diabetes, asthma and cardiovascular disease are all consistently higher in low-income communities than higher-income communities (*14*). This difference found in cities and regions across the United States as well as in other countries.

These trends are often explained by differences in behavior and lifestyle, such as diet, smoking, and physical activity patterns (*14*). Other arguments focus on the lack of services and programs, such as the lack of affordable health care, which limits low-income persons' access to quality medical services. A third set of explanations for this disparity center on environmental differences, such as low-income communities' disproportionate exposure to environmental hazards in natural environments, work environments, and living environments. This includes high levels of air, soil and water pollution, exposure to chemicals or injury risks at work, and for pedestrian injury, the presence of high speed, high volume streets, and lack of sidewalks and other pedestrian facilities in low-income neighborhoods.

SES and Injury

The relationship between SES and injuries of all types is well documented. Additionally, a number of studies have examined the relationship between pedestrian injury and SES**.** For example, Durkin's small area analysis of Northern Manhattan found that residence in a low-income census tract (defined as the percentage of households in a census tract with annual incomes under $10,000) was the most significant predictor of severe childhood injury (*3*). This analysis included pedestrian injury as well as falls, burns, assaults and other injuries. Runyan's review of adolescent injury also found a consistently higher risk for a variety of injuries, including motor vehicle related deaths, among low-income communities (*16*). Hippisley-Cox's cross-sectional survey of hospital admissions for childhood injury found that total injuries and severe injuries increased with lower household SES (defined by an index of parent/guardian unemployment, overcrowding, lack of vehicle, and renter status) (*17*). This relationship was strongest for pedestrian injury and held even when controlling for ethnicity, rural area, and proximity to a hospital.

However, these studies all relied upon a population-based measure of injury: specifically, the number of injuries per 10,000 or 100,000 persons. It is unclear if elevated injury rates would remain if differences in walking rates (exposure) between income groups were considered.

SES and Pedestrian Injury

While clear relationships between SES and health, injury, and pedestrian injury have been documented, the mechanisms behind these relationships are unclear. Literature has focused on several factors, including the physical environment, social environment (including services and programs), and behavior. In the following section describes a conceptual model to interpret the

relationship between SES and pedestrian injury outcomes. Within this framework, the literature analysis describes in more detail SES and pedestrian injury.

PROPOSED MODEL

We propose that a model of the relationship between SES and risk for pedestrian injury would be helpful in analyzing the factors that contribute to that risk (Figure 1). The model is based on a general model of injury or disease that considers the rate of injury to be a function of both exposure and risk per unit of exposure. This general model has been adapted to the pedestrian context and specified for children. It presents SES as the primary variable. In the first relationship, SES influences a variety of environmental and social factors (Figure 1). These modifying factors, in turn, influence the behavior of pedestrians, drivers, and others (Figure 1). Resulting from behavior, injury risk can increase or decrease (Figure 1). The combination of exposure and risk per unit of exposure determines the rate of injury (Figure 1).

Model Components: SES

SES can define characteristics of the individual (e.g., individual income, education; household income) or of the neighborhood (e.g., median household income for a census block). SES is related to behavior through an interaction with modifying factors such as the physical, social and political environments; availability of services and programs; and vehicle ownership by the pedestrians family. As discussed above, census data show that low-income persons make about twice as many walk trips as higher-income persons, mainly because they generally own fewer vehicles (*13*). It has also been shown that a larger percentage of low-income children walk to school compared to higher-income children (*9*). Neighborhood-wide SES is often reflected in the physical environment of a community, such as the existence and quality of parks and availability of recreation and school-based programs. These amenities affect how much children play in or near streets and sidewalks. Low-income neighborhoods may also have less pedestrian signage, or less well maintained streets. These characteristics could both affect driver and pedestrian behavior.

Model Components: Exposure/Risk Modifying Factors

The first model component, SES, modifies an individual's exposure to injury because SES often determines an individual's physical and social environments, public services available to the individual, and the individuals' ability to own a vehicle. For example, census data show that low-income groups make shorter trips than other income groups. Specifically, 60 percent of low-income persons' trips are three miles or less (*13*). Thus, the immediate environment may have a strong impact on low-income persons' travel behavior and injury risk. Below we discuss the physical environment, social environment, services, and vehicle ownership in context of this model component.

Physical Environment

Many studies focus on the relationship between the physical environment and risk for pedestrian injury. This approach is particularly relevant for children because children are most often injured near their homes. Thus, one can draw a relatively direct link between the physical environment in which a child's pedestrian injury occurs and probable characteristics of the child's household (i.e. SES).

Both Durkin and Dougherty and Pless suggest that the lack of parks and safe play areas in low-income neighborhoods is related to higher rates of pedestrian injury (*3, 18*). Children without safe play areas may tend to play on streets and sidewalks where they are more vulnerable to vehicle traffic.

Agran found curbside parking to be the most significant predictor of childhood pedestrian injury in a case-control analysis of Latino children in Orange County, CA (*6*). She suggests that this relationship is related to poor visibility of pedestrians. Roberts also found curbside parking to be related to injury due to reduced visibility and its association with higher-volume streets (*19*).

Stevenson and colleagues' case-control study of childhood pedestrian injury in Australia examined 40 traffic risk factors (*20*). While controlling for SES, they found vehicle traffic volume to be significantly associated with injury. In a case control study that considered environmental factors related to severe child pedestrian injury (*19*), Roberts used an existing scale that included parent occupation to measure SES. He found that the rate of pedestrian injury was twice as high for children in low-income households as for children in high-income households. In terms of environmental factors, traffic volume was one of the strongest predictors of injury. Areas with high traffic volumes had up to 13 times more injuries than low-volume areas.

Stevenson and colleagues also found the presence of sidewalks to be significantly associated with child injuries (*20*). Stevenson posits that the existence of sidewalks encourages children to use them as play space, and that children exercise less caution than they would while playing near a road without sidewalks.

Durkin suggests that the high incidence of pedestrian injury among low-income populations in general is related to a higher prevalence of hazards in low-income neighborhoods (*3*) such as poorly maintained roads or other hazardous walking or driving conditions. The cross-sectional study Dougherty and Pless of bicycle and pedestrian injury and death in Montreal showed that low-income neighborhoods (based on median household income) had up to six times more pedestrian injuries per population than high-income neighborhoods (*18*).

Although many studies suggest traffic calming as a key policy to improve the physical environment for pedestrians, Stevenson finds that traffic calming methods such as roundabouts and speed bumps have no effect on injury (*20*). This finding contradicts most pedestrian safety literature and suggests further examination.

Braddock's examination of childhood pedestrian collisions found that census tracts with the highest number of children per acre had the most collisions (*22*). Similarly, Rivara and Barber found that child pedestrian injuries were more strongly associated with the percentage of crowded housing per acre than with household income, race, or household structure (*1*).

Social Environment

Few studies examine the role of the social environment on walking and driving behavior. However, Runyan proposes that social norms, cues and pressures could explain higher pedestrian

injury rates in low-income neighborhoods (*16*). These norms could include different expectations of behavior or different requirements for safety. For example, it may be normal in some neighborhoods for children to play in the street, while such behavior is generally not allowed in others. Parents in some areas may allow or encourage their children to walk to school, while parents in other areas prefer to drive their children. Also, it may be common for some children to walk or play outside after dark, while others are required to come inside at dusk. The decisions of individual households as well as common values of neighbors influence these differences

Services

Durkin suggests that limited extracurricular activities and the lack of access to affordable childcare are potential factors in the high rates of pedestrian injury in low-income neighborhoods (*3*). Runyan also suggests differences in recreational activities, which could be related to the lack of after-school programs, as a mechanism of increased injury risk in low-income neighborhoods (*16*). If high cost or limited availability prevents children from enrolling in after-school programs or childcare, they may be more likely to play on public streets and sidewalks. While playing in the public streets or sidewalks is not a direct risk for injury, it could lead to higher rates of injury when combined with hazardous physical environments and lack of supervision.

Age, gender, and vehicle ownership

Although not yet well studied, age, gender, and vehicle ownership are important factors that modify the exposure and risk for injury to child pedestrians. Overall injury rates are affected by pedestrian exposure, which is often higher for older children. Nevertheless, younger children are more likely to be injured than older children due to their smaller size and less developed traffic safety skills (21). There is also a strong relationship between male gender and higher injury rates that has not been fully explored. For example, Durkin found that the pedestrian injury rate for boys to be three times higher than girls' (*3*). This gender difference may be related to differences in pedestrian or caregiver behavior or differences in exposure. Finally, as discussed above, there is a strong relationship between SES and vehicle ownership rates, which is directly related to more walking trips in low-SES households.

Model Components: Behavior

The physical environment, social environment, public services, and vehicle ownership affect behavior. In fact, they impact on behavior of drivers, pedestrians, caregivers, police, and others. For example, the use of pedestrian signals at intersections influence how a pedestrian crosses the street and the relative safety of their crossing. Also, an environment where there is strict enforcement of stop signs or speed limits, pedestrians have a lower injury risk. These behaviors ultimately define the risk of pedestrian injury.

The role of behavior in injury risk has not been well analyzed. This relationship is often assumed or made implicitly, but not explicitly discussed. In the case of pedestrian injury, behavior of drivers and pedestrians are clearly important, but the role of caretakers such as parents, teachers and other adults as well as peers is also important and often overlooked.

Vehicle speed is an example of driver behavior influencing pedestrian injury risk. Stevenson found that more vehicles exceed the speed limit in low-SES communities, and higher speeds increase the risk of pedestrian injury. The relationship between vehicle speed and injury is supported by statistics from the National Highway Traffic Safety Administration (NHTSA). While about five percent of pedestrians die when struck by a vehicle traveling 20 mph, the

pedestrian fatality rate rises to about 40 percent for vehicles traveling 30 mph, about 80 percent for vehicles traveling 40 mph, and nearly 100 percent for speeds over 50 mph (*21*). A similar relationship between vehicle speed and injury rates exists for pedestrians less than twenty years of age. Injury rates are 2.1, 7.2, and 30.7 times higher for young pedestrians hit by a vehicle traveling 20-29 mph, 30-39 mph, and over 40 mph, respectively, compared to pedestrians hit by a vehicle traveling between 10 and 19 mph (*21*).

Differences in vehicle speed could be related to variation in enforcement, in physical environment (including street design), or other factors. Dougherty and Pless suggest that lack of enforcement of speed limits may be related to pedestrian injury in low-income neighborhoods (*18*).

Pedestrian behavior is also clearly influential. Another example of how the environment affects behavioral decisions is crosswalks. There is a long-standing debate within traffic engineering over the provision of crosswalks. Because crosswalks demarcate a physical space for pedestrians, pedestrians use them more than unmarked crosswalks. This higher use, or exposure, has been reflected in higher injury rates. The injury rates have been used to support removal of crosswalks, often with the explanation that crosswalks 'encourage' pedestrians to cross when it is unsafe. However, this stated relationship between physical environment and behavior is not well understood, and the need for safe crossings is completely overlooked.

Runyan points out that young people are responsible for many injuries to child pedestrian (*16*). When all crashes are considered driver age was negatively correlated with crash incidence up to certain age where the trend was reversed (22).

Model Components: Exposure/Injury Risk

Behavior ultimately influences injury outcomes because behavior modifies individuals' exposure to risk. The relationship between exposure, and the next model component, injury, is not one-way: injury or perceived threat of injury might influence a person to reduce his exposure (i.e., modify his behavior). Exposure can be defined at the neighborhood or at the individual level, for example, by the number of walk trips, the distance walked, or the amount of time spent walking or playing on a street or sidewalk.

Injury risk is defined as the number of injuries per unit of exposure. Exposure can be measured many ways, including population, trips taken, distance traveled, and time spent per trip. Having a consistent measure of injury risk is important for evaluating changes in pedestrian safety over time, between places, and compared to other modes of travel. Currently, evaluating pedestrian injury risk is difficult due to the lack of data on walking volumes described above and the lack of a consistent measure of injury risk. Several different measures are described below.

Many analyses of pedestrian safety are based on the total number of pedestrian injuries and fatalities each year. According to NHTSA data, the total number of traffic-related pedestrian deaths has declined 16 percent over the past decade (*28*). These numbers are commonly used to argue that pedestrian safety is improving. However, these numbers do not account for differences in the total population studied or the number of pedestrian trips. It is likely that declines in total injuries are due to the overall decline in walking noted above.

To account for differences in population over time or place, many studies use a population-based measure, such as pedestrian injuries or deaths per 100,000 persons. For example, the California Department of Health Services reports that the pedestrian death rate per 100,000 persons ages 14 and under declined 48 percent from 1991 to 1999 (*29*). Such statistics provide a general measure of the prevalence of pedestrian injury and death among children, but

they do not account for differences in the number of walk trips over the decade. Population-based measures can also be misleading when comparing cities or states, since walking rates often differ significantly by location.

To adjust for this variation across geographic areas, others compare pedestrian risk based on walking rates. The Surface Transportation Policy Project (STPP) analysis of pedestrian safety in various California cities first divides pedestrian fatalities and injuries by population size to get an incidence rate. The STPP then uses the incidence rate and a pedestrian exposure index (based on the percent of the population that walks to work) to calculate the pedestrian danger index (*10*). This measure shows that cities with relatively high total injuries and fatalities but high numbers of pedestrians are actually safer than cities with fewer injuries and fatalities but very few pedestrians. Unfortunately, because this measure defines exposure as the percentage of the population that walks to work, it does not account for differences in the actual number of trips, distance traveled or time spent traveling.

To describe the relative safety of various modes of transportation, some analysts measure injuries per mile traveled. By this measure, pedestrians face a substantially higher rate of death compared to other modes, with an estimated pedestrian fatality rate of 49.9 per one hundred million miles traveled, while the rate for auto passengers and airline passengers is 1.4 and .16, respectively (*10*). However, this measure overestimates pedestrian risk relative to other modes because walking trips are generally much shorter than trips by other modes. To account for the differences in travel distance by mode, one can measure risk as injuries per trip. For example, data on student trips from the UNC Highway Safety Research Center show that there are 310 annual injuries per 100 million walking trips, compared to 490 and 1610, respectively, for the same number of vehicle trips with an adult driver and bicycle trips (*30*).

Another method that incorporates the number of walk trips to demonstrate relative risk compares the percentage of traffic deaths that are pedestrians to the percentage of total trips that are made by pedestrians. For example, STPP has calculated that walking makes up about six percent of trips but that pedestrians account for 13 percent of traffic deaths (*10*). This shows that pedestrian travel is relatively dangerous relative to other modes. This measure can also be used to compare pedestrian risk in different geographic locations.

A final measure of injury risk calculates the number of injuries per time spent in a mode. For example, Chu has calculated the number of fatalities per 10 million hours traveled by different modes, and by pedestrians in different locations and over time (*31*). This measure accounts for variation in speed by different modes. Since trips of similar types (i.e. commute trips, recreational trips, etc.) often take a similar amount of time, injury per time spent may be a fairer measure of risk than injury per trip or distance.

Model Components: Injury

In addition to the limited amount of data on walking volumes and the lack of a common measure of injury risk, our understanding of the dangers of walking is limited by incomplete data on pedestrian injuries.

Most pedestrian injury data comes from the Fatality Analysis Reporting System, or FARS. FARS is a database of police reported traffic collisions that occur on public roads. Another common data source is the General Estimates System, or GES. The GES is a national sample of police reported collisions resulting in property damage or personal injury or death. While these systems provide a fairly complete picture of pedestrian fatalities, both the FARS and GES databases present several limitations for understanding the problem of pedestrian injury.

First, because FARS is limited to collisions on public roadways, it excludes collisions that take place on private property such as parking lots and driveways. These are not considered traffic-related crashes by the Department of Transportation, and thus are not reported to state Departments of Transportation and are not included in pedestrian injury data. Second, pedestrians who are taken directly to the emergency room are often left off of police reports. Third, non-severe injuries or other injuries that do not result in a police response may also not be recorded. Fourth, for those collisions that are recorded, the police report includes only limited characteristics about a collision. It may not record where a pedestrian was hit, whether a crosswalk was available, or other characteristics of the driver, pedestrian, or environment (*4*). Finally, police reports are also commonly inaccurate. For example, many reports erroneously assign fault to the pedestrian. This could be because the police officer is unaware of pedestrian safety laws or because the driver assigns fault to the pedestrian and the pedestrian is either too young or too incapacitated to defend him or herself. In some areas, language barriers may also limit a pedestrian's ability to fully explain a collision to the reporting officer. A study in New York State found that although drivers were reported as responsible for almost three-quarters of fatal pedestrian collisions, only 16 percent of drivers were cited, and less than one percent was cited for violating a pedestrian safety law (*10*).

State departments of health also calculate pedestrian injuries. These calculations are generally based on reports from hospitals and ambulances. Thus, similar to the GES and FARS databases, health departments often miss non-hospitalized and non-severe injuries. In addition, hospitals and ambulance companies may not consistently provide records to health departments. Finally, differences in how injuries are recorded (i.e. by outcome (death, injury type) or by event (pedestrian-vehicle collision)), missing data, and changes in coding systems may affect whether and how pedestrian injuries are counted.

A final source of pedestrian injury data is insurance claims. Of course, many pedestrian injuries do not involve insurance claims. This is especially likely for collisions involving low-income pedestrians or others who may not have the resources to file a claim.

The result of these limitations is a significant under-counting of pedestrian injury. STPP estimates that pedestrian injuries, particularly non-hospitalized injuries, are underreported by as much as 56 percent (*4*). A study in Montana estimated that only 20 percent of pedestrian injury collisions were included in police reports (*32*). Obviously, the under-reporting of pedestrian injury poses a significant challenge to estimating the true risks of walking.

RECOMMENDATIONS BASED ON CURRENT REVIEW OF PROBLEM

The review and investigation of the relationship between SES and child pedestrian injury research problem described above demonstrates the limitations of our understanding. While many studies consider the role of the physical environment, few examine the impact of social environments, access to services and programs, or pedestrian and driver behavior. As Laflamme and Diderichsen conclude in their review of social differences in childhood traffic injury risks,

the mechanisms remain poorly understood (*26*). In addition, our understanding of injury risk is limited by incomplete data on child pedestrian exposure, the lack of a consistent measure of injury risk, and limited data on child pedestrian injuries. The recommendations below are presented in the framework outlined by the conceptual model.

Understanding and Measuring SES

Researchers should also endeavor to use a standard measure of household SES. The studies reviewed above used a variety of measures of SES, including family income, parent's occupation, education, and composite indices. Given the apparent relationship between pedestrian SES and injury, it is important to understand what factors are involved in this relationship. A consistent measure of SES would allow researchers to analyze variation in injury while controlling for SES, which is currently rarely done.

Social and Political Environments

As shown previously, much of the research on pedestrian injury focuses on characteristics of the physical environment. Few studies analyze the role of social or political environments in injury. Elements such as city priorities, neighborhood organizing, community norms and individual values may play important roles in behavior and exposure. Thus, research is needed on the interaction between these environments and behavior. Although some research has focused on pedestrian behavior, it is possible that the disparate rate of pedestrian injury among low-income communities is related to differences in driver behavior. It is crucial to better understand how both drivers and pedestrians perceive their environment and how they make behavioral decisions based on those perceptions. In addition, research should consider variation in police behavior and enforcement. Also, the role of parents and caregivers' behavior is generally overlooked, but is particularly salient for childhood pedestrian injury. Several changes to the risk modifying factors would likely reduce childhood pedestrian injuries, specifically in low-income communities.

The provision of affordable childcare would provide an option to parents who may not be able to watch their children but prefer them not to play unsupervised. This could also take the form of after-school and weekend programs at schools, community centers, and other community facilities. The provision and maintenance of safe public play spaces such as parks, playgrounds, and recreation facilities would also allow children to play in more protected areas.

For walking trips, vehicle speed reduction can be achieved through street design changes such as reduced lane width, reduced number of vehicle lanes, and the addition of street trees, bicycle lanes, and other "buffers." Pedestrian safety can also be improved through infrastructure such as extended signal crossing times, pedestrian refuge areas, wider sidewalks, stop bars, high visibility crosswalks, and pedestrian signage.

Finally, cities or other local jurisdictions can demonstrate the importance of pedestrian safety through enforcement of traffic laws, specifically pedestrian right of way and speed limits. Public streets are the vast majority of public space in most communities. Therefore, it is critical that public streets are safe places for all people to walk and play.

Broadening the Scope of Pedestrian-Vehicle Collision Data

First, more detailed information is clearly needed on the context in which childhood pedestrian injury occurs. Currently, police reports of pedestrian-vehicle collisions provide little information about road characteristics, driver behavior, and pedestrian behavior. These variables are critical to a more fine-grained analysis and understanding of pedestrian injury. Reports should include

information about the traffic control system, signal phase, signage, sidewalk condition, crossing condition, and other aspects of the road environment. Collision reports should also include vehicle speed, driver distraction, aversion attempts, and other aspects of driver behavior. A more complete picture of the pedestrian would greatly aid our understanding of injury patterns. Information gathered should include pedestrian movement, size, visibility, destination, and activity. Conflicts, or near misses, can also be used as surrogate measures for collisions. While these are not commonly reported, they can be observed much more frequently than collisions.

Second, information is also needed about non-hospitalized and non-severe pedestrian injuries. These injuries may have different characteristics than those that result in hospitalization, and would add to our understanding of the different conditions in which injury occurs.

Third, pedestrian injury records, whether from hospitals, ambulance services, police reports, insurance claims, or other sources should be gathered in a central database. This would create a more complete picture of the scope of pedestrian injury.

Fourth, revision of pedestrian laws may be needed, along with additional police training of pedestrian safety laws and collision reporting. As discussed above, pedestrians are often erroneously faulted for collisions, both by police and drivers. In the case of child pedestrians, in particular, drivers should be held responsible for pedestrian safety. Training would help ensure that police understand pedestrian rights and responsibilities and apply the law consistently. Additional resources should also be targeted for increased enforcement of pedestrian safety laws.

Most importantly, we need improved tools and systems for measuring pedestrian activity. As discussed above, the lack of data on pedestrian volumes prevents a true analysis of relative risk. The changes to the latest NHTS survey have increased the number of walk trips that are recorded, but many are still missed. At a national scale, additional changes should be made to the NHTS or other surveys to gather more information from a larger population, especially low-income households, non-English speakers and children. On a smaller scale, pedestrian measurement methods such as video analysis, automated detection systems, or hand counts could be utilized. Efforts should focus on developing consistent methods of measurement across locations.

Developing Consistent Measures

Future studies of pedestrian injury should utilize a standard measure of injury risk, such as injuries per walk trip or injuries per time spent walking or per distance walked. Of course, this requires improved pedestrian measurement tools and injury data, as described previously. A standard measure of injury risk would greatly improve our ability to compare research results and analyze injury across time, place, and income groups.

CONCLUSION

Understanding pedestrian injury risk is critical to efforts to encourage walking for transportation and health. We have provided a conceptual framework for the relationship between SES and child pedestrian injury. Applying this model, we understand that SES effects physical and social environments, which in turn affect behavior, and behavior modifies risk. This interpretation is especially relevant for low-income children given the disproportionate risk of injury to child pedestrians, higher rates of walking, and higher rates of inactivity-related health problems found in low-income communities, and the. The model helps highlight that our current understanding of the relationship between injury risk and SES is limited by the lack of adequate pedestrian-

exposure data, sufficient pedestrian injury data and a common measure of risk. Improving the quality of information gathered from collisions, developing tools to measure pedestrian trips, and focusing research on understanding the interaction between SES, behavior, exposure, and risk will help shape policy to reduce pedestrian injuries among low-income children and all pedestrians.

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LIST OF TABLE AND FIGURES

FIGURE 1.


Model: SES and Childhood Pedestrian Injury Risk
SES
Individual
Neighborhood
Social/Political environment
Services and Programs
Age
Exposure/Risk
Modifying Factors
Physical environment
Vehicle ownership
Gender
Behavior
Drivers
Caregivers
Pedestrians
Police/ enforcement
Exposure
Injury Risk
Walk trips
Playing in/near street
Injury
Likelihood of injury per trip,
per mile, or per time spent