UNIVERSITY OF CALIFORNIA SAN DIEGO

Pediatric Trauma in the California-Mexico Border Region: Injury Disparities by Area Deprivation Index

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in

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By

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The thesis of Alicia Gaidry Sykes is approved, and it is acceptable in quality and form for publication on microfilm and electronically.

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LIST OF ABBREVIATIONS

ACS……...…….American Community Survey

ADI……..Area Deprivation Index

AIS..……...Abbreviated Injury Scale

ICU…….Intensive Care Unit

ISS……Injury Severity Score

LOS…….Length of stay

MOI……..Mechanism of Injury

MVA/MVC…….……Motor vehicle accident/Motor vehicle collision

NAT……...Non-accidental trauma

RCHSD……Rady Children's Hospital San Diego

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ABSTRACT OF THE THESIS

Pediatric Trauma in the California-Mexico Border Region:
Injury Disparities by Area Deprivation Index

by

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The California-Mexico border region is a high-volume trauma area with populations of widely disparate socioeconomic status. This work analyzed differences in demographics and mechanism of injury in children using the Area Deprivation Index (ADI), a composite measure of 17 markers of neighborhood socioeconomic disadvantage. A retrospective review was performed of pediatric patients evaluated at the regional level I Pediatric Trauma Center between 2008 and 2018. Collected data included patient demographics, injury characteristics, and health care outcomes. Patient addresses were correlated to neighborhood disadvantage level using ADI

quintiles, with a higher quintile representing greater socioeconomic disadvantage. A total of 9,715 children were identified, of which 4,307 (44%) were Hispanic. Hispanic children were more likely to live in more disadvantaged neighborhoods than non-Hispanic children ($p<0.001$). There were markedly different injury mechanisms in neighborhoods with greater socioeconomic disadvantage (higher ADI) compared to those with less socioeconomic disadvantage. Sports-related and non-motorized vehicular trauma predominated in less disadvantaged neighborhoods, while higher ADI quintiles were strongly associated with pedestrian versus automobile, motorized vehicle accidents/collisions, and non-accidental trauma ($p<0.001$). This analysis represents the first study to characterize pediatric traumatic injury patterns based upon the neighborhood ADI metric. ADI can be a useful resource in identifying disparities in pediatric trauma and those at increased risk for vehicular and abusive injury who may benefit from increased resource allocation, social support, and prevention programs.

Chapter 1: Introduction

1.1 The United States-Mexico Border Region

The United States (U.S.)-Mexico border region is defined as the area of land within 62.5 miles (100 kilometers) North and South of the U.S.-Mexico international boundary.[1] This region spans approximately 2000 miles, including 140 miles between California and Mexico.[1] The California-Mexico border is the United States' most transited border with approximately 220,000 to 240,000 people crossing this border every day.[2,3] This southern California region includes San Diego County and Imperial County, and has increasingly become a focus of homeland security and health care initiatives.[4]

The California-Mexico border region is culturally and ethnically diverse, containing a large population of Hispanic immigrants from Central and South America. Based upon the most recent census survey, California has the nation's largest population of immigrants and children within immigrant families.[5,6] Within the California-Mexico border region, almost a quarter (23.4%) of residents of San Diego county and nearly one-third (30.7%) of residents in Imperial County are foreign-born, and nearly half (46.6%) of children living in San Diego have foreign-born parents.[7,8] California also has the largest Hispanic population of any state with approximately 39% of the 39.5 million people living in California having Hispanic ethnicity and 8.3% of these individuals living in the San Diego and Imperial Counties.[9,10] Within these two counties, approximately 37% of the population is Hispanic and, of those, nearly one-third (32%) are children and adolescents aged 19 years or younger.[10]

The U.S.-Mexico border region also contains a disproportionately high number of individuals living in poverty. Based upon the most recent California Poverty Measure, approximately 19% of individuals in the California-Mexico border region were living below the

federal poverty level between 2016 and 2018, as compared to approximately 12% of the total U.S. population living in poverty during that same time period.[11,12] Furthermore, a greater percentage of the Hispanic population in the California-Mexico border region live below 200% of the federal poverty level as compared to the non-Hispanic white population in this region.[13] Additionally, Hispanic individuals and Hispanic children less than 18 years of age living within this region are more likely to live in poverty than their national counterparts (31.8% and 37% vs. 23.4% and 20%, respectively).[14]

1.2 Trauma Care within the California-Mexico Border Region

The California-Mexico border region is a high-volume trauma area with over 12,000 patients being treated annually within the San Diego Country Trauma System.[15] This Trauma System consists of five adult trauma centers (three level 2 trauma centers and two level 1 trauma centers) and one pediatric level 1 trauma center.[15] Trauma centers are designated a "level" through accreditation by local, regional, and state organizations, such as the American College of Surgeon, with a designation of "level 1 trauma center" representing the highest level of trauma care.[15]

Rady Children's Hospital San Diego (RCHSD) is the only pediatric level I trauma center within the San Diego County Trauma System and the only pediatric hospital within the California-Mexico border region, providing care for approximately 1,000 traumatically injured children and adolescents within the San Diego and Imperial counties each year.[16] RCHSD is capable of caring for all children and adolescents, and provides trauma care for children up to 19 years of age who are injured within the California-Mexico border region.[16] Of note, children who are 15 years of age or older may receive care at any of the trauma centers within the San

Diego County Trauma System, and are therefore triaged to receive care at whichever hospital is closest to them at time of injury.[16]

1.3 Social Determinants of Health and Structural Violence

In the setting of the ethnic and cultural diversity and socioeconomic disparities within California-Mexico border region, the World Health Organization Social Determinants of Health Conceptual Framework provided the model within which I could begin to critically consider the influence of various structural determinants (e.g. socioeconomic, political, social, and individual factors) on an individual's health and health outcomes.[17] Using this framework, I wanted to study how factors such as neighborhood, socioeconomic disadvantage, and ethnicity might influence a child's risk for injury.

Previous research has shown that where people live and their ethnicity can influence their health and health outcomes. For example, where an individual lives can directly influence their health behaviors and ability access to various resources. Individuals living in socioeconomically disadvantaged neighborhoods may experience decreased access to healthy food, clean water; education and safety; higher rates of certain disease, such as diabetes and cardiovascular disease; higher utilization of health services; and earlier death.[18–22] The influence of neighborhood may even surpass the effects of poverty, as studies suggest that individuals living in poverty within less socioeconomically disadvantaged neighborhoods may have better health outcomes than those living in neighborhoods with greater socioeconomic disadvantage.[21,22] Recent data also suggest that Hispanic children living in the US-Mexico border region have a higher mortality rate than non-Hispanic children living in the US-Mexico border region and Hispanic children

living in the US at-large.[23] Mortality rate for these children is highest in non-metropolitan counties, which may be due to poverty, reduced access to care, or poorer quality of care.[23]

These examples of health inequity due to socioeconomic disadvantage and ethnicity illustrate the effects of structural violence. Structural violence is defined as the "constraint on human potential caused by economic and political structures" and represents a "violence of injustice and inequity [that is] embedded in ubiquitous social structures [and] normalized by stable institutions and regular experience."[24,25] Structural violence can be seen in the unequal access to resources, political power, education, and health care between individuals of different races, ethnicities, gender identities, migrant/refugee statuses, and socioeconomic statuses.[25] Within the context of health and well-being, this inequity often leads to a greater number of avoidable deaths, illnesses, and injuries in certain marginalized populations and/or communities.[26]

1.4 Key Research Questions

To explore the relationship between mechanism of injury, neighborhood disadvantage, and ethnicity for children living within the California-Mexico border region, I posed the following research questions to guide my data analysis:

1. Within the California-Mexico border region, does living in a certain neighborhood place a child at increased risk of certain injuries, regardless of ethnicity, age, and sex?

2. Within the California-Mexico border region, does having Hispanic ethnicity place a child at increased risk of certain injuries, regardless of age, sex, and neighborhood disadvantage?

I hypothesized that children who live in neighborhoods with greater socioeconomic disadvantage were more likely sustain more injuries secondary to motor vehicle accidents and pedestrian versus automobile accidents. Additionally, I hypothesized that children with Hispanic ethnicity were more likely to live in neighborhoods with greater socioeconomic disadvantage than non-Hispanic children, and therefore were at increased risk of sustaining injuries due to motor vehicle accidents and pedestrian versus automobile accidents. These hypotheses were formulated based upon previous studies which have highlighted the high rate of motor vehicle accidents within the US-Mexico border region, poor education in and inappropriate use of child safety restraints in minority groups and those with low socioeconomic status, and higher rates of child pedestrian collisions in poor neighborhoods those with Latinx ethnicity.[27–29]

1.5 Purpose of Study

Socioeconomic disadvantage can have a significant impact on a child's health and their health outcomes, however this important determinant of health is often overlooked. Because the California-Mexico border region contains populations of widely disparate socioeconomic statuses, it is important to consider the influence of socioeconomic disadvantage on various health care outcomes within this region as a health care provider. No prior study has reported the incidence of traumatic injuries of children within this unique region nor studied these injuries within the context of socioeconomic disadvantage. Thus, this analysis could provide insight into

disparities that may exist within similar regions. Results gained from such an analysis can also allow health care providers and public health officials to identify vulnerable populations and allocate resources accordingly.

Therefore, the purpose of this study was to determine what types of injuries are most commonly sustained by children within the California-Mexico border region and to identify which children are at increased risk for certain types of injuries based upon neighborhood disadvantage in an effort to direct funding and inform the development of local initiatives and policies aimed at improving pediatric trauma outcomes within this region by addressing root causes of structural violence and social suffering.[26]

2. Study Methodology

We performed a retrospective review of all patients ≤ 18 years of age living within the California-Mexico border region that were injured and evaluated in a Trauma Activation at a Level I Pediatric Trauma Center between January 1, 2008 and December 31, 2018. All data were obtained from the Rady Children's Hospital San Diego Trauma Registry, which is a prospectively maintained database.

In order to include only patients living within the California-Mexico border region, I first created a list of zip codes within the California-Mexico border region. This list included 5-digit zip codes 92227, 92231, 92233, 92243, 92249, 92250, 92251, 92257, 92259, 92266, 92274, 92275, 92281, 92283, as well as those beginning with 919, 920, and 921. Patients whose home addresses matched one of these zip codes were included in the data collection. Patients with incomplete or unavailable zip codes and those whose home zip code did not match any of the zip codes listed were excluded from this study. Additionally, due to the ADI database only including data correlating to 9-digit zip codes within the United States, patients whose address did not have a 9-digit zip code and patients not residing in the United States were not included in the ADI analysis.

Comprehensive data collected included patient age, sex, race, ethnicity, preferred language, home address including zip code, year of admission, mechanism of injury, Abbreviated Injury Scale (AIS), Injury Severity Score (ISS), intensive care unit (ICU) length of stay (LOS), hospital LOS, complications (delay in physician response, delay in trauma team activation, error in diagnosis, delay in diagnosis, failed non-operative management, delay to the operating room), discharge location, readmission, and mortality. For the focus of this project, our analysis included patient age, sex, ethnicity, home address with 9 digit zip code, year of

admission, and mechanism of injury. Mechanism of injury (MOI) was categorized as either blunt or penetrating. Further subgrouping of MOI was performed and is listed in Table 1. Patient address was then used to correlate data to neighborhood socioeconomic disadvantage level using the Area Deprivation Index (ADI).

Table 1. Mechanism of Injury Subgrouping

Mechanism of Injury Subgroup
Falls
Motor Vehicle Accident / Motor Vehicle Collision (MVA/MVC)
Off-Road Vehicle Accident (golf cart, dirt bike, and all-terrain vehicle accidents)
Non-Motorized Vehicle Accident (bicycle accident / scooter accident / skateboard accident)
Pedestrian versus Automobile (Peds vs. Auto)
Bicycle versus Automobile (Bike vs. Auto)
Sports-Related Injury
Non-Accidental Trauma (assault, self harm, child abuse, non-accidental firearm related injury)
Other (collision, drowning, suffocation, watercraft accident, injury by animal, accidental firearm-related injury, other)

2.1 The Area Deprivation Index

In order to examine the relationship between socioeconomic status and pediatric traumatic injuries within the California-Mexico border region, we chose to utilize the Area Deprivation Index (ADI). The ADI was first developed in 2003 in an effort to better understand the relationship between community socioeconomic measures and health outcomes.[30] By combining several key metrics from social and economic domains into a single measure, Singh, et al. felt that the ADI would better "reflect the multidimensional characterization of a community's socioeconomic position".[30] This index was later adapted by Kind et al. in 2018 to

Table 2. ADI Socioeconomic Domains and Individual Indicators

Socioeconomic Domain		Individual Indicator
Education		Percent of the population aged ≥ 25 years with < 9 years of education
		Percent aged ≥ 25 years with greater than or equal to a high school diploma
Economic	Poverty	Percent of families below the poverty level
		Percent of population below 150% of the poverty threshold
	Employment	Percent of employed persons ≥ 16 years of age in white-collar occupations
		Percent of civilian labor force population ≥ 16 years of age unemployed (unemployment rate)
	Income	Median family income
		Income disparity
Housing		Median home value
		Median gross rent
		Median monthly mortgage
		Percent owner-occupied housing units
		Percent of occupied housing units without a telephone
		Percent of occupied housing units without complete plumbing
		Percent of occupied housing units with more than one person per room (crowding)
Social		Percent of single-parent households with children < 18 years of age
Transportation		Percent of occupied housing units without a motor vehicle

provide neighborhood-level data and make the data "more accessible to policymakers, researchers, patients, caregivers, and clinicians."[31] The adapted ADI ranks neighborhoods by socioeconomic disadvantage in a region of interest and determines neighborhood disadvantage level based upon 17 indicators from American Community Survey (ACS) data within education, economic, housing, social, and transportation socioeconomic domains (Table 2).[31] The ADI has already been correlated with various health outcomes, such as pediatric burn injury severity and pediatric access to surgical care, however it has not previously been used to determine the relationship between neighborhood disadvantage level and health care outcomes for pediatric trauma patients, much less those living in the California-Mexico border region.[32,33]

For the purposes of this study, ADI ranking were divided into quintiles based upon national ranking adjusted for the state of California and the scores of our study cohort, with higher quintiles representing greater socioeconomic disadvantage (Table 3).

Table 3. Trauma Encounters by ADI Quintile

Quintile	Area Deprivation Index Score	Trauma Encounters, n (%)
1 (least socioeconomic disadvantage)	1-5%	1,904 (19.6%)
2	6-10%	1,784 (18.4%)
3	11-15%	1,885 (19.4%)
4	16-22%	2,017 (20.8%)
5 (greatest socioeconomic disadvantage)	23-99%	2,125 (21.9%)

2.2 Outcome Measures

Primary outcome was mechanism of injury by neighborhood disadvantage, as determined by ADI. Secondary outcomes included mechanism of injury by patient age and mechanism of injury by patient ethnicity (Hispanic versus non-Hispanic). Subgroup analysis was performed based upon patient age (<5 years, 5-9 years, 10-14 years, 15-18 years) and ethnicity (Hispanic, non-Hispanic). Patients missing data on ethnicity (n=164) were not included in the ethnicity subgroup analysis.

2.3 Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics 25 (International Business Machines Corp., Armonk NY) and Stata 16 software (StateCorp., College Station TX). Student t-test was used for continuous data and Chi-squared test was used for categorical data. A p value of <0.05 was considered to be statistically significant. Multivariate logistic regression modeling was performed to assess the relationship between mechanism of injury, neighborhood socioeconomic disadvantage (ADI), and patient ethnicity.

Chapter 3. Study Findings

3.1 Overall Findings

A total of 10,036 children were injured and evaluated in a Trauma Activation at a Southern California Level I Pediatric Trauma Center during the 11-year study interval. Of those, 9,715 children met inclusion criteria and were included in the final analysis. Median patient age was 7.4 years (± 5.1 years) and a majority of trauma activations involved injured children who were male (65.2%) and non-Hispanic (54.9%) (Table 4). The majority of pediatric traumatic injuries were attributable to falls, motor-vehicle accidents and collisions, and pedestrian versus automobile accidents (Table 4).

The annual number of trauma encounters decreased over the 11-year study period, with the highest number of encounters in 2008 (n=1,071) and the lowest in 2018 (n=682) (Figure 1). The number of injuries due to falls, pedestrian versus automobile accidents, bicycle versus automobile accidents, non-motorized vehicular accidents, off-road vehicle accidents, and sports-related injuries declined over the study period, however rates of motor vehicle accidents and collisions increased over this time (Figure 2).

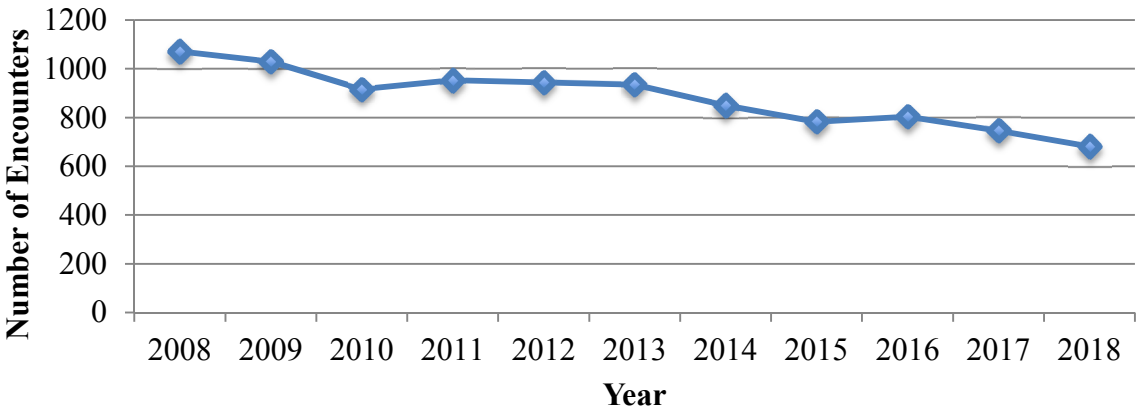


Figure 1. Overall Pediatric Trauma Patient Encounters

Table 4. Overall Demographics

Characteristic	Trauma Encounters, n (%) Total n = 9,715
Age Group	
<4 years	3,542 (36.5%)
5-9 years	2,256 (23.2%)
10-14 years	3,422 (35.2%)
15-18 years	495 (5.1%)
Sex	
Male	6,338 (65.2%)
Ethnicity	
Hispanic	4,307 (45.1%)
Non-Hispanic	5,244 (54.9%)
Mechanism of Injury	
Blunt	9,347 (96.2%)
Penetrating	368 (3.8%)
Mechanism of Injury Subcategory	
Fall	3,656 (37.6%)
Motor Vehicle Accident / Motor Vehicle Collision	1,354 (13.9%)
Pedestrian vs. Automobile	973 (10.0%)
Non-Motorized Vehicle Accident	867 (8.9%)
Sports-Related Injury	653 (6.7%)
Off-Road Vehicle Accident	541 (5.6%)
Non-Accidental Trauma	516 (5.3%)
Bicycle vs. Automobile	294 (3.0%)
Other	865 (8.9%)

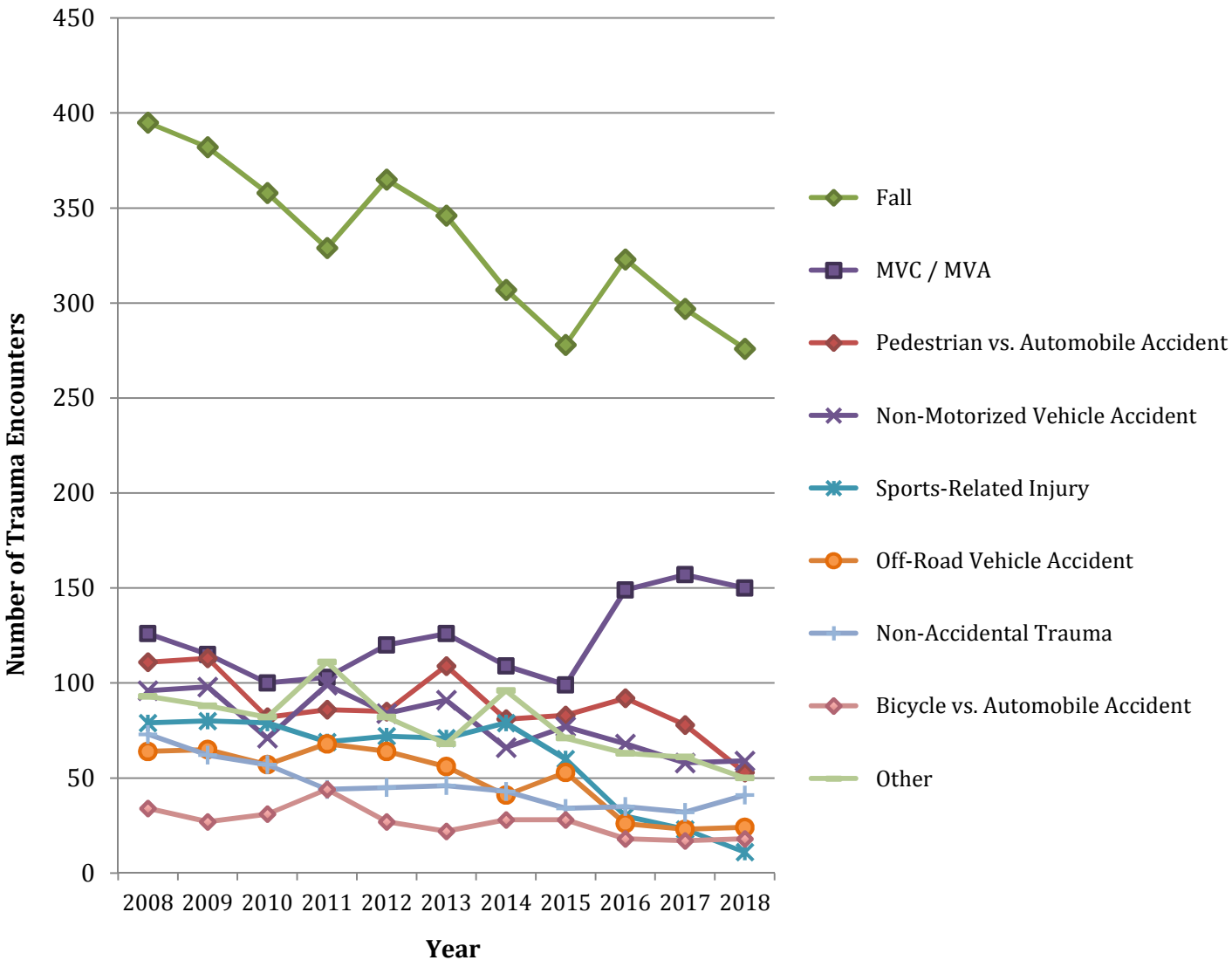


Figure 2. Pediatric Trauma Encounters by Year and Mechanism of Injury

3.2 Mechanism of Injury by Age Group

Most injured children were less than 5 years of age (36.0%) or between the ages of 10 and 14 years (35.2%) (Figure 3). Of the age groups that presented with the greatest number of injuries, younger children (age <5 years) appeared to be at greatest risk of injury due to falls and non-accidental trauma, while older children (10-14 years) were more likely to sustain injuries due to non-motorized vehicle accidents, bicycle versus automobile accidents, pedestrian versus

automobile accidents, off-road vehicle accidents, and sports-related injuries (Table 5). The 15-18 year age group included the fewest number of traumatic injuries compared to all other age groups (5%). Injuries sustained due to MVA/MVC were most common in children aged 5 to 9 years (36%), followed closely by children aged 10-14 years (31%).

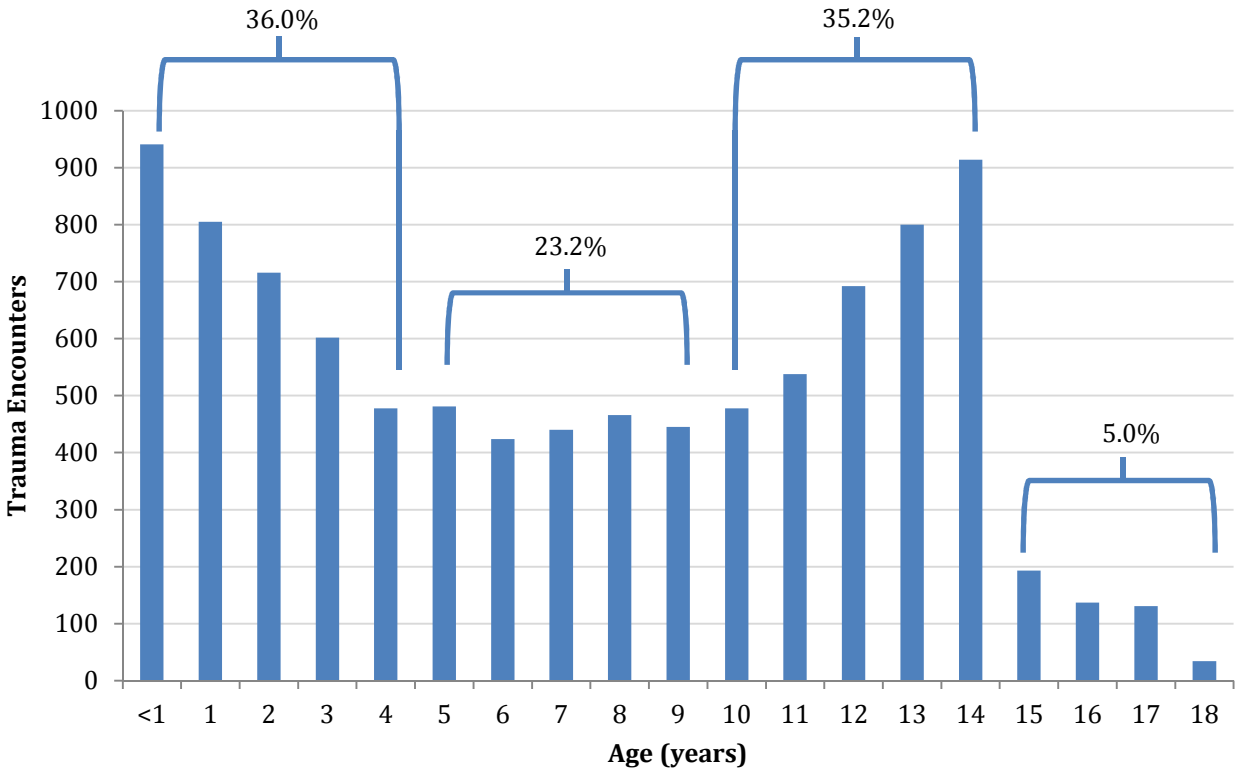


Figure 3. Distribution of Patient Age in Years for Trauma Encounters, 2008-2018

Falls were the most common mechanism of injury for all children under the age of 14 years (Table 5). The second- and third-most common injury mechanisms of children younger than 9 years of age were MVA/MVC (14.9%) and pedestrian versus automobile accidents (9.6%), respectively. For children between the ages of 10 and 14 years, the second- and third-most common mechanisms of injury were non-motorized vehicle accidents (16.6%) and sports-

related injuries (14.4%), respectively. Finally, children aged 15 to 18 most often sustained injuries due to sports (17.2%) or off-road vehicle accidents (16.2%).

Table 5. Mechanism of Injury by Age Group

Injury Mechanism	Age <5 Years, n (%)	Age 5-9 Years, n (%)	Age 10-14 Years, n (%)	Age 15-18 Years, n (%)
Fall	2,191 (61.9%)	783 (34.7%)	606 (17.7%)	76 (15.4%)
MVA/MVC	373 (10.5%)	492 (21.8%)	419 (12.2%)	70 (14.1%)
Peds vs. Auto	268 (7.6%)	291 (12.9%)	372 (10.9%)	42 (8.5%)
Non-Motorized Vehicle Accident	47 (1.3%)	201 (8.9%)	569 (16.6%)	50 (10.1%)
Sport-Related Injury	13 (0.4%)	64 (2.8%)	491 (14.4%)	85 (17.2%)
Off-Road Vehicle Accident	19 (0.5%)	94 (4.2%)	348 (10.2%)	80 (16.2%)
Non-Accidental Trauma	235 (6.6%)	44 (2.0%)	185 (5.4%)	48 (9.7%)
Bike vs. Auto	11 (0.3%)	80 (3.6%)	183 (5.4%)	20 (4.0%)
Other	385 (10.9%)	207 (9.2%)	249 (7.3%)	24 (4.9%)
Total	3,542	2,256	3,422	495

3.3. Neighborhood Disadvantage

Injured children living in the California-Mexico border were more likely to live in more disadvantaged neighborhoods than less disadvantaged neighborhoods (43% in Quintiles 4 & 5 vs. 38% in Quintiles 1 & 2). Additionally, injured children living in more disadvantaged neighborhoods tended to be younger than those living in less disadvantaged neighborhoods. Nearly half of injured children under the age of 10 years (46%) lived in neighborhoods with greater socioeconomic disadvantage (Quintiles 4 & 5) while 35% lived in neighborhoods with the less socioeconomic disadvantage (Quintiles 1 &2). Comparatively, 42% of children 10 years of age and older lived in neighborhoods with less socioeconomic disadvantage (Quintiles 1 & 2)

Table 6. Mechanism of Injury by ADI Quintile

ADI Quintile	Mechanism of Injury, n (%)								
	Fall	Non-Motorized Vehicle Accident	Sports-Related Injury	Non-Accidental Trauma	Peds vs. Auto	MVA/ MVC	Off-Road Vehicle Accident	Bike vs. Auto	Other
1	809 (42%)	232 (12%)	209 (11%)	50 (3%)	89 (5%)	151 (8%)	124 (7%)	49 (3%)	191 (10%)
2	661 (37%)	166 (9%)	145 (8%)	74 (4%)	146 (8%)	254 (14%)	124 (7%)	54 (3%)	160 (9%)
3	665 (35%)	166 (9%)	123 (7%)	106 (6%)	194 (10%)	301 (16%)	100 (5%)	57 (3%)	163 (9%)
4	744 (37%)	171 (8%)	88 (4%)	130 (6%)	245 (12%)	336 (17%)	88 (4%)	64 (3%)	151 (7%)
5	766 (36%)	132 (6%)	88 (4%)	153 (7%)	299 (14%)	312 (15%)	105 (5%)	70 (3%)	200 (9%)

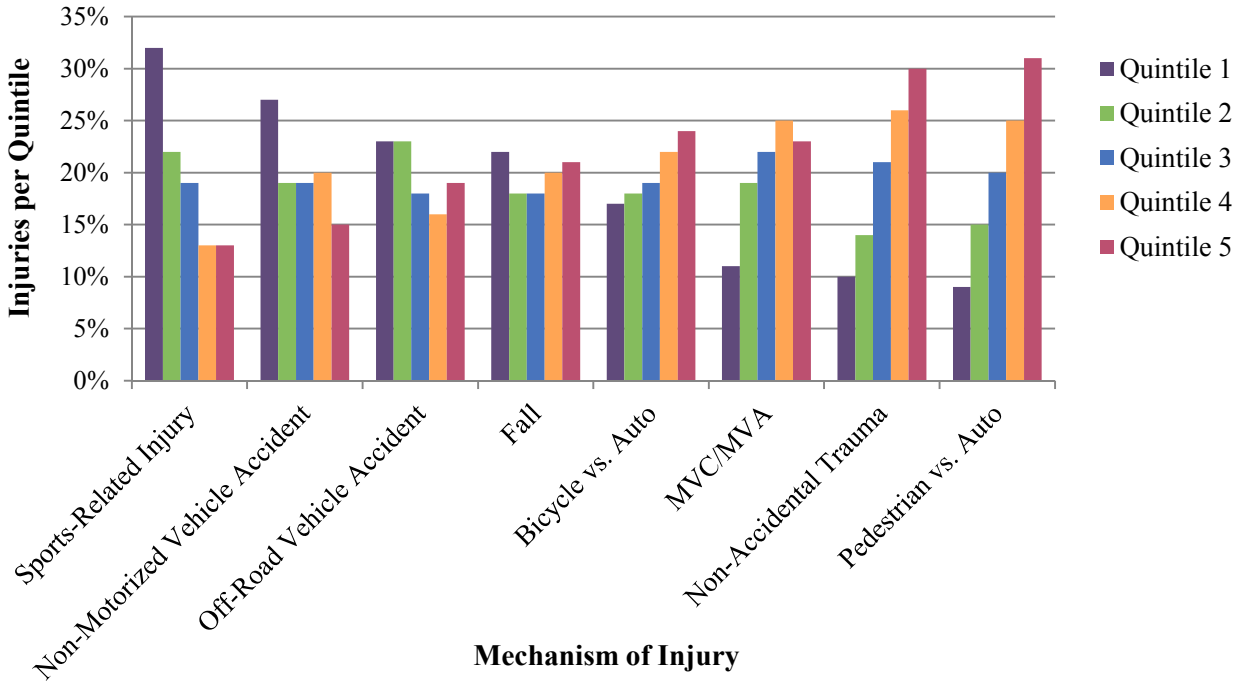


Figure 4. Mechanism of Injury by Area Deprivation Index (ADI) Quintile

while 38% lived in neighborhoods with the greater socioeconomic disadvantage (Quintiles 4 & 5).

There were markedly different injury mechanisms between neighborhoods with greater socioeconomic disadvantage (higher ADI) and those with less socioeconomic disadvantage (Figure 4). Overall, the vast majority of injuries were due to a blunt mechanism (96.2%) and falls were the most common mechanism of injury within each quintile (Table 6). However, children living in neighborhoods of least socioeconomic disadvantage (Quintile 1) were more likely to experience injuries due to non-motorized vehicle accidents (12.2%) and sports (11.0%) while children living in neighborhoods with greater socioeconomic disadvantage (Quintiles 2–5) were more likely to experience injuries due to a MVA/MVC (14.2%–16.7%), pedestrian versus automobile accidents (8.2%–14.1%), and non-accidental trauma (4.1%–7.2%).

Non-accidental trauma, pedestrian versus automobile accidents, and MVA/MVC injuries increased with increasing neighborhood socioeconomic disadvantage, while non-motorized vehicle accidents and sports-related injuries decreased with increasing neighborhood socioeconomic disadvantage (Figure 4). Injuries due to falls, off-road vehicle accidents, and bicycle versus automobile accidents were similar between ADI Quintiles (Figure 4).

3.3.1 Neighborhood Disadvantage by Age Group

Across all ADI Quintiles, the most common mechanisms of injury for children less than 9 years of age were falls and MVA/MVC. Within the 5 – 9 year age group, children living in neighborhoods with less socioeconomic disadvantage were more likely to sustain injuries due to non-motorized vehicle accidents while those living in more socioeconomically disadvantaged neighborhoods were more likely to sustain injuries due to pedestrian versus automobile

accidents. Across all age groups, children living in more socioeconomically disadvantaged neighborhoods were more likely to sustain injuries due to non-accidental trauma (Table 7). Overall, children and adolescents living within neighborhoods with less socioeconomic disadvantage (Quintiles 1 & 2) sustained a greater percentage of injuries due to falls as compared to those from neighborhoods of greater socioeconomic disadvantage (Quintiles 4 & 5) (Figure 5). Conversely, those living within neighborhoods with greater socioeconomic disadvantage (Quintiles 4 & 5) sustained a greater percentage of injuries due to MVA/MVC, pedestrian versus automobile accidents, and non-accidental trauma compared to those living in neighborhoods with less socioeconomic disadvantage (Quintiles 1 & 2) (Figure 5).

Within the 15 – 18 year age group, the most common mechanisms of injury were sport-related injuries, falls, off-road vehicle accidents, and MVA/MVC, across all ADI quintiles (Table 7). Adolescents aged 15 to 18 years living in neighborhoods of less socioeconomic disadvantage (Quintiles 1 & 2) were more likely to present with sports-related injuries and injuries related to falling, whereas those living in neighborhoods with greater socioeconomic disadvantage (Quintiles 4 & 5) were more likely to present with injuries due to pedestrian versus automobile accidents, bicycle versus automobile accidents, and non-accidental trauma (Figure 5).

Table 7. Mechanism of Injury by ADI Quintile and Age Group

	Non-Motorized Vehicle Accident	Bike vs. Auto	Peds vs. Auto	Fall	MVA/MVC	Non-Accidental Trauma	Off-Road Vehicle Accident	Sports-Related Injury	Other
Age <5 Years									
Quintile 1, n (%)	10 (1.8%)	3 (0.5%)	29 (5.2%)	410 (72.8%)	33 (5.9%)	21 (3.7%)	1 (0.2%)	2 (0.4%)	54 (9.6%)
Quintile 2, n (%)	11 (1.7%)	4 (0.6%)	44 (6.9%)	393 (62.0%)	66 (10.4%)	38 (6.0%)	1 (0.2%)	1 (0.2%)	76 (12.0%)
Quintile 3, n (%)	7 (1.0%)	0 (0.0%)	50 (7.4%)	412 (61.0%)	85 (12.6%)	44 (6.5%)	4 (0.6%)	0 (0.0%)	73 (10.8%)
Quintile 4, n (%)	8 (1.0%)	2 (0.3%)	55 (7.1%)	471 (61.0%)	92 (11.9%)	57 (7.4%)	5 (0.6%)	6 (0.8%)	76 (9.8%)
Quintile 5, n (%)	11 (1.2%)	2 (0.2%)	90 (10.0%)	505 (56.2%)	97 (10.8%)	75 (8.4%)	8 (0.9%)	4 (0.4%)	106 (11.8%)
Age 5 – 9 Years									
Quintile 1, n (%)	52 (12.3%)	12 (2.8%)	23 (5.4%)	205 (48.5%)	48 (11.3%)	7 (1.7%)	15 (3.5%)	18 (4.3%)	43 (10.2%)
Quintile 2, n (%)	44 (10.8%)	14 (3.4%)	36 (8.9%)	135 (33.3%)	95 (23.4%)	5 (1.2%)	26 (6.4%)	14 (3.4%)	37 (9.1%)
Quintile 3, n (%)	35 (8.2%)	12 (2.8%)	50 (11.7%)	136 (31.9%)	106 (24.9%)	10 (2.3%)	18 (4.2%)	13 (3.1%)	46 (10.8%)
Quintile 4, n (%)	39 (7.6%)	22 (4.3%)	87 (17.1%)	152 (29.8%)	136 (26.7%)	8 (1.6%)	14 (2.7%)	12 (2.4%)	40 (7.8%)
Quintile 5, n (%)	31 (6.4%)	20 (4.2%)	95 (19.8%)	145 (30.1%)	107 (22.2%)	14 (2.9%)	21 (4.4%)	7 (1.5%)	41 (8.5%)
Age 10 – 14 Years									
Quintile 1, n (%)	158 (19.5%)	31 (3.8%)	34 (4.2%)	170 (21.0%)	58 (7.2%)	21 (2.6%)	88 (10.9%)	164 (20.2%)	86 (10.6%)
Quintile 2, n (%)	104 (16.2%)	32 (5.0%)	57 (8.9%)	116 (18.0%)	79 (12.3%)	23 (3.6%)	80 (12.4%)	109 (17.0%)	43 (6.7%)
Quintile 3, n (%)	110 (16.4%)	44 (6.6%)	84 (12.5%)	105 (15.6%)	89 (13.3%)	39 (5.8%)	65 (9.7%)	96 (14.3%)	39 (5.8%)
Quintile 4, n (%)	112 (17.6%)	37 (5.8%)	91 (14.3%)	107 (16.8%)	93 (14.6%)	54 (8.5%)	54 (8.5%)	56 (8.8%)	33 (5.2%)
Quintile 5, n (%)	85 (12.9%)	39 (5.9%)	106 (16.0%)	107 (16.2%)	100 (15.1%)	49 (7.4%)	61 (9.2%)	66 (10.0%)	48 (7.3%)
Age 15 – 18 Years									
Quintile 1, n (%)	12 (11.1%)	3 (2.8%)	3 (2.8%)	24 (22.2%)	12 (11.1%)	1 (0.9%)	20 (18.5%)	25 (23.1%)	8 (7.4%)
Quintile 2, n (%)	7 (6.9%)	4 (4.0%)	9 (8.9%)	17 (16.8%)	14 (13.9%)	8 (7.9%)	17 (16.8%)	21 (20.8%)	4 (4.0%)
Quintile 3, n (%)	14 (13.6%)	1 (1.0%)	10 (9.7%)	12 (11.7%)	21 (20.4%)	13 (12.6%)	13 (12.6%)	14 (13.6%)	5 (4.9%)
Quintile 4, n (%)	12 (12.2%)	3 (3.1%)	12 (12.2%)	14 (14.3%)	15 (15.3%)	11 (11.2%)	15 (15.3%)	14 (14.3%)	2 (2.0%)
Quintile 5, n (%)	5 (5.9%)	9 (10.6%)	8 (9.4%)	9 (10.6%)	8 (9.4%)	15 (17.6%)	15 (17.6%)	11 (12.9%)	5 (5.9%)

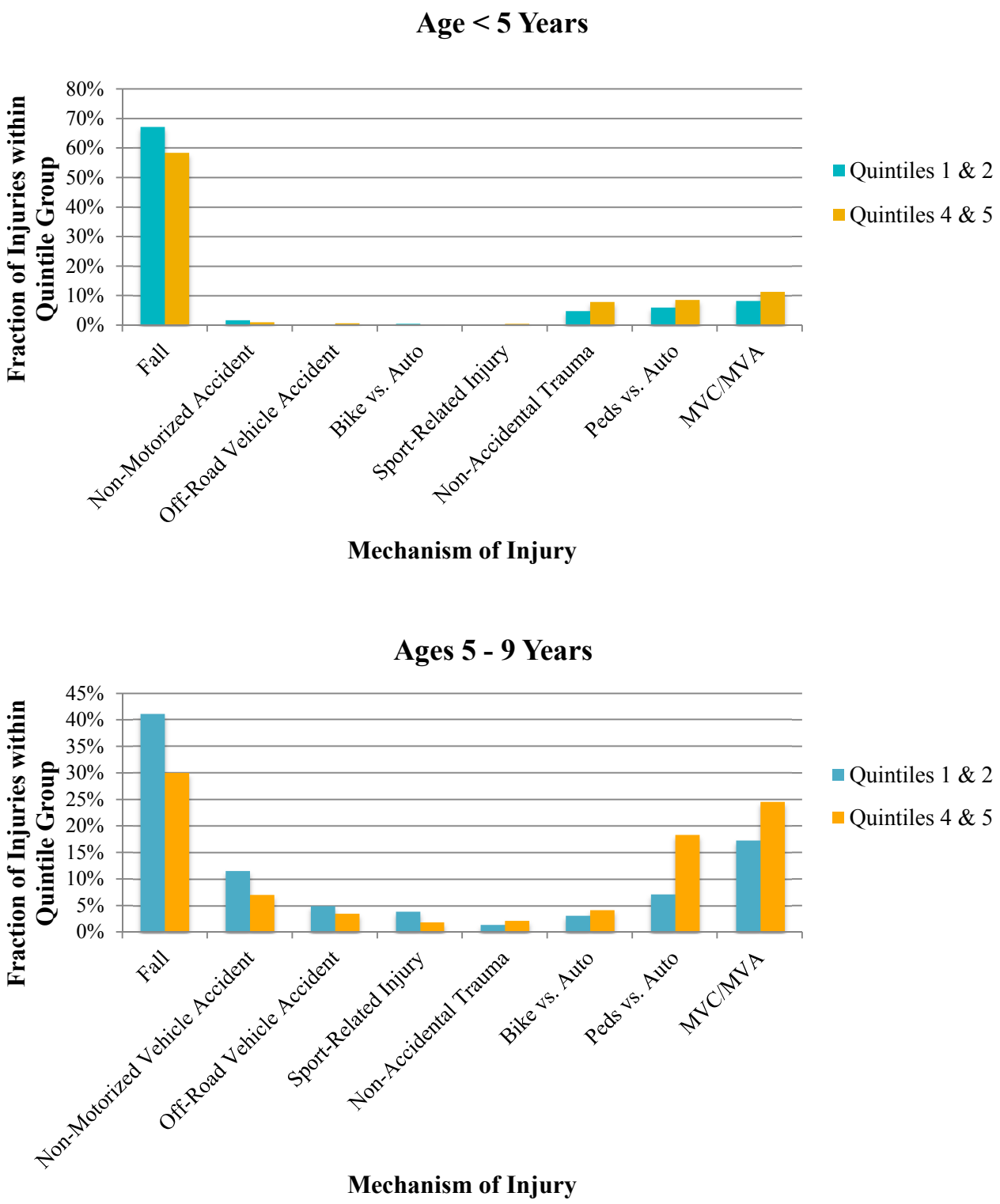
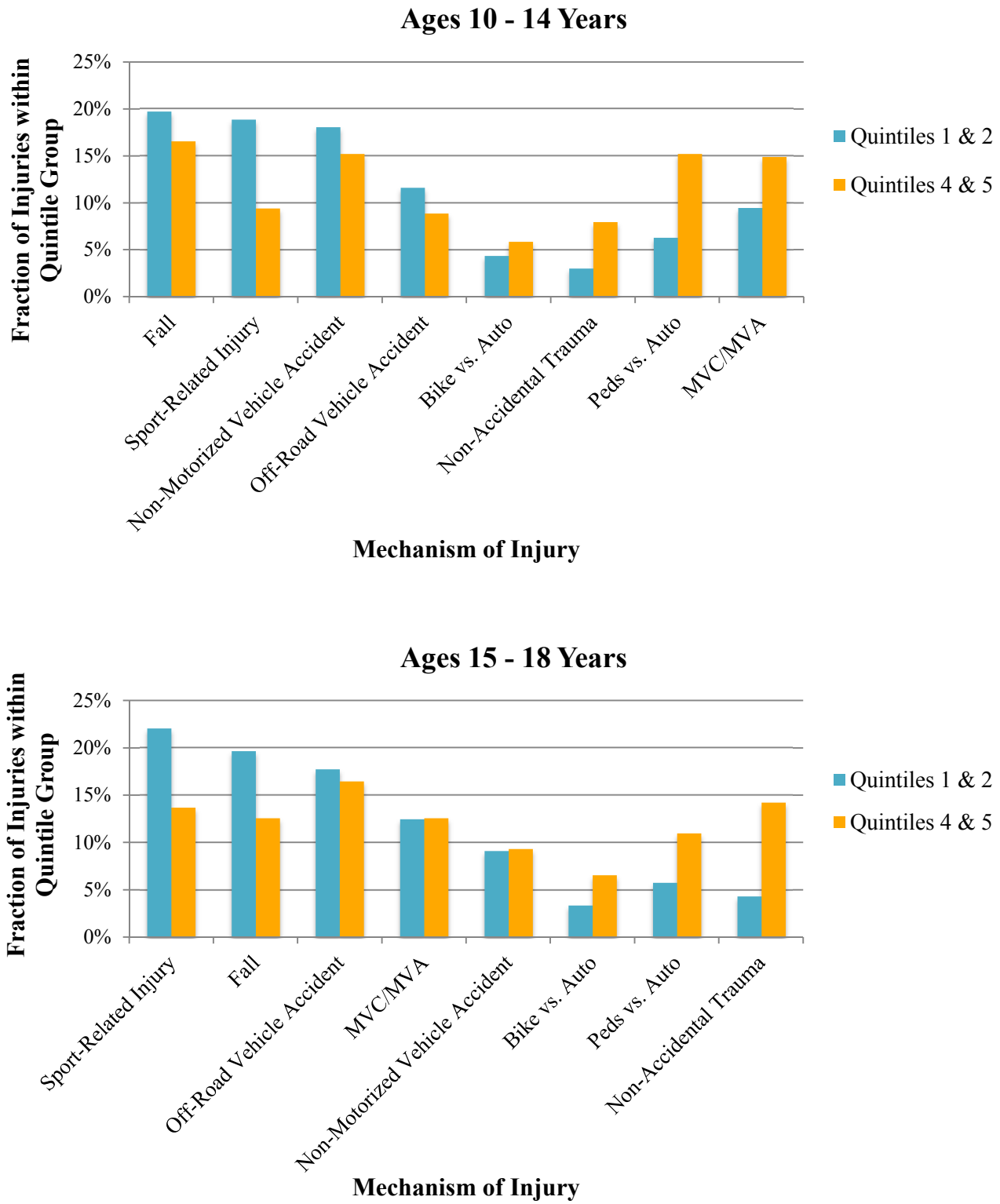


Figure 5. Mechanism of Injury by Age Group and ADI Quintile Grouping

Figure 5. Continued



3.4. Hispanic Ethnicity

Injured children less than 5 years of age were more often Hispanic ($p<0.001$), and those between the ages 10 and 14 years were more often Non-Hispanic ($p<0.001$) (Table 8). Additionally, injured Hispanic children more often lived in neighborhoods with greater socioeconomic disadvantage as compared to non-Hispanic children (Table 8).

Falls were the most common mechanism of injury for both Hispanic (37%) and non-Hispanic children (38%). However, Hispanic children experienced a significantly higher percentage of injuries due to MVA/MVC, pedestrian versus automobile accidents, and non-accidental trauma as compared to non-Hispanic children while non-Hispanic children experienced a higher percentage of injuries due to non-motorized vehicle accidents, sports, and off-road vehicle accidents, comparatively (Table 9, Figure 6).

Table 8. Age Group and ADI Quintile by Hispanic and Non-Hispanic Ethnicity Subgroups

	Hispanic	**Non-Hispanic**	***p* value**
Age, n (%)			
<5 Years	1748 (40.0%)	1784 (33.7%)	<0.001
5-9 Years	1040 (23.8%)	1205 (22.8%)	0.24
10-14 Years	1365 (31.2%)	2027 (38.3%)	<0.001
15-18 Years	216 (4.9%)	272 (5.1%)	0.66
ADI, n (%)			
Quintile 1	332 (7.6%)	1560 (29.5%)	<0.001
Quintile 2	614 (14.1%)	1158 (21.9%)	<0.001
Quintile 3	822 (18.8%)	1055 (20.0%)	0.16
Quintile 4	1151 (26.3%)	853 (16.1%)	<0.001
Quintile 5	1450 (33.2%)	662 (12.5%)	<0.001

Table 9. Mechanism of Injury by Hispanic and Non-Hispanic Ethnicity Subgroups

	Hispanic	Non-Hispanic	*p* value
Mechanism of Injury			
Fall	1627 (37.2%)	2009 (38%)	0.45
MVA/MVC	698 (16.0%)	647 (12.2%)	<0.001
Peds vs. Auto	528 (12.1%)	437 (8.3%)	<0.001
Non-Motorized Vehicle Accident	351 (8.0%)	512 (9.7%)	<0.01
Non-Accidental Trauma	275 (6.3%)	233 (4.4%)	<0.001
Sport-Related Injury	208 (4.8%)	439 (8.3%)	<0.001
Off-Road Vehicle Accident	171 (3.9%)	366 (6.9%)	<0.001
Bike vs. Auto	134 (3.1%)	160 (3.0%)	0.91
Other	377 (8.6%)	485 (9.2%)	0.35

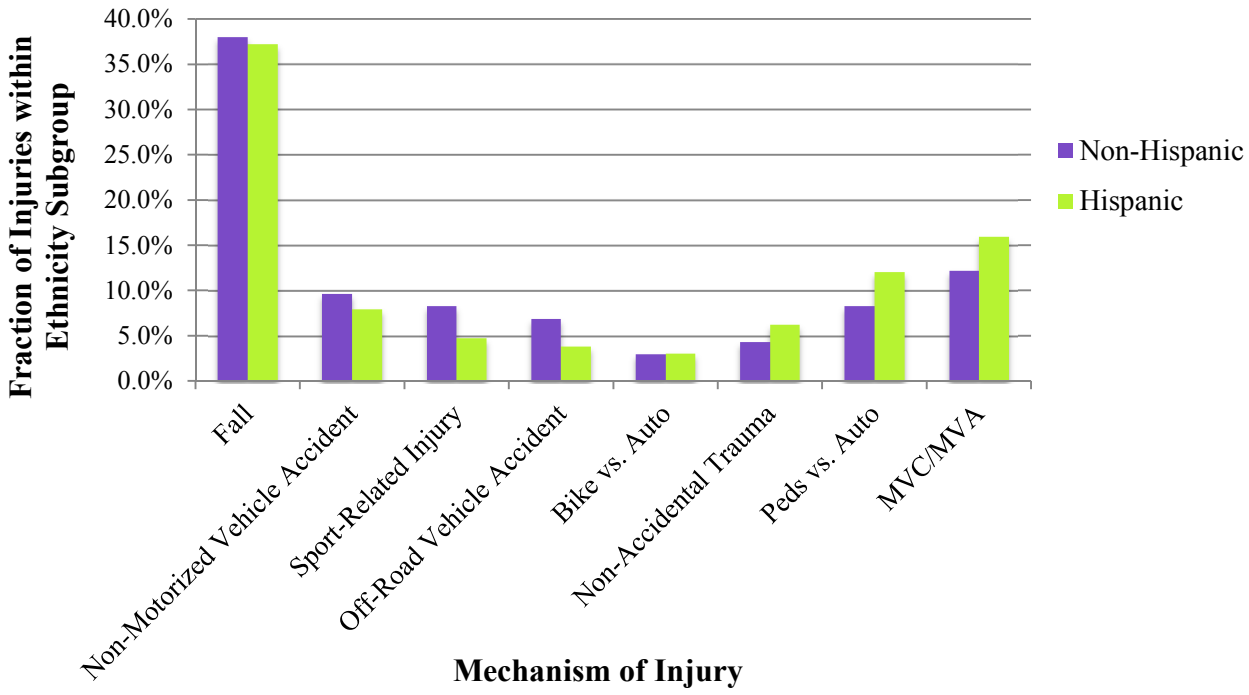


Figure 6. Mechanism of Injury by Hispanic and Non-Hispanic Ethnicity Subgroups

3.5 Multivariate Logistic Regression Analysis

3.5.1 Falls

Children who were younger and female were more likely to present to the hospital with injuries sustained from falling (Table 10). Additionally, children living in the least disadvantaged neighborhoods (Quintile 1) were found to have greater odds of presenting to the hospital with injuries sustained from falling as compared to children living within neighborhoods with greater socioeconomic disadvantage (Quintiles 2-5). Patient ethnicity was not found to contribute significantly to a child's odds of presenting to the hospital due to an injury sustained from falling.

Table 10. Logistic Regression Analysis of Injury Due to Falling

Covariate	**Odds Ratio (95% Confidence Interval)**
Age (continuous, in years)	
Age	0.83 (0.82-0.83)
Sex	
Male	1.00
Female	1.18 (1.07-1.30)
Ethnicity	
Non-Hispanic	1.00
Hispanic	0.94 (0.85-1.03)
ADI Quintile	
Quintile 1	1.00
Quintile 2	0.66 (0.57-0.77)
Quintile 3	0.61 (0.53-0.71)
Quintile 4	0.59 (0.51-0.69)
Quintile 5	0.56 (0.48-0.65)

3.5.2 Motor Vehicle Accidents/Motor Vehicle Collisions

Children living in Quintiles 2 – 5 had approximately twice the odds of presenting to the hospital after sustaining injuries due to being involved in an MVA/MVC as patients living Quintile 1 (least neighborhood disadvantage) (Table 11). Female patients had almost twice the odds of being involved in a MVA/MVC (OR 1.92, 95% CI 1.01-1.04) and Hispanic patients had higher odds of being injured in a MVA/MVC than non-Hispanic patients (OR 1.22, 95% CI 1.08-1.38). Increasing age was also found to be associated with increased odds of being injured in a MVA/MVC (1.02, 95% CI 1.01-1.03), however this was to a lesser extent than level of neighborhood socioeconomic disadvantage and patient ethnicity.

Table 11. Logistic Regression Analysis of Injury Due to MVA/MVC

Covariate	Odds Ratio (95% Confidence Interval)
Age (continuous, in years)	
Age	1.02 (1.01-1.03)
Sex	
Male	1.00
Female	1.92 (1.01-1.04)
Ethnicity	
Non-Hispanic	1.00
Hispanic	1.22 (1.08-1.38)
ADI Quintile	
Quintile 1	1.00
Quintile 2	1.91 (1.54-2.38)
Quintile 3	2.17 (1.46-2.69)
Quintile 4	2.27 (1.83-2.80)
Quintile 5	1.88 (1.51-2.34)

3.5.3 Pedestrian versus Automobile Accidents

Older and Hispanic children were found to have higher odds of sustaining injuries due to a pedestrian versus automobile accident (Table 12). Similar to MVA/MVC, children living in the most advantaged neighborhoods (Quintile 1) were the least likely to sustain injuries due to a pedestrian versus automobile accident. Odds of being involved in a pedestrian versus automobile accidents increased with increasing neighborhood disadvantage (Table 12). Patient sex was not found to contribute significantly to a child's odds of presenting to the hospital due to an injury sustained from a pedestrian versus automobile accident.

Table 12. Logistic Regression Analysis of Injury Due to Pedestrian versus Automobile Accident

Covariate	**Odds Ratio (95% Confidence Interval)**
Age (continuous, in years)	
Age	1.04 (1.02-1.05)
Sex	
Male	1.00
Female	1.13 (0.97-1.30)
Ethnicity	
Non-Hispanic	1.00
Hispanic	1.22 (1.05-1.41)
ADI Quintile	
Quintile 1	1.00
Quintile 2	1.75 (1.33-2.31)
Quintile 3	2.21 (1.70-2.89)
Quintile 4	2.68 (2.06-3.48)
Quintile 5	3.20 (2.47-4.14)

3.5.4 Bicycle versus Automobile Accidents

Children who were older, male, and living in the neighborhoods with greatest socioeconomic disadvantage (Quintile 5) had higher odds of presenting to the hospital with injuries due to a bicycle versus automobile accident (Table 13). Patient ethnicity was not found to contribute significantly to a child's odds of presenting to the hospital due to an injury sustained from a bicycle versus automobile accident.

Table 13. Logistic Regression Analysis of Injury Due to Bicycle versus Automobile Accident

Covariate	**Odds Ratio (95% Confidence Interval)**
Age (continuous, in years)	
Age	1.16 (1.13-1.19)
Sex	
Male	1.00
Female	0.46 (0.34-0.62)
Ethnicity	
Non-Hispanic	1.00
Hispanic	1.02 (0.79-1.30)
ADI Quintile	
Quintile 1	1.00
Quintile 2	1.26 (0.84-1.87)
Quintile 3	1.26 (0.84-1.87)
Quintile 4	1.43 (0.96-1.12)
Quintile 5	1.53 (1.03-2.27)

3.5.5 Non-Accidental Trauma

Odds of presenting to the hospital due to injuries sustained from non-accidental trauma (assault, self harm, and firearm-related injury) increased with increasing neighborhood disadvantage, regardless of patient ethnicity, age, and sex (Table 14). Patient age, sex, and ethnicity were not found to contribute significantly to a child's odds of presenting to the hospital due to an injury sustained from a non-accidental trauma.

Table 14. Logistic Regression Analysis of Injury Due to Non-Accidental Trauma

Covariate	Odds Ratio (95% Confidence Interval)
Age (continuous, in years)	
Age	1.00 (0.98-1.01)
Sex	
Male	1.00
Female	0.93 (0.77-1.13)
Ethnicity	
Non-Hispanic	1.00
Hispanic	1.18 (0.97-1.43)
ADI Quintile	
Quintile 1	1.00
Quintile 2	1.58 (1.09-2.29)
Quintile 3	2.13 (1.50-3.03)
Quintile 4	2.45 (1.74-3.47)
Quintile 5	2.67 (1.90-3.79)

3.5.6 Non-Motorized Vehicle Accidents

Children who were older, male, and living in the least disadvantaged neighborhoods (Quartile 1) had higher odds of presenting to the hospital with injuries due to a non-motorized vehicle accident (skateboarding accident, scooter accident, or bicycle accident) (Table 15). Patient ethnicity was not found to contribute significantly to a child's odds of presenting to the hospital due to an injury sustained from a non-motorized vehicle accident.

Table 15. Logistic Regression Analysis of Injury Due to Non-Motorized Vehicle Accident

Covariate	**Odds Ratio (95% Confidence Interval)**
Age (continuous, in years)	
Age	1.18 (1.16-1.20)
Sex	
Male	1.00
Female	0.34 (0.28-0.42)
Ethnicity	
Non-Hispanic	1.00
Hispanic	1.02 (0.87-1.20)
ADI Quintile	
Quintile 1	1.00
Quintile 2	0.77 (0.62-0.96)
Quintile 3	0.71 (0.57-0.89)
Quintile 4	0.75 (0.60-0.94)
Quintile 5	0.54 (0.42-0.69)

Chapter 4: Discussion

4.1 Key Findings

This analysis represents the first study to characterize pediatric trauma injury patterns based upon neighborhood disadvantage, and is the first to investigate the relationship between pediatric mechanism of injury, neighborhood socioeconomic disadvantage, and Hispanic ethnicity within the California-Mexico border region. From this analysis, we discovered several important key findings.

First, we found we found markedly different injury mechanisms for children living in neighborhoods with greater socioeconomic disadvantage as compared to those living in neighborhoods with less socioeconomic disadvantage within the CA-MX border region. Second, we found that greater neighborhood disadvantage and Hispanic ethnicity were independently associated with a child having increased odds of experiencing certain types of injuries. Lastly, we found that the Area Deprivation Index can be a useful resource for identifying disparities in pediatric trauma and those who may benefit from increased resource allocation, social support, and prevention programs.

In the sections that follow, I will explore the potential underlying factors that contribute to the study findings. I will first explore the relationship between mechanism of injury, neighborhood socioeconomic disadvantage, and Hispanic ethnicity in the context of this study's findings and published literature on the subject. Next, I will discuss the potential risk factors and current efforts to address the three most common mechanisms of injury for children and adolescents living within the California-Mexico border region. Finally, I will conclude by providing recommendations for policy, acknowledging the limitations of our work, and

describing the planned work that will continue beyond this initial study in efforts to improve the safety and well being of children within the California-Mexico border region.

4.2 Relationship Between Neighborhood Disadvantage and Pediatric Injury Mechanism

In this study, we found that injured children living in the California-Mexico border were more likely to live in more disadvantaged neighborhoods than less disadvantaged neighborhoods. We also found that injured children living in more disadvantaged neighborhoods tended to be younger than those living in less disadvantaged neighborhoods. These findings are similar to those of previous studies, which have found that children living in more socioeconomically disadvantaged circumstances are more likely to experience unintentional injury than those living in less disadvantaged neighborhoods.[34,35]

Our study also found that children living in neighborhoods with greater socioeconomic disadvantage had markedly different mechanisms of injury as compared to those living in neighborhoods of less socioeconomic disadvantage. After controlling for patient age and ethnicity, children living in more disadvantaged neighborhoods were found to be more likely to present to the hospital with injuries due to MVA/MVC, falling, pedestrian versus automobile accidents, and non-accidental trauma (assault, self harm, and firearm-related injury) while children living in the least socioeconomically disadvantaged neighborhoods were more likely to sustain sports-related injuries and injuries due to non-motorized vehicle accidents.

Social factors, such as lack of parental supervision of children living in neighborhoods with greater socioeconomic disadvantage, may contribute to an increased risk for injury due to falls or non-accidental trauma. Parental supervision and safe living conditions can play an important role in reducing the risk of unintentional injuries at home, and previous studies have

shown that parents living in disadvantaged circumstances may face greater challenges with regard to supervision than parents in advantaged circumstances and may require additional education on child safety or additional support with child care.[36–39] Certain environmental factors may also place a child living in neighborhoods with greater socioeconomic disadvantage at increased risk for injury due to falls and non-accidental trauma. Poverty, crowding, and having a limited area for safe play indoors and outdoors have been associated with increased risk for unintentional injury.[40,41] Certain types of housing, such as living in a rental property, living in poor quality housing, or living in transient housing have also been associated with increased risk for child injury.[41–45]

Environmental factors may also contribute to a child's increased risk for injury due to motor vehicle accidents and collisions, pedestrian versus automobile accidents, and bicycle versus automobile accidents. Lack of appropriate motor vehicle restraints (e.g. inability to afford appropriate car seat or booster seat, inappropriate use of this equipment, or lack of knowledge about appropriate safety restraints) or poor road conditions may place children living in neighborhoods with greater socioeconomic disadvantage at increased risk for injury due to motor vehicle accidents and collisions. Additionally, unsafe driving within a neighborhood, unawareness of safe road-crossing behaviors, and lack of sidewalks, crosswalks or bike lanes may cause children living in neighborhoods with greater socioeconomic disadvantage to be at increased risk for injury due to pedestrian versus automobile accidents and bicycle versus automobile accidents.

These environmental factors that contribute to a child's increased risk for sustaining injuries due to certain mechanisms are an example of structural violence. Those living in neighborhoods with greater socioeconomic disadvantage have an increased risk for certain types

of injuries due to unsafe or unhealthy living conditions. Lack of attention and financial support from public works (e.g. lack of funding directed towards improving roads or building safe pedestrian walkways in poor communities) could be perpetuating poor living conditions. Additionally, parents and caregivers living in areas of greater socioeconomic disadvantage may have poor access to health media and lack knowledge or awareness of safety measures and risk-reducing behaviors (e.g. child car seats, street safety, etc.), thus placing their children at increased risk for injury.

Efforts to recognize potential contributing factors that place a child at risk for injury are an important first step in reducing a child's risk for these preventable injuries. The Area Deprivation Index can serve as a useful tool to identify children at higher risk for certain injuries based upon neighborhood of residence. Once these at-risk neighborhoods have been identified, public health officials can then perform focused assessments of these neighborhoods to identify potential risk factors that place children living in these neighborhoods at risk for certain injuries. These assessments can then be used to inform policy makers and public health officials for the design and implementation of interventions aimed at addressing these issues. Such measures might involve constructing safer roads, pedestrian walkways, and bike lanes in high-risk neighborhoods, and providing educational programs to parents, caregivers, and children on safety measures that can reduce a child's risk for injury. Identifying at-risk neighborhoods can inform local programs in order to direct their efforts more effectively, and these measures will play an important role in combatting the increasing number of pediatric injuries within the California-Mexico border region.

4.3 Relationship Between Hispanic Ethnicity and Pediatric Injury Mechanism

Certain mechanisms of injury were more commonly encountered in children with Hispanic ethnicity as compared to non-Hispanic children. Hispanic children sustained significantly more injuries due to motor vehicle accidents and collisions, pedestrian versus automobile accidents, and non-accidental trauma than non-Hispanic children ($p<0.001$). Injured Hispanic children were also more likely to live in more disadvantaged neighborhoods than non-Hispanic children. After controlling for age, sex, and neighborhood socioeconomic disadvantage, Hispanic children had higher odds presenting to the hospital with injuries due to motor vehicle accidents and collisions and pedestrian versus automobile accidents than non-Hispanic patients.

A Hispanic child's increased risk for sustaining injuries due to MVA/MVC and pedestrian versus automobile accidents may be related to environmental and cultural differences. Cultural practices and the effects of acculturation have been shown to influence rates of disease and injury between and among ethnic groups.[46] Moreover, different environmental exposures, perceptions of injury risk, injury prevention practices, parenting practices, and language barriers have been recognized as potential factors contributing to a Hispanic child's increased risk for injury as compared to a non-Hispanic white child.[47] Language barriers may also be contributing to increased risk for certain injuries. Hispanic families that are not English-speaking or have lower levels of language acculturation may have less access to health information and educational material, which, in turn, can lead to less awareness of child safety guidelines and risk-reducing practices.[48,49] Previous survey-based studies have reported that while Hispanic parents perceived more risk than non-Hispanic white parents, they had overall less safety knowledge and were less likely than non-Hispanic families with children to use injury prevention

measures.[50,51] Thus, it is possible that a combination of cultural practices and language barriers may be contributing to a Hispanic child's increased risk for injury due to MVA/MVC and pedestrian versus automobile accidents.

Although we were not able to determine immigration status of the pediatric patients included in this study and their families due to the limitations of data available within the database, due to the large population of Hispanic immigrants to the California-Mexico border region, it is possible that many of the injured Hispanic children included in this study are first- or second-generation immigrants. This factor would be important to determine in future studies, as immigrant families face unique challenges that may place them at higher risk for injury, such as separation from their family, difficulties in satisfying basic needs in a new environment, and challenges in accessing services and social support in a new society.[52]

As Hispanic children appear to be at increased risk of injury due to pedestrian versus automobile accidents and MVA/MVC, an important next step toward decreasing these types of injuries will be to identify the specific factors that contribute to a Hispanic child's increased risk for these injuries. This could be accomplished through qualitative interview-based research involving Hispanic parents and caregivers within the California-Mexico border region to learn about perceptions of the safety of their home and local environment and practice of risk-reducing behaviors. A better understanding of cultural practices as well as the social, economic, political, and environmental factors that may contribute to a Hispanic child's increase risk for injury can help policy makers and public health officials better align objectives of public health interventions with those of the community while at the same time gaining local buy-in and support by involving members of Hispanic communities in the development of injury prevention strategies and practices.

4.4 Falls

Falls were the most common mechanism of injury for children living within the California-Mexico border region. Within this region, children with the highest odds of presenting to the hospital due to injuries sustained from falling were younger, female, and lived in neighborhoods with the least socioeconomic disadvantage. Similar to our findings, falls are the leading cause of non-fatal injuries for children ≤ 18 years of age within the United States and children less than 5 years of age are more likely to sustain injuries due to falls compared to older children nationwide.[53,54]

Across all quintiles, the vast majority of falls were considered minor (ISS ≤ 8) and injury severity due to falls was similar between the quintiles. That being said, it is possible that children living in least disadvantaged neighborhoods were more frequently injured due to falls or perhaps that parents of children living in these neighborhoods were more likely to bring their child into the hospital for evaluation after sustaining injuries due to a fall. As the vast majority of injuries were minor, it is possible that parents who perceived their injury to be less severe did not feel it would be necessary to bring their child in for evaluation and/or that they wanted to avoid the potential cost of medical care, as those living in more disadvantaged neighborhoods were less likely to have private health insurance.

Different mechanisms of falling have been found to be associated with certain pediatric age groups as the potential hazards children are exposed to change as they continue to grow and develop.[55,56] Previous studies have found that children younger than 1 year of age most often fall from slipping out of a caregiver's arms, children between the ages 1 and 9 most often fall from playground equipment or furniture, and children between 10 to 14 years of age often fall during recreational activities (e.g. skateboarding, jumping on a trampoline) or from slipping / tripping.[57]

By determining fall etiology within a particular age group, specific interventions can be recommended for each age group to address their unique risk factors and reduce their overall risk of injury due to falling. That being said, further study is needed to determine if the specific mechanisms of falling for these age groups within the California-Mexico border region are similar to those reported by previous studies.

From 2012 to 2019, the number of children injured due to falls has steadily decreased across all age groups in the United States. Increasing awareness of environmental factors that increase a child's risk for falling has likely contributed to this decline in injuries. Current recommendations for fall injury prevention include supervision of younger children, instillation of home safety devices, removal of tripping or slipping hazards in the home, use of appropriate protective gear when participating in sports or recreation, and providing education of safe behaviors to parents, caregivers, and children.[53,56]

4.5 Motor Vehicle Accidents / Motor Vehicle Collisions

Motor vehicle accidents and motor vehicle collisions (MVA/MVC) were the second-most common mechanisms of injury for children living within the California-Mexico border region. Children between ages 5 and 14 were most often injured due to a MVA/MVC, with this age group constituting 67% of the trauma encounters for injuries sustained due to this mechanism. Injuries due to MVA/MVC appear to be a more common mechanism of injury for children within the California-Mexico border compared to the United States at-large. Within the United States, motor vehicle accidents are the seventh leading cause of non-fatal injury in children aged 5 to 9 years, the fifth leading cause of non-fatal injury in children aged 10 to 14 years, and the fourth leading cause of non-fatal injury in children aged 15 to 18 years.[54] Although nationally a

less common cause of injury as compared to falls, motor vehicle accidents are far more fatal and are the leading cause of death among children aged 5 to 18 years.[58]

The rate of pediatric injuries due to motor vehicle accidents and collisions in the California-Mexico border region increased to its highest in 2016 and remained high through 2018. Per the 2020 and 2021 California Highway Safety Plans, serious injuries to unrestrained children under age 15 increased steadily between 2014 and 2018, and this number has continued to rise.[59,60] Within California, the five most common types of motor vehicle accidents that result in serious injury or fatality of an unrestrained child passenger are those involving improper turning (27.2%), driving or bicycling under the influence of alcohol or drugs (25.2%), unsafe speed (17.5%), automobile right of way (10.7%), and traffic signals and signs (8.7%).[60]

Within the California-Mexico border, Hispanic children and children living in neighborhoods with greater socioeconomic disadvantage had greater odds of sustaining injuries due to MVA/MVC. While both factors increased a child's odds of sustaining injury due to MVA/MVC, living in a neighborhood with greater socioeconomic disadvantage contributed to a greater degree than Hispanic ethnicity. One reason for this finding may be a higher rate of nonuse of protective devices, such as seatbelts and car seats, in this population. A review of the San Diego County Regionalized Trauma System between 1985 and 1990 found that Hispanic children were 4 times more likely to not have worn a seatbelt and 3.7 times more likely to not have been restrained than non-Hispanic white children.[61] As injured Hispanic children were more likely to live in more disadvantaged neighborhoods, this factor may be partly responsible for their increased risk for injury due to this mechanism. Alternatively, it is possible that children living in neighborhoods with greater socioeconomic disadvantage may be less likely to use appropriate child safety restraints as compared to children who live in neighborhoods with

less socioeconomic disadvantage due to lack of education on appropriate use of these devices and/or inability to afford the equipment.

Improving awareness and education of parents and caregivers on safe driving and appropriate use of child safety restraints is an important step in reducing the serious injuries and fatalities associated with unrestrained child passengers involved in motor vehicle accidents and collisions. In the most recent California Highway Safety Plan, the contributors acknowledge a need for the development of educational programs among multicultural and diverse ethnic populations, including providing child safety seats and education classes to low-income and at-risk families to increase use of child safety restraints. Through engagement with various local and community-based programs, the California Highway Patrol and California Office of Traffic Safety is working to decrease unrestrained child passenger fatalities by providing education and distributing child car seats to low-income families and underserved communities.[60] At present, programs involved in this effort include the California Restraint Safety Education and Training (CARSEAT) IV and Child Passenger Safety Program.[60]

Additionally, Child Safety Seat Programs within San Diego and Imperial Counties are also working to provide child passenger safety education as well as distribute and install car seats at no cost to qualified, low-income applicants. These programs include the "Keep 'Em Safe" Program offered by the Pacific Safety Center in San Diego County and the Child Safety Seat Program in Imperial County Public Health Department and El Centro California Highway Patrol.[62,63]

Efforts to decrease pediatric injuries due to MVC will also need to involve partnership between the United States and Mexico to regulate border crossings and provide education to parents and children on the United States side and potential migrants on the Mexico side on

pedestrian and motor vehicle safety.[64,65] Unsafe and fast driving, lack of restraints, overcrowding of vehicles, and driving at night on unfamiliar and rural roads are likely to continue as long as individuals are driven the enter the United States illegally.

4.6 Pedestrian versus Automobile Accidents

Within the California-Mexico border region, pedestrian versus automobile accidents were the third leading cause of injury. Older children, Hispanic children, and children living in neighborhoods with greater socioeconomic disadvantage had greater odds of sustaining injuries due to pedestrian versus automobile accidents. Moreover, the odds of a child sustaining injuries due to a pedestrian versus automobile accident increased with increasing neighborhood disadvantage ($p<0.001$).

A 2012 geographic analysis of collisions involving child pedestrians in Orange County, California using the California Statewide Integrated Traffic Records System (SWITRS) and U.S. census population data found that child pedestrian collisions were nearly nine times more frequent in the poorest neighborhood quartile than in the wealthiest neighborhood quartile.[29] This study also found that that increased neighborhood crowding, low levels of education, low levels of English speaking ability, and Latinx ethnicity were associated with increased risk of pediatric collision.[29] Recognized risk factors for injury due to pedestrian versus automobile accidents include vehicles traveling at higher speeds as well as being a pedestrian in an urban area or at night, and crossing at non-intersection locations.[66,67]

Given that Hispanic children were also more likely to live in more disadvantaged neighborhoods, it might be suggested that Hispanic ethnicity represents a covariate, such that living in a neighborhood with greater socioeconomic disadvantage is what contributes to a

child's increased risk for sustaining injuries due to a pedestrian versus automobile accident. However, both living in a neighborhood with greater socioeconomic disadvantage and having Hispanic ethnicity were independently associated with a child's increased odds of sustaining injury due to this mechanism on multivariate logistic regression. It is possible that Hispanic individuals may live in more urban areas or areas that have less availability of crosswalks or sidewalks and less enforcement of speed limits. That being said, further study is needed to determine what specific social, economic, political, and structural factors might be contributing to a child's increased risk of sustaining these types of injuries within the California-Mexico border.

Since the 1970's, injury-prevention programs have demonstrated efficacy in reducing the incidence of pediatric versus automobile-related injuries. More recently, an interactive pedestrian safety education program in Los Angeles elementary schools, "LA Street Smarts", that was established in 2009, was associated with increased knowledge of pedestrian safety, safe crosswalk behaviors, and lower incidence of pedestrian related injuries in elementary school-aged children. For continued improvements in child pedestrian safety, however, ongoing education and reinforcement of safe behavior is needed. The 2021 California Highway Safety Plan outlines the State Highway Patrol's efforts to provide community outreach and education, with focus on cities and counties with high rates of pedestrian fatalities and injuries through programs such as the Community Pedestrian and Bicycle Safety Program and Complete Streets Safety Assessments (CSSA).[60]

4.7 Current Efforts to Decrease Pediatric Injuries within the California-Mexico Border Region

Current local efforts to decrease the pediatric injuries within California-Mexico border region include those led by the United States-Mexico Border Health Commission and the County of San Diego Health and Human Services Agency. These organizations could potentially serve as regional stakeholders in public health initiatives aimed at improving the safety and well being of children living within the California-Mexico border region.

The United States-Mexico Border Health Commission (BHC) is a public international organization that was first established in 2000 and serves to provide international leadership to address border health challenges and coordinate binational efforts to improve the health and quality of life of residents living within the United States-Mexico border.[68] In 2020, the BHC defined five public health priorities of binational concern in "Healthy Border 2020".[69] Two of the five public health priories included child health and injury prevention, both pertinent to pediatric injury prevention within the California-Mexico border region.[69] Within this document, the BHC outlines an "Injury Prevention Strategy" aimed at reducing unintentional injury deaths, increasing seat belt use, reducing mortality rate of road traffic injuries and road traffic-related deaths, reducing alcohol consumption, reducing disabilities caused by road traffic injuries, and reducing hospitalizations for nonfatal injuries.[70] Measures to achieve these objectives include (1) enforcing seat belt laws, (2) ensuring children are safely and properly restrained when in a vehicle, (3) ensuring all child safety seats meet industry standards, (4) training multidisciplinary workgroups to define necessary mechanisms to tie BHC activities together with programs managed by local and state public health authorities, (5) promoting road improvements (e.g. Safe Roads/Carreteras Seguras), (6) reinforcing seat belt use in adults and the use of child safety car

seats, and (7) adopting and adapting the U.S.-Mexico *Safe Kids* model across the border region.[70] They plan to measure their progress using the number of preventive measures and campaigns aimed at promoting injury prevention or the prevention of deaths related to road traffic collisions.[70]

Within the County of San Diego Health and Human Services Agency, the Public Health Service administration directs public health programs and works to promote health and protect and support children, families, and communities among other services.[71] In 2012, the County of San Diego Health and Human Services Agency established the "Live Well San Diego" program as a means to engage members of the community to "take action to improve their health and quality of life."[71] This program brings together local, regional, and national stakeholders from across all sectors of the community and strives to create safe neighborhoods while supporting the health and well being of the community.[71] In efforts to improve the health and well being of those living within the California-Mexico border region, the County of San Diego Health and Human Services Agency set forth a Public Health Services Strategic Plan for 2013-2018.[71] This Strategic Plan included goals to (1) improve the health and well being of women, infants, children, and families, (2) reduce the rate of fetal and infant deaths, and (3) create social and physical environments that promote good health for all.

At a national level, the National Prevention Council set forth a National Prevention Strategy in 2020, which strives to reduce the national burden of preventable deaths and major illness due to injury. Their these efforts include work to (1) create, sustain, and recognize communities that promote health and wellness through prevention, (2) ensure that prevention-focused health care and community prevention efforts are available, integrated, and mutually

reinforcing, (3) support people in making healthy choices, (4) eliminate health disparities, improve the quality of life for all Americans.[71]

4.8 Policy Recommendations

Policy plays an important role in child injury prevention.[40] Policies that support the creation of safe environments and promote behaviors that prevent child injury, if broadly implemented and enforced, have the potential to save many lives. Based upon the findings of this study, children with Hispanic ethnicity and those living in more socioeconomically disadvantaged neighborhoods are at greatest risk for injury. Therefore, policies should be aimed at providing a safer environments and education on injury prevention for these populations. Neighborhoods identified as having greater socioeconomic disadvantage should be examined for potential hazards that would increase a child's risk for injury due to MVA/MVC, pedestrian versus automobile accidents, and bicycle versus automobile accidents. Additionally, factors that increase a child's risk for non-accidental trauma, such as inappropriate storage of firearms, within neighborhoods of greater socioeconomic disadvantage should also be assessed and addressed.

Policy that promotes the creation of safer roads, availability of walkways and bike lanes, provision of child safety seats or restraints, and mandates safe storage of firearms has the potential to overcome the structural violence within neighborhoods of greater socioeconomic disadvantage that increases a child's risk for injury. Integrating injury prevention education into schools systems and community-based organizations in a variety of languages can assist in providing education to these communities. Health care providers could partner with local

schools and community-based organizations to provide this education to parents, caregivers, children and adolescents.

Lastly, ongoing surveillance of injury rates, mechanism of injury, and health outcomes on a local and regional level should be conducted. Monitoring these data while also identifying neighborhoods with the greatest burden of injuries within the California-Mexico border region and making this information available to policymakers, public health officials, health care professionals could assist them in recognizing and prioritizing areas of intervention and education.

Chapter 5. Limitations:

Our work has limitations similar to other retrospective studies utilizing a large, single institution database for secondary analysis. First, the data used for our analysis was obtained from a single institution. Although this institution is the region's only pediatric trauma center and the majority of regional pediatric injuries are treated at this institution, subsets of injured children are treated at other adult trauma centers or hospitals. Children with severe, life-threatening injuries are taken to the closest hospital for treatment, which may or may not be the children's hospital. For example, patients aged 16 to 18 years may be treated at adult trauma centers. This may partially explain why the 15-18 year age group in this study had the fewest number of traumatic injuries compared to all other age groups. Children with traumatic injuries may also present across the border for care, as previous study has shown that within the US-Mexico border cost can be a motivation for pursuing care at outside the US system.[72] Additionally, children who were injured and did not survive to reach the hospital and those who were taken to other regional hospitals for care were not included in these data. For these reasons, our data has limited generalizability. Second, this study was retrospective and utilized a database for secondary analysis. As certain data were not routinely included in hospital trauma registry data entry, these data were not able to be included in our analysis. For example, the locations of where injuries occurred were not included in the data registry. Therefore, it is possible that some injuries might have occurred outside of the border region. Our study was also not randomized and therefore cannot control for all potential confounding factors. Further study is needed to better elucidate specific factors that contribute to a child's increased risk for certain types of injury, which could be done with further prospective study and/or qualitative research (e.g. explanatory sequential research design).

Chapter 6. Planned and Recommended Future Research

Following completion of this study, my research team and I were awarded the Rady Children's Hospital San Diego Advancing Pediatric Health Disparities Research Grant to continue this work. The study represents the first phase of a three-phase project, which will ultimately aim to implement measures to improve outcomes among injured children identified as living in neighborhoods with greater socioeconomic disadvantage.

Phase II of this project will be to assess outcomes of pediatric trauma patients from areas with greater neighborhood disadvantage. During this phase, we will prospectively collect data from the prehospital, hospital, and discharge settings in an effort to identify specific factors that contribute to poor outcomes within each ADI quintile and ethnicity group. We plan to incorporate an element of qualitative research to investigate the issues experienced that parents or caregivers of various neighborhood demographics when seeking health care for their children, during their child's hospitalization, and following their child's discharge from the hospital.

During phase III of this work, identified factors contributing to poor health outcomes for pediatric trauma patients will be used to inform the design of public health initiatives aimed at both addressing structural barriers that place a child at risk of injury and informing and educating parents and caregivers on preventative safety measures. These efforts will be in collaboration with community members within at-risk neighborhoods in efforts to improve outcomes among injured children living within neighborhoods of greater socioeconomic disadvantage in the California-Mexico border region. Three areas of intervention will be identified and public health initiatives will be designed and implemented over the next three years in an effort to improve outcomes of pediatric injuries within the California-Mexico border region.

Chapter 7. Conclusions

This analysis represents the first study to characterize pediatric trauma injury patterns based upon neighborhood ADI metric and is the first study to investigate relationship between pediatric mechanism of injury, neighborhood socioeconomic disadvantage, and ethnicity within the California-Mexico border region. This study discovered markedly different injury mechanisms for children living in neighborhoods with greater socioeconomic disadvantage as compared to those living in neighborhoods with less socioeconomic disadvantage within the California-Mexico border region. Children living in neighborhoods with greater socioeconomic disadvantage were more likely to sustain an injury due to a MVA/MVC, pedestrian versus automobile accident, bicycle versus automobile accident, or non-accidental trauma, whereas children living in less socioeconomically disadvantaged neighborhoods were more likely to sustain injuries due to sports or off-road vehicle accidents.

Differences in injury mechanism between children living in neighborhoods with different socioeconomic disadvantage may be explained, in part, by structural violence and social determinants of health. Those living in neighborhoods with greater socioeconomic disadvantage may have poorer road conditions, less enforcement of speed limits, lack of safe walkways for pedestrians and lack of bike lanes, all of which can increase a child's risk for injury due to motor vehicle accidents or collisions. Additionally, lack of access to health information and risk-reducing resources, such as car seats or gun safes, among other social, economic, political, and environmental factors may contribute to a child's increased risk for injury.

The Area Deprivation Index can be a useful resource for identifying disparities in pediatric trauma and those at increased risk for vehicular and abusive injury who may benefit from increased resource allocation, social support, and prevention programs. Identification of

the specific factors that contribute to a child's increased risk for injury are as important first step when deciding how to design and implement a public health intervention aimed at reducing morbidity and mortality associated with pediatric trauma. Once these specific factors have been identified, they can then be used to inform the design of public health interventions. Members of the community should also be involved in the design and establishment of these interventions, in order for these efforts to be successfully implemented.

Policies that aim to provide safer environments and education on injury prevention for Hispanic populations and those living in neighborhoods with greater socioeconomic disadvantage as well as multi-stakeholder involvement will be necessary for long-lasting change. Ongoing research is also needed to continue to identify children who are at increased risk for injury, identify what factors contribute to their increased risk for injury, and provide ongoing assessment of implemented programs aimed at improving the health and safety of children living within the California-Mexico border region.

This work reveals health disparities experienced by Hispanic children and children living in neighborhoods with greater socioeconomic disadvantage within the California-Mexico border region. My research team and I will continue to build upon this work by identifying specific factors that contribute to poor outcomes within each ADI quintile and ethnicity group and developing programs aimed at addressing health care disparities experienced by Hispanic children and children living in neighborhoods with greater socioeconomic disadvantage. I look forward to the opportunity to continue this work through the support of the Rady Children's Hospital San Diego Advancing Pediatric Health Disparities Research Grant and hope that this work will ultimately improve the safety and well being of children living in the California-Mexico border.

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