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Pedestrian Safety on San Jose Roads: The Impact of Traffic Safety Infrastructure

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The Impact of Traffic Safety Infrastructure

by

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INTRODUCTION

Intent of Study

How successful have the City of San Jose's traffic safety improvement programs been in reducing pedestrian injuries/fatalities on city streets? This research question focuses on the impact of the City of San Jose's traffic safety programs on pedestrian safety between 2010 and 2014. The research aims to determine the extent to which traffic safety programs and infrastructure reduce rates of pedestrian injuries/fatalities and the severity of pedestrian injuries when incidents occur.

BACKGROUND

Policy Background

Every time someone crosses the street on a dark and busy road characterized by high-speed traffic, his or her first thought is for his or her own personal safety. From the first day a person walks, he is taught to look both ways before crossing the road, and to press the crosswalk button at an intersection. However, these basic lessons about personal safety on roads must be supplemented by a safely engineered transportation system.

Pedestrians have to trust that when they look left before crossing the street, proper lane delineations ensure that cars drive on the correct side of the road. Moreover, pedestrians must trust that streetlights reveal their presence to oncoming cars. Furthermore, pedestrians want to trust that road engineering and traffic enforcement help deter speeding. In sum, citizens expect that their tax dollars help fund a safe transportation system that fosters safe transportation for both vehicles and pedestrians. The responsibility for ensuring successful implementation of traffic safety programs and infrastructure lies with transportation officials.

While police and fire departments garner the majority of attention and funding in the realm of public safety at the local level, traffic safety represents one of the most fundamental public safety needs. Globally, there are 270,000 pedestrian fatalities every year (World Health Organization, 2013). Moreover, pedestrian fatalities represent 22% of all fatalities occurring on roads around the world (World Health Organization, 2013). In the United States in 2014, motor vehicle traffic deaths occurred at a rate of 10.6 deaths for every 100,000 people (Center for Disease Control and Prevention, 2017). By comparison in that same year, firearms deaths occurred at a rate of 10.5 deaths for every 100,000 people (Center for Disease Control and Prevention, 2017).

In San Jose, the 10th largest city in the United States, traffic safety represents a significant public health issue. In 2014, in fact, there were 42 traffic crash related deaths in San Jose, whether they were walkers, bikers, motorcyclists, or drivers (City of San Jose, 2015). By comparison, in that same year, there were 32 homicides in San Jose (San Jose Police Department, 2017).

The large share of traffic-related deaths and injuries in San Jose demands a robust government response in the form of traffic safety measures. Broadly speaking, traffic safety measures represent government agency efforts to address the problem of traffic collisions that result in injuries and/or fatalities for drivers, passengers, bicyclists, and pedestrians. Policies and programs designed to reduce vehicle collisions with other vehicles, pedestrians, and bicycles typically involve changing driver/pedestrian/bicycle behavior and investing in safer road infrastructure. Examples of traffic safety infrastructure include targeted pedestrian crossings, traffic signal installations, guardrails,

median islands, road shoulder improvements, and brighter streetlights, among many others (City of San Jose, 2015).

In 2014 the City of San Jose became a registered partner in the Toward Zero Deaths program (TZD) of the American Association of State Highway and Transportation Officials (AASHTO). This is the American version of Sweden's Vision Zero initiative, designed to reduce pedestrian deaths by 50% by 2020. Vision Zero has been adopted around the world as an aspiration: to end pedestrian deaths and injuries through infrastructure design. (City of San Jose, 2015)

The City of San Jose Transportation Department prioritizes traffic safety through targeted investments in education programs and road infrastructure. In fact, in the next 5 years (2018-2022), the City of San Jose has committed to spending $107 million on road safety improvement projects (City of San Jose, 2017). Furthermore, City of San Jose policy guides the implementation of traffic calming policy. Approved on April 25, 2000, and revised on June 17, 2008, City Council Policy 5-6 aims to improve the safety of city streets, especially in the proximity of schools and residential neighborhoods (City of San Jose, 2000, 2008). Council Policy 5-6 divides traffic safety measures into two categories: "basic" and "comprehensive" (City of San Jose, 2000, 2008). "Basic" measures include "traffic control devices and programs that are implemented on a day-to-day basis to regulate, warn, guide, enforce and educate motorists, pedestrians and bicyclists; and generally apply to all streets" (City of San Jose, 2000, 2008). "Comprehensive" measures, on the other hand, include road infrastructure changes to reduce vehicle speeds and improve safety conditions for pedestrians (City of San Jose, 2000, 2008). Lastly, Council Policy 5-6 ensures that traffic safety projects benefit the whole of San Jose,

stipulating that, “Traffic calming projects should be designed and implemented with the goal of not transferring negative traffic conditions from one neighborhood roadway to another” (City of San Jose, 2000, 2008).

The City of San Jose invests funds toward both citywide traffic safety measures and targeted programs to address localized problems (City of San Jose, 2017). Analysis of crash incident data in addition to community input allows the city to target traffic calming programs and pedestrian safety infrastructure towards particularly dangerous intersections and roadways (City of San Jose, 2017).

Moreover, the City of San Jose’s General Plan, adopted in 2011, incorporates development guidelines that emphasize pedestrian safety. The following standards provide examples of how the City of San Jose prioritizes pedestrian safety as a planning standard. The General Plan stipulates that the city design transportation projects that improve safety for motor vehicle travel while increasing access for pedestrians and bicyclists through the implementation of traffic calming projects (City of San Jose, 2011). Specifically, the General Plan calls for enhancements such as “wider sidewalks, shade structures, attractive street furniture, street trees, reduced traffic speeds, pedestrian-oriented lighting, mid-block pedestrian crossings, pedestrian-activated crossing lights, bulb-outs and curb extensions at intersections, and on-street parking that buffers pedestrians from vehicles” (City of San Jose, 2011). For pedestrians in particular, the General Plan provides guidelines for street enhancements that make pedestrians more visible to drivers, with installations such as improved lighting and crosswalk signage (City of San Jose, 2011).

In focusing on the issue of pedestrian safety on San Jose roads, this research aims to provide insights into the impact of government traffic calming programs and infrastructure on the safety of pedestrians. The main problem this research deals with is the degree to which San Jose's pedestrian safety program tackles the city's goal of reducing pedestrian injuries and fatalities. The outcome of this research may lend insights into traffic infrastructure planning at the local level that better accommodates pedestrians.

METHODOLOGY

Borrowing from Sylvia and Sylvia (2012), the research applies a time-series design to evaluate the impact of traffic safety measures on pedestrian safety in San Jose. This non-experimental design leverages data on traffic incidents involving pedestrians between 2010 and 2014 in order to evaluate the impact of specific traffic safety programs on pedestrian safety (data not yet available after 2014).

Examining data before and after a program implementation allows for a quantitative analysis of the degree to which a specific program mitigated pedestrian injuries/fatalities. For example, analysis of data on pedestrian related crash incidents in 2010 and 2011 compared to the same data from 2013 and 2014 allows for examination of the impact of a traffic safety project completed in 2012. In sum, this time-series research design allows for an analysis of the degree to which the data changes as a result of the program implementation.

Data

Data collected includes traffic safety project information obtained from City of San Jose Capital Improvement Program Budget publications between 2010 and 2014. The City of San Jose's budget publications provide detailed background on traffic safety improvement projections as it pertains to pedestrian safety. Useful background includes the types of infrastructure installed, project goals, project locations, and project timelines.

In addition, traffic incident information provided by the City of San Jose's Department of Transportation (DOT) allows for the evaluation of the impact of the pedestrian safety improvement strategies. San Jose's Department of Transportation provides publicly available information about traffic incidents resulting in pedestrian injuries and fatalities. The data sets include the following: locations, road conditions, times, dates, # of fatalities, # of injuries, severity of injuries, vehicle type, and vehicle action (City of San Jose, 2017).

The research centers on applying the time series methodology to San Jose Traffic Capital Project implementations. Specifically, the research identifies pedestrian safety projects that were fully implemented between 2010 and 2014, and examines crash data before and after the implementation. The following flow chart displays the research plan.

Examine City of San Jose published budgets to identify completed projects between 2010-2014.

↓

Retrieve crash data from the City of San Jose Transportation Department.

↓

Look for crash data in areas of the City/targeted intersections where pedestrian safety improvement projects were implemented.

↓

Identify the number of crashes involving pedestrians and the severity of injuries at those intersections.

↓

Draw conclusions about the impact of the pedestrian safety projects, including number of avoided deaths and injuries.

LITERATURE REVIEW

Traffic safety measures represent government agency efforts to address the problem of traffic collisions that result in injuries/fatalities for drivers, passengers, bicyclists, and pedestrians. Policies and programs designed to reduce vehicle collisions with other vehicles, pedestrians, and bicycles typically involve changing driver/pedestrian/bicycle behavior and investing in safer road infrastructure. The scholarly research and government agency reports provide the most informative research about traffic safety.

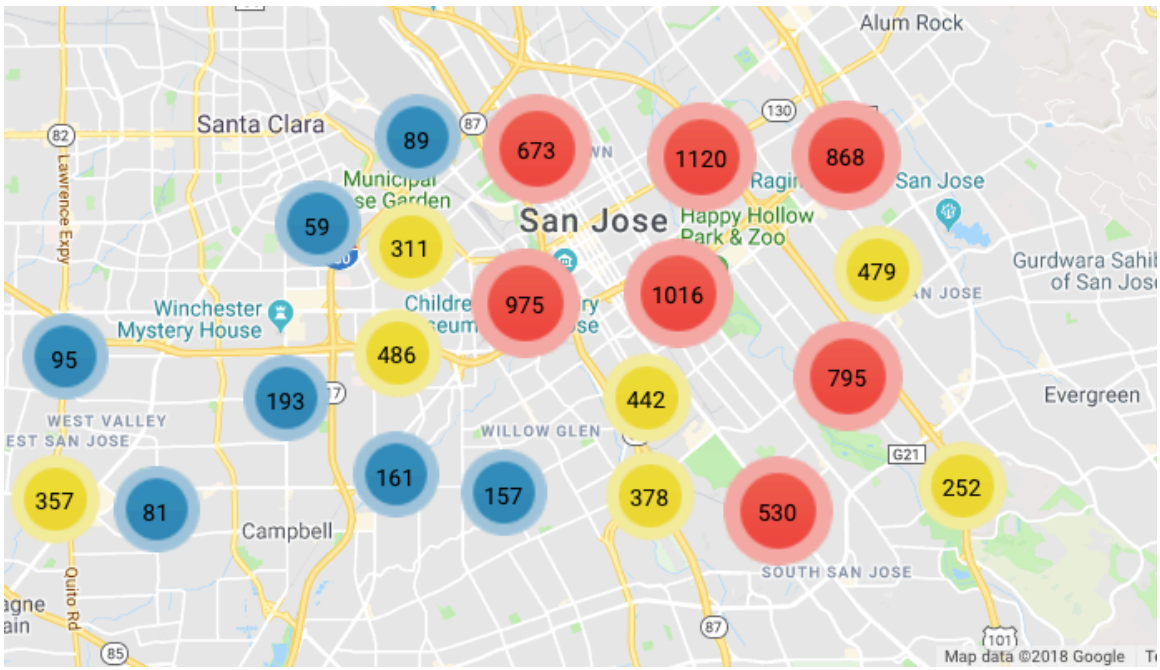
Government agency decision-making processes, crash reduction engineering measures, and theoretical approaches to addressing traffic safety are the three main subject areas within the realm of traffic safety. Literature addressing traffic safety mechanisms relies on crash data produced by government agencies to inform policy frameworks for implementing crash mitigation measures.

The City of San Jose (2015) examined crash data from 2010-2014 to identify transportation corridors with exceptionally high levels of vehicle collisions with other vehicles, pedestrians, and/or bicyclists. For example, city transportation officials found that 50% of all traffic fatalities occurred on 14 major street segments. Moreover, these 14 major street segments represent 3% of all city streets.

Kevin Miller (Miller, 2016) stated that the City of San Jose leveraged the crash data to develop “Safety Priority Streets” where they target road design changes and other traffic safety mechanisms. In this manner, the City of San Jose develops data-driven transportation safety policies with the aim of reducing injuries and fatalities. As Figure 1 demonstrates, an evaluation of the data was used to create a graphic to depict the areas in the city characterized by high rates of vehicle collisions. The red circles represent the

street intersection which see the highest number of collisions, with the yellow circles representing the second highest and blue the third highest.

Figure 1: 2010-2015 San Jose Crash Data



Source: City of San Jose Department of Transportation, 2015

Other research also emphasizes the important role that data plays in the design of traffic safety improvement measures. For instance, McAndrews (2013) cites the importance of traffic safety performance measures in driving transportation policy decisions. Again, the City of San Jose exemplifies performance-driven transportation policy, as the Transportation Department cites improved performance in categories such as “pedestrian fatalities” to justify increased Capital Improvement expenditures for transportation-safety related infrastructure (City of San Jose, 2013).

However, alternative research suggests that sound transportation safety policy relies on community input in addition to data. Lubitow, Rochester, and Zinschlaug

(2016), in exploring the case study of bicycle lane implementation in the City of Chicago, found that the citizens in certain neighborhoods resisted the decision to install bicycle lanes in their neighborhoods because of concerns that the bicycle lanes would slow down vehicle traffic. So, the City of Chicago had to weigh the neighborhood concerns against the community benefits coming from increase bicycle access to City streets. Based on this research, Lubitow, Rochester, and Zinschlaug (2016) conclude that city governments should supplement data-driven traffic safety measures, such as bicycle lane installations, with community input.

Municipal traffic safety measures implemented in the city of The Hague on the west coast of the Netherlands provide insights into how municipalities can incorporate road designs into efforts to reduce pedestrian injuries and fatalities. In 1989, public officials in The Hague adopted a transportation and urban planning concept called "Den Kern Gezond", which translates to a "Healthy Heart for the Inner City" (World Health Organization, 2013). Post World War II development in The Netherlands emphasized urban planning designs that prioritized wider roads and more traffic lanes in urban areas that facilitated faster motor vehicle transportation (World Health Organization, 2013). This urban redevelopment design, however, made urban streets less safe for pedestrians and bicyclists (World Health Organization, 2013).

The "Den Kern Gezond" plan represented a methodological change for urban planning in The Hague, as transportation officials prioritized pedestrian safety over ease of motor vehicle transportation when designing roads (World Health Organization, 2013). The core elements of the "Den Kern Gezond" plan included prioritizing pedestrian safety in the budget, leaving transportation policy decision-making to local governments, and

linking urban development design with pedestrian-safety oriented infrastructure (World Health Organization, 2013). As part of the "Den Kern Gezond", the roads characterized by high traffic were moved underground (World Health Organization, 2013). This major infrastructure undertaking opened space for safer pedestrian and bicycle transportation around the city (World Health Organization, 2013).

The "Den Kern Gezond" plan yielded significant positive impacts on pedestrian-safety records in The Hague. In a city with a population over one and a half times the size of San Jose, pedestrian injuries sunk from approximately 60 in 1993 to approximately 15 in 2009 (World Health Organization, 2013). Furthermore, The Hague saw ten or fewer pedestrian fatalities annually (World Health Organization, 2013).

The latest research on traffic safety concentrates on to whom to assign the responsibility of ensuring safe transportation. Many theorists urge policy-makers and government officials to view traffic-related injuries and fatalities as a public health problem. McAndrews (2013) notes that vehicle-related fatalities represent the leading cause of death in America for people between the ages of 5 and 34. McAndrews (2013) writes that with fatality figures comparable to smoking and cancer, government officials have a responsibility to treat road safety as a significant public health policy problem.

Developing alternative methodologies for conceptualizing traffic safety in urban environments, many researchers emphasize the important role that safety infrastructure plays in reducing injuries and fatalities. The theory behind the global municipal movement towards Vision Zero hinges on the notion that traffic safety road designs represent the most valuable tool for reducing pedestrian injuries and fatalities. Fink (2016) notes that municipalities implementing Vision Zero policies target resources

towards lowering the frequency and impact of vehicle collisions with pedestrians and bicyclists.

Similar to McAndrew's (2013) discussion of public health, Elvebakk (2007) considers vehicle related fatalities an ethical issue that demands a government response. Elvebakk (2007) cites the Swedish experience with Vision Zero policies, detailing the systems approach that characterizes the theoretical basis for Vision Zero. Vision Zero is a systems approach to traffic safety that focuses on the leading causes of pedestrian-related vehicle collisions, with the goal of eliminating pedestrian fatalities on roads and sidewalks (Elvebakk, 2007).

As opposed to targeting resources towards driver error, such as improved licensing standards and stricter speeding laws, Vision Zero programs fund road infrastructure improvement measures that foster safer conditions for pedestrians. Moreover, instead of trying to prevent accidents, Vision Zero programs aim to reduce impacts to pedestrians resulting from accidents. McCartt and Redding (2013) discuss Vision Zero-type traffic safety engineering mechanisms, such as bicycle lane barriers, bulb-outs to reduce traffic speed, and increased lighting to enhance the visibility of pedestrians.

Similarly, the World Health Organization recommends that municipalities around the world adopt a multifaceted approach to pedestrian-safety oriented road design that focuses on accident prevention. The "Safe Systems Approach" aims to mitigate vehicle-pedestrian collisions by developing safer roads for all types of travelers, including motor vehicles, bicyclists and pedestrians (World Health Organization, 2013). The core elements of the "Safe Systems Approach" philosophy include the anticipation of human

error for both pedestrians and drivers, understanding the extent to which pedestrians are exposed on streets, and engraining a culture of responsibility on the part of the government to prevent pedestrian injuries and fatalities (World Health Organization, 2013). Similar to the Vision Zero philosophy, the World Health Organization's "Safe Systems Approach" aims to transform the way governments approach road design through a focus on vehicle-pedestrian collision prevention during the design stage, rather than responding with preventative measures after the implementation of a roadway.

The City of San Jose (2015) began a Vision Zero program based on the Swedish model, with the goal of eliminating pedestrian fatalities immediately. San Jose's program tailors the traffic infrastructure principals of the Swedish model toward road corridors with particularly high incidences of pedestrian injuries and fatalities. Moreover, San Jose's program supplements road safety enhancements with traffic safety education and tools to make pedestrians more visible to drivers. The City of San Jose Transportation Department targets traffic safety education at schools around the city (City of San Jose, 2015). Moreover, the Transportation Department targets areas with high pedestrian traffic, such as school zones, for the installation of safety measures such as flashing beacons at crosswalks (City of San Jose, 2015).

Considerable research focuses on the ways in which transportation infrastructure influences pedestrian behavior. Transportation specialists study how municipalities' efforts to design traffic safety projects must take into account pedestrian tendencies. Cooper, et al., find that pedestrians typically walk a maximum of 10 to 16 minutes for any given trip (Cooper, et al., 2012). Moreover, pedestrians tend to choose the shortest route possible in order to reach a given destination (Cooper, et al., 2012). For example,

pedestrians may choose to illegally cross a street in order to reach bus stop rather than walk further down the street to reach a traffic light. Therefore, regardless of the existence of a crosswalk or intersection, pedestrians often choose to put themselves in harm's way to reach a destination in a shorter period of time (Cooper, et al., 2012).

Cooper, et al., suggest that transportation officials, accordingly, should design road segments that allow pedestrians to walk the shortest routes possible to highly visited destinations, such as transit stops (Cooper, et al., 2012). Rather than install street enhancements for the purpose of vanity, such as median landscaping, Cooper, et al., find that installing crosswalks better furthers the goal of pedestrian safety improvement (Cooper, et al., 2012).

In addition, research on pedestrian-safety related transportation engineering examines the techniques municipalities employ to accommodate multiple modes of transportation. Cooper, et al., conclude that modern road designs should look to connect highly visited destinations rather than increase ease of transportation and parking for cars (Cooper, et al., 2012). Cooper, et al., suggest that road designs that ease pedestrian access to shorter routes between destinations provide confidence in the road system as a whole.

As a result of pedestrian-safety traffic infrastructure, municipalities can advance the goal of reducing traffic and pollution by encouraging walking (Cooper, et al., 2012). Appleyard, et al., also describe the how pedestrian-safety oriented road design enhances pedestrian access to roads, but often at the expense of slowing traffic. Appleyard, et al., in studying comparable road segments in Oakland and Denver, find that roads amenable to quicker routes for vehicles work against pedestrian access and safety (Appleyard, et al.,

2017). Appleyard, et al., conclude that road designs for traffic efficiency and road designs for pedestrian access work against one another (Appleyard, et al., 2017).

Implementing pedestrian-safety purposed road infrastructure requires designing streets for all kinds of pedestrians. Dipetrillo, et al., compare various municipalities' approaches to the implementation of street improvements for pedestrians with disabilities. Depretrillo, et al., contend that designing roads with safe access for disabled pedestrians, such as curb ramps for wheelchair access, improves safety for all pedestrians by making sidewalks easier to walk on and step off at points of crossing (Dipetrillo, et al. 2016).

Municipalities employ a variety of mechanisms to make roads safer and more accessible for pedestrians. Street intersections represent some of the most dangerous areas for pedestrians. Transportation officials can maximize funding allocated for transportation infrastructure by investing in pedestrian-safety oriented improvements at street intersections. Studies show that the majority of vehicle-pedestrian collisions occur at street intersections (World Health Organization, 2013). The city of Albany, Oregon leveraged transportation funding to enhance safety at street intersections by increasing visibility for both pedestrians and drivers (World Health Organization, 2013).

Johnson describes how transportation officials in Albany installed curb extensions and advanced stop bars at street intersections to help prevent vehicles from encroaching upon crosswalks. These mechanisms also increase visibility for both pedestrians and drivers. A curb extension, also called a bulb out, is an extension of the sidewalk into the roadway at the point of intersection between two streets (Johnson, 2005). Curb extensions narrow the roadway at the point of intersection with a perpendicular roadway in order to

enhance visibility for approaching vehicles to see pedestrians waiting to cross the street (Johnson, 2005).

Extending the sidewalk out onto the near lane of the street also allows pedestrians to better view oncoming vehicles (Johnson, 2005). Moreover, by narrowing the road at the point of intersection, curb extensions lessen the time pedestrians spend on the roadway while crossing the street (Johnson, 2005). Johnson describes how municipalities enhance the safety improvements that curb extensions provide by adding flashing beacons and road stripes to mark the crosswalk (Johnson, 2005).

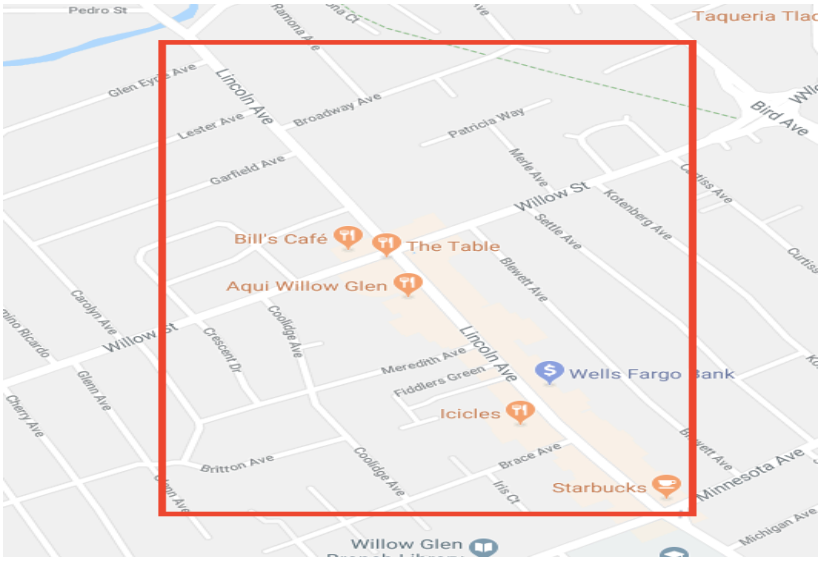
Advanced stop bars are road markings that encourage vehicles to stop or yield a few feet prior to the crosswalk (Johnson, 2005). These simple markings enhance pedestrian safety by increasing the distance between pedestrians and oncoming vehicles while also allowing for greater visibility for pedestrians (Johnson, 2005). By creating a buffer between pedestrians and oncoming vehicles in the near lane, advanced stop bars allow pedestrians to better view oncoming vehicles in the far lane (Johnson, 2005). Through a before and after study, Johnson found that Albany saw an increase in the number of vehicles yielding before crosswalks at intersections where the City had installed curb extensions and advanced stop bars (Johnson, 2005). Interestingly, Johnson also finds that public and commercial vehicles yielded more often than non-public/commercial vehicles (Johnson, 2005).

However, research shows that road markings such as advance stop bars negatively impact pedestrian safety unless municipalities add other enhancements such as flashing beacons to increase the visibility of the pedestrian in the view of a driver (World Health Organization, 2013). Without additional safety mechanisms to make the pedestrian more

visible to the driver, street crossing markings can give a pedestrian a false sense of security when crossing a road (World Health Organization, 2013). In addition, studies show that crosswalk markings enhance safety only on two lane roads, as three or more lanes expose pedestrians to oncoming traffic for a dangerously long period of time (World Health Organization, 2013).

Other municipalities implement alternative road infrastructure changes to improve pedestrian safety. Agrawal et al. examine the City of San Jose's implementation of the Lincoln Avenue Road Diet to assess the extent to which the pilot program improves pedestrian safety and access to Lincoln Avenue. The City of San Jose, the Willow Glen Neighborhood Association, and the Willow Glen Business Association proposed the idea of a Road Diet for the heavily visited segment of Lincoln Avenue between Minnesota Avenue and Coe Avenue (Agrawal, et al., 2017). Lincoln Avenue, running north and south in the Willow Glen neighborhood of San Jose, sees heavy pedestrian and bicycle traffic due to the street's proximity to businesses, restaurants, and residential neighborhoods (Agrawal, et al., 2017).

Figure 2: Lincoln Avenue Road Diet Map



Source: Google Maps, 2018

In 2015, the City of San Jose Department of Transportation reduced the number of road lanes on that segment of Lincoln Avenue from four to three (Agrawal, et al., 2017). The Road Diet changed Lincoln Avenue from two vehicle lanes moving each direction to one vehicle lane for each direction, one bicycle lane for each direction, and one turn lane in the middle of the street (Agrawal, et al., 2017). Research shows that lowering the number of lanes on a given street positively impacts pedestrian safety (World Health Organization, 2013). Moreover, narrower street lanes improve street safety by encouraging slower vehicle speeds (World Health Organization, 2013).

The City of San Jose aimed to reduce vehicle speeds, improve pedestrian safety, and make the road more accessible for pedestrians and bicyclists (Agrawal, et al., 2017). Studies show that a significantly high number of major and/or fatal pedestrian injuries

occur when the vehicle involved exceeds 18.5 miles per hour (World Health Organization, 2013). A before and after study of the Lincoln Avenue Road Diet reveals that road changes reduced the number of vehicles that exceed the speed limit by 5 miles per hour by 44% and reduced the number of vehicles that exceed the speed limit by 10 miles per hour by 60% (Agrawal, et al., 2017). In addition, the Road Diet reduced traffic on Lincoln Avenue by 23% during the morning commute hour (Agrawal, et al., 2017). However, the reduced traffic and lower vehicle speeds on Lincoln Avenue negatively impacted neighboring streets as drivers chose to use alternative routes. For example, streets adjacent to Lincoln Avenue experienced increased vehicle speeds and a 10% increase in traffic as a result of the Road Diet (Agrawal, et al., 2017).

Scholarly and government research material on traffic safety measures vary greatly. Yet most researchers and government sources emphasize the importance of data analysis as a basis for transportation policy. In addition, research suggests that municipalities in the United States are increasingly embracing Vision Zero programs to improve pedestrian safety.

FINDINGS

An analysis of the data set provided by the City of San Jose Transportation Department shows an overall decline in vehicle collisions with pedestrians between 2010 and 2014, with a peak in incidents of pedestrian injuries/fatalities in 2012 (City of San Jose, 2010, 2011, 2012, 2014). The Transportation Department's vehicle-pedestrian incident data tracks incidents by identification numbers. For every occurrence of a car colliding with a pedestrian, City staff records the time of the accident (including date), the streets that intersect at the site of the accident, the proximity to the nearest street intersection (North of, East of), the weather at the time of the accident (clear, cloudy, fog, or rain), the degree of daylight at the time of the accident (dark-no streetlight, dark-streetlight, dark-streetlight not functioning, daylight, or dusk/dawn), the type of road surface on which the accident takes place (wet or dry), the mode of transportation of the pedestrian involved in the incident (pedestrian, skateboard, or wheelchair), who is at fault (pedestrian or car driver), the driver's gender, the driver's age, the vehicle direction at the site of the accident (North, South, East, or West), and the vehicle action type (backing up, changing lanes, entering traffic, making left turn, making right turn, making U-turn, merging lanes, other unsafe turning, parked, parking maneuver, passing other vehicles, proceeding straight, ran off road, slowing/stopping, stalled, stopped, and travelling the wrong way).

The comprehensiveness and detail with which the City of San Jose conducts accident assessments allows for a wide variety of methods of analysis. However, the numbers of accidents involving pedestrians, in addition to the degree of the pedestrian's injury for each incident, represent the most critical pieces of information for this research question. The City of San Jose accident assessments divide the pedestrian injuries into 4

different categories: minor injury, moderate injury, major injury, and fatality. An analysis of the total number of accidents for each injury type (minor, moderate, major, fatality) by year (2010, 2011, 2012, 2013, 2014) allows for a baseline assessment of the relative safety of San Jose's streets over time.

Determining the number of vehicle-pedestrian incidents by degree of injury and by year requires manipulation of the dataset. Due to the fact that the data is not filtered by year and type of pedestrian injury, a pivot table facilitates a quicker and clearer analysis of the desired injury totals by year. After inserting a pivot table into the Microsoft Excel dataset, the data was filtered for "Accident Time" as the row level, with the value columns filtered as "Sum of Minor Injuries", "Sum of Moderate Injuries", "Sum of Major Injuries", and "Sum of Fatalities".

However, the fact that San Jose Transportation Department records the "Accident Time" in date form (month/day/year) necessitates additional manipulation of the row label. For example, determining the total number of incidents by category for 2010 requires filtering the "Accident Time" for "before 1/1/2011". Moreover, viewing the total number of incidents by category for 2011 requires filtering the "Accident Time" for "between 1/1/2011 and 1/1/2012". After replicating this "Accident Time" filter for years 2012 and 2013, viewing the total number of incidents by category for 2014 requires filtering the "Accident Time" for "between 1/1/2014 and 12/31/2014" (final year of available collision data).

Totals

Filtering the crash data with the methodology described above allows for an examination of the change in total pedestrian-involved crashes between 2010 and 2014 in the City of San Jose. In addition, an analysis of the total incidents by category of injury to the pedestrian (minor, moderate, major, and fatality) shows the change in severity of collisions in terms of degree of impact to the pedestrian.

The total number of pedestrian-involved crashes (vehicle-pedestrian incidents) in 2010 was 303. The total incidents in 2010 were comprised of 151 minor injuries, 106 moderate injuries, 41 major injuries, and 5 fatalities. In 2011, the total number of vehicle-pedestrian incidents was 307, a 1% increase from 2010. This total included 134 minor injuries (11.3% decrease from 2010), 113 moderate injuries (6.6% increase from 2010), 44 major injuries (7.3% increase from 2010), and 16 fatalities (220% increase from 2010). The year 2012 saw a total of 327 pedestrian-involved crashes, a 6.5% increase from 2011. The 327 total crashes were comprised of 135 minor injuries (a 1% increase from 2011), 125 moderate injuries (a 10.6 increase from 2011), 57 major injuries (a 29.5% increase from 2011), and 10 fatalities (a 37.5% decrease from 2011).

The total number of vehicle-pedestrian incidents in 2013 was 277, representing a 15.3% decrease from 2012. The 277 total included 119 minor injuries (a 11.9% decrease from 2012), 103 moderate injuries (a 17.6% decrease from 2012), 35 major injuries (a 62.9% decrease from 2012), and 20 fatalities (a 100% increase from 2012). In the final year included in the dataset, 2014, there were a total of 291 vehicle-pedestrian incidents (a 5.1% increase from 2013). In 2014, there were a total of 106 minor injuries (a 10.9%

decrease from 2013), 129 moderate injuries (a 25.2% increase from 2013), 36 major injuries (a 2.9% increase from 2013), and 20 fatalities (no change from 2013).

Figure 3: Number and Severity of Incidents

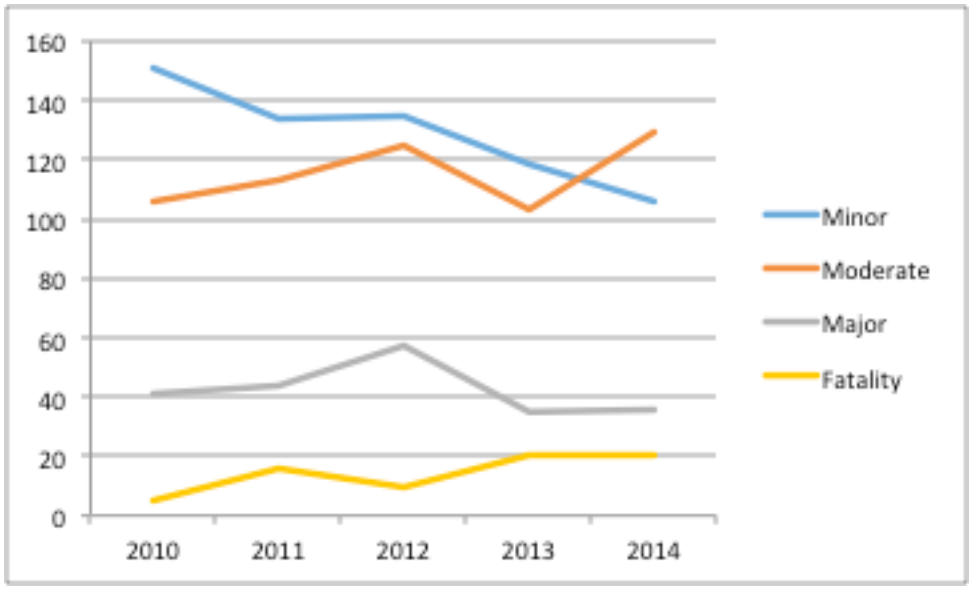
	Minor	Moderate	Major	Fatality	**Total**
2010	151	106	41	5	**303**
2011	134	113	44	16	**307**
2012	135	125	57	10	**327**
2013	119	103	35	20	**277**
2014	106	129	36	20	**291**

Source: City of San Jose Department of Transportation, 2015

In summary, 2014 saw a 4.0% decrease in total vehicle-pedestrian incidents from 2010. In 2014 compared to 2010, when broken out by degree of injury to the pedestrian, there was a 14.6% decrease in minor injuries, a 21.7% increase in moderate injuries, a 13.9% decrease in major injuries, and a 300% increase in fatalities. In addition, the greatest decrease in total injuries occurred between 2012 and 2013; 327 incidents compared to 277 (a 15.3 % decrease).

The low point in total pedestrian-involved collisions occurred in 2011 (307 incidents), with the high point occurring in 2012 (327). However, when divided categorically by degree of injury to the pedestrian, the results vary among the 5 years of study. The greatest number of minor injuries took place in 2010 (151), while 2014 saw the low point in minor injuries (106). The peak in moderate injuries took place in 2014 (129), with the low point occurring in 2013 (103). The highest number of major injuries occurred in 2012 (57), while the lowest number of major injuries occurred in 2013 (35). Moreover, 2013 and 2014 saw the greatest number of fatalities (20), while 2010 saw the lowest number of fatalities (5).

Figure 3: Change in Incidents



Source: San Jose Department of Transportation, 2015

Budgets

An analysis of the funding allocated to pedestrian safety infrastructure from 2010 to 2014 allows for a comparison between program implementation and program outcomes. Program implementation is defined as the installation of traffic safety infrastructure. Furthermore, program outcomes are defined by the vehicle-pedestrian collisions from calendar years 2010 through 2014.

An examination of the City of San Jose Capital Improvement Program published budgets from fiscal years 2009-2010 to 2014-2015 provides a snapshot of the dollar totals allocated to road safety capital improvement projects. This examination also allows for an analysis of the projects' progressions over time.

The City of San Jose divides the Adopted Capital Budget into various categories including Developer Assisted Projects, Sanitary Sewer System, Storm Sewer System, Water Pollution Control, Water Utility, Library, Parks and Community Facilities Development, Public Safety, Airport, Parking, Communications, Municipal Improvements, Service Yards, and Traffic. The City of San Jose divides the Traffic Capital Improvement Program into the subcategories of "Maintenance and Rehabilitation", "Safety and Efficiency", "North San Jose Projects", "Regional System Expansion", "Community Livability", "Planning and Policy", and "Strategic Support".

The "Safety and Efficiency" subcategory best encapsulates the funding allocated toward pedestrian safety improvement projects. This annual budget fluctuates depending on the availability of funding and the completion stages of major projects. Federal, State, and local grants provide the core of the funding for these safety improvement projects. In addition, Construction Excise Taxes and Building and Structure Construction Taxes provide the City of San Jose the funding necessary to augment those grants.

In fiscal year 2009-2010, the City allocated $46.2 million toward 'Safety and Efficiency' projects. This allocation represents 18.4% of the total 2009-2010 Traffic Capital budget of $250.6 million (City of San Jose, 2010). In fiscal year 2010-2011, the 'Safety and Efficiency' budget lessened to $35.3 million, but represented 20% of the total Traffic Capital budget (City of San Jose, 2011). The 2011-2012 'Safety and Efficiency' budget of $23.9 million represented 11.8% of that fiscal year's Traffic Capital budget (City of San Jose, 2012).

Figure 4: Safety and Efficiency Budgets

Safety and Efficiency Budgets Fiscal Year	
2009-2010	$46,200,000
2010-2011	$35,300,000
2011-2012	$23,900,000
2012-2013	$33,400,000
2013-2014	$46,900,000

Source: City of San Jose Department of Transportation, 2015

The 2012-2013 'Safety and Efficiency' budget grew to $33.4 million, representing 12% of that fiscal year's Traffic Capital budget (City of San Jose, 2013). In fiscal year 2013-2014, the 'Safety and Efficiency' budget grew significantly to $46.9 million, representing 14.5% of the 2013-2014 Traffic Capital budget (City of San Jose, 2014). In sum, in the four-year span of budgets, 2013-2014 ($46.9 million) saw the largest amount of funding allocated toward 'Safety and Efficiency' projects, while 2011-2012 saw the lowest amount of funding ($23.9 million). However, in terms of portion of total Traffic Capital Improvement budgets, 2010-2011 represented the largest share (20%), while 2011-2012 represented the lowest share.

The funding allocated toward 'Safety and Efficiency' shrunk dramatically in 2011-2012 due to funding limitations resulting from the national economic downturn (City of San Jose, 2011). Federal, State, and local grants largely fund traffic safety projects. The national recession reduced the availability of grant revenue. In addition, local development taxes such as the Building and Structure Construction Tax and the Construction Excise Tax also support traffic safety projects. As with grant revenue, the recession caused a significant decrease in development tax revenue (City of San Jose, 2011).

Within the "Safety and Efficiency" subcategory, several significant ongoing capital projects stand out for serving the goal of making San Jose roads safer for pedestrians. The "Traffic Safety Improvements" Project aims to create safer roads through "guardrail installation, energy dissipaters, median island safety modifications, sidewalk improvements, roadway and shoulder widening, safety fencing, barricade installation, and safety signing" citywide. Actual expenditures on this project include $301,750 in 2009-2010, $460,581 in 2010-2011, $381,740 in 2011-2012, $480,803 in 2012-2013, and $722,841 in 2013-2014 (City of San Jose, 2014).

In addition, the "Bicycle and Pedestrian Facilities" Project focuses on sidewalk and crosswalk improvements to create safer streets for pedestrians. Actual expenditures on this project include $369,245 in 2009-2010, $594,319 in 2010-2011, $1,089,753 in 2011-2012, $250,603 in 2012-2013, and $664,171 in 2013-2014 (City of San Jose, 2014). Lastly, the "Safety-Pedestrian Improvements" Project forwards the goal of pedestrian safety through "crosswalks enhanced with flashing beacons, high visibility markings, median refuge, and curb return treatments." Actual expenditures on this project include $561,249 in 2012-2013, and $458,370 in 2013-2014 (City of San Jose, 2014).

Tracking the money allocated towards the above-mentioned ongoing projects allows for an analysis of the citywide capital improvements aimed at creating safer roads for pedestrians. However, honing in on two specific projects targeted toward particularly dangerous roads areas allows for a clearer depiction of the geographic dispersal of Traffic Capital project funding. The "San Carlos Street Multimodal Streetscape Improvements" Project aimed to create a safer roadway on San Carlos Street in downtown San Jose, between Second and Market Streets (City of San Jose, 2013). This area of downtown San

Jose is characterized by high pedestrian traffic due to its proximity to San Jose State University, Plaza de Cesar Chavez, Children's Discovery Museum of San Jose, the South of First Street Area (SOFA), San Jose McEnery Convention Center, and several large hotels.

Moreover, downtown workers and tourists frequent the Valley Transportation Authority (VTA) bus lines and VTA Light Rail station located on San Carlos Street. The pedestrian safety enhancements funded by the "San Carlos Street Multimodal Streetscape Improvements" Project include roadway narrowing to slow traffic, sidewalk widening for easier pedestrian access, and improved crosswalks that allow for safer pedestrian crossing of San Carlos Street (City of San Jose, 2013). The Department of Transportation began this project in 2010, and completed the project in 2012. The total funding spent on this project was $2.1 million (City of San Jose, 2013).

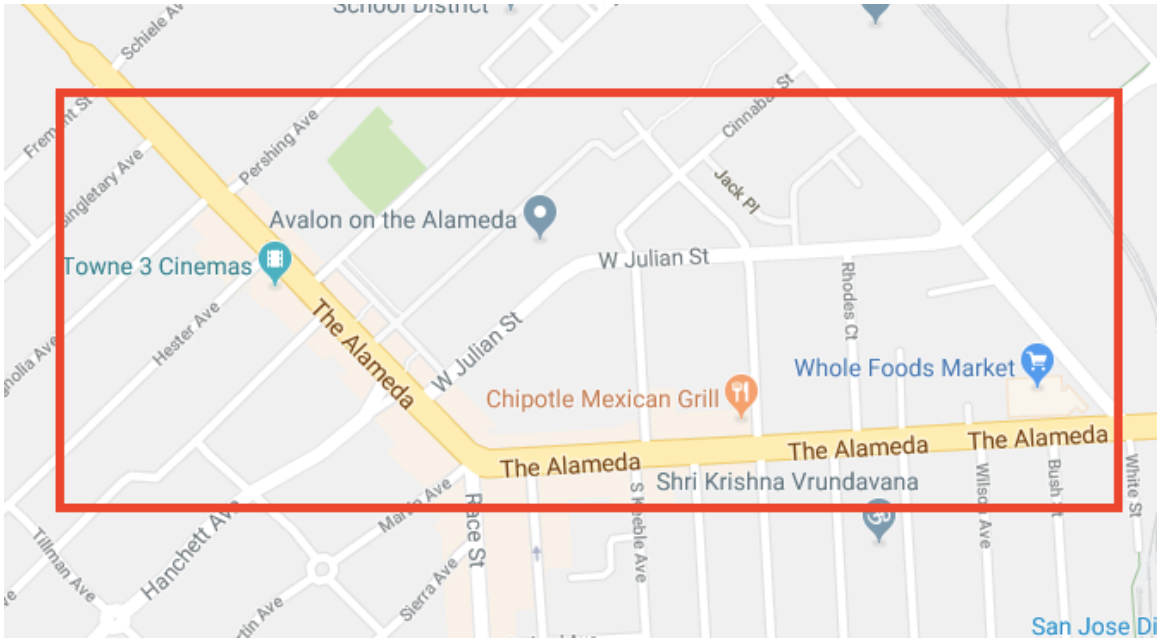
Figure 5: San Carlos Street Multimodal Improvement Scope

Source: City of San Jose Department of Transportation, 2015

The Department of Transportation also completed a significant and relatively high cost pedestrian safety project in an area west of downtown San Jose. “The Alameda – A Plan for a Beautiful Way” Project focused on pedestrian safety road infrastructure improvements on The Alameda, between Stockton Avenue and Fremont Street (City of San Jose, 2013). This roadway serves as a commuter corridor between downtown San Jose and West San Jose, and cuts through an area of San Jose with a mix of small businesses and residential neighborhoods. In addition, pedestrians frequent this roadway due to its proximity to the SAP Center (Stadium for the San Jose Sharks NHL hockey team), retail and restaurants along The Alameda, Whole Foods Market, Herbert Hoover Middle School, and Lincoln High School.

“The Alameda – A Plan for a Beautiful Way” Project aimed to create a safer roadway for pedestrians through the installation of a “raised median with landscaping, enhanced pedestrian crosswalks with median refuges, bulb-outs, ADA ramps”, and enhanced street lighting (City of San Jose, 2013). The Department of Transportation began this project in 2009 and completed the project in 2012 (City of San Jose, 2013). The City of San Jose spent a total of $4.7 million on “The Alameda – A Plan for a Beautiful Way” Project.

Figure 6: The Alameda – A Plan for a Beautiful Way Project Scope



Source: City of San Jose Department of Transportation, 2015

ANALYSIS

The City of San Jose allocates funding for roadway infrastructure improvement projects to make San Jose's streets more efficient, more accessible by different modes of transportation (bicycle, light rail, and bus), safer for drivers, and safer for pedestrians. This paper focuses on pedestrian safety. In particular, the research conducted for this paper aims to find a correlation between the dollars spent on pedestrian-safety related projects and the number of pedestrian injuries/fatalities taking place on San Jose roads between 2010-2014.

The Findings section of this paper describes the total dollars spent on traffic safety projects, highlighting several notable ongoing projects where the primary focus was pedestrian safety. In sum, the total funding for traffic safety projects dipped between fiscal years 2009-2010 and 2011-2012, but increased to similar starting point levels by fiscal year 2013-2014 ($46.2 million in 2009-2010, $35.3 million in 2010-2011, $23.9 million in 2011-2012, $33.4 million in 2012-2013, and $46.9 million in 2013-2014).

The Findings section of this paper also references the total vehicle-pedestrian incidents by year, and further points out the annual total incidents by degree of injury. When comparing the total dollars spent annually on traffic safety projects to total number of injuries that took place annually, there exists a small similarity between the two measures. Between 2009-2010 and 2010-2011, the traffic safety funding dropped by $10.9 million (23.6%). Between 2010 and 2011, the number of vehicle-pedestrian incidents increased by 4. However, this increase in incidents represents a relatively insignificant increase of 1.3%.

However, the increment of change for dollars spent and incident occurrences during the 2-year window from 2010 to 2012 shows a potentially more significant relationship between funding allocated toward traffic safety and vehicle-pedestrian incidents. The funding allocated toward traffic safety decreased by $22.3 million between 2009-2010 and 2011-2012, representing a 48.3% reduction. During that same period of time, the total number of vehicle-pedestrian incidents increased by 24, or 8.0%. Specifically, the number of moderate injuries increased by 17.9%, major injuries increased by 39.0%, and the number of fatalities doubled during that two-year span.

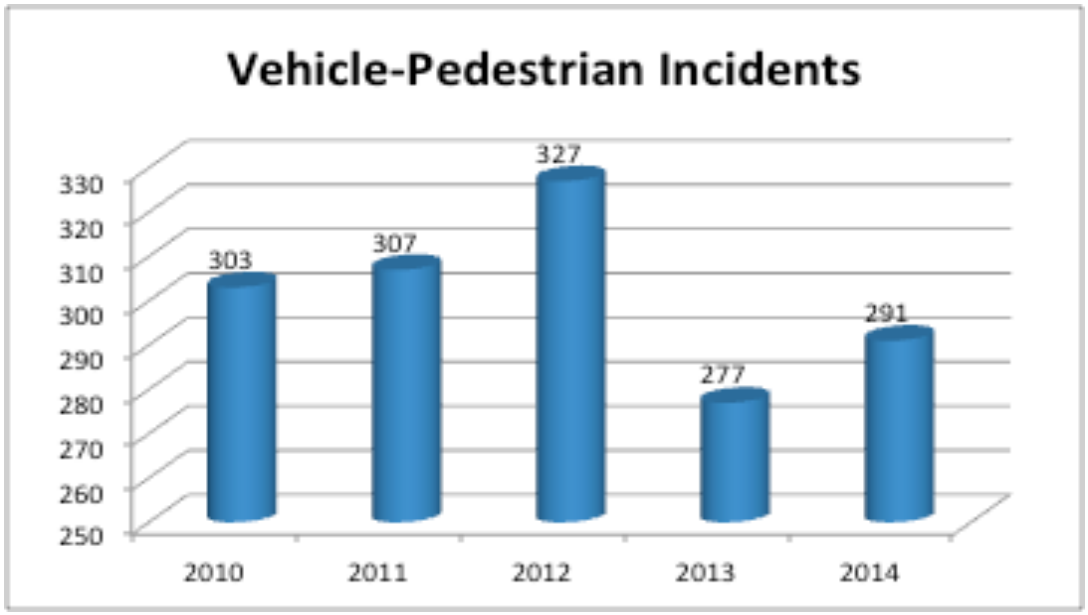
The two-year span of time between 2011-2012 and 2013-2014 also shows a potential relationship between traffic safety funding and vehicle-pedestrian incidents. Between 2011-2012 and 2013-2014, the traffic safety funding increased by $23.0 million, representing a 96.2% increase. In that same two-year span of time, the number of vehicle-pedestrian incidents decreased by 36, or 11.0%.

In sum, the funding allocated toward traffic safety improvement projects and the number of vehicle-pedestrian incidents follows opposite paths between 2010 and 2014. Funding levels began at $46.2 million in 2009-2010 and dipped to a four-year low at $23.9 million in 2011-2012, representing a 48.3% decrease. By 2013-2014, funding levels returned to 2009-2010, ending the four-year window of study at $46.9 million.

Paradoxically, total vehicle-pedestrian incidents increased from the 2010 level of 303 to a four-year peak of 327 in 2012. Again, in reverse of the funding level increase in the final two years of study, vehicle-pedestrian incidents decreased to similar starting point levels at 291 in 2014. The charts below illustrate the contrasting traffic safety

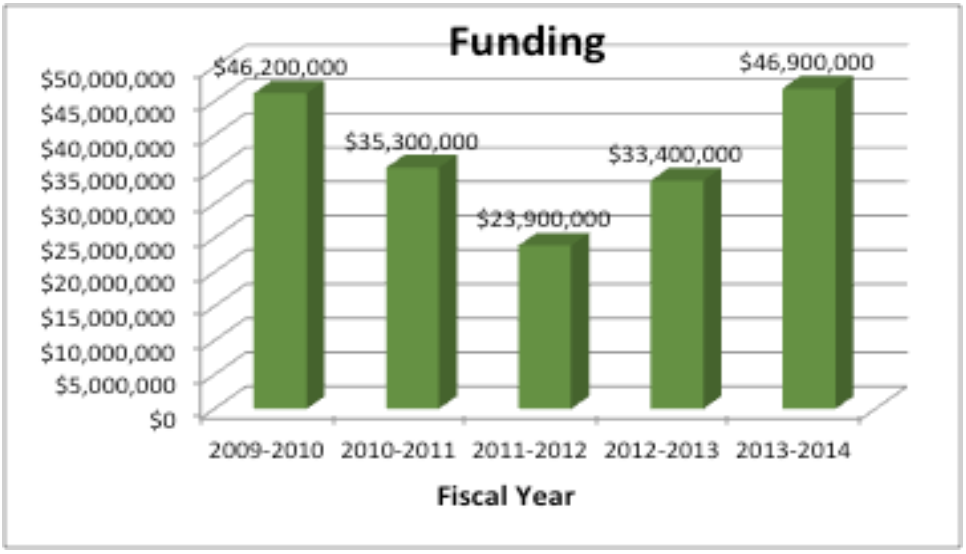
funding and vehicle-pedestrian incident trajectories between fiscal years 2009-2010 to 2013-2014 and calendar years 2010 to 2014.

Figure 7: Variation in Vehicle-Pedestrian Incidents



Source: City of San Jose Department of Transportation, 2015

Figure 8: Variation in Funding



Source: City of San Jose Department of Transportation, 2015

The reversing paths of the two measures show that as funding increased, vehicle-pedestrian incidents decreased. As traffic safety funding decreases, the number of vehicle-pedestrian incidents increases, as seen from 2010 to 2012. In addition, as observed in the two-year span of time between 2012 and 2014, the number of vehicle-pedestrian incidents decreases as the traffic safety funding increases. Thus, an analysis of the data suggests a correlation between traffic safety funding increases and vehicle-pedestrian incident decreases.

However, the change in vehicle-pedestrian incidents during the four-year window of study does not necessarily demonstrate causation, or a statistically significant correlation between the two measures. While the percentage changes in traffic safety funding levels between 2010 and 2014 are significant, the percentage changes in vehicle-pedestrian incidents are relatively minor. For example, the greatest percentage change in traffic safety funding occurred between 2011-2012 and 2013-2014, increasing by 96.2%. The corresponding percentage change in vehicle-pedestrian incidents during that same period of time, which would potentially suggest a correlation between traffic safety spending and vehicle-pedestrian collisions, represented an 11% decrease.

Moreover, while overall traffic safety spending between 2010 and 2014 varied significantly, the number of vehicle-pedestrian incidents occurred at similar levels during the four-year time span. For example, the annual average number of vehicle-pedestrian incidents between 2010 and 2014 was 301. The largest deviation from the average annual vehicle-pedestrian incident level was 26, which occurred in 2012. This year only represents an 8.6% deviation from the average annual incident level of 301. In sum, total

annual vehicle-pedestrian incidents came in at relatively similar levels between 2010 and 2014.

In a city as large as San Jose, several outside factors detract from the likelihood of a correlation between traffic safety spending and the minor variation in vehicle-pedestrian incidents during the four-year scope of study. For example, variations in traffic levels from year to year may contribute to increases and decreases in annual vehicle-pedestrian incidents. Furthermore, changes in weather may cause variations in incident levels. For example, particularly wet winters and springs may increase the likelihood of vehicle-pedestrian incidents due to lower visibility and more slippery streets that make vehicle breaking more difficult.

However, a closer analysis of vehicle-pedestrian incident variations at two particular road segments may allow for inferences about the impact of pedestrian safety oriented traffic infrastructure. As detailed in the Findings section, the Department of Transportation implemented two significant traffic safety projects between 2010 and 2014. The San Carlos Street Multimodal Improvements project installed traffic safety enhancements on San Carlos Street between 2nd and Market Streets, aiming to make this highly used road segment safer for pedestrians. The Department of Transportation completed this project in 2013-2014. An analysis of vehicle-pedestrian incidents at this road segment between 2010 and 2014 reveals that one incident occurred annually between 2010 and 2012, with no incidents occurring in 2013 and 2014.

The Findings section also describes The Alameda – A Plan for a Beautiful Way project. For this project, the Department of Transportation installed traffic safety infrastructure on The Alameda, between Stockton Avenue and Fremont Street, with the

goal of creating a safer street for pedestrians. The Department of Transportation completed this project in 2013-2014. Similar to the San Carlos Multimodal Improvements project, three vehicle-pedestrian incidents occurred between 2010 and 2012. In addition, zero incidents occurred on that road segment in 2013 and 2014.

In sum, the Department of Transportation completed both the San Carlos Street Multimodal Improvements and The Alameda – A Plan for a Beautiful Way projects in 2013-2014. Moreover, three vehicle-pedestrian incidents occurred on both road segments, San Carlos Street and The Alameda, between 2010 and 2012. In the case of both road segments, no vehicle-pedestrian incidents took place between 2013 and 2014. An analysis of the timing of the incident occurrences suggests that the completion of the projects correlates with the reduction in vehicle-pedestrian incidents, but the numbers are small.

In addition, the reductions in vehicle-pedestrian incidents on both road segments between 2010 and 2014 lack the statistical significance to infer a correlation between road safety project implementation and vehicle-pedestrian incidents. While the implementation of pedestrian-safety improvements on San Carlos and the Alameda may reduce the likelihood of vehicle-pedestrian incidents, the three-incident drops after 2013 in both cases does not prove a correlation between project completion and vehicle-pedestrian incidents. Similar to the previously discussed relationship between traffic safety spending and citywide vehicle-pedestrian incidents, too many outside factors may influence the variation in incidents' occurrences between 2010 and 2014. For example, drier road conditions and/or reduced traffic levels may contribute to reduced incident occurrences on San Carlos and The Alameda after 2013.

Thus, the three scopes of study during the four year time-span between 2010 and 2014 include city-wide dollars spent and vehicle-pedestrian incidents, the San Carlos Street Multimodal Improvements project and vehicle-pedestrian incidents occurring on that road segment, and The Alameda – A Plan for a Beautiful Way and vehicle-pedestrian incidents occurring on that road segment. An analysis of the data of all three areas of study yields no statistically significant correlation between dollars spent and vehicle-pedestrian incidents. In the case of city-wide dollars spent, the geographical scope is too large to suggest that, for example, an increase in dollars spent in one given year causes vehicle-pedestrian incidents to drop. In addition, in the case of both San Carlos Street Multimodal Improvements and The Alameda – A Plan for a Beautiful Way projects, the number of vehicle-pedestrian incidents before and after the project implementations are too small to infer a statistically significant correlation between dollars spent on projects and the rate of vehicle-pedestrian incidents.

CONCLUSION

This study examines the relationship between the City of San Jose's pedestrian-safety related capital improvement projects and the vehicle-pedestrian incident levels between 2010 and 2014. An overview of the funding allocated toward pedestrian-safety related projects during that four-year span shows a sharp dip in spending levels from 2009-2010 to 2011-2012. By 2013-2014, funding levels increased to the starting point level in 2009-2010. An analysis of the vehicle-pedestrian incident data from 2010 to 2014 reveals a contrasting trajectory of change to that of pedestrian-safety related funding levels. However, the increments of change in vehicle-pedestrian incidents during the window of study lack the statistical significance to infer causation between pedestrian-safety related funding levels and the rate of vehicle-pedestrian incidents.

This study also hones in on two particular pedestrian-safety oriented projects implemented in the middle of the four-year span of time: San Carlos Street Multimodal Improvements and The Alameda – A Plan for a Beautiful Way. While drops in vehicle-pedestrian incidents after project completions in both cases suggest a correlation between project implementation and rates of vehicle-pedestrian incidents, the reduction in incidents is too small in both cases to infer causation.

However, an examination of post-2014 vehicle-pedestrian incidents at both locations may reveal more statistically significant data. While this study failed to find data to support a statistically significant correlation between pedestrian-safety project funding and a reduction in vehicle-pedestrian incidents, the availability of incident data allows for a wide variety of topics for future analysis. The City of San Jose's shift of focus to the Vision Zero transportation policy in 2014 places greater prioritization and

funding toward pedestrian-safety projects. An analysis of traffic incident records in future years may reveal a correlation between the shift to Vision Zero and a reduction in vehicle-pedestrian incident levels.

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