Evaluating and Improving Pedestrian Safety in Utah

Pedestrian Safety Issues, Actions and Recommendations

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EXECUTIVE SUMMARY

The essential findings and issues regarding pedestrian safety in Utah are:

- There were 687 pedestrian-vehicle crashes reported in Utah in 2000, representing a reduction of 11.1 percent since 1997.
- There were 33 pedestrian fatalities reported in Utah in 2000. This value represented the reversal of a trend that had seen the number of fatalities increase from 25 in 1993 to 35 in 1999.
- The portion of pedestrians injured in pedestrian-vehicle collisions increased from 69 percent in 1993 to 94 percent in 2000.
- One conjecture is that larger vehicles in Utah's traffic stream are contributing to the increasing pedestrian injury rate.
- Based on 1997-1998 data, Utah had the third-highest child pedestrian fatality rate (1.7 fatalities per 100,000 children) in the United States.
- Also, based on 1997-1998 data, Salt Lake City-Ogden was the 12th "most dangerous" metropolitan area in the United States for pedestrians. This information, published in the annual *Mean Streets* report, is awarded national attention including publication in *USA Today.*
- Of the 1998-1999 pedestrian-vehicle crashes in Utah, 92.6 percent occurred in six heavily urbanized counties: Cache, Davis, Salt Lake, Utah, Washington, and Weber. These counties were home to 84.4 percent of Utah's population in 2000.
- Based on 1997-1999 pedestrian-vehicle crash data, 15 cities featured one or more sites or corridors with multiple incidents: Kaysville, Logan, Murray, Ogden, Orem, Provo, Riverdale, Roy, St. George, Salt Lake City, South Salt Lake, Springville, Taylorsville, West Jordan, and West Valley City.
- Also, based on 1997-1999 data, 117 sites located along federal-aid roads experienced one or more pedestrian-vehicle crashes per year.
- In 2000, 31.7 percent of the drivers involved in pedestrian-vehicle collisions were between the ages of 15 and 24; one driver was under age 15. The drivers in the 15-24 age group represented 23.2 percent of all drivers in Utah in 1999.
- In 2000, persons under age 20 and over age 65 represented 54 percent of all pedestrians involved in motor vehicle collisions. In Utah and nationally, these age groups are the most vulnerable to pedestrian-vehicle crashes.
- Utah has the highest ratio of persons under age 20 and over age 64 to persons between ages 20 and 64 in the United States, at 90.1 per 100; the ratio is expected to increase to 97.7 by 2025.

Numerous additional findings and issues are presented in the report. This report also presents a number of recommendations in multiple areas. The No. 1recommendation is that multiple interventions be implemented to improve and maintain pedestrian safety. To rectify the issues and concerns, a combination of education, engineering, enforcement, monitoring, medical response and policy is required. The following represent the key recommendations:

- An effort should be made in driver education courses to enhance the level of pedestrian awareness.

- Pedestrian safety should be expanded on in the *Utah Driver Handbook*.
- Pedestrian safety questions should be included on the state driver licensing examination.
- A pedestrian safety brochure or pamphlet should be included with the documents that are transferred at the time of purchase of a vehicle, particularly large private vehicles (sport utility vehicles, vans and full-size pickups). Research has shown that pedestrians are more susceptible to severe injuries and fatalities in collisions with large private vehicles than with small vehicles.
- Pedestrian safety training should be instituted for the elderly, particularly to reevaluate cognitive skills and reiterate street-crossing fundamentals.
- Child pedestrian safety training should involve parents.
- Pedestrian safety training should emphasize aspects such as the effects of alcohol, how to select an appropriate time to cross, looking behavior, the visibility of pedestrians to motorists, and the need for increased alertness after the changeover from daylight savings to standard time.
- Specialized pedestrian safety efforts are needed adjacent to high school and college campuses, and in residential areas on Halloween.
- Pedestrian-vehicle collision data should be monitored and studied on an ongoing basis. Utah CODES prepares annual summaries of Utah's traffic safety statistics, but additional, ongoing work is needed to identify site-specific problems and assess the impacts of improvements.
- Gather data on the amount that people walk. Research suggests that the amount of walking has been declining since the 1970s. Basing pedestrian crash statistics on pedestrian-miles traveled rather than population or vehicle-miles traveled would clarify pedestrian safety trends.
- A statewide policy for grade-separated pedestrian crossings should be developed.
- Innovative traffic signal phasing strategies should be employed to enhance pedestrian safety and minimize pedestrian-vehicle conflicts.
- New pedestrian safety measures such as crossing flags and countdown pedestrian indicators appear to be successful, but need to be formally evaluated.
- Safe walk-to-school routes should be evaluated; alternative routes may be suggested, and guidelines for future school sites may be developed.
- Lengthened green phases should be considered at intersections near senior living centers and where there is a large number of elderly pedestrians. Elderly pedestrians require, on average, 50 percent more time to cross a street than younger pedestrians.
- The economics of pedestrian-vehicle collisions should be studied, including liability issues, the costs of injuries and fatalities, and the benefits of improvements.
- Freeway pedestrian crossing warning signs should be installed at freeway sites and along freeway corridors that have recurring pedestrian incidents.
- Innovative funding mechanisms are needed to finance pedestrian safety improvements. Existing programs, such as Transportation Enhancements, Safe Sidewalks, and Community Development Block Grants, while indispensable, are somewhat restrictive on the projects that can be supported.

- Because the risks to pedestrian safety increase at night, illumination should be considered as a mitigating strategy.

1. INTRODUCTION

This document offers recommendations for improving pedestrian safety in Utah. A number of agencies and organizations would be responsible for implementing the recommendations, including the Utah Department of Transportation (UDOT), regional planning organizations, municipal jurisdictions, pedestrian safety and educational organizations, community groups, and concerned individuals. A more complete list of organizations that might be involved in implementation is offered at the end of this report.

This research project, "Evaluating and Improving Pedestrian Safety in Utah," was initiated in December 2000. Two interim reports have been prepared thus far, including *Facilitation of Pedestrian Crossings in 28 States and Literature Review of Pedestrian Safety Measures* (Cottrell 2001) and *Literature Review of Pedestrian-Vehicle Crashes and Analysis of Pedestrian-Vehicle Crashes in Utah* (Cottrell et al. 2001). The final chapter of each report features recommendations pertaining to the subjects discussed in that report. This report incorporates and organizes those recommendations, adds new ones, and provides links to pedestrian safety policies and plans that are currently in place in Utah. The primary resource document for this report was the *Statewide Pedestrian and Bicycle Plan* (SPBP), which was approved by UDOT in February 2001. While the SPBP considers both pedestrians and bicycles, the current research, and this report, focuses on pedestrian-related concerns.

The *Statewide Pedestrian and Bicycle Plan* (SPBP) considers the following pedestrian-related issues:

- Pedestrian-vehicle crash statistics and outcomes;
- Federal legislation and regulations;
- Statewide planning actions regarding walkways and support facilities, railroad crossings, shared usage of trails and paths, safety and liability matters, driver awareness, pedestrian safety education, legislation, usage of controlled-access highways, and enforcement;
- Regional planning actions;
- Local planning and community advocacy;
- Public transit access;
- Inventories of pedestrian facilities;
- Construction zones; and
- Snow removal.

The SPBP also refers to a number of organizations within Utah that are involved in pedestrian movement and safety. The responsibility for implementing the recommendations in this report would be with these organizations. The SPBP also provides synopses of pedestrian-related documents that have been prepared by these organizations. The following text addresses each of the preceding issues. Because they are both numerous and important, the statewide planning action items are considered individually. The format of the body of this report is to, within each section,

identify the key issues and concerns, describe any policies, plans or actions as discussed in the SPBP or other writings, then offer one or more recommendations.

2. PEDESTRIAN SAFETY ISSUES, ACTIONS AND RECOMMENDATIONS

Construction Zones

Key Findings and Issues

The Utah Labor Commission, Utah Occupational Safety and Health Division reported that three highway construction workers were killed on the job in 1998. The report did not indicate if the fatalities resulted from collisions with private motor vehicles. Data on worker injuries relating to motor vehicle collisions were not available, nor were more recent statistics.

Nationally, between 1992 and 1999, from 106 to 136 highway worker fatalities occurred each year. About 23 percent of the fatalities were attributable to workers being struck by motor vehicles. In July 2001, the Federal Highway Administration (FHWA), in a report to a Congressional panel, stated that the national trend was toward an increasing number of highway work zone fatalities.

Another concern is the safety of the pedestrian who must traverse a construction or maintenance zone. Utah's pedestrian-vehicle collision data does not readily indicate the number of incidents occurring within construction and maintenance zones. Further study of UDOT's Centralized Accident Records System (CARS) data would be needed to isolate these cases. Eldridge (1998) notes that a common technique in urban construction projects is to close a section of the adjacent sidewalk, accompanied by a "Sidewalk Closed - Please Use Other Side" sign. Such closures can create detour-related inconveniences and delays, particularly if the street is wide. Further, a safety hazard can be created if some pedestrians insist on "hugging" the construction project while walking partially within a traffic lane.

Policies, Plans and Actions

UDOT requires each contractor working on a state highway project to file an accident prevention plan. These plans include sections on traffic control and public protection; the public protection section addresses the management of pedestrians. The plan, once filed, is operative for three years.

Recommendations

The FHWA suggests the following highway work zone safety improvements:

- Remove safety program costs from the competitive bid process, to ensure that neither safety costs nor necessary precautions are forfeited;
- Close roads entirely for some repair projects, while incorporating maximum work efficiency techniques;
- Toughen work zone traffic laws (for example, increase fines for speeding);
- Toughen the enforcement of work zone traffic laws;
- Incorporate highway work zone safety instruction into driver education courses;
- Employ intelligent transportation systems technology in advance of work sites to warn motorists of potential delays and the need to consider alternative routes.

Both the FHWA and the Laborers' Health and Safety Fund of North America suggest that improved traffic safety training may be needed for highway workers and flaggers. Highway work zone safety instruction tips for motorists include being attentive, turning on the vehicle's headlights, obeying posted speeds, not changing lanes, not tailgating, and avoiding distractions such as cell phone use.

In many cities, construction projects are bordered with separate, sometimes covered walkways for pedestrians. If not already in place, local agencies in Utah should consider requiring that a pedestrian walkway be provided adjacent construction sites. The extent of the requirement and the type of walkway would depend on the location and size of the project. The requirement would supplant the "sidewalk closed" alternative. It may be necessary to reduce roadway capacity in such cases to allow sufficient space for the walkway.

Driver Awareness

Key Findings and Issues

Pedestrian safety literature indicates that the greatest concerns with regard to driver behavior are alcohol abuse, speeding, yielding tendency (or a lack thereof), and unlawful driving (other than speeding or being under the influence). Studies have shown that anywhere from 7 percent to 26 percent of drivers involved in pedestrian-vehicle collisions have a high blood-alcohol content. By comparison, 9 percent of all motor vehicle occupants, including drivers who were involved in alcohol-related crashes in 1998, were injured or killed. This indicates that the portion of drivers who are under-the-influence and are involved in pedestrian-vehicle collisions is potentially greater than the portion of drivers who are under-the-influence and are involved in fatal motor vehicle collisions. One conclusion is that a pedestrian may be more susceptible than a moving vehicle to being hit by an impaired driver (Vestrup and Reid 1989; Lane et al. 1994).

Studies of driver reactions to pedestrians attempting to cross (i.e., the pedestrian is on the curb, looking at traffic and preparing to step into the street, but has not yet started to cross) have shown that drivers slow no more than 2 mph. No difference in driver behavior has been observed between marked and unmarked crossings. Drivers tended to show a greater propensity to stop, however, when the pedestrian was "conspicuously" dressed in bright or reflective clothing (Harrell 1992-93; Knoblauch et al. 2000). Rouphail (1984) found that, once a pedestrian was in the process of crossing at an unsignalized location, 0.5 percent of all drivers failed to stop or slow down. While this percentage is small, it nonetheless constitutes a major risk factor for pedestrians attempting to cross at unprotected locations. For example, if such a road has an average daily traffic volume of 10,000, up to 50 vehicles per day could involve a pedestrian in either risky, evasive maneuvers or a collision.

Both Baker et al. (1974) and Vestrup and Reid (1989) found that driver negligence was a factor in 38 percent to 46 percent of all pedestrian-vehicle collisions. Negligence included speeding and failing to yield. Of the negligent drivers in these studies, between 37 percent and 58 percent had poor driving records, including multiple prior moving violations and involvement in two or more crashes. Jordan (1998) suggested that, given the large number of unlicensed, unregistered and uninsured drivers in Philadelphia, greater effort was needed in enforcement and in improving driver compliance with motor vehicle regulations. Such "unlawful" drivers were considered to be a risk for pedestrians.

Policies, Plans and Actions

A number of agencies in Utah have put effort into modifying and controlling traffic flow, including traffic controls, traffic calming, and pedestrian-vehicle separation. Techniques include signals, school zone speed restrictions, stop signs, speed bumps, and bollards. These approaches are in addition to warning signs, flashing lights, and enforcement. The objective of these types of techniques is to modify driver behavior on the road. The *Utah Driver Handbook* includes a short paragraph on how drivers should respond to pedestrians who are attempting to cross a street. There is also a short section entitled "Drivers Must Remember," which emphasizes when drivers must yield to pedestrians. Otherwise, attempts to modify driver behavior off the road appear to be limited.

Recommendations

It may be useful to incorporate pedestrian awareness into driver education. Thompson et al. (1985) concluded that a number of drivers may habitually overestimate the ability of pedestrians to cope with traffic. The development of a pedestrian safety module for a drivers' education course might be considered. Sarkar et al. (1999) found that driver-licensing manuals were insufficient to educate motorists on pedestrian conflicts and the vulnerability of pedestrians. To increase driver awareness, the *Utah Driver Handbook* should include wording on driver behavior and pedestrian safety concerns including school zones, nighttime visibility, roads with no shoulder or sidewalk, bus stops, and walkways and crosswalks near senior living centers.

Pedestrian safety-related questions should be included on the Utah driver license examination. Exam questions tend to emphasize how the driver should react to a stopped school bus. Other issues should be addressed, including pedestrian visibility, midblock crossings, and right turns. Such questions might serve to increase the "pedestrian awareness" of motorists.

The portion of pedestrians injured in pedestrian-vehicle collisions in Utah increased from 69 percent in 1993 to 92 percent in 1999. The speculation is that larger vehicles in Utah's traffic streams are a contributing factor in the heightening injury rate. An enhanced awareness of pedestrian safety may be needed for the owners of pickup trucks, sport-utility vehicles, and vans. Statistics show that the severity of pedestrian injuries from these vehicles is greater than those caused by passenger cars. One suggestion would be to include a pedestrian safety brochure among the documents that are transferred at the time of purchase of a motor vehicle, with particular attention to large private vehicles.

Enforcement

Key Findings and Issues

A study of the related factors in Utah's year 1999 pedestrian-vehicle crashes reveals that a number of improper driver actions preceded the incident. These actions included hit and run, speeding, improper parking, an unclear windshield, improper backing, under the influence of alcohol, improper overtaking, headlights insufficient or out, defective brakes, crossing over the centerline, and improper turning. As discussed in Cottrell et.al. (2001), it is nearly impossible, based on the information typically provided in a police accident report, to attribute the cause of each crash to the driver or pedestrian. Chapman et al. (1982) estimated that 29 percent of 2,157 pedestrian-vehicle crashes could be wholly or partially attributed to the driver. The estimate was based on

interpretations of the events purportedly occurring prior to each crash. It is evident that, in many of the cases, the motorist was at fault through either poor or illegal execution of a driving maneuver. Several articles in the pedestrian safety literature suggest a need for attention to drivers' compliance with standard motor vehicle regulations, such as vehicle registration, licensing, insurance, and so forth (Baker et al. 1974; Jordan 1998). A lack of one or more of these may be associated with a careless, reckless or inattentive driver.

Policies, Plans and Actions

During 2000, the Utah Highway Patrol (UHP) made 4,969 arrests for driving under the influence. A total of 900 of the arrests were made by the UHP's Special Emergency Response Team. The Utah Highway Safety Office (UHSO) provides portable breath testers and a few breath alcohol testing vehicles to law enforcement agencies. The UHSO also provides equipment such as radar guns and portable speed monitors for traffic law enforcement. In 1999, 42.5 percent of the drivers involved in a pedestrian crash in Utah were issued a citation. This figure increased to 50.9 percent in 2000, although only 25 percent of the drivers involved in fatal pedestrian crashes were cited. No data were found on citations for speeding, other moving violations, or jaywalking.

Recommendations

Ongoing enforcement of traffic laws and the issuing of citations for moving violations are recommended as strategies to enhance pedestrian safety. Enforcement is considered to be one element of a package of strategies that also includes education, traffic engineering, pedestrian provisions, and medical intervention.

It is not apparent that efforts are being made by either law enforcement agencies or the Driver License Division of the Utah Department of Public Safety to track the performance and credentials of Utah's drivers. An in-depth examination of Utah's pedestrian-vehicle crash data might reveal the extent of any problems with driver compliance. Tough post-crash procedures, such as driver license suspension, increased fines, and thorough driving record checks, might improve pedestrian safety. Pre-crash strategies might include random checks of driver license currency, consistently issuing citations for moving violations, and vehicle registration checks. Britt et al. (1995) recognize, however, that the long-term effects on pedestrian safety of various traffic enforcement efforts, including intensive campaigns and behavioral suggestions, are unclear.

The research for this study did not produce any findings on the effects of enforcement targeted at pedestrians. It is probable that the level of enforcement of pedestrian regulations varies widely between jurisdictions in Utah and abroad. It is not clear if a crackdown on jaywalking, for example, would have a noticeable or lasting effect on pedestrian safety. Pedestrians should nonetheless be encouraged to cross streets properly and to use the available facilities. Zegeer and Zegeer (1988) found that grade-separated pedestrian facilities are least likely to be used adjacent to high schools and colleges. A related finding is that, in Utah, busy roads in the vicinity of high schools and colleges have high pedestrian-vehicle crash rates (Cottrell et al. 2001). Pedestrian safety enforcement, combined with safety education and appropriate, user-friendly facilities, is recommended for the peripheral areas of campuses.

Federal Legislation and Funding

Key Findings and Issues

Transportation Enhancements (TE) funding was established by the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), and continued and expanded by the Transportation Efficiency Act for the 21st Century (TEA-21), as a means of supporting non-highway construction oriented projects. Among the 12 eligible areas for TE funding are pedestrian and bicycle facilities, and pedestrian and bicycle safety and education. The SPBP states, however, that few community sidewalk projects are large enough to meet the requirements for eligibility as TEs. The UDOT Enhancements Program recommends TE project awards of between $100,000 and $500,000. The result is that the number of applications for TE funding does not reflect community needs for small projects, such as sidewalks. Eldridge (1998) notes that TE funding allocations in Utah are restricted to construction; TE project planning must be done by local agencies and organizations using their own resources.

Policies, Plans and Actions

Despite the preceding criticisms, UDOT's Enhancement Program has completed a number of pedestrian overpasses, crossing improvements, and sidewalk projects. Other completed projects include pedestrian-bicycle paths and pedestrian tunnels. It is recognized, though, that many viable pedestrian safety improvements do not meet the recommended $100,000 minimum cost. For example, the National Transportation Enhancements Clearinghouse reports that a three-year pedestrian safety campaign in the small state of Rhode Island cost $48,000. A bicycle safety program in the city of Lawrence, Kan., cost $29,000. Only larger projects, such as a statewide bicycle safety campaign in Oregon and a downtown revitalization project in Auburn, Wash., had six-figure costs.

Recommendations

It is recommended that attention be given to innovative funding mechanisms for pedestrian safety improvements. The emphasis should be on finding ways to fund low-cost pedestrian safety projects that do not meet the existing requirements of the TEs. Restrictions also exist among other funding sources, such as UDOT's Safe Sidewalks Program (projects must be along state highways) and the U.S. Department of Housing and Urban Development's (HUD's) Community Block Development Grants (projects must benefit persons of low and moderate income and be part of broader community development programs). One approach would be to reduce the minimum cost requirement for TE projects. Another approach would be to develop new funding mechanisms, such as impact fees, improvement districts, private contributions, enhancements based on performance measurement systems, and so forth. (*It is recognized that, as of the writing of this document, modification of UDOT's Enhancements Program is on hold pending the year 2003 reauthorization of federal surface transportation funding*).

Inventorying Pedestrian Facilities

Key Findings and Issues

Many pedestrian safety problems may be related, in part, to the lack of unsuitable pedestrian facilities. For example, if a pedestrian is hit by a motor vehicle on a highway along which there is

no sidewalk, one of the contributing factors may be the lack of a sidewalk. Also, if a pedestrian-vehicle collision occurs at night in a poorly lit or unlit area, one of the contributing factors may be the absence of artificial lighting. It is difficult to discern the contribution of the lack of pedestrian facilities in pedestrian-vehicle crashes. For example, one of the pedestrian actions prior to a crash, as summarized in Dearden and Allred (2000), is "walking in roadway with traffic." Another action is "walking in roadway against traffic." There is no indication, however, of the availability of a sidewalk in these cases. Qin and Ivan (2001), in their model of exposure risk to pedestrians (which can be used to predict pedestrian-vehicle crashes), show that the availability of a sidewalk is a key explanatory variable.

Policies, Plans and Actions

The SPBP suggests that the UDOT Pedestrian and Bicycle Planning Office compile and periodically update a comprehensive inventory. The compilation would include existing pedestrian facilities, areas with sidewalk discontinuity, areas needing new sidewalks, areas needing sidewalk rehabilitation or replacement, and areas needing improved accessibility. The SPBP indicates that some cities were beginning to compile inventories. Also, school districts, as mandated by Utah Code, were involved in identifying safe walk- and bike-to-school routes.

Pedestrian-related indexes, combining multiple effects, have assisted in evaluating, ranking and programming improvements to pedestrian facilities. A Pedestrian Friendliness Index (PFI) has been used by the Mountainlands Association of Governments (MAG) in Utah County to develop pedestrian trip-end ratios for transportation modeling purposes. The Wasatch Front Regional Council (WFRC) has adapted the MAG's trip-end ratios to the regional transportation model for Salt Lake City-Ogden. The PFI rates pedestrian environments on a scale from one (low) to four (high). The index is based on the ratio of the total length of sidewalks to the total length of road within a study area. The index serves to convert raw pedestrian facilities and amenities data into a quantity that can be readily assessed and ranked.

Recommendations

Fundamental Data Needs

To begin any pedestrian-related planning project, a baseline is needed. Five ingredients are essential to establishing a pedestrian facilities inventory:

- The length, capacity and location of pedestrian facilities (by type of facility);
- The conditions of the facilities;
- Lighting along pedestrian facilities, at pedestrian crossings, and along roads that are used by pedestrians;
- The level of usage of pedestrian facilities, possibly combined with an overall assessment of the demand for walk trips; and
- Funding resources and amounts for pedestrian-related projects.

Multiple techniques are available for collecting, entering, storing, and displaying each of the preceding inventory items. For example, pedestrian facility locations can be identified in the field, then locked into a database using a global positioning systems (GPS) device. Alternatively, if a municipality has encoded its street network into a transportation geographical information system (GIS-T), a pedestrian facilities network can be developed as a GIS-T overlay. A number of methods exist for determining the number of pedestrians using a given facility. These include manual counts, recording the number of times that a pedestrian-actuated pushbutton is used, videotaping or remote

counting using video technology, and compressible metal plates on the walkway surface. A number of advanced counting methods exist, too, including positioning sensor tools, moving object extraction methods, and automated human head location. The advanced techniques are suggested for locations with very heavy pedestrian volumes.

Condition Data

The conditions of pedestrian facilities should be evaluated, including the surface, lighting, accessibility, cleanliness, capacity, and encroachment of vegetation. Concrete sidewalks are subject to spalling, cracking, sagging and section pop-up (Bowman et al. 1989). These distresses can present tripping hazards, accessibility difficulties for the disabled, and drainage problems. Walkways in extremely poor condition may force the pedestrian to use the road as an alternative. Two of the most challenging situations to the disabled are curbs and pedestrian bridges. Ramps at street-curb interfaces can provide a smooth transition; of course, gutters must be kept clean, and drop-offs that appear following deterioration must be corrected. Pedestrian bridges, stairs and ramps must be kept free of debris and well-lit; bridges must be inspected periodically for evidence of corrosion. Lighting is of primary concern in pedestrian tunnels and in any nighttime walking situation (Zegeer and Zegeer 1988).

Pedestrian-Related Indexes

The use of pedestrian-related indexes may supplement pedestrian facilities inventory data. The PFI has been successfully applied by the MAG in Utah County. A number of indexes have been applied in other jurisdictions. Portland, Ore., in particular, has successfully used the Pedestrian Environment Factor, the Pedestrian Potential Index, and a Deficiency Index. The National Highway Traffic Safety Administration (NHTSA) has developed a Walkability Index, while additional indices based on pedestrian exposure have been proposed (Knoblauch et al. 1984; Jin et al. 1998). The various inputs to these indices include sidewalk continuity, the ease of street crossings, local street network characteristics, topography, vehicle speeds, roadway widths, traffic volumes, and user ratings. Further study of pedestrian-related indexes is suggested to determine the measures that would be most useful in Utah. For example, an appropriate measure for Utah would need to consider street width (in recognition of Utah's wide roads) and winter maintenance.

Safe Walk-to-School Routes

Technical studies of safe walk-to-school routes should be conducted, with evaluation after implementation. Child pedestrian crashes would be evaluated by time of day and location. Crashes occurring along safe routes to school – particularly those happening during peak school commute periods – might indicate a need for reconsideration of the route. Such evaluations might also be instructive in determining future K-12 school sites.

Local Planning and Community Advocacy

Key Findings and Issues

A survey on the pedestrian and bicycle planning activities of the 24 regional, county and city planning departments in Utah was conducted in April 1998 (Eldridge 1998). At that time, more than half of the departments had at least one separate (Class I) bicycle-pedestrian trail, one-third had set aside funds for specific projects, and seven employed a bicycle-pedestrian trained planner.

Formal planning was limited, however, as only two departments had developed a master plan for pedestrian and bicycle facilities. The following year, the *Cache MPO Pedestrian/Bicycle Plan* indicated that six cities had incorporated plans for pedestrian facilities into either their master plans or recreation plans. One Cache County city had developed a separate bicycle-pedestrian-equestrian plan.

According to the SPBP, the UDOT Pedestrian and Bicycle Planning Office distributed walking and biking questionnaire and comment cards to the public. The cards provided little information on pedestrian needs. The conclusion was that pedestrians lack organizational structure. Hence, there are few coordinated constituencies and few formal statements on pedestrian interests.

Policies, Plans and Actions

The Salt Lake City Transportation Division has made progress in enhancing pedestrian safety over the past few years. For example, the city has installed a number of countdown pedestrian signal timers in the downtown area. At unsignalized crossings, containers of warning flags, to be used by pedestrians, have been set up. A number of neighborhood roads now feature sequences of speed bumps and raised crosswalks. The City's year 2001 budget for pedestrian safety improvements was $150,000. Further study is needed to determine if these enhancements have reduced pedestrian injury and fatality numbers. In a September 2001 speech, Mayor Rocky Anderson claimed that pedestrian fatalities had dropped to nil since the introduction of the new pedestrian safety measures. The extent of involvement of community organizations in pedestrian safety in Utah is not known. A number of non-governmental entities have developed pedestrian safety policies, however. For example, the Utah Parent Teacher Association has established several resolutions regarding school pedestrian safety. Also, campus environments, such as those at the University of Utah and Utah State University, have implemented operating regulations for walkways on university property. The primary objective of these regulations is to ensure pedestrian safety.

Recommendations

Salt Lake City's pedestrian safety improvement efforts are exemplary. Although further study is needed to confirm the effects of the improvements – relative to their cost – it is recommended that other jurisdictions consider making similar efforts. A few of the potential local funding sources for pedestrian-related projects are municipal bonds, development impact funds, and private monies. It is recommended that any municipality having an interest in implementing pedestrian safety improvements pursue innovative funding strategies.

A study of Utah's pedestrian-vehicle crashes confirms that crash rates are highest in urbanized areas. For example, of the 1,468 pedestrian-vehicle crashes occurring in Utah during 1998 and 1999, 1,359 (92.6%) occurred in the six urban counties of Cache, Davis, Salt Lake, Utah, Washington, and Weber (Cottrell et al. 2001). The cities in these counties, therefore, should make pedestrian safety improvements. Although the research did not tabulate pedestrian-vehicle crash totals by city, high intersection crash rates, high corridor crash rates, or high intersection crash totals were observed in Kaysville, Logan, Murray, Ogden, Orem, Provo, Riverdale, Roy, St. George, Salt Lake City, South Salt Lake, Springville, Taylorsville, West Jordan, and West Valley City. Each of these cities should consider comprehensive pedestrian safety improvements and the development of a pedestrian-bicycle plan. If these actions are underway or have been completed, such as in St. George and Salt Lake City, the efforts should be both continued and evaluated.

Pedestrian Safety Education

Key Findings and Issues

Chapman et al. (1982) estimated that 71 percent of 2,157 pedestrian-vehicle crashes were either wholly or partially attributable to the pedestrian. This finding indicates that behavioral modification and safety education are essential. A number of pedestrian behavior studies have been conducted. Chapman et al. (op. cit.) found that children and the elderly exhibited similar street crossing behaviors. For example, these pedestrians tended to focus on the location of their crossings. In contrast, adults tended to emphasize the timing of their crossings. The crossing strategy of adults usually involved a healthy amount of "looking behavior." On the other hand, 39 percent of children did not look before crossing, while 70 percent of pedestrian crash victims over age 60 did not see the oncoming vehicle. In other studies, the following pedestrian behaviors were observed (*Human Behavior* 1976; Knoblauch et al. 2000; Mueller et al. 1987; Rouphail 1984; Vestrup and Reid 1989; Virkler 1998; Knoblauch et al. 2000):

- 15 percent of 1,300 pedestrians at a signalized crossing crossed against the signal.
- 14.5 percent of 1,914 pedestrians at or near an unsignalized, marked crosswalk either crossed outside of the markings or when the gap between oncoming vehicles was probably too narrow.
- 10 percent of the pedestrians in a study in Brisbane, Australia were "runners" who started to cross during the clearance interval of signals.
- Groups of pedestrians tended to cross together at a convenient location, regardless of the presence of a marked crossing. Members in the "back" of the group tended to rely on those in front for their safety.
- Some studies indicate that pedestrians are less vigilant in marked crosswalks, presuming that they are protected; other studies indicate the opposite effect.
- A psychological study, in which pedestrians were interviewed soon after crossing a street, found that some pedestrians were cautious by nature while others were risky. The risky pedestrians were observed to be somewhat reckless in their crossing strategy.
- In one study, of 5,248 pedestrians hit by motor vehicles in the state of Washington, 3.4 percent of the walkers wearing light and reflective clothing were killed, 5.4 percent of those wearing mixed colors were killed, and 8.2 percent of those wearing dark colors were killed.

Although it is evident that pedestrian safety education would benefit all age groups, pedestrian safety education tends to be targeted at schoolchildren. Ehrlich (1985) estimated that safe street crossing training for children in grades K-3 reduced child pedestrian-vehicle crash rates (for these age groups) by 20 percent. A similar 20 percent reduction was estimated for safety messages aimed at children related to darting out into the street. School crossing guard training appears to be effective. Florida is currently the only state with mandatory training for crossing guards. Forester argues that street crossing training for children is most effective if there is parental involvement, and if the training involves some outdoor practice.

A pedestrian safety program in Halifax, Nova Scotia, was determined to be responsible for a 44 percent reduction in pedestrian-vehicle crashes over an 8-year period. The program included multiple campaigns such as safety lessons in the grade school curriculum, a National Safe Driving Week, monthly "Crosswalk Bulletins," "School's Out" week, and traffic engineering improvements (Kennedy 1984).

Policies, Plans and Actions

The Utah Pedestrian and Bicycle Safety Program was initiated in Salt Lake County in 1996. The program's objectives include educating students between ages 5 and 14 on pedestrian safety and increasing driver awareness of children as pedestrians. The UHSO operates the program. Among the program's campaigns are "It's Up to You to Cross Alive," developed in 1999, which teaches children how to cross streets defensively. "Green Ribbon Month," developed in 1998, occurs during September and is implemented by elementary schools. The activities include safety assemblies in schools, and the attachment of green ribbons to signs, cars, people, and crosswalk signs to remind drivers to be alert to children crossing streets.

The Utah Safety Council (USC) provides free brochures and pamphlets on traffic and pedestrian safety. The USC also houses a traffic safety video library. The Utah Technology Transfer (T^2) Center also has a safety video library. The videos serve as safety awareness and instructional tools that can be shown in either private or public settings.

The Utah Department of Health, Division of Family Health Services, Child Injury Prevention Program provides pamphlets with the theme: "Is It Safe to Cross Now?" Their educational efforts focus on the physical limitations of children, how parents might teach children to cross safely, and pedestrian safety tips intended for all ages.

The *Utah Driver Handbook* features a section on pedestrians and joggers. The handbook suggests that pedestrians walk facing traffic, wear light-colored clothes, yield to motor vehicles, use sidewalks, use marked crosswalks, obey pedestrian signals, and look left and right before crossing.

Recommendations

Parental Involvement in Child Pedestrian Safety Training

Several authors recommend that parents receive special training in child pedestrian safety (e.g., Rivara et al. 1989). Research has shown that a significant portion of parents overestimates the abilities of their children to walk safely. The development of a child pedestrian safety program for parents should be considered. Child pedestrian safety education typically focuses on street crossing. Many child pedestrian-vehicle crashes occur, however, when the child darts out midblock. It is evident that safety education should include street-playing behavior in addition to street crossing. The development of a module on street-play safety should be considered.

Elderly Pedestrian Safety Education

Pedestrian safety training for the elderly is needed, particularly to periodically reevaluate cognitive skills and sensory abilities. These tend to deteriorate with age, and the individual needs to adapt to the changes. Studies have shown that the elderly demonstrate a crossing strategy similar to that of children. The finding that 70 percent of pedestrians over age 60 did not see the oncoming vehicle before being hit confirms a reduction in cognitive skills with age. Therefore, some of the fundamentals of street crossing, particularly "looking behavior," may need to be reiterated to the elderly.

Considerations in Pedestrian Safety Education

Based on various authors' assessments of where and why pedestrian-vehicle crashes occur, pedestrian safety training needs to focus on the following: the selection of good places to cross

roads, pedestrian visibility (particularly at night), executing proper technique when crossing a road (i.e., looking both ways and being alert), and on taking proper care when in the road (while working or walking along a road with no pedestrian facilities). For example, wearing light or reflective clothing appears to reduce a pedestrian's risk of being killed by a motor vehicle. Further to the preceding recommendations, Chapman et al. (1982) suggest that choosing a time to cross is more important than the location of the crossing. The timing of the crossing results from an assessment of the crossing situation *upon approaching* the curb, rather than while standing at the curb. Pedestrian safety materials should incorporate these findings.

Pedestrians and Alcohol

In addition to the previous points, pedestrian safety training should emphasize the effect of alcohol on the pedestrian's ability to use good judgment when walking and crossing. Jehle and Cottington (1988) found that intoxicated pedestrians were three to four times more likely to be hit by a motor vehicle than their nonintoxicated counterparts. Curtin et al. (1993) determined that the percentage of pedestrians who had both consumed alcohol and were hit by a motor vehicle was substantially greater than the number of drivers who were under the influence and had hit a pedestrian. Bradbury (1991) found that injury severity among impaired pedestrians was greater than among impaired ones. The portion of struck pedestrians with a high blood alcohol content ranged, in various studies, from 30 percent to 65 percent, although in one study only 6.5 percent had a detectable blood alcohol level (Baker et al. 1974; Brainard et al. 1989; Peng and Bongard 1999; Vestrup and Reid 1989). In all studies, the portion of pedestrian-vehicle crashes in which alcohol may have been a contributing factor was greater on Fridays, Saturdays and at night than at other times. These findings indicate the need for an increased awareness of alcohol consumption as a contributing factor in pedestrian-vehicle crashes.

Pedestrian-Vehicle Crash Statistics and Outcomes

Key Findings and Issues

In 1999, there were 720 pedestrian-vehicle crashes in Utah. Beginning in 1997, reporting criteria excluded crashes occurring on private property. There were 1,137 pedestrian-vehicle crashes in 1996, but the change in reporting criteria invalidates the conclusion that there was a major reduction in pedestrian-related collisions. It is evident, however, that the number of pedestrian-vehicle crashes decreased from 773 in 1997 to 720 in 1999, a reduction of 6.6 percent.

There were 35 pedestrian fatalities resulting from pedestrian-vehicle crashes in 1999. This represented a 40 percent increase over the 25 pedestrian fatalities witnessed in 1993. The portion of pedestrian-vehicle collisions resulting in pedestrian fatalities increased from 2.4 percent in 1993 to 4.9 percent in 1999. The portion of pedestrian-vehicle crashes resulting in pedestrian injuries also increased, from 69 percent in 1993 to 92 percent in 1999. Injuries included those that were incapacitating (33 percent of all pedestrian-vehicle crashes in 1999), "probable" (39 percent), and "possible" (20 percent). "Possible" and "probable" injuries were those that could not be diagnosed at the time of the crash.

Children aged 10 to 14 years were most prone to being hit by a motor vehicle in 1999, with that group comprising 15.2 percent of the pedestrians involved and 15.5 percent of those injured. Children aged 5 to 19 years were involved in 41.3 percent of the pedestrian-vehicle crashes in 1999,

and represented 42.9 percent of those injured. Also, in 1999, 26.2 percent of the fatally-injured pedestrians were under age 15, while 14.3 percent were aged 60 or more.

The research team examined 1997-1999 pedestrian-vehicle crash data obtained from the CARS database. A total of 1,996 crashes occurred on federal-aid roads during the three-year period (475 occurred on non-federal aid roads). A total of 117 high-crash sites along federal-aid roads (3 or more pedestrian-vehicle crashes between 1997 and 1999) were identified, with 78 (two-thirds) along state highways. A total of 25 state highway corridors, varying in length from 1.7 to 91.9 miles, experienced nine or more pedestrian-vehicle crashes between 1997 and 1999.

Policies, Plans and Actions

Prior to this study, UDOT's Division of Traffic and Safety performed in-house analysis of the state's pedestrian-vehicle crash data. For example, Cheng (1990) published a study of pedestrian-vehicle crashes occurring in Utah between 1979 and 1987. Also, a five-year assessment of school age pedestrian crashes was issued as a pamphlet in the early 1990s.

Since the early 1990s, the Utah Crash Outcome Data Evaluation System (Utah CODES) has been housed at the University of Utah. Utah is one of 27 states participating in CODES, a program originally established by NHTSA to determine the benefits of seat belt and helmet laws. The objective of CODES is to link motor vehicle crash data with health outcomes data for the purpose of guiding research, education, and policy development. Utah CODES produces an annual summary of Utah's motor vehicle crash data; one chapter is devoted to pedestrian incidents. Representative findings from the year 2000 summary include:

- 95.5 percent of the 687 pedestrian-vehicle crashes resulted in an injury to the pedestrian. This figure represents the continuation of a trend toward an increasing portion of pedestrian-vehicle crashes resulting in a pedestrian injury or fatality.
- 56.7 percent of the 30 fatal pedestrian-vehicle crashes occurred between 6 p.m. and 6 a.m., despite the overall low number of pedestrian trips during these hours.
- 31.9 percent of the 656 pedestrian-vehicle crashes in which the pedestrian was injured occurred between 2 p.m. and 6 p.m.
- The number of pedestrian-vehicle crashes in Utah decreased to 687 in 2000, representing an 11.1 percent reduction since 1997.
- The number of pedestrian fatalities in Utah decreased to 33 in 2000, representing the reversal of a trend in which the number had increased from 25 in 1993 to 35 in 1999.
- The total number of pedestrian-vehicle crashes increased substantially from 1999 to 2000 in at least three counties, including Davis (from 48 to 58), Summit (4 to 7) and Tooele (4 to 9).
- The total number of pedestrian-vehicle crashes decreased substantially from 1999 to 2000 in at least four counties, including Cache (from 24 to 18), Utah (127 to 117), Washington (24 to 14), and Weber (76 to 68).
- The number of fatal pedestrian-vehicle crashes in Salt Lake County increased from 14 to 19 between 1999 and 2000. This was the only county to see a significant increase.
- 31.7 percent of the 703 drivers involved in pedestrian-vehicle collisions were between the ages of 15 and 24 (and one driver was under age 15!).
- 49.4 percent of the 785 pedestrians involved in pedestrian-vehicle crashes were under age 20.
- 4.6 percent of the 785 pedestrians involved in pedestrian-vehicle crashes were over age 65, but this age group accounted for 18.2 percent of the fatalities.

- 45.5 percent of the 33 pedestrian fatalities involved a pedestrian crossing a road at a location other than an intersection.

Other findings in the Utah CODES summary are similar to those in Cottrell et al. (2001), although the latter report discusses 1997-1999 data only.

Recommendations

Recurrent Pedestrian-Vehicle Crash Intersections

Seven sites witnessed five or more pedestrian-vehicle crashes between 1997 and 1999. It is suggested that field investigations of these seven sites be conducted. The sites are:

Washington Boulevard and 30th Street (*Ogden*)
State Street and 250 South (*Salt Lake City*)
State Street and Exchange Place-350 South (*Salt Lake City*)
State Street and 1300 South (*Salt Lake City*)
300 West and 100 South (*Salt Lake City*)
Main Street and 400 South (*Springville*)
Redwood Road and 4100 South (*West Valley City*)

Recurrent Pedestrian-Vehicle Crash Corridors

Five state highway corridors are among the top three in the state in terms of either pedestrian-vehicle crashes per mile or pedestrian-vehicle crashes per 100 million vehicle-miles of travel (VMT). It is suggested that field investigations of these five corridors be conducted:

SR 34: 300 West to I-15 interchange (*St. George*) – 1.69 miles
SR 189: East Bay Boulevard to 3700 North (*Provo*) – 4.69 miles
SR 203: Country Hills Boulevard to 2100 South (*Ogden*) – 1.94 miles
SR 204: 3600 South to 400 South (*Ogden*) – 4.02 miles
SR 273: US89 (*Farmington*) to 500 North (*Kaysville*) – 2.58 miles

(*The research team recognizes that the year 2000 signalization of SR 273 at 300 South in Kaysville may be contributing to improved pedestrian safety at this location and along the SR 273 corridor.*)

Monitoring and Evaluation

NHTSA recommends that pedestrian-vehicle crash data be regularly evaluated. Trend analysis is suggested, with consideration of the ages of those involved, the geographical location, the type of road, the type of pedestrian facility, and the severity of the injuries. It is recommended that Utah's pedestrian-vehicle crash data be monitored and studied on an ongoing basis. This need is being fulfilled, in part, by the Utah CODES summaries. Separate efforts are needed, however, to link the crash data with traffic engineering improvements, safety campaigns, and policy implementation. The identification and investigation of sites at which pedestrian-vehicle collisions recur is needed as well. Utah's population growth, changing demographics, trends in the amount of walking, and increases in motor vehicle usage mandate the continuous study of pedestrian safety.

Public Transit Access

Key Findings and Issues

The Transit Cooperative Research Program (TCRP) has identified the safety of pedestrian crossings adjacent bus stops as a concern. The concern is with stops located along high-speed arterials having widely-spaced traffic signals, low pedestrian volumes, and few opportunities for either protected or marked crossings. The TCRP is looking to fund a study entitled *Safe Roadway Crossings for Bus Passengers*, with the objective of producing a bus stop traffic signal warrant for pedestrian crossings. The warrant would be included in the *Manual on Uniform Traffic Control Devices* (MUTCD). Researchers and pedestrian safety advocates have also observed that, in many cities, pedestrian-vehicle crashes are concentrated near transit stops, including bus stops and light-rail stations.

Policies, Plans and Actions

The Utah Transit Authority (UTA), in their efforts to preserve safe, TRAX light-rail operations, provides a list of motorist and pedestrian safety "reminders." It is not known if the UTA or any of the other transit operators in Utah are monitoring pedestrian safety in the vicinity of transit stops.

Recommendations

As indicated above, research is being initiated on safety of pedestrians while accessing public transportation. To contribute to the research, a recommendation would be to examine Utah's pedestrian-vehicle crash data for incidents occurring at and near transit stops. The examination would include both bus and light-rail services. Such a study might lead to suggestions for pedestrian safety improvements at and near transit stops. One of the difficulties of the analysis would be in confirming that the pedestrian involved was either accessing or leaving a transit stop at the time of the crash.

Railroad Crossings

Key Findings and Issues

Pedestrian-train collisions at railroad-highway grade crossings in Utah occur infrequently. Between 1997 and 2000, one pedestrian fatality occurred at a public rail-highway crossing. Trespasser collisions (pedestrian-train incidents not at railroad-highway grade crossings) in Utah occur with some regularity. The annual number of trespasser fatalities in Utah was between 1 and 3 from 1997 to 2000. During those same years, the annual number of nonfatal trespasser incidents was between 1 and 5 (Federal Railroad Administration 2000).

Policies, Plans and Actions

Operation Lifesaver was established to educate the public about railroad crossing and right-of-way safety, promote enforcement of traffic laws at grade crossings, and encourage research on railroad safety. The Utah Chapter of Operation Lifesaver is involved in these activities, including the annual publication of train collision data.

Recommendations

Pedestrian safety education should give attention to proper railroad track crossing techniques. Pedestrians should be encouraged and warned to be alert when walking along or across railroad

tracks away from standard at-grade crossings. Trespasser incidents should be investigated for possible safety improvements.

Regional Planning

Key Findings and Issues

The MAG adopted the *Utah County Non-Motorized Trails Plan* in November 1996. The impetus for the development of the plan was, at the time, the non-attainment status of Utah County's air quality. The plan identifies an extensive network of trails that are mapped and funded annually. The MAG's planning efforts included the development and application of the PFI, as well as pedestrian trip-end estimation. Eldridge (1998) considered the MAG's non-motorized planning efforts to be the most significant yet completed in Utah.

One of the ongoing duties of the WFRC is to forecast travel demand in the Salt Lake City-Ogden area. In an effort to update its model, the WFRC completed a travel model recalibration study in 1994. The WFRC determined that adequate data were not available to properly represent non-motorized trips in the model. That is, no correlation was found between non-motorized trips and the levels of pedestrian friendliness, as measured using the PFI.

The Cache MPO produced a long-range pedestrian-bicycle plan in June 1999. The plan identified areas of high pedestrian activity, recommended safety and awareness programs, described funding sources, and listed both short-term and long-term projects.

Policies, Plans and Actions

Based on their findings in the recalibration study, the WFRC recommended, in the interim, that their model use non-motorized trip-end ratios developed for the Provo-Orem region by MAG. For future forecasting needs, the WFRC recommended that adjustments to zonal average non-motorized trip-end ratios be made based on estimated changes to each traffic analysis zone's PFI.

Recommendations

The WFRC recommendations are a reasonable compromise to the data inadequacy concerns mentioned above. It is evident, though, that the collection of additional data on walking would be useful. The data would include walk origin and destination, trip purpose, and trip frequency information. As discussed in Cottrell (2001), an ongoing concern is that the *amount* of walking done by the typical individual has been gradually decreasing since the 1970s. Any changes in pedestrian safety statistics should be evaluated in terms of changes in the cumulative amount of walking. For example, the trend in a measure such as crashes per thousands-of-miles-walked might provide a more accurate picture of pedestrian safety than crash rates that are based on population or VMT. The difficulty of obtaining the required data on walking is recognized. Further recommendations on how best to collect the data would require additional study.

The MAG's and the Cache MPO's non-motorized planning efforts are exemplary. The development of similar regional pedestrian-bicycle plans is recommended for Utah's other urban regions, including Salt Lake City-Ogden and St. George. Such plans would establish benchmarks and objectives, while also enhancing the understanding of existing needs. For example, Eldridge (1998) discusses a latent demand for pedestrian travel. The hypothesis is that a number of pedestrian trips are not taken because adequate pedestrian facilities are not available. The presumption is that private motor vehicles are used in place of walking. Assessments of both the latent and the future demand for walk trips would involve home-based travel surveys, workplace travel surveys, and forecasts based on changes in Utah's demographics.

Safety and Liability Concerns

Key Findings and Issues

Nationally, in 1999, 47 percent of all pedestrian injuries and 79 percent of all pedestrian fatalities occurred in collisions with motor vehicles away from intersections. The conclusion is that lower speeds are prevalent at intersections, such that pedestrian-vehicle impacts are less severe than at midblock locations. Further, these statistics allude to the severity of high-speed crashes that are prevalent along suburban arterials and rural highways. Males represented 59 percent of all injured pedestrians and 70 percent of all pedestrian fatalities; these figures are disproportionate to the percent of males in the population. The riskiest hours of the day for pedestrians are between 6 p.m. and 9 p.m.; 25 percent of all pedestrian fatalities occurred during this time. On weekends, pedestrians were killed at the rate of 1.4 per hour between 9 p.m. and 10 p.m. (*Traffic Safety Facts 1999*). Some other findings, based on various research studies, are as follows (Agran et al. 1994; Bell et al. 1980; Braddock et al. 1991; Centers for Disease Control 1997; Cottrell 2001; Dougherty et al. 1990; Ehrlich 1985; Ferguson et al. 1995; Lane et al. 1994; Mueller et al. 1987; Mueller et al. 1990; Olson et al. 1993; Rivara et al. 1989):

- In the state of Washington, 69 percent of 5,248 injured pedestrians were hit during dry weather, 28 percent were hit during wet weather, and 3 percent were hit during snow or icy conditions. Pedestrian activity may have been lighter during inclement weather.
- The most vulnerable areas for pedestrians are typically where pedestrians have the greatest exposure: low-income tracts, tracts in which there is a high percentage of female-headed households, and tracts in which there is a large number of persons per household.
- One study found that the child pedestrian-vehicle crash rate on Halloween, between 4 p.m. and 10 p.m., is four times that at other times of the year.
- Data on mean walking speeds indicate that elderly pedestrians may need up to 50 percent more time to cross a street than younger pedestrians.
- Several authors suggest that the greatest impacts on pedestrian mortality would be through traffic safety improvements, modifications to vehicular body designs, and child pedestrian safety education.
- Low-speed child pedestrian crashes, in which the child is run over by a backing or other slow-moving vehicle, is an ongoing problem. In a review of data from St. Louis, Mo., of 13 children run over by vehicles, only one was over age 6.
- One author found that pedestrian-vehicle collisions increase dramatically during the first few weeks following the changeover from daylight savings time to standard time.
- High pedestrian fatality rates are associated with dark areas where there is no artificial lighting.
- The following pedestrian safety enhancements were estimated to reduce pedestrian-vehicle collisions by 29 percent or more at the respective sites: illumination of an intersection, conversion from two-way to one-way streets, ordinances governing the location and treatment of pedestrians at bus stops, and ordinances governing ice cream vendors.

The legal responsibilities of a public agency in the event of a pedestrian-vehicle crash are dependent upon the specifics of the incident. In most cases, either the driver or the pedestrian is held at fault for the collision. Any lawsuits or settlements remain limited to the parties involved. A public agency or private property owner could potentially be liable in a slip, trip and fall incident, or when facilities are inadequate (poor or no lighting, missing or no warning signs, etc.). An extensive review of pedestrian safety and liability matters was beyond the scope of this research.

Policies, Plans and Actions

A detailed review of specific linkages between the preceding findings and pedestrian safety policies in Utah was not conducted. The following recommendations presume that these issues need to be addressed.

Recommendations

The findings and issues discussed above suggest the need for multiple interventions. These would include pedestrian safety education and increased awareness of the individual concerns. Some further mitigating strategies are as follows:

Child Pedestrians

To improve child pedestrian safety, it may be important to examine the ages of the children who walk to and from school. Dramatic changes in the child's street-crossing ability occur as the child ages from about six to the pre-teen years. A large proportion of very young children walking to and from school may indicate the need for special provisions. The implementation of this recommendation would involve surveys and interviews of both parents and children. Tight (1988) suggests that child pedestrians are at the greatest risk for a motor vehicle collision within 500 meters of a school. Jordan's (1998) findings are contradictory, but the need for special consideration of the pedestrian crossing provisions within the vicinity of a school is evident. Bass et al. (1992) suggests that late afternoon restrictions on vehicular travel on certain streets might be a way to reduce child pedestrian injuries. It is at this time of the day that children are returning home from school or are outside playing.

A few other recommendations for improving child pedestrian safety follow. First, given that a number of small children are run over by vehicles backing down a driveway, circular driveways might be a countermeasure. Second, reducing motor vehicle speeds (via traffic controls or traffic calming) and the density of curb parking may be safety enhancements. If child pedestrian safety on Halloween is a problem in Utah, intervention may be needed. Intensive community pedestrian safety patrols, organized by community and neighborhood groups, would be one approach. The magnitude of the need for these recommendations would require an up-close assessment of Utah's pedestrian safety data.

Elderly Pedestrians

A potential strategy at crossings that are frequented by the elderly would be to increase the pedestrian green time. (This may be a particularly useful strategy throughout Utah, where the streets in urbanized areas are typically wide). Pedestrian crossing speeds should be based on walking speeds of the elderly. Hoxie and Rubinstein (1994) suggest a design speed of 0.9 m/sec (3.0 ft/sec) for the elderly. Coffin and Morrall (1995) recommended design speeds of 1.0 m/sec (3.3 ft/sec) for midblock crossings and 1.2 m/sec (3.9 ft/sec) for signalized intersections. Further interventions recommended for elderly citizens include specialized traffic controls, signing, enforcement, and pedestrian safety training at senior living centers. According to the U.S. Census Bureau, as of 1996, Utah was projected to have the second-fastest elderly population growth rate in the country between 1995 and 2025 (5.1 percent to 6.9 percent per year). In fact, in 1995, Utah had the highest ratio of youth (under age 20) and elderly (over age 64) to adults in the United States, at 90.1 per 100. This ratio is expected to increase to 97.7 in 2025 (Campbell 1996). These projections indicate that the needs of elderly (and child) pedestrians in Utah will continue to grow.

Other Issues

Given that pedestrian exposure is a problem in low-income tracts, tracts in which there is a high percentage of female-headed households, and tracts in which there is a large number of persons per household, traffic engineering modifications may have the greatest impacts in these areas. The modifications might include signing, traffic controls, traffic calming devices, and on-street parking regulations. Studies of U.S. Census data would be required to isolate the problem areas.

Pedestrians should be made aware of the heightened safety concern at the changeover from daylight savings to standard time. Pedestrians should be reminded of the earlier darkness and be encouraged to increase their vigilance. Also, installation of lighting would be an effective countermeasure at recurring pedestrian-vehicle crash sites at which artificial lighting is poor or non-existent. An in-depth examination of Utah's pedestrian safety data might reveal locations where lighting could have circumvented a collision.

Liability

Although a review of pedestrian safety and liability concerns was not part of this research, such a review might be beneficial. Among the findings would be the legal costs of pedestrian safety incidents, the economic benefits of safety improvements, and a determination and review of who was at fault in various cases.

Shared Usage of Trails and Paths

Key Findings and Issues

The SPBP addresses the notion of requiring bicyclists to use sidewalks. The SPBP indicates that such shared usage is problematic, in that most sidewalks are not designed to accommodate both bicycles and pedestrians. Bicyclists are impeded by pedestrians and pedestrians may feel threatened by the presence of bicycles. The SPBP states that requiring bicyclists to use sidewalks does not adequately serve commuter and serious cyclists, may reduce pedestrian use, and may increase the risk of injury to sidewalk users.

Policies, Plans and Actions

The SPBP emphasizes Utah Code 27-14-6, which states "Pedestrian safety considerations shall be included in all state highway engineering and planning where pedestrian traffic would be a significant factor on all projects within the state or any of its political subdivisions." UDOT policy issue A.06 in the SPBP gives municipalities the option of closing sidewalks to bicycle travel within limited areas if there is a capacity or safety concern. The designation of pedestrian sidewalks as bikeways is strongly discouraged. UDOT policy issue A.07 states that bicyclists may be required to dismount and walk their bicycles through crosswalks and yield to pedestrians.

Recommendations

The SPBP's stance on shared-use sidewalks is sensible. It is recommended that bicycles not be prevented from using sidewalks, but that there be no requirement to use them. Jordan and Leso (2000) offer a number of suggestions for minimizing conflicts on paved, shared-use pedestrian-bicycle-jogging-skating paths. These include providing a yellow centerline on blind curves, and

white lines with directional arrows at driveways and roadway crossings. The purpose of the striping would be to reduce the number of path users straying onto the wrong side of the path.

Snow Removal

Key Findings and Issues

Snow removal along sidewalks and shoulders is of particular concern for pedestrians. A walkway that has not been cleared of snow may force a pedestrian to either use the opposite side of the street, or walk along the roadway shoulder. If the pedestrian attempts to use the sidewalk, his or her mobility may be impaired, and the risk of a slip or fall is imminent. At numerous locations, the interface between the sidewalk and road at a crossing is blocked by snow that has been piled onto the shoulder. A pedestrian's options include taking a detour, hurdling the snowpile, or walking along the edge of a traffic lane. On roads with no sidewalk, snow is typically deared onto the shoulder. If the shoulder is inaccessible because of snow, a pedestrian may be forced to encroach upon a lane of moving traffic. Each of these conditions presents a safety hazard to the pedestrian.

In a national survey, Briscoe (2001) found that 70 percent of agencies do not cite owners for failing to clear sidewalks, but that the 30 percent who do are often quite vigilant. A total of 58 percent of all agencies surveyed had been sued at least once for a sidewalk incident; in only 25 percent of the cases was the homeowner alone targeted for recovery of injury-related damages. As an example, one city agreed to a $25,000 settlement in response to being sued after a pedestrian fell on an ice-covered sidewalk.

Policies, Plans and Actions

In the SPBP, UDOT policy issues J.03 and J.04 indicate that snow removal from sidewalks and paths is the responsibility of local governments and adjacent property owners. It is probable that most of the agencies in Utah defer the responsibility for clearing sidewalks to adjacent property owners. Municipal ordinances regarding snow removal can be associated with deadlines for clearance as well as penalties.

Recommendations

The potential liability for failing to clear sidewalks, along with the associated safety hazards, should be made clear to the presiding agencies. Periodic inspections of sidewalk snow removal should be conducted to verify that they are being cleared. A record of citizen complaints should be kept on file and reviewed after each winter season. Property owners should be instructed on their responsibilities for sidewalk maintenance and municipal ordinances regarding sidewalk snow clearance should be enforced as needed.

A roadway snow removal technique that is consistent in retaining either access to the sidewalk or space along the shoulder (for roads with no sidewalk) is desirable for pedestrians. It is not known if snowplow training includes lessons on pedestrian-enabling snowpile placement. The incorporation of such lessons is recommended. Alternatively, access between a sidewalk and the road could be retained as part of walkway snow clearance. One problem, however, may be in determining who is responsible for maintaining access between a sidewalk and a road. For example, a property owner might clear the adjacent sidewalk, but be unwilling to clear snow that has been piled along the shoulder – particularly if the pile was created by a snowplow. This problem needs to be rectified.

Further study, discussions with community groups and business owners, and the development of a policy are suggested.

Statewide Legislation

Key Findings and Issues

During the summer of 2000, UDOT conducted a survey of state DOTs on their efforts to facilitate pedestrian crossings. The 28 states that responded experienced 50 percent of the nation's year 1999 pedestrian fatalities (*Traffic Safety Facts 1999*). The survey results indicate that the responding states were not as progressive as local jurisdictions in applying state-of-the-art pedestrian crossing warning systems. The state DOTs were, however, using traditional pedestrian facilities such as pushbuttons and pedestrian-actuated signals, bridges, underpasses, barriers, and refuges. Slightly less than half of the responding state DOTs were involved in pedestrian safety education activities. These activities typically included school crossing guard training, safety brochures, and community programs. Only six of the 28 states had a policy for grade-separated pedestrian crossings. The overall assessment is that a minority of the responding states were aggressive and current in their accommodation of pedestrian crossings. The results indicate a need for increased attention to pedestrian safety policies and programming at the state level. The survey is discussed in detail in Cottrell (2001).

Policies, Plans and Actions

The State of Utah passed the Pedestrian Safety and Facilities Act (PSFA) in 1998. The PSFA allowed counties and municipalities to construct pedestrian facilities, including sidewalks and pedestrian safety enhancements, along state highways. The PSFA also allowed counties and municipalities to use their Class B and C road funds for pedestrian safety devices. Highway authorities were mandated to consider pedestrian safety in all highway engineering and planning where pedestrian traffic would be significant. A State Traffic and Pedestrian Safety Coordinating Council was created by the Act to perform a number of duties, including the promotion of pedestrian safety plans, the review of state and local plans relating to pedestrian safety, and the making of recommendations on pedestrian safety to highway authorities, law enforcement agencies, and school districts.

Recommendations

While the PSFA was a groundbreaking piece of legislation, the Act does not require that funds be dedicated to pedestrian improvements. McCann and DeLille (2000) argue that funding levels are correlated to pedestrian mode splits. Further, an increase in the pedestrian mode split may be related to the provision of pedestrian facilities, which may be associated with an improved level of pedestrian safety (ibid.). It is recommended, therefore, that a funding mechanism, based on either requirements or incentives be established. The scope of the requirements and incentives may be restricted to state-owned highways. The need for innovative funding mechanisms is discussed in the "Local Planning and Community Advocacy" section.

Usage of Controlled-Access Highways

Key Findings and Issues

Ten percent or more of the pedestrian-vehicle crashes were fatal along seven state highway corridors in Utah between 1997 and 1999. Along three of the corridors, however, 24 percent or more of the pedestrian-vehicle crashes were fatal. All three of those corridors were freeways.

Policies, Plans and Actions

The SPBP indicates that regulations regarding pedestrian usage of freeways have evolved. Whereas in 1970 pedestrians were prohibited from using interstate freeways, today statutes do not prohibit such usage. The SPBP states that a pedestrian using the shoulder of a controlled-access highway (or any roadway) is not afforded the same legal protection as a pedestrian using a sidewalk or crosswalk. UDOT policy issue F.02 in the SPBP suggests that restrictions on pedestrian usage of highways consider the availability of alternative routes.

Recommendations

The following freeway corridors featured the highest ratios of pedestrian fatalities to pedestrian-vehicle crashes (0.24 to 0.38) in Utah between 1997 and 1999. It is suggested that these corridors be considered for pedestrian safety management strategies. It is possible that some of the fatally-injured pedestrians were construction or maintenance workers. These corridors are:

I-15: Provo-Orem boundary to Perry (91.9 miles)
I-80: Tooele interchange to I-84 interchange (88.9 miles)
I-215: 3900 South interchange to 2200 North interchange (24.3 miles)

It is evident that the high speeds of travel on these freeways contribute to the high likelihood of a pedestrian fatality in the event of a motor vehicle collision. In California, a special warning sign is posted along freeway segments that see intermittent pedestrian crossings. The sign is shown in Figure 1. These signs alert motorists to the possibility of pedestrian activity where it would not otherwise be expected. The impact of these signs on pedestrian safety is unknown. The installation of such signage, however, is recommended for freeway sites or segments that witness recurring pedestrian incidents. It is recognized that these signs must be applied carefully, to avoid the *encouragement* of pedestrian crossings at high-speed locations.

Figure 2.1 Freeway Pedestrian Crossing Warning Sign (California)

Walkways and Supporting Facilities

Key Findings and Issues

The SPBP states that a 1993 study by the MAG found that a low level of pedestrian "friendliness" existed in low population density areas where pedestrian destinations were far from residential areas and where there were few or no pedestrian facilities.

Zegeer and Zegeer (1988) note that a before-after study in Japan found that pedestrian-vehicle crashes were reduced by 85 percent per grade-separated crossing structure. Moore and Older (1965) determined that the ratio of grade-separated crossing time to at-grade crossing time (*R*) needs to be 0.75 or less for there to be 100 percent usage of the facility. Richter and Fegan (1983) found that the elderly and disabled prefer to use the longer but safer route provided by a grade-separated pedestrian crossing.

According to the CARS data, 36.3 percent of the 818 pedestrians hit in 1999 were crossing at an unsignalized location. Of the 38 pedestrian fatalities in 1999, 47.4 percent were crossing at an unsignalized location. The CARS data do not distinguish between crossings at marked and unmarked crossings. By comparison, 15 percent of the pedestrians hit and 2.6 percent of the pedestrians killed were crossing at a signalized intersection. In addition, 10.5 percent of the pedestrians killed were crossing against a signal. The database does not indicate if any of the pedestrians hit who were crossing at a signalized intersection were disobeying the traffic controls.

Zegeer et al. (1982) found that fewer than 35 percent of pedestrians used pedestrian-actuated devices when such devices were available. The deficiencies noted in pushbutton signals included interference with coordinated signal timing systems, pedestrian impatience with the wait time, and unnecessary delays to vehicles caused by pedestrians who either cross without waiting or change their minds. Zegeer et al. (op. cit.) also found that there was no significant difference between the number of pedestrian-vehicle crashes at intersections with standard, concurrent pedestrian signal phases and intersections with no pedestrian signal indications. Abrams and Smith (1977) evaluated three types of pedestrian signal phasing. The late release of pedestrians with respect to vehicles was useful at locations with heavy right turn volumes. Scramble timing, in which there is an exclusive, pedestrian-only phase (in which pedestrians cross in all directions, including diagonally), increased delays to both vehicles and pedestrians. This type of phasing eliminates pedestrian-vehicle conflicts, however, and is the safest. The early release of pedestrians with respect to vehicles also increased pedestrian and vehicle delays, but may be effective in reducing conflicts with turning vehicles.

Zegeer et al. (1984) determined that the flashing DON'T WALK indication was not effective in warning pedestrians about turning vehicles, and the steady DON'T WALK was ineffective in controlling pedestrians during the clearance interval. Alternative indications, such as DON'T START, WALK WITH CARE, and animated "eyes" (which suggest a looking behavior to pedestrians), were all easily understood by pedestrians. Countdown pedestrian indicators (CPIs), several of which are in service in Salt Lake City, were determined to increase the functionality of pedestrian signals in Minneapolis-St. Paul from 67 percent to 75 percent. A total of 78 percent of all pedestrians preferred the CPIs to the traditional indicators. Illegal crossings dropped only slightly, from 15 percent to 13 percent, following installation of the CPIs (Farraher 2000).

For crossings at unsignalized locations, embedded, pedestrian-actuated crosswalk flashers have been observed to decrease pedestrian-vehicle conflicts. Observations of the flashers indicate that

they are most effective when traffic volumes are moderate to high and pedestrian volumes are significant. One city, though, considered overhead flashers to be more effective than in-pavement flashers. One type of crosswalk flasher is activated by the presence of a pedestrian, rather than by pedestrian actuation. Pedestrians were observed to exercise greater caution when they were unaware that the crosswalk would flash (Van Winkle and Neal 2000).

In one study, pedestrian barriers led to a 20 percent reduction in pedestrian-vehicle crashes in Tokyo (Zegeer and Zegeer 1988). Barriers were considered to be most effective in downtown areas, near pedestrian overpasses, along high-speed roads with uncontrolled access, where little or no separation exists between the road and the walkway, near high-pedestrian generators, and on bridges that allow pedestrians. Barriers were considered to be minimally effective near high school and college campuses, on streets that allow curb parking, where the barriers cause sight restrictions, where pedestrian crossing points are not provided, and where motorists need access to a walkway.

In a study in London, pedestrian-vehicle crashes increased following the installation of pedestrian refuges, although vehicle-vehicle collisions decreased. To be effective in improving *pedestrian* safety, the refuges should be fitted with illuminated bollards, extend through the crosswalk, be "reinforced" with crosshatch markings, and have protective end treatments (Zegeer 1991). Pedestrian refuges should be avoided where the roadway alignment is poor, vehicles may be prone to hitting the island, the turning movement volume of trucks is high, and a lack of space forces the island to be narrow (Zegeer and Zegeer 1988).

Policies, Plans and Actions

The MAG's non-motorized transportation plan included urban design and development guidelines, traffic calming information, and recommendations for improvements in "walkability." The SPBP provides a number of statements advocating the development of walkways. The plan offers the assistance of UDOT to communities in assessing their walkability needs and in designing facilities. Ten UDOT policy issues for walkways are discussed in the SPBP. The plan notes that these "are to be evaluated over time for the possible adoption of policies within UDOT or for use in developing standard procedures for planning, identification of facility needs, project concept development, environmental review, design, construction, and maintenance of State transportation facilities."

As discussed earlier, the Salt Lake City Transportation Division has deployed several pedestrian safety enhancements, including pedestrian crossing flags and CPIs. The flags are available for pedestrians to carry while crossing a street at an unsignalized, midblock, marked location. Although no formal studies have been conducted, observations of the crossing flags are: motorists tend to be alert to the potential for a pedestrian upon seeing the flags posted at the curb; business and property owners are interested in maintaining the flags as part of the Adopt-a-Crosswalk Program; and the number of flag sites rapidly increased from four to 49 between January and June 2001. Flag theft has been a problem, and only 14 percent of all pedestrians crossing have been observed to use the flags. The city of Spanish Fork has started to install crossing flags (Bergenthal 2001).

Recommendations

Policy Issues: Overall

The evaluation of the ten UDOT policy issues on walkways, discussed in the SPBP, should be moved forward and, ultimately, policies should be adopted. Guidance should be provided on each issue. Where appropriate, minimum design standards and planning thresholds should be given.

Policy Issue: Grade-Separated Crossings

In the SPBP, policy issue A.02 mentions that projects should consider the potential for increasing pedestrian travel by providing grade-separated crossings. There is currently, however, no UDOT policy on grade-separated crossings. It is recommended that such a policy be developed.

The MUTCD does not offer specific criteria on grade-separated pedestrian crossings. Based on UDOT's survey of state DOTs, summarized in Cottrell (2001), grade-separated crossing guidelines vary by state; some states do not appear to have any formal guidelines. Louisiana's guidelines offer a compromise between data-intensive warrants and vague, planning-related factors; the guidelines are based on those offered in Bowman et al. (1989). The criteria are:

- Freeways (high-speed roadways): 100 pedestrians and bicycles crossing during the peak 4 hours, 7,500 through vehicles during the same 4 hours, and an AADT of 25,000.
- Arterials: 300 pedestrians and bicycles crossing during the peak 4 hours, 10,000 through vehicles during the same 4 hours, and an AADT of 35,000.
- Caveat: The volumes apply to the completion year of a grade-separated project.
- Exceptions: One of the three criteria is greatly exceeded, a high percentage of pedestrians or bicyclists are children, a nearby, attractive crossing opportunity negates the need for a grade-separated facility.

To ensure that a grade-separated pedestrian facility is used, and that pedestrians do not continue to cross at-grade, it is important to plan the crossing such that *R*, defined above, is less than or equal to 0.75. A pedestrian origin-destination study may be needed to determine the optimal location of the crossing. If the *R* threshold cannot be attained, pedestrian barriers may be needed to prevent or at least discourage at-grade crossings. The needs of the elderly, disabled, and visually impaired must be considered when designing grade-separated pedestrian crossings given these groups' preference for such facilities. Among the considerations are the usage of stairs, ramp gradients, ramp configurations, the slip resistance of walkway surfaces, surface textures, and the locations of landings and rest areas (along the way). Based on the survey of state DOTs, the costs of grade-separated pedestrian crossings are variable, based on the specific site conditions, length, width, height above the road, materials, and so forth. The mean cost of a pedestrian bridge appears to be about $1.2 million.

Policy Issue: Crosswalks at Unsignalized Locations

UDOT policy issue A.02 also mentions the placement of crosswalks at locations at which there is no traffic signal. It is indicated that such placement "should consider pedestrian safety and convenience." It is recommended that the placement of midblock crossings be given greater, more detailed attention. A policy should include firm guidance on when and where midblock crossings should be used, and whether they should be at-grade or grade-separated. Crosswalk flashers, either overhead or embedded, appear to be associated with a high rate of driver compliance. Pedestrian compliance with the flashers – that is, the extent to which a pedestrian will use the crosswalk – depends on crosswalk placement and traffic volume levels. Pedestrian warning flashers appear to be most effective when they are supplemented with bright, luminescent signs both at and in advance of the crossing. Zebra crosswalks (crosswalks enhanced with approach markings, hatched striping, and signs) appear to be effective in improving pedestrian safety. The literature offers conflicting findings on the effect of marked crosswalks. Some authors suggest that pedestrians are less vigilant when "protected" by a marked crosswalk. Other authors have found that pedestrians increase their looking behavior when in a crosswalk. The resolution of these conflicting findings might come through study of the behavior of pedestrians in Utah. The results might indicate how effective marked crossings are, as well as how various enhancements can improve the safety of the

crossings. There are also conflicting findings in the literature on the effect of marked crosswalks on drivers. Some drivers tend to slow upon seeing a crosswalk – regardless of the presence of a pedestrian – while others react only upon seeing a pedestrian. It may be useful to study the speeds of drivers in the vicinity of marked crossings. Such studies may be most beneficial in areas where there are pedestrian safety problems.

The pedestrian crossing flag installations in Salt Lake City are popular, although their impact must be assessed. Despite the lack of an assessment, it is recommended that such installations continue with possible expansion into other cities. An expansion would be sensible because the flags are a low-cost safety improvement, and private support from adjacent property owners can be sought. An evaluation of the impact of the flags on pedestrian safety should be conducted. Issues that need to be addressed include the effect of the flags on pedestrian-vehicle collisions, choosing the best sites for the flags, the optimal size, weight and coloring of the flags, how to reduce flag theft, and instructions for proper use of the flags. The evaluation should also determine if the flags induce a change in pedestrian vigilance.

Policy Issue: Sidewalk Provision

UDOT policy issues A.04, A.05, A.08 and A.09 all refer to the provision of sidewalks. An additional concern is the maintenance and upkeep of sidewalks. Research has found, for example, that sidewalks placed on a non-uniformly compacted subgrade are subject to "pop-up" (where the center of the sidewalk rises), "sagging" (where the center of the sidewalk falls), cracking, and spalling. Freezing and thawing and tree roots can also produce such effects. Sidewalks in such condition can be somewhat hazardous to pedestrians. Corrective maintenance strategies, such as replacing sidewalk sections that are in poor condition, should be established. Routine maintenance strategies, such as cleaning and snow removal, should also be in place.

Other Issues: Accommodating Pedestrians at Traffic Signals

The following recommendations are offered in response to the preceding findings and issues regarding pedestrian signals:

- Exclusive pedestrian signal phasing seems to be of greatest use only where there are high pedestrian and traffic volumes. Otherwise, the special phasing does not have an effect on pedestrian safety. This finding should be considered during the development of traffic control-related pedestrian safety strategies.
- An alternative to concurrent pedestrian-vehicle phasing might be needed in locations where traffic is heavy but pedestrian volumes are light. Studies have shown that such locations are particularly dangerous for pedestrians. Traffic signal phasing improvements may be needed for these locations. A pedestrian-actuated early-release phase would be one approach.
- Pedestrian conflicts with left-turning vehicles at "T" intersections are typically high during the early part of the green phase, and low during the remainder of the green. At four-legged intersections, the conflicts are low during the first part of the green, but are high for the latter half. Possible signalization strategies include the late release of pedestrians for "T" intersections, and early release or pedestrian-only phases for four-legged intersections.
- The MUTCD offers criteria for pedestrian signals. Based on an article by Robertson (1984) and others, the criteria can be disputed. The argument opposing widespread usage of pedestrian signals is that there is no strong evidence that such signals improve pedestrian safety. It is clear, however, that pedestrian signals are needed in many situations.
- Pedestrian startup times and volumes should be considered in pedestrian signal timing. Design startup times range from 3 seconds for the young to 3.75 seconds for the elderly.

- Signal timing at locations with heavy pedestrian volumes should be carefully developed. The size of a pedestrian "herd" can affect the amount of time required for a pack of walkers to cross a street. The "herd size" can also affect the amount of mid-crossing refuge space needed by pedestrians.
- Overall pedestrian and vehicle delays are minimized with standard, concurrent pedestrian-vehicle signal timing. Alternative phasing schemes may be needed, to serve certain pedestrian and vehicle movements. Overall delay should not serve as the sole measure of performance.
- If there is a heavy right-turn volume, the late release of pedestrians is a useful strategy for reducing the right-turn queue length. Signing is needed to inform both drivers and pedestrians of the signal phasing scheme.
- The safest signalization strategy for pedestrians is scramble timing, which provides pedestrians with an exclusive phase. Pedestrians can cross in all directions, including diagonally – during the scramble phase. Delays to both pedestrians and vehicles are high with scramble timing, but pedestrian safety is enhanced.
- To increase pedestrian compliance with pedestrian pushbuttons, response time should be quick – preferably immediate.
- Certain pedestrian signal display enhancements seem to work well, including DON'T START, WALK WITH CARE, countdown pedestrian indications, and animated eyes.
- Some of the traditional pedestrian signal indications, including both the steady and flashing DON'T WALK displays, offer little information and are frequently confusing to pedestrians.
- To facilitate the placement and timing of pedestrian signals and other pedestrian facilities, the following need to be determined: the portion of pedestrians who are elderly, the portion of pedestrians who are children (under age 16 and under age 10), primary pedestrian origin-destination pairs (particularly for the placement of midblock and grade-separated crossings), and pedestrian volumes.
- On wide streets, which are quite commonplace in Utah, pedestrian signals that enable full, nonstop crossing should be considered. On busy streets, the red intervals of the crossing approaches can be offset to allow one approach to continue to flow while the pedestrian is crossing the other approach (Urbanik et al. 2000).
- If an adequate green time for full crossing of a wide street cannot be provided, then a pedestrian refuge island should be installed. The island should both meet minimum design standards and deflect vehicle impacts.

3. EMERGENCY MEDICAL RESPONSE

An emergency medical response (EMR) is frequently needed to manage pedestrian crash victim trauma. Occasionally, the driver and-or an occupant also experiences trauma. One of the objectives of the work of Utah CODES is to assess the post-EMR outcomes of motor vehicle collisions. A review of the pedestrian-vehicle cases would be useful. Suggestions for improvements in EMR might result from this effort. Relative to the preceding recommendation, research has shown that particular attention must be paid to head, abdominal and chest injuries, as these can be quite severe. An evaluation of the medical response and outcome for pedestrians who experience these types of injuries might be useful. The findings may serve to improve the EMR for pedestrians with these types of injuries.

Elderly pedestrians must be treated carefully, since pre-existing debilities can combine with vehicle collision injuries to produce outcomes that are of greater severity than injuries of a similar nature in younger pedestrians. An evaluation of the health outcomes of elderly pedestrian crash victims would be useful. The findings might indicate needs for post-traumatic care.

In contrast to some of the preceding recommendations, several authors have suggested that improved medical treatment will not necessarily improve pedestrian mortality. That is, the emphasis must be placed on preventing crashes. Despite the potential ineffectiveness of enhanced medical treatment in improving pedestrian mortality, however, Sklar et al. (1989) states that improved response and treatment for elderly pedestrians might indeed decrease the mortality rate.

4. IMPLEMENTATION

The following agencies and organizations would be among those responsible for implementing the recommendations offered in this report:

State Agencies

Utah Department of Environmental Quality: Air Quality Division (www.eq.state.ut.us/eqair)
Utah Department of Natural Resources: Parks and Recreation Division (www.nr.utah.gov/recreation.html)
Utah Department of Health: Division of Family Health Services, Child Injury Prevention Program (hlunix.hl.state.ut.us)
Utah Department of Public Safety: Driver License Division, Utah Highway Safety Office, and Utah Highway Patrol (www.dps.state.ut.us)
Utah Department of Transportation (www.dot.state.ut.us)
Utah Labor Commission: Utah Division of Occupational Safety and Health (www.labor.state.ut.us/Utah_Occupational_Safety__Hea)
Utah State Council for Health and Physical Activity (www.utahfitness.org)
Utah Office of Education (www.usoe.k12.ut.us)

State Organizations

Utah Chapter of Operation Lifesaver (www.co.utah.ut.us/org/utol/)
Utah Crash Outcome Data Evaluation System (www.utcodes.org)
Utah Parent Teachers Association (www.pta.k12.ut.us)
Utah Safety Council (www.utahsafetycouncil.org)

Regional Planning Organizations

Cache Metropolitan Planning Organization (www.n1.net/~cachempo)
Wasatch Front Regional Council (www.wfrc.org)
Mountainlands Association of Governments (www.mountainland.org)

Public Transportation

Utah Transit Authority (www.utabus.com)

Local Agencies

City and county parks and recreation departments
City and county planning and engineering departments
City and county police and sheriff's departments
County health departments
Local school districts

The development of an implementation plan was beyond the scope of this research study.

5. FURTHER RESEARCH

The issues and recommendations discussed in this report indicate needs for further research in the following areas. The findings should be of use in pedestrian-related policy development and in the formulation of safety enhancement strategies.

- Develop a pedestrian safety brochure to be included among the documents that are transferred at the time of purchase of a motor vehicle.

- Determine the number of citations that are issued to pedestrians, recognizing that the number varies by jurisdiction; also, ascertain the effects that driver and pedestrian enforcement have on pedestrian safety.

- Identify the relationships between pedestrian facilities, safety and demand. It is expected that pedestrian safety and demand are positively correlated with improved facilities; the converse is also expected.

- Evaluate the various pedestrian indexes that are currently in use and propose new ones, as needed. Such indexes have the potential to quantify "walkability."

- Perform field studies of intersections and corridors that have experienced recurring pedestrian-vehicle collisions. Examine pedestrian volumes, behavior, and facilities, measure traffic volumes and vehicle speeds, and develop site-specific mitigating strategies, including lighting improvements.

- Examine pedestrian safety in the vicinity of public transit stops; a national study, sponsored by the TCRP, is under development.

- Collect data on the amount of walking that people do, including walk trip distances, purposes and frequencies. Compare pedestrian-vehicle crash numbers to walking amounts.

- Study child pedestrian safety near schools, paying particular attention to the ages of the children and the level of motor vehicle activity.

- Determine the extent to which child pedestrian safety on Halloween is a problem. Develop mitigating strategies.

- Examine area-wide pedestrian-vehicle crash data, looking for correlations with income levels, household sizes, and other demographic measures.

- Examine wintertime pedestrian safety data. Work toward establishing correlations with wintertime pedestrian volumes and snow clearance policies.

- Review the effectiveness of the Pedestrian Safety and Facilities Act. For example, how many pedestrian safety devices have been introduced as a result of the Act? Has pedestrian safety improved?

- Determine the impact of freeway crossing pedestrian warning signs on pedestrian safety.

- Study pedestrian behavior at various types of crossings in Utah; consider the ages and abilities of the pedestrians.

- Study vehicle speeds and driver behavior near marked crossings at unsignalized locations.

- Determine the level of usage and safety impacts of pedestrian crossing flags.

- Develop alternative, pedestrian-oriented signal phasing strategies for intersections featuring wide street crossings.

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