

## Socio-Economic Conditions: A Driver of Pediatric Injury Prevention

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### Abstract

**Background:** Developing Injury Prevention Programs (IPP) is accorded a lot of importance in American College of Surgeons (ACS) level 1 Pediatric Trauma Centers (PTC). Trauma remains the main killer in the pediatric population and determining priorities in IPP is difficult due to competition for limited resources. This study evaluates factors that could help determine resourcing priorities of IPP by evaluating its impact in Motor Vehicle Accidents (MVA).

**Materials and Methods:** Retrospective chart review of all children involved in MVA from 2016 - 2018 as pedestrians or bicyclists was performed. Demographics, injury type, and Injury Severity Score (ISS) subdivided the cohort. Average income for Zip codes where MVA occurred was obtained from publically available county records. Zip codes and average incomes from sites of MVA were compared to those of school districts participating in the IPP to assess effectiveness and community need.

**Results:** Patient population was 64% minority (Hispanic and African American) and 60% male. Extremity (30%) and head and neck (30%) accounted for preponderance of injuries. Race did not significantly correlate to specific type of injury or increased ISS. 67% of pedestrian and bicyclist MVA occurred on weekdays. 47% concordance was noted between IPP and trauma zip codes. Incidences occurred in low-income areas compared to average median household income for the country.

**Conclusion:** Ethnic minorities and low-income areas are disproportionately affected in pedestrian and bicyclist MVA. Trauma centers should partner with local area schools as part of community outreach to decrease morbidity and mortality. Socioeconomic status should factor into allocation of resources.

**Keywords:** *Pedestrian Injury; Motor Vehicle Accidents; Pediatric Injury Prevention; Road Safety Outreach*

### Introduction

Traffic-related injuries are the leading cause of death and disability in the pediatric population, accounting for 61% of pediatric trauma cases [1,2]. Although the rates and frequencies of motor vehicle occupant deaths have decreased, similar declines have yet to occur amongst pedestrian and bicyclist injuries, especially for children [3,4].

To better secure the safety of future generations, pediatric injury prevention programs (PIPP) have increased in urban areas in which such crashes are more likely to occur. These road safety education programs have become an important tool in reducing the incidence of pediatric pedestrian and bicyclist motor vehicle crashes (MVC). In a recent study, pedestrian safety instruction by parents was noted to

be minimal (6%). However, when schools or parents conducted pedestrian safety instruction, child knowledge of pedestrian safety was increased, and risky pedestrian behavior decreased. Crossing guards have also been shown to be beneficial for maintaining the safety of an intersection for both passengers of motor vehicles and child pedestrian crossing [5]. Evaluating the effectiveness of PIPP remains difficult, as there are multiple factors that can predict injury frequency and outcomes.

As of June 2018, the state of Florida in the United States has been ranked second amongst all states for pedestrian traffic fatalities [6]. The increasing need to provide education amongst the youth population has become apparent as this population contributes significantly to the number of such fatalities. Measures have been taken in areas such as the Miami-Dade county (the most populous county in the state) with their newly implemented WalkSafe program to educate children in schools. Data from the WalkSafe program has revealed an increased awareness amongst grade school children for pedestrian safety [7]. Further, the Tampa Bay area has two counties amongst the top ten with the most pedestrian fatalities [8]. In an effort to decrease these fatalities, our Level 1 Pediatric Trauma Center, located in the Tampa Bay area, has partnered with the community to provide educational programs for children regarding pedestrian and road safety. These programs have the potential to reduce pediatric pedestrian and bicyclist incidents depending on their effectiveness in altering behavior and retention of knowledge, as children grow older.

This study analyzes incidences of pedestrian and bicyclist MVC in order to determine at-risk community areas and age population. Based on previous analyses of incidences in other locations, we hypothesized that we would have similar results, and that occurrences of pedestrian and bicyclist MVC are increased in areas of low-income and high minority populations [9]. As resources for PIPP are scarce, the objective of the study was to evaluate if the trauma outreach program was reaching the population at highest risk.

### Methods

Retrospective chart review of 88 children admitted to an American College of Surgeons (ACS) Accredited Level 1 Pediatric Trauma Center with ICD-10 injury codes of V03.00XA (pedestrian on foot injured in collision with car, pick-up truck or van in traffic accident) and V13.4XXA (pedal cycle driver injured in collision with car, pick-up truck or van in traffic accident) was performed over a recent three year period (2016 - 2018). We included all subjects aged 0 - 18 and studied demographics such as sex and ethnicity. The subjects were broken down into four age groups: infants (0 - 2 years), toddlers (3 - 5 years), children (6 - 12 years), and adolescents (13 - 18 years).

For education the program used simulation videos, colored placards, play acting by experienced teachers (usually graduate students). Interactive discussion was encouraged amongst all age groups to promote participation. The school education programs were reinforced by twice a year visits to the schools in the respective school districts. The school districts were chosen based on the interest exhibited by the administration of these schools and their proximity to the trauma center. The program was monitored by an experienced director and was funded through the hospital trauma outreach program in addition to other funding sources.

ZIP (Zonal Improvement Plan) codes, similar to Postal Index (PIN) Codes used in some countries, for sites of MVC were compared to the school district zip codes in which the Trauma Center PIPP performed road safety outreach to determine the efficacy of the PIPP. Average median household income for zip codes of incidences was obtained from publicly available data sources. The outcome variables were correlation between concordance of PIPP and trauma incidence, Injury Severity Score (ISS), type of injury and hospital length of stay (LOS). Type of injury was divided into five major systems- head and neck, thoracic, abdominal, pelvic and extremities- to determine significance of sustained injuries. These variables were used as predictors of morbidity and mortality. Subjects with predisposing conditions or prior diseases that could change the morbidity or mortality outcome of a subject were excluded.

We further evaluated the discordance/concordance between lack of geographical coverage of IPP and being an injury victim at the trauma center.

**Results**

**Patient population characteristics (Table 1)**

Of all cases reviewed, 71 (80.7%) were children involved as pedestrians and 17 (19.3%) were children involved as bicyclists. In total, 18 (20.5%) were categorized as infants, 15 (17%) as toddlers, 41 (46.6%) as children and 14 (15.9%) as adolescents. 27 (30.7%) of the pediatric subjects identified as Black or African American, 30 (34.1%) as Hispanic/Latino, and 22 (25%) as White; 9 (10%) pediatric subjects had undisclosed ethnicities. The study subjects were predominantly male (60%, n = 53). Average injury severity score increased with age; infants and toddlers had an average ISS of 11.8 (range: 1 - 59), children 13.9 (1 - 75) and adolescents 17.8 (4 - 43).

**Bicyclist characteristics (Table 1)**

For bicyclists, there were 2 (11.8%) toddlers, 9 (52.9%) children and 6 (35.3%) adolescents. Mean age was higher for pedestrians (14.45) than bicyclists (12.41). 9 (52.9%) of the bicyclists identified as White, 4 (23.5%) as Hispanic/Latino and 3 (17.6%) as Black or African American; 1 (5.8%) subject had an undisclosed ethnicity. 15 of the bicyclists were male, 2 were female. For bicyclists, children had the highest number of bicycle injuries (52%) but adolescents had a higher severity of injury (11.4 average ISS versus 10.1).

	Total (n = 88)		Pedestrian (n = 71)		Bicyclist (n = 17)	
Age						
Infant (0 - 2 years)	18	(20.5%)	17	(23.9%)	1	(5.8%)
Toddlers (3 - 5 years)	15	(17.0%)	16	(22.5%)	1	(5.8%)
Children (6 - 12 years)	41	(46.6%)	32	(45.0%)	9	(52.9%)
Adolescents (13 - 18 years)	14	(30.7%)	8	(11.2%)	6	(35.3%)
Gender						
Male	53	(60.2%)	38	(53.5%)	15	(88.2%)
Female	35	(39.8%)	33	(46.4%)	2	(11.8%)
Ethnicity						
Black or African American	27	(30.7%)	24	(33.8%)	3	(17.6%)
Hispanic/Latino	30	(34.1%)	26	(36.6%)	4	(23.5%)
White	22	(25.0%)	13	(18.3%)	9	(52.9%)
Undisclosed	9	(10.0%)	8	(11.2%)	1	(5.8%)

**Table 1:** Demographics of pediatric population involved in pedestrian and bicyclist vs. MVCs from 2016 - 2018.

**Crash and injury characteristics (Table 2)**

When evaluating the incidents by season, it was found that 20 (22.7%) incidents occurred in the winter (December through February), 25 (28.4%) in the spring (March through May), 17 (19.3%) in the summer (June through August) and 26 (29.5%) in the fall (September through November). 67% of the pedestrian and bicyclist MVC occurred on weekdays. 33 of the pedestrian and bicyclist injuries occurred in 2016, 32 in 2017 and 23 in 2018.

	Incidents	
Season		
Winter (December-February)	20	(22.7%)
Spring (March- May)	25	(28.4%)
Summer (June- August)	17	(19.3%)
Fall (September-November)	26	(29.5%)
Day of the Week		
Weekday (Monday-Friday)	59	(67.0%)
Weekend	29	(33.0%)
Year		
2016	33	(37.5%)
2017	32	(36.3%)
2018	23	(26.1%)

**Table 2:** Crash and injury incidents based on time of year, day of week and year.

Of all injuries, extremity and head and neck injuries made up the majority (Table 3), with each representing 30% of all injuries. All other major system injury types, such as pelvic, abdominal and thoracic each accounted for 12% of all injuries. Children had the most reported injuries across all major systems amongst all age groups. Extremity injuries in children accounted for 35% of injuries reported while head and neck injuries in children accounted for 30% of injuries reported. Race did not significantly correlate with any specific type of injury or an increase in ISS ( $p = 0.371$ ). Total mortality was 7%. Two infants, two children and two adolescents sustained fatal injuries; five were pedestrians. Five were male.

	Infants	Toddlers	Children	Adolescents
Abdominal	6	5	12	7
Extremity	15	11	37	11
Head and Neck	15	13	32	13
Pelvic	3	6	17	6
Thoracic	9	7	9	7

**Table 3:** All reported injuries broken down by age group and major systems.

### Road safety pediatric injury prevention program and MVCs

When zip codes of school districts participating in the PIPP were compared with zip codes in which incidents occurred, there was a 47% overlap in zip codes. 53% of injuries happened in trauma center catchment area where there was no IPP. PIPP education did not significantly correlate with ISS ( $p = 0.468$ ). The average median household income in zip codes with a PIPP was \$36,640 while the average median income for those without an active PIPP was \$42,687 ( $P < 0.05$ ). Overall, the PIPP was taught in areas with an average median income of \$53,665.

### Discussion

This study analyzed trends in pediatric pedestrian and bicyclist MVC in the region surrounding the Level 1 Pediatric Trauma Center for the first 3 years after introduction of the PIPP and compared trends amongst age and ethnic groups. The demographics of the injury victims were very similar to national data. The results indicated that ethnic minorities and low-income groups are disproportionately affected by pedestrian and bicyclist MVC incidents. Other studies have also indicated that low-income areas and minority populations have a higher incidence of pedestrian crashes [17]. It has also been shown that black children have a higher risk of injury from motor vehicle traffic as pedestrians [18,19]. Additionally, these neighborhoods tend to be highly populated with increased traffic density. Greater exposure leads to higher pedestrian injury risk [20]. Furthermore, certain areas have environmental risks that should be considered. For example, sidewalks that are absent, narrow, or in need of repair have been identified as an environmental factor that increases the risk of pediatric pedestrian injuries [21]. The PIPP should consider such areas of high risk, primarily the areas of low-income and minority populations.

Our data collected was comparable with national data collected on bicyclist and pedestrians MVC incidents. This study had a higher number of males involved in pedestrian and bicyclist MVC (60%) compared to nationally reported data (50%). Additionally, national data reports that 66% of pedestrian traffic injuries occur on weekdays, in concordance with the 67% of incidents found in this study. 88% (15) of the bicyclists were male in this study, while national data reports that 92% of bicyclists injured in traffic accidents were male [22].

Recent data has suggested that in pediatric trauma cases, an ISS greater than 15 is demarcated as the major trauma threshold and the mortality rate for an ISS between 16 and 24 is 5.8% [10,11]. This study demonstrated that average ISS increased with age group, indicating a possible need to improve on road safety education for older adolescents who usually are not the focus of such programs. While road safety educational programs could decrease the injuries in older age groups, especially as the educated participants grows older, there are many other factors to consider. An increase in ISS with age group could be due to a lack of adult supervision, as children get older. This increase could also be due to an increase in reckless behavior as noticed by the preponderance of male participants. Cognitive development factors should also be considered in determining pedestrian safety [11]. Children aged 6 - 12, sustained the most injuries and had a higher number of incidents as compared with all other age groups. This finding stands in contrast with trends from 2006 - 2015, which indicated that injury rates are higher for ages 15 - 19 [12]. Other studies have indicated that pedestrians with the most non-fatal injuries are ages 10 - 15 [13]. Better concentration and attention skills in youth has been shown to lead to safer pedestrian practices because there are multiple stimuli to consider when doing pedestrian activities such as walking across streets [14,15]. The higher number of injuries recorded for children in this study could be because young children may not attend to the stimuli and details needed to safely make choices as a pedestrian [16]. Infants and toddlers would have the protective factor of adult supervision and less external exposure because of their age and lack of school attendance.

While the trauma center PIPP was found to have some coverage in low-income ZIP codes, the overall income level in IPP coverage areas was significantly higher than in areas without IPP. A significant number of the victims at the trauma center were from low income ZIP codes. While evaluating the PIPP outreach, it became clear that the program was reaching a population that was at a lower risk for injury. With this background we have started reorienting PIPP coverage based on socio-economic factors. This unique focus on ZIP codes and median incomes has not been previously reported in other injury prevention program studies. Ongoing studies will reveal if reorienting PIPP program will reduce trauma burden in the community. Based on our analysis, ZIP codes and median incomes are a useful tool to direct limited resources available for PIPP. This data is publicly available for all counties in the United States. Further we believe that the findings of this study are easily translated to developing countries where trauma center and school interactions are minimal. Based on our results we would recommend governmental tax exemptions to hospitals for reinvesting in their community by setting up school outreach programs. In a young country, improving the morbidity and mortality in pediatric trauma, will have a significant impact on national health and socio-economic indicators.

For PIPP effectiveness, one should consider the age groups that are best targeted for initial exposure to road safety and at what interval road safety knowledge be reassessed and reinforced to ensure proper retention. We think our program is using the right media to reach the youngsters but ongoing evaluation of retention is necessary with adjustments to be made as necessary. In tailoring such programs it is important that constant reinforcement is provided through the elementary, middle, and high school age groups to have the greatest impact on the most vulnerable population.

### Conclusion

Socioeconomic factors should be considered while implementing PIPP. The limitations of this study are in its sample size and its retrospective nature. However, this should not detract from the unique focus of this study on socioeconomic indicators such as ZIP codes and median incomes that have not previously been addressed. Developing trauma center public outreach programs to reach the lower socioeconomic strata will positively impact morbidity and mortality in this vulnerable section of society.

### Compliance with Ethical Standards

### Conflict of Interest Statement

- None. The authors report no proprietary or commercial interest in any product mentioned or concept discussed in this article.
- This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.
- The study was carried out after Institutional Review Board approval. No subjects were harmed. No animals were utilized at any point to prove study concepts. HIPPA provisions were respected.

### What is known:

- Pediatric trauma is a major cause of morbidity and mortality.
- Pedestrian and Bicycle injuries are the most common causes of pediatric trauma.
- Trauma is preventable.
- Trauma centers have a responsibility to maintain the health and wellbeing of the communities that they serve.

### What does the study add:

- Socio-economic status is a risk factor for pediatric trauma.
- Ethnic and minority groups are at higher risk for pediatric trauma.
- Publically available data sources may help drive trauma outreach education to decrease the incidence of preventable trauma.
- Injury Prevention Programs should be made available to schools by local partnerships with trauma centers.

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### Author Contributions

Both authors conceived and designed the analysis, collected the data, contributed data or analysis tools, performed the analysis, and wrote the paper.

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