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Center of a Tension: An Analysis of Center Turn Lanes

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UCLA Institute of Transportation Studies

Center Of A Tension

An analysis of center turn lanes

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Faculty Advisor: Adam Millard-Ball
Client: Los Angeles Department of Transportation

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16. Abstract
Removing a center turn lane from a three-lane road does not appear to interfere with safety goals. In fact, in some cases, it appears it may improve safety. I compared streets with a center turn lane to those that once had a center turn lane, but later removed it. The streets that once had center turn lanes — but later removed them in favor of treatments such as bike lanes — registered an average of 42% fewer crashes per million vehicle miles traveled (VMT) than the comparison streets with center turn lanes. Furthermore, the additional safety benefits held up when measuring across a selection of sub-crash groups, such as fatal and severe crashes and pedestrian and bicycle collisions. While a before-and-after analysis suggested that part of this effect can be attributed to lower crash densities on our treatment streets, this did not invalidate the fact that these streets still observed absolute reductions in crash rates after the removal of a center turn lane, suggesting that center turn lane removal can coexist with safety objectives.

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UNIVERSITY OF CALIFORNIA

Los Angeles

CENTER OF A TENSION

An analysis of center turn lanes

A comprehensive project submitted in partial satisfaction of the requirements for the degree Master of Urban and Regional Planning.

by

Michael Rosen

Client: Los Angeles Department of Transportation

Client Supervisor: Severin Martinez

Advisor: Adam Millard-Ball

Disclaimer

This report was prepared in partial fulfillment of the requirements for the Master in Urban and Regional Planning degree in the Department of Urban Planning at the University of California, Los Angeles. It was prepared at the direction of the Department and of the Los Angeles Department of Transportation as a planning client. The views expressed herein are those of the authors and not necessarily those of the Department, the UCLA Luskin School of Public Affairs, UCLA as a whole, or the client.

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Table of Contents

Executive Summary

In 2015, Eric Garcetti, then the mayor of Los Angeles, released his vision for a brighter future in roadway safety: By 2025, the city of Los Angeles would aim for zero traffic fatalities (Executive Directive 10, Garcetti, 2015). He called this program "Vision Zero," modeled after similar traffic safety initiatives pioneered in Northern Europe.

Eight years later, this goal appears farther out of reach than ever. In 2022, traffic fatalities in Los Angeles actually hit their highest mark in the last two decades (Smith, 2023). 312 people died in traffic collisions in the city of Los Angeles in 2022, a somewhat incredible 68% *increase* in traffic fatalities since the introduction of the program, suggesting that something is not working or, at the very least, that the pace and scale of implementation is not sufficient.

As the city rethinks how to approach the problem of eliminating these preventable deaths, it is worth thinking about specific infrastructural interventions to further this goal. One ubiquitous strategy is the traditional road diet, which converts a street from two lanes in each direction to a single lane in each direction with a center turn lane.

Most often, the road diet prescription looks like this: Take a road with a width of at least 40 feet and two travel lanes in both directions. Erase all existing striping. Insert one travel lane in both directions and paint a yellow-striped lane in the middle of the road to facilitate left-turn movements. The goal of these diets, originally, was to both promote road efficiency and reduce conflict between cars in mixed traffic, therefore making streets safer. When there is additional space available, that space is most often allocated to parallel on-street parking; if there is still further space, bike lanes are added.

Does the traditional road diet modification meet its goal of improving safety? Decades of national research and case studies indicate the answer is "Yes" (FHWA, 2014). There is not much of a debate surrounding the safety efficacy of going from four to three lanes. But it is possible that this consensus has spawned an impulse to add center lanes indiscriminately – sometimes in cases where a street might have the space but not the apparent need or benefit. This is at least partially true in Los Angeles, where past practices by the Department of Transportation added center turn lanes to single lane streets — often with lower traffic volumes — simply because there was space, with no subsequent assessment of whether any safety-related goals were achieved.

Building on this discourse, I asked one central question: Does going from three lanes to two lanes improve safety outcomes? For this capstone, I reasoned that — if traditional three lane configuration roadways are falling short on transportation safety related goals

— their associated road space could be repurposed to achieve greater safety benefits and possibly other citywide goals of supporting more walking and bicycling infrastructure.

Ultimately, I found little evidence that removing a center turn lane from a three lane road interferes with safety goals. In fact, in some cases, it appears it may improve safety. For this capstone, I compared streets with a center turn lane to those that once had a center turn lane, but later removed it. The streets that once had center turn lanes — but later removed them in favor of treatments such as bike lanes — registered an average of 42% *fewer* crashes per million vehicle miles traveled (VMT) than the comparison streets with center turn lanes. Furthermore, the additional safety benefits held up when measuring across a selection of sub-crash groups, such as fatal and severe crashes and pedestrian and bicycle collisions. While a before-and-after analysis suggested that part of this effect can be attributed to lower crash densities on our treatment streets, this did not invalidate the fact that these streets still observed absolute reductions in crash rates after the removal of a center turn lane, suggesting that center turn lane removal can coexist with safety objectives.

Given these findings, I present a specific recommendation to the Los Angeles Department of Transportation: Continue repurposing the center turn lanes on streets that have a single lane of through traffic in each direction while collecting data to further understand where this style of street reconfiguration makes sense, what potential benefits it may yield, and what traffic conditions and volumes may impact the efficacy of removing a center turn lane. While most of the streets in this study carried fewer than 10,000 average daily travelers, two of the streets examined exceeded this threshold, suggesting this treatment may not necessarily be limited to low-volume streets. Additional research can better help understand suitable context and conditions for this “three to two lane” conversion and any associated benefits in crash reduction.

Introduction

Due to interventions from safety enthusiasts and transportation professionals in the latter part of the 20th century, traditional road diets — identifiable by their signature center turn lane (Figure 1) — have proliferated across the City of Los Angeles as they have in many other parts of the country. Past local research on the classic road diet has found that there are between 20% and 50% fewer crashes on these streets compared to their four lane counterparts (Martinez, 2016; Venegas, 2022; FHWA, 2014.)

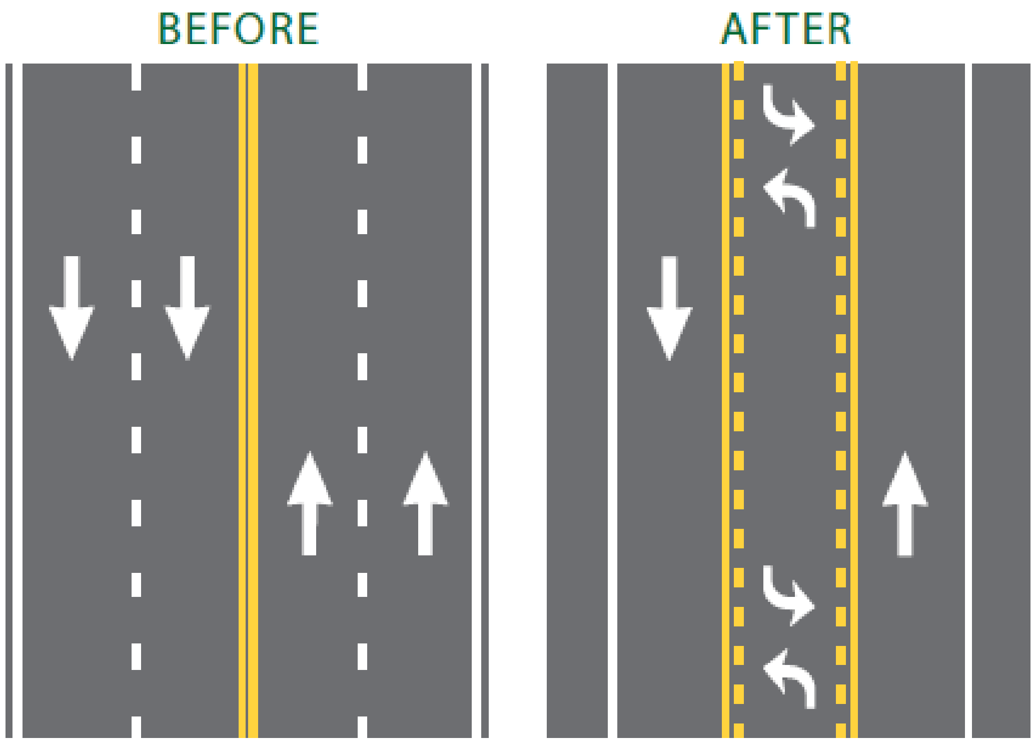

Figure 1: A diagram showing the most common type of road diet configuration, converting a street with two lanes in each direction to one lane in each direction with a shared center turn lane.

Source: FHWA

Although the subject of road diets is well worn, this research looks at the matter with a new twist. While previous case studies and research have largely found road diets to provide the expected safety benefits, this capstone instead focuses on a unique road diet typology that is neither widely studied nor given much attention. It analyzes situations where the benefits of a traditional road diet may be less expected: streets where a key road diet feature — a center turn lane — is removed to make space for other modes and uses.

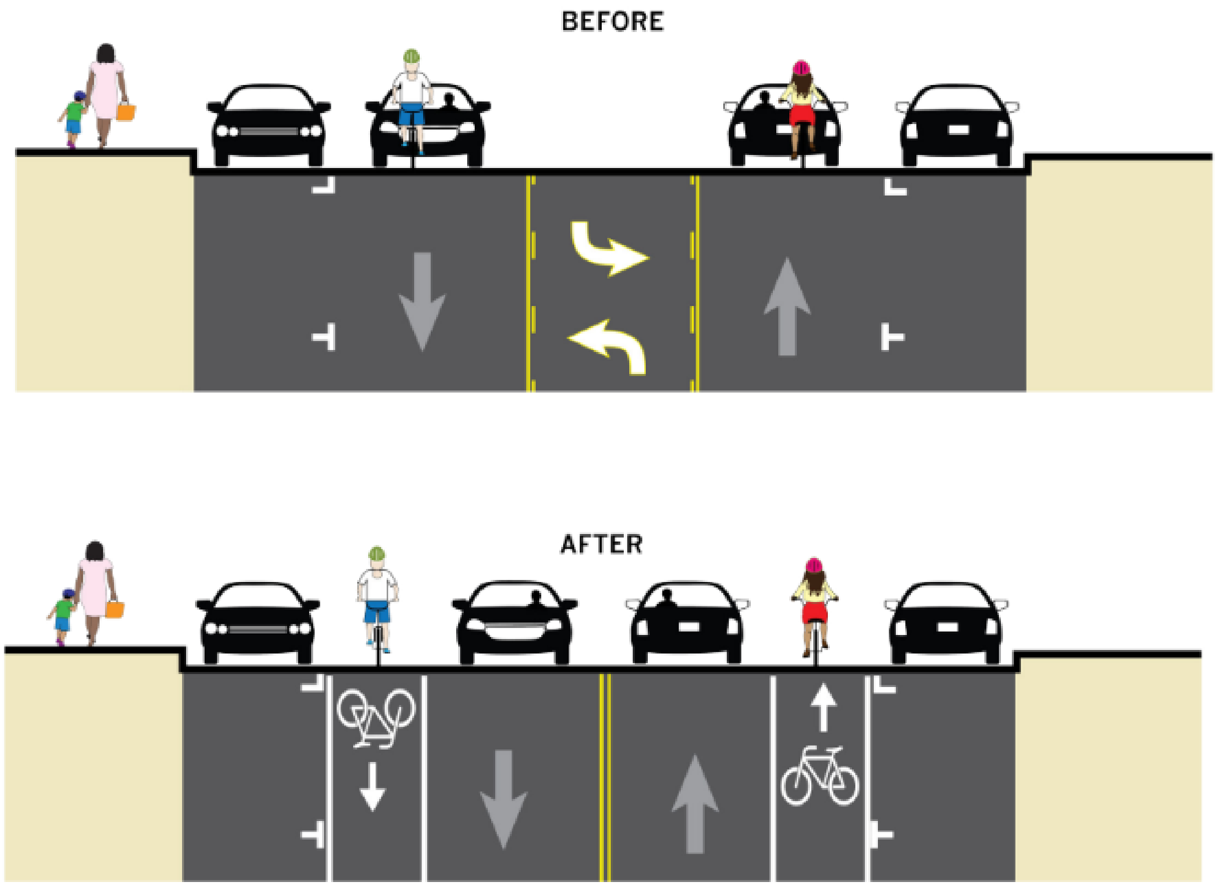

Figure 2: A diagram showing a three to two lane conversion.

Source: Severin Martinez

Figure 3: 19th Street goes from three to two lanes to make room for bike lanes.

Source: Google Street View

Traditional road diets were born out of a desire to move traffic more efficiently and safely. Over time, their implementation has expanded to advance other local priorities such as implementing bike lanes to promote bicycling, a more sustainable and spatially efficient means of travel. But there are also unconventional road diets that are implemented without adding a center turn lane, a key feature of the traditional road diet. In some cases, road diets even remove existing center turn lanes, usually in favor of providing space for dedicated bike lanes or wider parking lanes. Removing a street feature commonly associated with improved safety can seem counterintuitive, but the logic goes that doing away with a center turn lane, at least in some contexts, can further calm traffic and yield even greater safety benefits while advancing other city goals such as promoting more walking and bicycling.

It figures that, in the case where there is a steady flow of traffic, a mechanism for separating left-turn traffic would result in fewer conflicts between turning cars and free-flowing traffic. This is often the justification for converting a street from two lanes of traffic in each direction to a single lane with a shared center turn lane. But it is possible that on certain streets, removing the center turn lane and converting the street to just a single travel lane in each direction may lead to even greater safety benefits due to the reduction of travel space for cars and a corresponding addition of space for non-automobile travelers. If a center turn lane is not needed in certain contexts, it may make sense for the Los Angeles Department of Transportation to repurpose the roughly 10 feet of space that the lane occupies toward other ends, such as wider sidewalks for pedestrians or Class II or IV bike lanes for cyclists.

Since eliminating traffic conflicts is the primary motivation for instituting center turn lanes, investigating the safety benefits on streets that are similar but differ in whether or not they have center turn lanes consumes the focus of this capstone. To measure the effectiveness of center turn lanes, I calculated the rate of crashes per million vehicle miles traveled (VMT) on a sampling of streets with center turn lanes and compared the findings to the crash rates on a collection of similar streets that once had center turn lanes, but later removed them. On this latter set of streets, the space that would otherwise accommodate a lane dedicated to left turns was reallocated to offer protection to active transportation modes; in all cases but one, that meant Class II striped bicycle lanes.

Identifying the specific mechanisms for the reduction in crashes is beyond the scope of this study. However, I hypothesize that reducing automobile capacity creates safer conditions for pedestrians by slowing through-traffic. Furthermore, the “safety in numbers” (Jacobsen, 2003) effect produced by an increased density of cyclists and pedestrians could carry over to general safety benefits, creating safer conditions on the streets that reduced overall automobile capacity.

The classic road diet configuration, and the center turn lane it is commonly associated with, has a demonstrated positive safety record. This demonstrated safety record does not contradict research on converting a street from two lanes in each direction to a single lane in each direction with a center turn lane. However, it may contradict some of the common wisdom about the nature of center turn lanes relative to a two-lane arrangement.

Street space is precious, and how it is allocated reflects broader policies and city priorities. It ought not to be misused. Therefore, I suggest repurposing the space once used by the aforementioned subset of center turn lanes for two primary purposes: enlarging sidewalks and painting bicycle lanes. Allocating street space to enable and encourage more walking and bicycling (and reduce excess space for driving) will advance City policies aimed at making streets safer. In addition, there can be welcome environmental benefits from the increased use of these two climate-friendly modes of transportation: the amount of vehicle miles traveled (VMT) has a nearly one-to-one relationship with the number of lanes provided, and a decrease in vehicle capacity will ideally lead to a reduction in VMT (Duranton and Turner, 2011). Most importantly, however, is the imperative to rethink the best ways to use our limited street space to ensure the greatest safety benefits.

Literature Review

A Brief Summary of the Traditional Road Diet

A road diet, broadly defined, describes any time a lane is removed from a street in order to facilitate a safety-related reuse of that road space. The “classic” or “traditional” road diet is usually applied to a four-lane road. The four lanes — two in each direction — are reduced to three total lanes: one in each direction, and a third lane down the center of the road that allows for turns in either direction, better known as a center turn lane.

In their seminal 1999 paper “Road Diets: Fixing the Big Roads,” Dan Burden and Peter Lagerwey coined the term “road diet,” suggesting that the insertion of a center turn lane would both increase “efficiency of movement” and significantly reduce crashes. When “diagnosing” the preferred candidates for this treatment, they identified their “ideal roadway patient” as a four-lane road with an annual average daily traffic (AADT) of between 12,000 and 18,000 (Burden and Lagerwey, 1999). These days, it is commonly accepted that the traditional road diet is a suitable measure for streets experiencing approximately 20,000 AADT or fewer.

While Burden and Lagerwey were the first to coin the specific term of a “road diet,” the practice of making roads narrower preceded their coinage by decades. Burden and Lagerway identify three cities as using the practice for decades prior to the mid-1990s: Santa Monica, Portland and Seattle, three bastions of municipal progressivism over the years. They claim the 1972 conversion of N 45th Street, which runs through the Wallingford neighborhood of Seattle and past the University of Washington, as the first “road diet” on record. To this day, a center turn lane runs down N 45th Street, underscoring the enduring nature of this treatment.

In a presentation for the Transportation Research Board in 1999, Thomas Welch made one of the earliest appeals for the efficacy of a 4-to-3 road diet (Welch, 1999). Welch’s presentation provides some empirical evidence for safety benefits while echoing Burden and Lagerway’s core argument: Providing a center turn lane moves traffic-delaying vehicles into a space where they can await their turn, improving the efficiency of the roadway while reducing midblock turns and therefore potential conflicts. These days, road diets increasingly take on numerous forms, such as the conversion of the additional roadspace into bicycle lanes, a landscaped median, or even a six-to-four lane conversion.

Effectiveness of Traditional Road Diets

Much of the original literature on the subject of traditional road diets included evidence for their safety benefits. In the aforementioned 1999 TRB presentation, Thomas Welch used a before-and-after method of crash analysis, finding a 34% reduction in crashes after the implementation of the center turn lane. Burden and Lagerwey, for their part, compiled analysis of various case studies and estimated that road diets generally result in a reduction in crashes of 50% (Burden and Lagerwey, 1999).

In her 2022 UCLA capstone, Kimberly Venegas found a noticeable decrease in crashes on high-volume streets with road diets in Los Angeles (Venegas, 2022). In her analysis, there were 44% fewer crashes on the road diet corridors relative to control corridors. The Federal Highway Administration (FHWA) recognizes the classic road diet as a proven safety countermeasure and estimates they can reduce crashes by between 19 and 47 percent (FHWA, 2014).

The Role of Center Turn Lanes

Although the benefits of individual traditional road diet features are difficult to tease out, it is widely believed that their success rests in part on the addition of a center turn lane that reduces the likelihood of a left turning driver being rear ended and improves overall visibility and predictability for all road users. But is it possible that there are streets where actually *removing* center turn lanes and implementing, say, bicycle lanes instead may lead to greater overall safety benefits?

As Venegas pointed out in her capstone, the suggested AADT threshold of 20,000 for "ideal" road diet candidates may not have been rigorously tested and instead somewhat arbitrarily determined. In her research, Venegas did not identify a clear ceiling on the circumstances under which conventional road diets should be implemented, as the corridors she studied demonstrated positive safety outcomes in situations with AADT in excess of 27,000. Literature is similarly limited on the subject of center turn lanes specifically and whether it may be more advantageous to remove them in favor of other street designs in urban settings where a roadway otherwise just has a single lane of traffic in each direction.

Much of the safety-focused literature thus far has measured the impact of the traditional road diet – in other words, the conversion of a four lane road to a three lane road. But I could not find much empirical study of the three to two lane road diet phenomenon. In his book "Walkable City Rules: 101 Steps to Making Better Places," the urban planner and author Jeff Speck includes a chapter on the pitfalls of arbitrarily adding center turn lanes, writing that such a decision can lead to worse safety outcomes for cyclists and pedestrians (Speck, 2018).

Speck writes, “the extra pavement width encourages speeding, lengthens crossing distances, and takes up roadway that could otherwise be used for on-street parking or bike lanes. In contrast, when no turn lane is inserted, the occasional pauses that drivers must make for other vehicles turning contributes properly to the everyday friction that keeps speeding in check.”

For her master’s thesis at California Polytechnic State University, San Luis Obispo, Sherie George conducted a Complete Streets analysis of various streets in California. One of her case studies was of 19th Street in Sacramento, which converted a three lane street to two lanes and installed two bike lanes with the extra road space. Quoting Ed Cox, the city of Sacramento’s Bicycle and Pedestrian Coordinator, George reports that “(t)he result of three to two road diet conversions, such as 19th street, is slower speed, lower collisions, and little congestion impacts.”

Beyond these brief references, the literature on road diets falling into the “three to two conversion” category appears barren. In order to help remedy the paucity of three to two road diet literature, I undertook the following analysis.

Methodology

In order to evaluate the safety benefits of road diets that remove center turn lanes from three lane roadways, I conducted a statistical investigation. I explored two distinct methods of answering this question.

The first was a like-to-like comparison; for this method, I used a treatment and control group to draw insights. This involved identifying streets belonging to two separate categories. The first category included streets with a single travel lane in each direction and a center turn lane. The second category included similar streets that previously had a center turn lane, but later removed that lane in favor of alternative street features (usually bike lanes). This allowed me to make direct comparisons between these two groups of streets.

The second method was a before-and-after “differences-in-differences” approach, used commonly in econometrics when evaluating the effects of a policy treatment. Due to the nature of my data — only three of our “treatment” streets had crashes that I could count as “before” the treatment, limiting the size of the sample — this “differences-in-differences” approach did not produce statistically significant effects, and therefore the like-to-like approach was used as my primary mechanism for evaluating the outcomes.

The treatment category was supplied by data from the Los Angeles Department of Transportation. Unfortunately, not all potential study corridors were suitable for this analysis. Some corridors were too new to have any useful data, others were too short in segment for practical analysis purposes, and in one case traffic volumes were so low that I was unable to identify any comparable control corridors. In total, I was left with five streets that had removed center turn lanes where I could conduct viable analyses. These streets were scattered across the city of Los Angeles and ranged from AADT of just over 5,000 to just under 25,000.[1] Having a range of AADTs helped to understand the potential contexts under which a three to two lane conversion would make the most sense; it also helped to assess if there may be a ceiling at which this type of conversion starts to see negative returns on safety.

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[1] AADTs were estimated using LADOT’s subscription to StreetLight Data Analytics, a web platform the Department uses to estimate traffic data (volume, speeds, travel patterns) by aggregating mobile device data, and cross-checked with a sample of 24-hour counts recorded by LADOT and available on the City’s NavigateLA web portal. I did not see significant differences between StreetLight and NavigateLA and therefore proceeded with the StreetLight estimates.

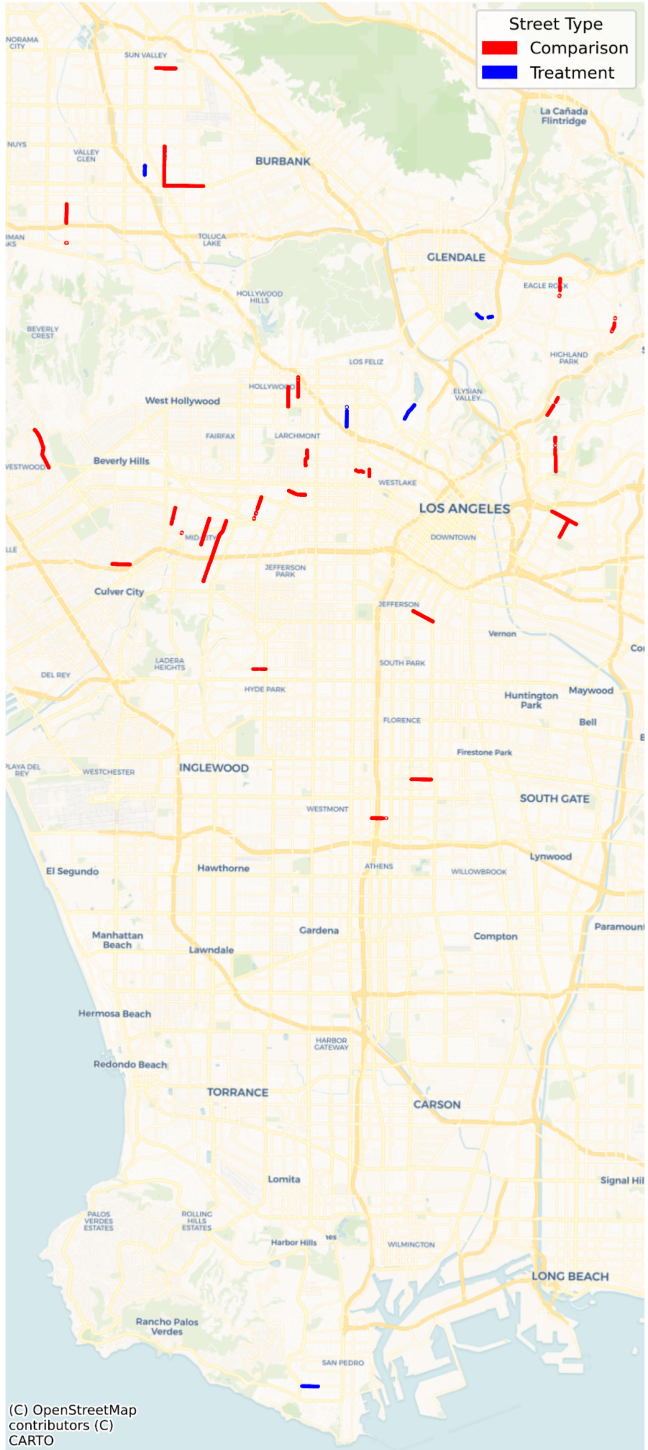

Figure 4: A Map of Treatment and Comparison Corridors

Once my study corridors were determined (Table 1), I identified control corridors: similar streets with existing center turn lanes that have not changed in their configuration (Tables 2 through 6). For each treatment street, I compiled at least 4.5 times the amount of mileage in comparison corridors. While LADOT supplied some three lane streets, I identified additional corridors by scanning Google Earth satellite imagery and verifying the availability and applicability of traffic count data to make for sound comparison corridors for my treatment group.

Treatment Corridor	**Limit 1**	**Limit 2**	**Length (mi.)**	**AADT**	**Crashes/1M VMT**	**Year of Treatment**
Edgemont Street	Melrose Avenue	Santa Monica Boulevard	0.48	5497	1.26	2015
19th Street	Walker Avenue	Western Avenue	0.35	5622.6	1.68	2019
York Boulevard	Verdugo Road	Aguilar Street	0.42	7452	1.02	2003
Colfax Avenue	Hatteras Street	Oxnard Street	0.23	12769	1.98	2021
Silver Lake Boulevard	Van Pelt Place	Berkeley Avenue	0.42	21875	1.06	1999

Table 1: Treatment Corridors Studied

Comparison Group	**Limit 1**	**Limit 2**	**Length (mi.)**	**AADT**	**Crashes/1M VMT**
Lincoln Park Avenue	Mission Road	Flora Avenue	0.87	3393	1.75
Griffin Avenue	Avenue 39	Montecito Drive	0.51	4312	2.35
Crescent Heights Boulevard	Pico Boulevard	Airdrome Street	0.41	5534	0.65
54th Street	Hillcrest Drive	Crenshaw Boulevard	0.32	6069	3.24

Table 2: Edgemont Street Comparison Corridors

Comparison Group	Limit 1	Limit 2	Length (mi.)	AADT	Crashes/ 1M VMT
108th Street	Figueroa Street	Spring Street	0.35	5795	5.71
Townsend Avenue	Colorado Boulevard	Yosemite Drive	0.43	5986	0.00
Evergreen Avenue	Cesar Chavez Avenue	Wabash Avenue	0.47	6312	2.23
92nd Street	Avalon Boulevard	Central Avenue	0.49	6835	3.21

Table 3: 19th Street Comparison Corridors

Comparison Group	Limit 1	Limit 2	Length (mi.)	AADT	Crashes/ 1M VMT
Avenue 64	Meridian Street	Church Street	0.25	6682	1.64
4th Street	Vermont Avenue	Westmoreland Avenue	0.41	7424	1.35
Redondo Boulevard	Jefferson Boulevard	Pico Boulevard	1.64	8356	3.05
Rimpau Boulevard	Olympic Boulevard	Pico Boulevard	0.56	8786	1.35
Bronson Avenue	Fountain Avenue	Hollywood Boulevard	0.48	9025	2.42
Wabash Avenue	City Terrace Drive	Soto Street	0.7	9094	2.76
Tujunga Avenue	Victory Boulevard	Lankershim Boulevard	1.01	9295	2.36

Table 4: York Boulevard Comparison Corridors

Comparison Group	Limit 1	Limit 2	Length (mi.)	AADT	Crashes/ 1M VMT
Jefferson Boulevard	Central Avenue	San Pedro Street	0.53	11408	2.25
Beverly Glen Boulevard	Wilshire Boulevard	Sunset Boulevard	1.04	11925	0.16
8th Street	Lorraine Boulevard	Wilton Place	0.44	12580	1.75
Strathern Street	Beck Avenue	Fair Avenue	0.49	13429	2.36
Gower Street	Santa Monica Boulevard	Sunset Boulevard	0.48	14790	0.55
Hauser Boulevard	Pico Boulevard	Washington Boulevard	0.7	15506	0.72

Table 5: Colfax Avenue Comparison Corridors

Comparison Group	Limit 1	Limit 2	Length (mi.)	AADT	Crashes/ 1M VMT
Fulton Avenue	Riverside Drive	Magnolia Boulevard	0.47	17076	1.00
Wilton Place	Council Street	3rd Street	0.4	20573	1.61
Burbank Boulevard	Cahuenga Boulevard	Lankershim Boulevard	0.97	20964	3.47
National Boulevard	Castle Heights Avenue	Livonia Avenue	0.43	22504	2.15

Table 6: Silver Lake Boulevard Comparison Corridors

Having both my study and comparison corridors in place, I then collected collision data. For crashes, I used the Transportation Injury Mapping System database, which extracts all crashes resulting in injury from the Statewide Integrated Traffic Records System. TIMS is operated by UC Berkeley and is used by researchers, policymakers, and elected officials across the State. In this case, I pulled crash data over the course of the entire study period — from the earliest date in the TIMS database, January 1, 2011, to the latest date available, December 31, 2022. This included all fatal and severe collisions as well as crashes resulting in minor injury. The first step in interpreting this data was extracting all potentially relevant crashes in Los Angeles County; this dataset contained nearly 300,000 crashes over this period of time, all with “point” coordinates indicating the location of the crash in space.

Next, I identified the coordinates for my control and treatment streets. For this, I used the “Street Centerlines” database from the City of Los Angeles’s Open Data Portal. This data contains line segments for the center of each street within city limits. The spatial file also included coordinates for each of these segments. To obtain the coordinates for each of the centerlines for my control and my treatment streets, I used StreetLight, which provided segment coordinates alongside ADT counts.

At this point, I had two separate datasets: a .csv file with 300,000 crashes, and my streets data with my streets of concern. With these compiled, I moved over to a Jupyter notebook — a platform for writing and executing code — where I used the programming language Python to conduct the bulk of my analysis.

Because the street centerlines are straight-line segments — and the crash data can occasionally be slightly off-center from the street itself — it was necessary to create a buffer around the street segments in order to accurately capture all of the crashes of interest. I used the GeoPandas buffer function to create eight meter buffers on either side of the street; I used eight meters, or roughly 25 feet, on both sides of the centerline in order to cover the entire street width and a few extra feet in either direction to account for slight mapping discrepancies.

After this step, I filtered the data to include only crashes where the “primary road” listed matched the street of interest. In order for the buffers to correspond appropriately to the sought-after distance, I shifted the coordinate reference system (CRS) from a geographic coordinate system (measured in degrees) to a projected coordinate system (measured in meters.)

Once these buffers were established, I used the GeoPandas spatial join function to connect each crash in our large crash dataset to our specified buffer zones. However, this merely matched each crash between January 1, 2011 and December 31, 2022 to the specified buffers. For each of my treatment streets, I wanted to limit the observed crashes to those *after* the center turn lane was removed. Similarly, for each of the comparison streets attached to the study streets, I wanted to limit the observed crashes to that same time period.

For example, the center turn lane on Edgemont Boulevard between Melrose and Santa Monica was removed on August 6, 2015. The selected comparisons for Edgemont were segments of 54th Street, Griffin Avenue, Lincoln Park Avenue, and Crescent Heights Boulevard, all of which still had their center turn lanes. I needed to count only the crashes that occurred *after* August 6, 2015 for Edgemont and its four comparison streets. I replicated this time delineation process for each treatment corridor and its corresponding control corridors.

After bringing in a third dataframe that contained each street segment, the street name, and the average daily traffic volume for these street segments according to figures produced by StreetLight, I calculated vehicle miles traveled for each of the street segments. To do so, I used the Federal Highway Administration's method for calculating crash rates by roadway mileage: crashes divided by the number of days multiplied by the length of the street segment. From there, the calculation was simple; I multiplied the length of the street by the number of daily travelers and then by the number of days since the removal of the center turn lane of the control street or the associated comparison street to calculate a projected VMT.

A "crashes per mile" rate for road segments is calculated as:

$$R = \frac{C}{N \times L}$$

Where:

R = Crashes per mile for the road segment expressed as crashes per each 1 mile of roadway per year.
C = Total number of crashes in the study period.
N = Number of years of data.
L = Length of the roadway segment in miles.

Figure 5: Formula Used to Calculate Crash Rates.

Source: FHWA Roadway Safety Information Analysis

With VMT calculated for each street segment, I then calculated crashes per million vehicle miles traveled for each of the streets. This allowed me to normalize the crashes based on volume and account for the fact that streets with greater traffic volume are likely to have more total crashes.

After deriving crash rates for the treatment and control corridors, I calculated the difference in crash means between the control corridors and the treatment corridors for three distinct categories, looking at rates of collisions overall, severe and fatal collisions, and bicycle and pedestrian collisions.

Findings

I found that the control streets — those that retained their center turn lanes — actually counted on average 42% higher crash rates than the treatment streets where the center turn lanes were removed.

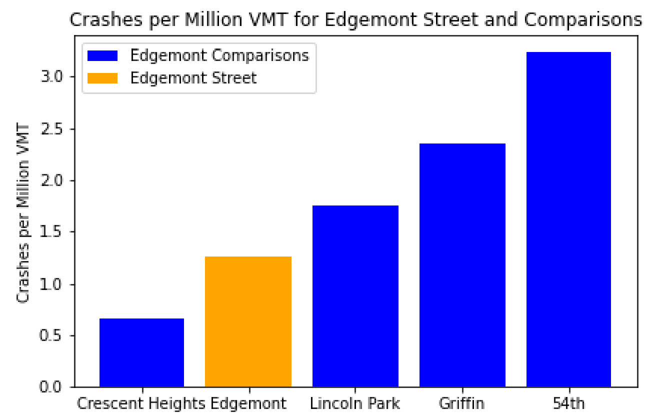

Figure 6: Crash Rates for Treatment and Control Corridors (Edgemont Street)

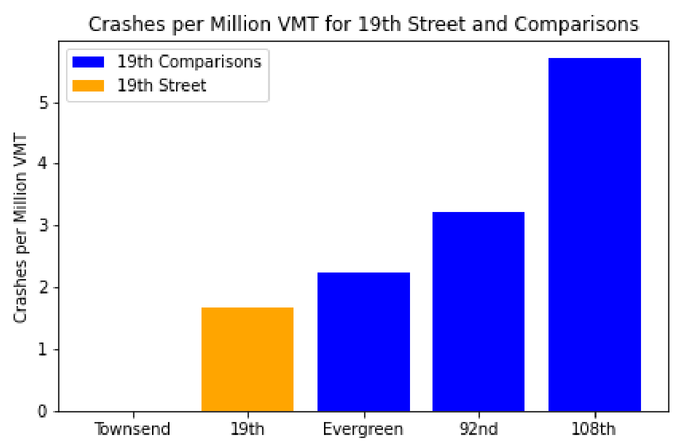

Figure 7: Crash Rates for Treatment and Control Corridors (19th Street)

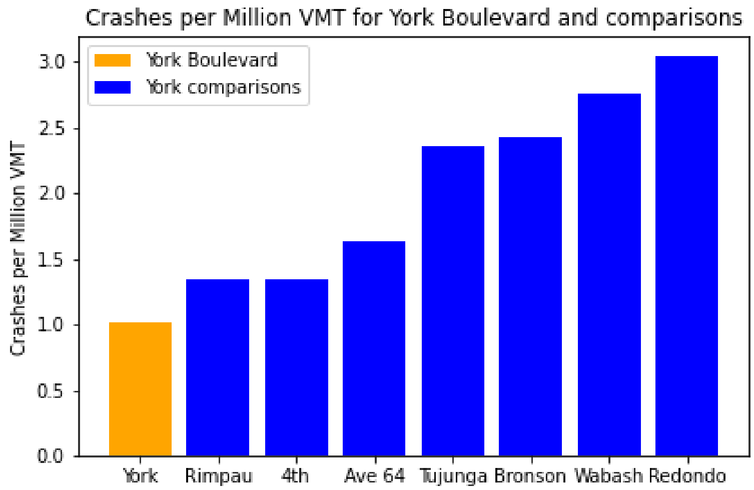

Figure 8: Crash Rates for Treatment and Control Corridors (York Boulevard)

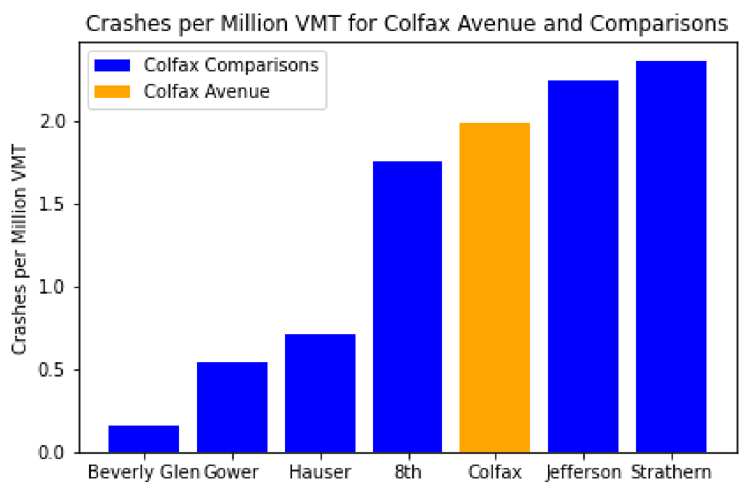

Figure 9: Crash Rates for Treatment and Control Corridors (Colfax Avenue)

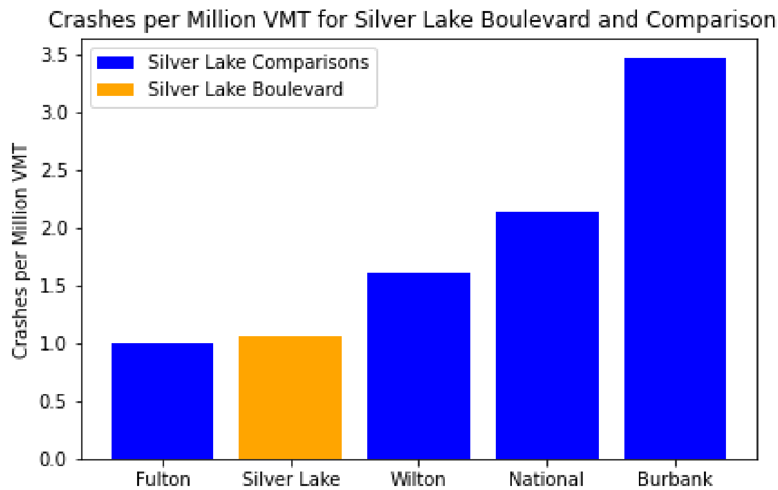

Figure 10: Crash Rates for Treatment and Control Corridors (Silver Lake Boulevard)

Even in cases where it looked like treatment corridors compared relatively unfavorably — most notably in the Colfax Avenue comparison group — sample considerations explain at least part of the disparity. Colfax removed its center turn lane in August of 2021, leaving a very brief window for the study period. The short window meant that Colfax's 1.98 crashes per million VMT were derived from three total crashes (Appendix A). In other words, one crash in either direction would have significantly shifted the results.

The findings were even more dramatic when looking specifically at fatal and severe crashes as well as bicycle and pedestrian crashes. While it should be noted that the overall volume of these more serious crashes was significantly lower than than the total volume of crashes, reducing the sample of study and therefore the reliability of the results, I nonetheless found there were 104% more fatal and severe crashes per million VMT on the comparison streets relative to the treatment streets over the course of the study period, as shown in Table 3.

For bicycle and pedestrian crashes, the difference was 19% between the control streets and the streets that went from three to two traffic lanes. The difference in bicycle and pedestrian crash rates does not account for bicycle and pedestrian volumes since these data are not regularly collected by LADOT. However, past research indicates that the addition of bike lanes tends to increase bicycle ridership, and therefore the crash rates may be more pronounced if the treatment corridors experience higher volumes of bicycle and pedestrian activity (Taylor-Gratzer, 2016).

Although the sample is small, the takeaway suggests center turn lanes may not be the best use of space to achieve the City's transportation safety goals in certain contexts.

It is important to address certain potential limitations to the study. As Figure 7 demonstrates, one of the control corridors stood above the rest: 108th Street between Figueroa Street and Spring Street, which counted nearly twice as many crashes per million vehicle miles traveled relative to any control or treatment corridors. The reason why this corridor seemingly has such a drastically higher crash rate relative to all the other streets studied is unclear, though it may reflect broader systemic transportation issues. A recent study from Boston University School of Public Health (BUSPH) and Harvard T.H. Chan School of Public Health found that Black and Hispanic Americans are the victims of significantly higher fatal crashes per mile traveled (Raifman and Choma, 2022). The census tract where 108th and Figueroa sits is 60% Hispanic, 37% Black, and only 1% white. This street segment stands out even more when tracking the rate of fatal and severe crashes over the course of the study period, as noted in Figure 7[2].

[2] The fundamental characteristics of 108th Street, such as the width of the street and the volume of the traffic, are not dissimilar from other streets in the control cohort. It is possible that because it sits halfway between two major east-west arterial (Century Boulevard and Imperial Highway) – and is one of four streets across a one-mile stretch that crosses the 110 Freeway – that it is drawing particularly aggressive traffic due to travelers trying to bypass traffic on those major streets. Regardless of the reasons why 108th Street is an outlier, it raises some interesting questions. The crash rates on 108th Street — somewhat independently from the primary results of this capstone — may point to important structural issues in our infrastructure.

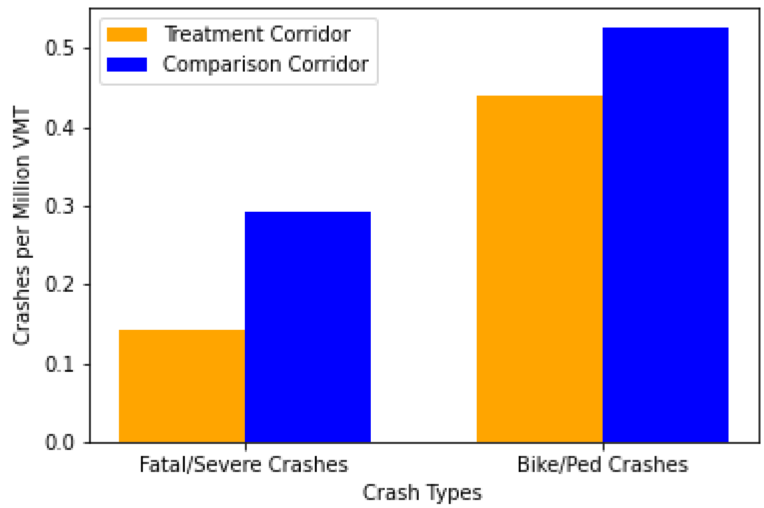

Figure 11: Comparison of Severe and Fatal Collisions and Pedestrian and Bicycle Collisions between Treatment and Control Corridors

To avoid skewing the findings based on this anomalous corridor, I reran the results with 108th Street omitted. When excluding this corridor, the treatment corridors still performed better than the comparison corridors, but not by as wide a margin.

Crashes (per million VMT)	**Treatment**	**Comparison**	**% Difference**	**P-value**
Total Crashes	1.40	2.00	42.76	0.008
Fatal and Severe Crashes	0.14	0.29	104.36	0.597
Pedestrian and Bike Crashes	0.44	0.53	19.85	0.109

Table 7: Summary of Findings

Crashes (per million VMT)	Treatment	Comparison	% Difference	P-value
Total Crashes	1.4	1.85	31.75	0.007
Fatal and Severe Crashes	0.14	0.22	53.37	0.553
Pedestrian and Bike Crashes	0.44	0.48	9.38	0.101

Table 8: Summary of findings excluding 108th Street outlier

Even without 108th, study corridors record about 32% fewer crashes after center turn lane removal than our comparison corridors over the same period of time. On fatal and severe crashes, control streets still record 53% more crashes than our study streets and 9% when looking at bicycle and pedestrian collisions specifically. Even discounting 108th Street as an outlier, the results suggest that removing center turn lanes can modestly improve safety.

After compiling the summary statistics in Tables 7 and 8, I subjected these results to a two-sample z-test, which allowed me to determine whether the difference between each of the groups met a statistical significance threshold of sub-0.05 p-value. In both the overall summary findings and the findings excluding 108th Street, the difference in overall crashes between the treatment group and the comparison group was found to be statistically significant. Fatal and severe crashes and bicycle/pedestrian crashes, on the other hand, fell short of the 0.05 alpha level in both cases; this was due to the small sample of crashes in these categories for the treatment groups on hand.

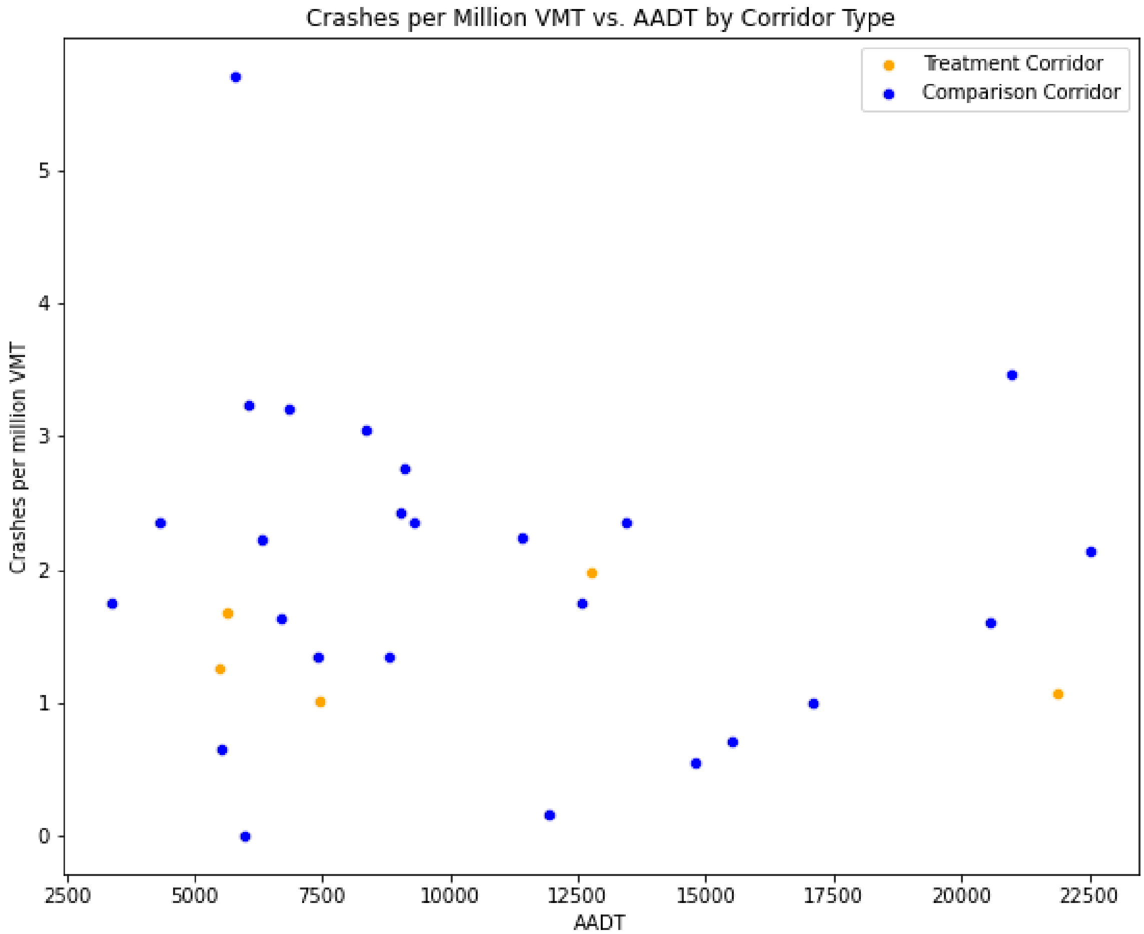

Figure 12: Visualization of Crash Rates for Treatment and Control Corridors Relative to AADT.

Looking at the relationship between average daily traffic and crashes per million VMT, it appears that the safety benefits of removing center turn lanes do not erode as volumes increase. In fact, among the treatment corridors, Silver Lake Boulevard had one of the lowest crash rates, yet had by far the highest traffic volumes. In line with past research indicating that traditional road diets can succeed when exceeding 20,000 AADT, there does not appear to be a clear ceiling that precludes removing center turn lanes on single lane streets. This finding suggests that removing center turn lanes on streets with a single lane of traffic in each direction is a prudent safety measure, regardless of the traffic volume on the street itself, though more analysis is needed to state this confidently.

Finally, I supplemented my first analysis by conducting a “differences-in-differences” analysis. This involved taking the three corridors with both before-and-after crashes in our available database — Edgemont, 19th, and Colfax — and running an ordinary least squares (OLS) regression with results split into before and after categories.

	Crashes/1M VMT (before)	Crashes/1M VMT (after)
Treatment streets	1.61	1.44
Comparison streets	2.99	1.85

Table 9: Before-And-After “Differences-in-Differences” Summary

The before and after means proved surprising. Control corridors showed a significant decrease in crashes after the treatment period while treatment corridors declined only slightly, suggesting that at least part of the effect that I measured in my like-to-like comparison can be attributed to the lower crash volumes on the treatment streets.

That being said, these results must be taken with a grain of salt. As is evident in Table 10, the p-value for the variable “difference_in_difference_effect” was 0.130, exceeding the traditional social science p-value threshold of 0.05. This finding of statistical insignificance is consistent with the small size of the sample available to conduct a before-and-after analysis. York Boulevard and Silver Lake Boulevard — our two treatment streets with the longest track record of center turn lane removal — needed to be removed due to the lack of available pre-removal crashes. Colfax Avenue, on the other hand, only removed its center turn lane in August of 2021, leaving a short period of time to observe post-removal effects. For these reasons, I defer to the like-to-like analysis to guide my conclusions.

```
                            OLS Regression Results
==============================================================================
Dep. Variable:     crashes_per_million_VMT   R-squared:                       0.482
Model:                                 OLS   Adj. R-squared:                  0.399
Method:                      Least Squares   F-statistic:                     5.820
Date:                     Thu, 08 Jun 2023   Prob (F-statistic):           6.74e-14
Time:                             14:33:58   Log-Likelihood:                -391.31
No. Observations:                      204   AIC:                             840.6
Df Residuals:                          175   BIC:                             936.8
Df Model:                               28
Covariance Type:                 nonrobust
=====================================================================================================
                                    coef    std err          t      P>|t|      [0.025      0.975]
-----------------------------------------------------------------------------------------------------
Intercept                         1.2405      0.660      1.879      0.062      -0.063       2.544
difference_in_difference_effect   1.1586      0.763      1.519      0.130      -0.346       2.664
```

Table 10: OLS Regression results for DID analysis

Need For Additional Research

This research focused exclusively on crashes as one proxy for overall safety. I found that the corridors that removed center turn lanes had lower collision rates relative to control corridors, even when excluding an apparent outlier. In the context of both Vision Zero and broader transportation goals, repurposing space from center turn lanes to other street features such as bike lanes should be further explored and implemented based on my findings. However, there may be other areas of interest that deserve further analysis.

For example, this research does not account for the potential for three to two lane conversion to shift travel choices from driving to walking or bicycling. In the past, road diets have been shown to increase bicycle ridership, and it may be that the trend holds for the type of street conversion studied in this capstone (Taylor-Gratzner, 2016). This could, potentially, further underscore the safety improvements if the proportion of bicycle collisions decreases even when accounting for changes in bicycle ridership. There is a well-observed “safety in numbers" effect when it comes to active transportation (Jacobsen, 2003); the more walkers and cyclists along the road, the safer those individuals will be. Other areas of interest include analyzing potential differences in overall traffic speeds when center turn lanes are eliminated or simply conducting a more robust before-and-after analysis for corridors as center turn lanes are removed.

Additionally, this analysis does not take into account the presence of driveways along corridors of interest. It is possible that more driveways lead to more traffic conflict due to the unexpected movements in and out of these midblock entryways. Alternatively, it is possible that an increase in opportunities for left turns can result in overall slower traffic as more cars will travel slower and come to a stop that holds up traffic without the ability for impatient drivers to overtake a car waiting to turn left. If counted, it would be useful to include the quantity of driveways in a regression analysis to control for their effects on the ultimate outcomes. Unfortunately, due to time constraints, the consideration of driveway frequency was not included in this analysis, though I observed that all treatment and control corridors generally had driveways throughout.

Some investigation into the shifting crash collection methods may illuminate and sharpen future analyses of center turn lanes. In 2021, the Los Angeles Police Department stopped recording minor traffic collisions, instead relying on individuals to self-report crashes online. Since the policy change, Los Angeles has seen a substantial drop in minor collisions reported while severe and fatal crashes are reaching all-time highs. Given these changes in crash reporting, it may be the case — particularly for the Colfax corridor and comparison corridors — that collisions are being significantly underestimated. These changes should be considered in any future projects that take up this question.

Other points of interest may include whether or not a street is largely a commercial corridor, a residential street or a mix of both, as well as an analysis of the posted speed limits and actual speeds on the streets of concern or the presence or absence of bus routes along a given corridor. Overall, there is a need for more basic research on this type of road diet typology to understand the extent of its potential benefits and tradeoffs.

Recommendations and Conclusion

Given these findings, I would like to extend one central recommendation to the Los Angeles Department of Transportation: Along corridors with the three lane configuration studied in this paper, continue to remove center turn lanes across the City of Los Angeles and replace them with bike lanes while collecting pre- and post data. This will allow the City to further understand the potential benefits of this specific type of road diet and the ideal range of its applicability. In addition to facilitating lower crash rates associated with the corridors that removed center turn lanes, using the space to implement bike lanes could help the City achieve other transportation-related goals such as increasing the proportion of trips that are made by bicycle and improving connections to public transit. My analysis suggests this could be an effective tool to advance safety, and likely climate related, policies.

For many decades, cities have operated under a lightly tested assumption that center turn lanes are not only beneficial for the flow of vehicle traffic but for general road safety overall. I find scant evidence to support the latter assumption in the roadway typology I studied; center turn lanes do not appear to make streets with a single lane of through traffic significantly safer. The former assumption about efficiency, meanwhile, assumes a car-centric view of efficiency by prioritizing vehicle flow. In light of a growing number of City policies that aim to curb transportation emissions, it may be time to start thinking about alternative ways to use road space to support more sustainable and efficient modes of travel that do not pollute and occupy less space.

By repurposing street space as described in this paper, I believe that Los Angeles will more successfully meet its Vision Zero and climate goals. There are two separate but distinct points to be made here. First, the presence of center turn lanes have proven to improve safety across a large body of empirical literature. This capstone does not intend to impugn these well-established qualities of center turn lanes. Separately, it is also a well-established fact that reducing automobile capacity is the best possible way to make other users of the road safer. Moving from three lanes to two streets may better serve the Vision Zero goals of the Los Angeles Department of Transportation in many contexts across our city.

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Appendix A — Github links

Central analysis:
https://github.com/michaelrosen3/center_of_a_tension/blob/main/Streetlight_gdf.ipynb

Analysis with 108th Street removed:
https://github.com/michaelrosen3/center_of_a_tension/blob/main/Streetlight_gdf_NO_108TH.ipynb

Differences-in-differences analysis:
https://github.com/michaelrosen3/center_of_a_tension/blob/main/Streetlight_gdf_REDOING_DID.ipynb

Appendix B — Full OLS regression table

OLS Regression Results

Dep. Variable:	crashes_per_million_VMT	R-squared:	0.482
Model:	OLS	Adj. R-squared:	0.399
Method:	Least Squares	F-statistic:	5.820
Date:	Thu, 08 Jun 2023	Prob (F-statistic):	6.74e-14
Time:	14:33:58	Log-Likelihood:	-391.31
No. Observations:	204	AIC:	840.6
Df Residuals:	175	BIC:	936.8
Df Model:	28		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	1.2405	0.660	1.879	0.062	-0.063	2.544
difference_in_difference_effect	1.1586	0.763	1.519	0.130	-0.346	2.664
var_2012	0.3882	0.610	0.636	0.525	-0.816	1.592
var_2013	-0.4328	0.610	-0.709	0.479	-1.637	0.771
var_2014	-0.0736	0.610	-0.121	0.904	-1.278	1.131
var_2015	1.0591	0.610	1.736	0.084	-0.145	2.263
var_2016	0.7849	0.612	1.283	0.201	-0.422	1.992
var_2017	0.1721	0.612	0.281	0.779	-1.035	1.379
var_2018	-0.0442	0.612	-0.072	0.943	-1.252	1.163
var_2019	0.9188	0.612	1.502	0.135	-0.289	2.126
var_2020	0.1651	0.617	0.268	0.789	-1.052	1.382
var_2021	-1.4646	0.617	-2.375	0.019	-2.682	-0.248
var_2022	-1.5581	0.625	-2.494	0.014	-2.791	-0.325
street_108th_Street	5.7453	0.726	7.912	0.000	4.312	7.179
street_19th_Street	0.1012	0.751	0.135	0.893	-1.381	1.583
street_54th_Street	1.9406	0.726	2.672	0.008	0.507	3.374
street_8th_Street	2.4377	0.726	3.357	0.001	1.005	3.871
street_92nd_Street	1.2209	0.726	1.681	0.094	-0.212	2.654
Colfax_Avenue	0.6911	0.729	0.948	0.344	-0.748	2.130
Crescent_Heights_Boulevard	0.6784	0.726	0.934	0.351	-0.755	2.112
Edgemont_Street	-0.8709	0.852	-1.023	0.308	-2.552	0.810
Evergreen_Avenue	1.3833	0.726	1.905	0.058	-0.050	2.817
Gower_Street	2.2720	0.726	3.129	0.002	0.839	3.705
Griffin_Avenue	0.6353	0.726	0.875	0.383	-0.798	2.068
Hauser_Boulevard	0.1970	0.726	0.271	0.787	-1.236	1.630
Jefferson_Boulevard	1.9007	0.726	2.617	0.010	0.468	3.334
Lincoln_Park_Avenue	0.3910	0.726	0.538	0.591	-1.042	1.824
Strathern_Street	1.5770	0.726	2.172	0.031	0.144	3.010
Townsend_Avenue	-0.0804	0.726	-0.111	0.912	-1.514	1.353

Omnibus:	22.650	Durbin-Watson:	2.190
Prob(Omnibus):	0.000	Jarque-Bera (JB):	53.055
Skew:	0.480	Prob(JB):	3.02e-12
Kurtosis:	5.306	Cond. No.	18.7

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.