Effect of lighting on nighttime pedestrian collisions on the White Mountain Apache Reservation. Douglas R. Akin, Class of 1988.

Injuries are the leading cause of death in most Indian communities and motor vehicle crashes account for a majority of these deaths. In October 1985, the Indian Health Service (IHS) initiated an injury surveillance project in the Whiteriver Service Unit. All severe injuries on the White Mountain Apache Reservation resulting in hospitalization or death were investigated. A roadside hazard study was also conducted in the summer of 1985 to examine the roadway and roadside for potentially hazardous conditions that could cause or contribute to the severity of a motor vehicle crash. These two projects led to a motor vehicle crash study by the Office of Environmental Health in the fall of 1986. The primary objectives were to identify the magnitude and characteristics of all motor vehicle crashes on the White Mountain Apache Reservation during the two year study period, and to define the etiology of motor vehicle collisions with pedestrians. The study revealed some alarming concerns. Of the 24 fatalities, 7 (29%) were pedestrians. This is an annual pedestrian death rate of 37.6 per 100,000. compared to a national rate of 3.58 per 100,000 - more than 10 times greater than the national average. Of the 32 pedestrian collisions, 11 occurred within a one-mile section of State Road 73 in Whiteriver, Arizona. This section was poorly illuminated. 63% of all pedestrian collisions occurred after dark and 75% of fatal pedestrian collisions occurred on Friday and Saturday nights.

Based on this study, funding was obtained in 1988 to install street lighting along this one-mile section of roadway. Because of delays in securing approval to install the street lights, the project was not completed until December 1988. This study obtained additional baseline data for 1987 and 1988 and evaluated the effect of the street lights on the rate of motor vehicle collisions with pedestrians.

Review of the Literature:

Each year in the US, 7,000-8,000 pedestrians are killed in collisions with motor vehicles.[1,2] An additional 150,000 receive nonfatal injuries.[2] The rate of pedestrian collisions and fatalities appears to be decreasing, especially when the increased number of vehicles on the roadways and the increased vehicle miles driven are taken into consideration.[3] During the 1970's, there was an average of 9,400 pedestrian fatalities per year compared to 8,000 in 1981 and 7,300 in 1982.[1,3,4] Pedestrian collisions account for 18% of all highway fatalities. The number of deaths per 1,000 police-reported injuries is 52 for pedestrians, 27 for motorcyclists and 12 for motor vehicle occupants. Several factors influence pedestrian collision and fatality rates including age, sex, geographic differences, season of the year, day of the week, time of day, alcohol consumption, vehicle design, emergency services available, roadway design, and the roadside environment.[1] The majority of nonfatal injuries occur during the day, while the majority of pedestrian fatalities occur at night in spite of reduced pedestrian and motor vehicle traffic during these hours. This is probably due to decreased visibility of pedestrians at night and the known increased use of alcohol by adult drivers and pedestrians during these times.

Two-thirds of all pedestrian fatalities occur between the hours of 6 pm and 6 am, with the highest incidence at 6-10 pm. The greatest number of pedestrian fatalities occur approximately one hour after sunset.[1] A study by the Highway Safety Research Institute (HSRI) found the peak for nonfatal pedestrian collisions to be between 3-4 pm, compared to 7-8 pm for fatalities.[2] HSRI also found that the majority of pedestrian collisions occurring at night involved pedestrians between the ages of 15-55 years of age. Most pedestrian collisions involving children occurred in the daytime. 30-40% of fatalities involved alcohol use by the pedestrian in the 15-64 age group. Alcohol use by the driver was 14% of the fatal cases and 8% of the non-fatal.

A New Mexico study found that pedestrian collisions were characterized by non-intersection locations, the hours of darkness, and alcohol involvement. 80% were outside of intersections, 56% occurred between 6 pm and midnight and 26% between midnight and 6 am; and 61% involved alcohol use by the pedestrian and 14% by the driver.[4]

Hazlett and Allen found that nighttime, dark clothing and alcohol influenced the occurrence of pedestrian collisions. They found that 87% of the drivers who hit a pedestrian at night claimed difficulty in seeing the pedestrian. They also showed that alcohol caused an interference in the visual mechanism further compounding the problem of nighttime visibility. From their experiments, they found that pedestrian visibility distances could be increased and the loss of perception by alcohol could be counterbalanced by raising roadway illumination or by increasing the positive contrast of the pedestrian.[5] A review of police reports and death certificates for pedestrian collisions in Washington State (1981-1983) found that limited visibility due to fog or lack of street lights and limited pedestrian visibility due to dark clothing were key factors in the pedestrian collision/fatality rates. A third of all pedestrians were injured while in marked crosswalks.[6]

Certain groups are at more risk to pedestrian collision injuries as well as fatalities based on their age, sex, drinking habits, location, race, and per capita income. Some of these differences may be due to increased exposure by some

groups. Pedestrian death rates are the highest for the elderly while pedestrian injury rates are highest for children in the 5-14 year-old age group. 70% of pedestrians killed are males, five out of six injuries and two out of three deaths occur in urban areas, and half of adult pedestrian injuries and fatalities involve alcohol. Lower income groups have a higher incidence of pedestrian deaths and Native Americans have the highest death rate for pedestrian collisions.[1]

An HSRI study utilizing data from the NHTSA Fatal Accident Reporting System (FARS) and total pedestrian collisions data from Michigan and Washington state found that only about 3% of children under age 15 suffer fatal injuries. After age 30, the percentages for fatal injuries are twice as high as those for nonfatal injuries. Children and adults over 60 years of age are struck more often during the afternoon and early evening while young and middle-aged adults are struck at night and in the early morning.[2] The Washington state study also found that the very young and elderly had a higher death rate while children and adolescents less than age 19 were most likely to receive nonfatal injuries. Death rates per 100,000 population were 2.4 for whites, 3.8 for blacks, 5.6 for "other", and 14.8 for Native Americans. 12% of the injured were from rural areas but accounted for a case-fatality rate of 14.3% compared to 4.4% for urban areas. Besides higher vehicle speeds, they felt this could be due to the availability of emergency medical services. They also found that 46% of pedestrian deaths for children under age 5 occurred at home in the driveway or garage.[6] Hall found that 47% of the pedestrians were struck crossing the roadway, 19% walking with traffic, 8% standing in the roadway, 6% walking in the roadway, 5% walking into the vehicles path, 11% "other", and 4% unknown. Most of the pedestrians struck while crossing a highway were walking to taverns.[4]

Matthias and Stonex, in a 3- year study of pedestrian collisions in Arizona found that physical factors played a role. The elderly are more at risk because of their reduced mobility, reaction time, and sensory abilities. Small children are at risk because of their size and visibility. They found a slightly higher collision rate on Indian Reservations compared to other rural counties. This may be due to under reporting by tribal police departments.[7] Waller found that not only does alcohol increase the probability of an injury-producing incident, but it also increases vulnerability to injury in a crash.[8]

The countermeasure selected to reduce nighttime pedestrian collisions is to increase visibility for both the pedestrian and driver by increasing lighting levels along roadways using fixed point lighting. This is particularly useful where there are a clustering of collisions. Intervention strategies to reduce pedestrian collisions and specifically night time pedestrian collisions can be centered on the pedestrian, motor vehicle, motor vehicle operator, or roadway environment using education, enforcement, or engineering. Historically, intervention strategies have centered around education with mixed results.[3,6,9] The more often a person is required to perform a task, the less likely they will continue to perform the task.[9] A person is more likely to install a smoke detector than to buckle their seat belts every time they enter their vehicle. Haddon and Baker found that passive measures that protect an individual automatically, such as air bags, without any action required from the individual were the most successful.[10] The success of enforcement in reducing injuries is also open to question.[9] Pedestrian behavior is difficult to change, especially alcohol related behavior. Gayer, Talbot and Pless found that teaching children to avoid cars is difficult and conveys the message to vehicle drivers that it is the responsibility of the pedestrian to avoid collisions and not theirs. They concluded that environmental modification involving engineering changes to roads, vehicles, and traffic may be the most successful and most cost effective approach to reducing pedestrian collisions.[11] One problem with this approach is that in many cases pedestrian collisions are scattered over large areas without much clustering.[4,7,12]

The installation of street lights is a passive intervention strategy requiring no action by the driver or pedestrian. Street lighting has been in effect in the United Kingdom since the middle ages. The City of London was responsible for the upkeep of over 15,000 street lamps as long ago as 1738.[13] Walton states that fixed roadway lighting probably offers the most comprehensive means of correcting poor night visual environments. When properly applied, roadway lighting can provide quick, accurate, and comfortable seeing conditions for the night driver and can result in an overall improvement in highway accident statistics.[14]

Most of the lighting studies found in the literature were conducted in the United Kingdom and published in "The Lighting Journal". In a 1966 study by Harris and Christie, a 43% reduction in nighttime pedestrian collisions at 64 sites in the UK resulted from increasing street lighting levels.[15] The Commission Internationale de L'Eclairage analyzed 30 studies of 244 urban sites where either no lighting, or poor lighting was replaced by good standards of lighting and found between 45 and 57% reduction in injuries.[16] During the 1973/74 energy crisis in the UK, public lighting was reduced by 50% with a resulting 12% increase in nighttime personal injury collisions even though the daytime rate dropped by 6% due to reduced speed limits and fuel shortages.[16] In New Mexico, Hall found that improved lighting was a viable countermeasure at 29% of the pedestrian collision sites. This did not include the sites where lighting was not practical because of an isolated occurrence or a lack of electrical power.[4]

Early fixed light lamps were of the mercury-vapor, incandescent, or fluorescent types. Currently, high and low pressure sodium and metallic halide lamps are in use with the trend towards high pressure sodium illuminaires.[18]

The high pressure sodium lamps are more economical and provide better color rendition.[16] Illumination levels for roadways vary from 0.4 foot candles in residential areas to 1.0 foot candles in commercial areas.[17] Illuminaires should be mounted 40 or more feet above the roadway to provide more uniform illumination and to reduce direct glare. Mounting brighter lamps on higher poles with wider spacing reduces the number of poles which may be hit by vehicles.[17] Poles should be placed a minimum of 10 feet off of the roadway for low speed rural collectors, rural roads, and local streets where curbs are not used. Breakaway poles should not be used along streets in residential areas where they can fall on pedestrians or damage adjacent buildings.[18]

Investigative method:

One of the objectives of this study was to identify all of the motor vehicle collisions with pedestrians which occurred during the two year period from 1987 to 1988 and to combine this with data from the 1985 to 1986 study to compile four years of baseline data prior to installation of street lights. It had become apparent from the previous study that several sources of information would have to be consulted because of non-reporting of motor vehicle crashes between the White Mountain Apache Tribe and the State of Arizona. Therefore, motor vehicle crashes were identified by reviewing White Mountain Apache Tribal Police Department accident reports, Arizona Department of Transportation accident data, and Indian Health Service Hospital emergency room log, and patient medical records at Whiteriver. All crashes were crossed referenced between the three sources of information to eliminate duplication. In several instances, motor vehicle crash victims were identified only in hospital records leading us to believe that these crashes were not investigated by the police. All but three of these crash victims were located to determine crash sites. The three records were not used in this report.

Evaluation of the severity of injury for crash victims was determined from medical records at the Whiteriver PHS Indian Hospital and from the severity-of-injury code on the ADOT records. Pedestrian traffic volume was determined by counting pedestrians walking along and crossing the roadway at several sites at different times of day.

Results and Discussion:

There were 571 motor vehicle crashes identified during the two year study period which occurred on the White Mountain Apache Reservation. Of those, 69% (396) were single vehicle crashes, 28% (158) were multiple vehicle crashes, and 3% (17) were unknown. 55% of the crashes occurred during daylight hours and 38% after dark.

21% (120) of all crashes in the study resulted in severe injury to motor vehicle occupants. The injuries caused by the 120 crashes included 24 fatalities and 128 people being hospitalized. It should be noted that a large number of vehicle occupants also received minor injuries in these crashes. The total number of ambulatory injuries was not recorded. The 24 fatalities resulted in an annual motor vehicle death rate of 129 per 100,000 population on the Reservation. The death rate was calculated at 206 per 100,000 population for males, and 53 per 100,000 population for females. The national IHS figures for the years 1981-85 give an all Indian motor vehicle death rate of 69.1 per 100,00 population, a rate for Indian males of 99.5 and females of 39.5 per 100,000 population. The 1985 all U.S. motor vehicle death rate was 19.1 per 100,000 population.

Alcohol use was associated with 42% (50) of the severe injury crashes compared to 59% (13) of the fatal crashes. The increase in alcohol association with severe injury crashes is consistent with national trends and is not a unique characteristic of the Reservation.

During this two year study period there were 32 motor vehicle collisions with pedestrians. While this represented only 5% of the total number of motor vehicle crashes, it resulted in 8 fatalities (33 % of all motor vehicle fatalities), 19 hospitalizations, and 6 victims who were treated and released. The annual pedestrian death rate per 100,000 population for the White Mountain Apache Reservation was 43 compared to 6.32 for the State of Arizona and 3.52 for the nation, or more than ten times greater than the national average.

59% (19) of the motor vehicle/pedestrian collisions occurred on State Road 73. Of these, 11 occurred in a one mile stretch of highway between the tribal liquor store and the H-Market Grocery Store. 62% (20) of the all pedestrian collisions occurred at night and 74% of pedestrian collisions on SR 73 occurred at night. Of the 11 pedestrian collisions occurring on SR 73 in the lighting project zone (mile post 338.2 to 339.4), 73% occurred at night. State Road 73 through Whiteriver is poorly illuminated. Some street lights are located along the highway but few function and all are antiquated. 50% (16) of the pedestrians were hit while attempting to cross the highway. Ten pedestrians were hit walking along the road and six were injured while standing in the road. 60% (19) of the pedestrian collisions involved alcohol, and of those, 83% (16) involved alcohol use by the pedestrian. Since the tribal liquor store is located along State Road 73, there is heavy pedestrian traffic crossing this highway from housing subdivisions located nearby. This explains, in part, the high percentage of alcohol-involvement among pedestrians.

The highest number of pedestrian collisions (7) occurred between the hours of 7 pm and 8 pm. Of these 7 collisions, 4 resulted in fatalities. 59% of all pedestrian collisions occurred between 5 pm and 9 pm. 73% of all pedestrian collisions in the lighting project zone occurred between 5 pm and 9 pm. Pedestrian collisions occurred

during all days of the week; however, on Friday there was a significant increase in pedestrian collisions. 63% (5) of the fatal collisions occurred on Friday. Pedestrian collisions in the lighting project zone were evenly distributed throughout the week. December had the highest number of pedestrian collisions at 6 followed by June and July with 4 each. 45% (5) of pedestrian collisions in the lighting project zone occurred in November and December. There were no monthly trends observed for fatal pedestrian collisions.

B. Follow-up Study, 1987 - 1988: The total number of motor vehicle/pedestrian collisions on all roads remained constant at 33. However, the number of fatalities declined 38%, to 5. There were 18 hospitalizations and 10 victims who were treated and released. The number of pedestrian collisions along SR 73 dropped 26% to 14. The number of pedestrian collisions in the lighting project zone dropped 36% to 7. There were no fatalities in this zone. The number of pedestrian collisions occurring after dark remained constant in the lighting project zone (71%) but decreased to 57% along SR 73, and 36% for all roads.

The peak time period for all pedestrian collisions changed from 7 pm to 9 pm in the 1985-86 study to 6 pm to 7 pm where 18% occurred. 40% (2) of the fatalities also occurred during this time period. 71% of the pedestrian collisions in the lighting project zone occurred between 5 pm and 8 pm. Pedestrian collisions in the lighting project zone were evenly distributed by day of the week and month. The decrease in the number of pedestrian collisions in the lighting project zone from 1985/86 to 1987/88 may be random variation due to small numbers.

Police records for 1989 were reviewed. There were no motor vehicle/pedestrian collisions in the lighting project zone. However, many of the motor vehicle injuries identified at the hospital could not be investigated because of incomplete police records. The Police Chief reports that no nighttime motor vehicle crashes of any type have been reported in the lighting project zone. Pedestrian traffic volume observations were made to determine if the increased lighting would result in more pedestrians utilizing this section of roadway, thus increasing the exposure of pedestrians to traffic. Additional post-project traffic data is needed to make any conclusions. However, there does not appear to be an increase in motor vehicle/pedestrian collisions after installation of the roadway lights.

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