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A Comprehensive Study of a Road Diet Implementation in the US and Abroad

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Abstract

Road Diets are far from a new technique for designers to apply to roadways. Yet after over 50 years of implementation and countless studies into their effectiveness, it is only relatively recently that the process is gaining widespread recognition and implementation. Each year, more states and countries are examining potential road diets and putting them into place. Still, there remains great skepticism and opposition in many corners. In addition, cities and states may be drawing from many of the same sources in how to go about the process of a road diet and evaluate them, yet their methodology, goals, and even terminology can vary from region to region. This paper reviews both domestic and international road diets to examine the key steps of the process and what knowledge and techniques can be learned from each case study. How to best evaluate a good site for a road diet, how to best design and integrate one into a complete streets design, and how to best evaluate the effectiveness of the process. This evaluation is essential for both determining what tweaks need to be made to optimize efficiency and to sell an often-skeptical public about its effectiveness. By taking the best of what has come before, a better process going forward can be described and demonstrated to a degree.

Keywords

Road Diets, Traffic Safety, Transportation

1. Introduction

Historically, the US has been defined by growth. Its growth in size as the country sought to continually expand and later by development within all the land. The history of transportation has been no different as our infrastructure has sought to keep up with that unfettered growth. The solution to these issues has always been to build. To build new roads and transit and to constantly build on those that exist with additional lanes. In the past few decades, however, the views on this process have subtly shifted. The default thought is still to build, but the realization that this process is not sustainable has set in. Constant building is never a long-term fix as traffic always rises to meet the capacity while concerns over cost and equity have increasingly become a major concern. Solving this is no simple issue, but one of the major tools that has emerged is the road diet. The road diet seeks to modify an existing roadway to remove a lane contrary to traditional wisdom. This lane may be replaced by a dedicated bus lane, bicycle lanes, or any number of possibilities.

This paper seeks to examine the process of a road diet from all angles. The study will look at how road diets are being planned and implemented around the world and the efficacy of said process where it has been implemented. This efficacy will be analyzed both from how positively or negatively the process affects traffic in and around the site area as well as how effective it is at encouraging alternative forms of transportation. In addition, various concerns about the project from a long-term outlook to equity concerns are included to achieve a thorough view of the viability of a road diet.

1.1. Objective

The objective of this paper is to examine the current process of the road diet throughout the world to get a better understanding of how to implement and evaluate them effectively. This will be achieved by analyzing the process and thought processes that go into planning and implementing a project and most importantly, by analyzing the diverse types of road diets being performed and their effectiveness. This paper will primarily seek to establish a state of the process in the United States through various case studies while also considering work being done outside of the country.

In the article, the selection of both domestic and international case studies, specifically the analysis of twelve US states and six countries in their experiences with implementing road diets, aims to provide a robust and comprehensive understanding of the subject matter. This decision was made with the intention of covering a wide variety of eventualities, which is the basis for its justification, considering varying contextual factors, regulatory frameworks, urban design principles, and societal influences. By including a mix of domestic and international case studies, the intention is to enhance the depth and breadth of insights gained from the research.

1.2. Glossary

Average Daily Traffic (ADT): the average number of vehicles which travel on a given section of roadway a day over a period of less than a year.

Annual Average Daily Traffic (AADT): the average number of vehicles which travel on a given section of roadway a day found by dividing the total yearly volume by 365.

Bike lane: a portion of the road which is devoted to the exclusive or preferential use by bicyclists by markings and/or signage.

Buffered bike lane: a type of bike lane with a dedicated space between the ridable area of the lane and a vehicle lane. This space is denoted by pavement markings and allows for more comfort and safety for bicyclists particularly on roadways with high speeds or volumes.

Bus Bulbs: a type of curb extension which aligns the bus stop with the parking lane to ensure that buses can load and unload passengers without shifting from a traffic lane.

Bus Lane: a paved lane of traffic devoted to buses which can be placed curbside or offset by a parking lane.

Crash Modification Factors (CMF): a multiplicative value which indicates the proportion of crashes that can be expected after the implementation of a particular countermeasure. All values are greater than zero.

Crash Reduction Factors (CRF): the percentage crash reduction that might be expected after implementing a given countermeasure. The value can be negative or positive.

Level of Service (LOS): the quality of traffic service to a given flow rate in a roadway.

Road diet: the roadway reconfiguration that is designed to improve traffic safety, mobility, and access for all users. It usually removes one lane devoted to vehicle traffic into a reclaimed roadway that can be used for turning lanes, bus lanes, pedestrian refuge islands, bike lanes, sidewalks, bus shelters, parking, or landscaping.

Shared lane markings (or sharrow): a type of lane marking which indicates that a roadway is intended to be used by both vehicular and bicycle traffic.

Two-Way Left Turn Lane (TWLTL): a dedicated center lane for left turns by users heading in both directions on a street which allows drivers to leave and not block the through lane.

85th percentile speed: the speed at which 85% of vehicles travel below a given roadway.

2. Background and Current Practices

Since at least 1972 in Seattle, Washington, the road diet has been a successfully implemented policy (Welch, 1999). There are many permutations and justifications for a road diet, but at the heart of them all, a road diet is the process by which a lane of travel is removed. The most common arrangement of this process is performed on a four-lane road, two lanes in each direction. One through lane in each direction is removed and a two-way left turn lane is added in the center. As shown in **Figure 1**, this extra roadway space can be used in a variety of ways such as bicycle lanes, parking, pedestrian facilities such as sidewalks or refuge islands, medians, or for transit usage (Federal Highway Administration, 2017).

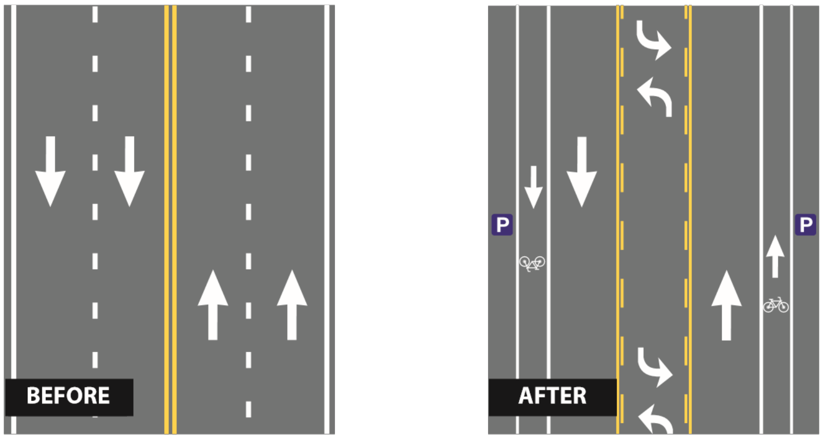

Figure 1. Example four-lane to three-lane road diet (Federal Highway Administration, 2016).

While these specific road diet types are the most common both in terms of implementation and analysis, a road diet can be effective in many other arrangements. Examples included elsewhere in this report include one-way roads, wider than four-lane roads, and roads which have already gone under a diet in the past. Still, most of these results will be using numbers relating to the most typical four-lane to three-lane arrangement (Knapp et al., 2014).

The states of California, Iowa, and Washington have led the charge, but the number of states which have made road diet modifications or even just considered them grows by the year. Typically, these roadways have an ADT between 2000 and 26,000 vehicles per day, though a 20,000 vehicle per day limit is more typical. The exact figure varies by agency though many have prioritized lower ADT roads, particularly at first (Knapp et al., 2014).

For example, the state of Tennessee breaks down the required analysis, and likelihood of success for approving road diet, as described in **Table 1**. The process for the initial screening is described in five requirements:

- Positive safety analysis.
- Not a bus route or agency allows pull-offs to reduce impact to traffic operations.
- Not an interstate diversion route or other diversionary routes are available.
- Project has local support.
- Speed limit is less than 45 mph.
- No intersecting roads with AADT > 3000.

While a project is not required to meet every one of requirements, they act as a useful guide along with the goals of the community. The capacity and LOS analysis is conducted using a program such as Synchro or Highway Capacity Software (HCS) to ensure that the roadway will still operate at an acceptable level ten years after modification. The traffic study is an even more in-depth look at the roadway using microsimulation programs such as SimTraffic or Vissim and appropriate analysis of possible diversions (Tennessee Department of Transportation, 2023).

Table 1. Road diet approval requirements for AADT ranges (Tennessee Department of Transportation, 2023).

	AADT	Initial Screening	Capacity/ LOS Analysis	Traffic Study	Context Elements
Level 1	To 3: <12,000 To 5: <18,000 (Likely Approval)	X			O
Level 2	To 3: >12,000 or <20,000 To 5: >18,000 or <30,000 (Moderate Analysis Required)	X	X		O
Level 1	To 3: > 20,000 To 5: > 30,000 (Significant analysis Required)	X	X	X	O

a. X = Must be included. b. O = Optional, but must be included if Initial Screening criteria are not met for Level 1; Initial Screening and Capacity Analysis criteria are not met for Level 2; or Initial Screening, Capacity Analysis, and Traffic Study criteria are not met for Level 3. c. Any other conversion besider to 3 lanes or to 5 lanes will require a Level 3 assessment.

A traffic simulation analysis by Stamatiadis et al., and shown in **Figure 2**, indicated that in the peak hour, for signalized intersections where the side street volume is 300 vehicles per hour and there is a low number of left turns, a 1500 vehicle per hour main street volume is the point at which a three-lane set up begins to be less efficient than a four-lane option. When that number rises to 700 vehicles per hour on the side street, the break point rises to 1750 vehicles per hour on the main street. When there is a high rate of left turns, however, the original four-lane design is more efficient, but the changes in delay remain minimal. The amount of queuing is also shown to be reduced with a three-lane road diet when the volume on a main street is low and there are low left turn percentages. When left turns are high, the road diet is usually the better option for reducing queuing with higher volumes increasing the effect, though again these differences are minimal. In the end, the study determined the following basic guideline for the evaluation of whether a road diet should be recommended for consideration (Stamatiadis et al., 2014).

While road diets can spring up as a part of various improvement programs, it can be helpful to proactively look ahead to identify roadways that could lose a lane or two. Having this information at the ready can especially be helpful when a resurfacing project is being prepared as a road diet can be much more easily and cheaply instituted at the same time. Even away from a set resurfacing project, road diets are a relatively cheap remediation method since most of the work is in the form of repainting. The cost can increase when applied alongside other safety improvements to the roadway such as pedestrian refuge islands. One

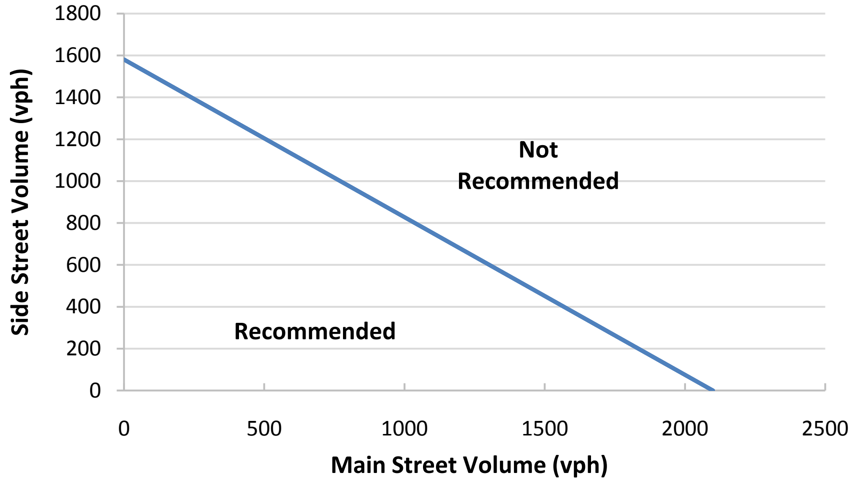

Figure 2. Guideline for operational performance at signalized intersections (Stamatiadis et al., 2014).

strategy for generating this list is using Geographic Information Systems (GIS). As an example, the Mid-Region Metropolitan Planning Organization (MRMPO) conducted a GIS research to identify potential road diet candidates on New Mexico roadways based on roadway geometric and traffic characteristics (Mid-Region Metropolitan Planning Organization, 2017).

These road diets can be implemented to increase mobility for users (via transit, bicycle, or pedestrian), calm traffic, increase safety, and better integrate a road into the existing environment (Federal Highway Administration, 2017). The project can also introduce a variety of secondary impacts both positive and negative including property values and reducing capacity, so it is important to fully consider the impacts (Knapp et al., 2014). The degree that a project affects these concerns comes down to the goals or the project, the characteristics of the existing corridor, and the implementation. There have been many attempts to quantify these gains, but the results of these are extremely mixed if mostly positive.

When it comes to analyzing the safety impact of a road diet project, current standards from the Federal Highway Administration (FHWA) give a suggested CMF of 0.71 (or a 29% reduction in crashes) for narrowing a roadway from four lanes to three as well as Pedestrian CMFs of 0.81 in urban areas and 0.53 in suburban areas for a road diet. The former carries a five-star rating while the latter two are four stars rated out of five (Crash Modification Factors Clearinghouse, n.d.). The 0.71 value comes from a larger study into CRFs for Traffic and Intelligent Transportation Systems (ITS) improvements which looked at 45 road diets, the 0.81 from a Pawlovich study in Iowa, and the 0.53 was taken from a 2018 analysis of 15 four to three-lane road diets which sought to control for uncertainty (Harkey et al., 2008; Pawlovich et al., 2006; Persaud et al., 2010). An important part of the Harkey study is the difference in results between the sites in Iowa, which yielded a CMF of 0.536 and those in California and Washington which yielded a CMF of 0.811 (Sun & Rahman, 2019). Rear-end, sideswipe, left-turn, bicycle, and pedestrian crashes are especially sensitive to road diets and these specific collisions can be reduced in many cases as the project often addresses their causes. They do so by providing road calming which reduces the number of speeders, by reducing the number of conflict points, and providing dedicated facilities for alternate transportation users (Knapp et al., 2014). Certain types of rear end conflicts can be increased however, especially when more congestion is created (Stamatiadis et al., 2014).

While there are many factors that vary in the analyses between studies, location may be an underappreciated one. More study should be conducted into whether the quality of implementation by each state into what is affecting the results or if the issue merely comes down to the objectives of each state. Still, these results should caution against the direct use of crash reduction figures from other studies without appropriate consideration. Those looking into implementing a road diet should look for studies which analyzed similar roads with similar goals when deciding on expected crash reduction benefits to generate a more realistic expectation. Road diet policies and even the name for the improvement vary across the country. Some of the alternate names include Lane Conversion, Lane Elimination, Lane Narrowing, Lane Reduction, Road Narrowing, Road Re-channelization, and Road Reconfiguration. Some of these states emphasize the improvements to pedestrian traffic, others to bike traffic, and still others to road operations (Federal Highway Administration, 2016).

It is also important to consider driveway and intersection density/type, existence of transit on the corridor, 85th percentile speed, right of way, the potential pedestrian and bicycle activity, and the many other roadway characteristics (Knapp et al., 2014). Any road diet design needs to take these concerns into account to minimize any negative impacts. Too many access points can hinder the effectiveness of a two-way left turn lane as there can be too many points of conflict. Removing a lane could make the use of existing transit in the corridor untenable with the increased congestion and the removal of a lane that would normally be used to pass a stopped bus. The existence of transit in the corridor also needs to be considered in the context of bike traffic to minimize or eliminate conflict between the two. A lack of pedestrian and bicycle facilities to connect to or nearby destinations for them to go to can ensure these improvements remain unused. The road diet needs to be a part of a greater planning structure which considers the impact both inside and outside of the subject area.

3. Analysis of Domestic Case Studies

3.1. California

A 2014-2015 study was conducted in Davis, California with a look at the impact of the road diet on bicycling. The study area was a section of Fifth Street which was reduced from four to three lanes. The speed limit was reduced from 30 to 25 mph with five to seven-foot bicycle lanes added on each side along with new pedestrian facilities. As a result of the introduction of the road diet, an average increase in bicycle traffic of 243% was noted along Fifth Street. However, there was no statistically significant pattern noted for pedestrian traffic. Peak travel time decreased including a statistically significant amount in the evening over the corridor. The study does raise the tricky question about whether the effects are being felt instead on other parallel roads with bike traffic being diverted to the improved road and traffic diverted to and congesting other streets. Like many of the studies conducted, the alternate roads were not considered in the analysis (Gudz, Fang, & Handy, 2016). This is a major issue for several reasons. For a start, capacity analyses are more effective the larger the area that is considered since the knock-on effects on traffic often occur well beyond the area of implementation for better or worse. In addition, reducing the capacity of a roadway may reduce the traffic on a specific road, but it is essential to ensure that the traffic is not just using another road instead.

A study which was conducted in San Jose, California was far more comprehensive in this regard. This study looked at the roadway in both the area where the road diet was applied and where it was not applied as well as roads in the surrounding area to see if they would be negatively affected. Four travel lanes on Lincoln Avenue were reduced to one in each direction with a two-way left turn lane in the middle. The extra space was used to make bike lanes on each side of the street (Nixon et al., 2017).

Two sites in the road diet section, four sites on Lincoln Avenue outside of the road diet, 16 sites on major streets in the area, and 23 sites on nearby residential streets which would likely see diversion traffic were surveyed as part of the analysis collecting counts and speed. The road diet locations saw all day drops of 6% in volume while the non-road diet portions of Lincoln Avenue saw a 2% drop, neighborhood streets saw a 5% drop, and major streets saw no change in the area. These changes equaled out to an overall 2% drop in the area. The change was much starker in the AM and PM peak hour as the road diet led to drops of 23% and 12% respectively. Lincoln Avenue saw significant decreases of 14% and 10% in those peak periods. The other road types saw more minimal changes. Drilling down to more specific locations certain local roadways noted significant spikes in locations which made for obvious diversion points (Nixon et al., 2017). Pedestrian and bike activity increased by 83.19% and 19.96% respectively on the roadway after the road diet. There was a minor reduction in injuries for the year following the implementation of the project, a number which went down as the year went on in possible correlation with minor modifications made during the project (City of San Jose, 2016).

Speeders, or those traveling at 5+ and 10+ MPH over the speed limit, dropped by 44% and 60% over the road diet section, but they all saw significant increases on the other road types, especially during peak hours. Major streets saw respective 24% and 43% increases in those categories. The major streets which saw the biggest increases were again those parallel to Lincoln Drive which made for obvious diversion routes (Nixon et al., 2017). 2 of 23 neighborhood streets saw an increase in speeds which yielded an undesirable speed for a 25-mph road (City of San Jose, 2016). This study is perhaps the firmest indication that any road diet cannot just look at the specific corridor where the improvement was performed as so many other analyses do.

In Pasadena, a road diet was built in June 2010 on a one-mile stretch of Cordova Street yielded an improved bicycle level of service with no change to pedestrians or vehicles. Speeds were reduced over the corridor and a minor reduction in collisions and injuries. The road diet in Los Angeles was performed in 2011 on a two-mile segment of Seventh Street which maintained many pedestrians and bicyclists. This road diet saw a tripling of bike traffic while maintaining satisfactory conditions at major intersections (Federal Highway Administration, 2015).

3.2. Delaware

A 2012 road diet was completed in Claymont, Delaware along a one-mile stretch of Philadelphia Pike. This underused segment existed as a four-lane road with on-street parking and sidewalks in each direction. Two lanes were removed and replaced with a two-way left turn lane and bike lanes in each direction added. Based on simulation results, the traffic remained acceptable at each signalized intersection, above an LOS C, and similarly to the before condition. Queues from this analysis increased in the southbound direction and decreased in the northbound direction. Volumes along the road increased from approximately 14,490 to 15,918 from 2008 to 2016. This increase in volume along Philadelphia Pike corresponds to a significant decrease in traffic on a neighboring road which would expect to see diversions if there were any. The crash rate saw a reduction of 11%, but there was a corresponding increase in pedestrian accidents at the entrance and exit of the facility which may indicate a poor design at these locations. Also, the road diet saw a significant increase in speed compliance within the project corridor versus outside of it (RK&K, 2017).

Another road diet was implemented on a 1-mile stretch of Memorial Drive with an AADT of about 9000 vehicles/day in 2019 (Delaware Department of Transportation, 2020; Wahed & Arellano, 2020). This project sought to convert a two-lane roadway into one with a single lane in each direction. The saved space from converting two 11-foot lanes was converted to five-foot bike lanes in each direction with two buffer lanes each way between the driving lane and median and between the bike lane and parking lane (Wilmington Area Planning Council, 2017). Travel time heading westbound increased from 96 to 104 seconds, an increase of 8%, while travel time heading eastbound increased from 98 to 103 seconds, an increase of 5%, based on travel time runs. Crash data is left subject to a small sample size due to a short four month after period, but in that abbreviated time, crashes went up from 12 a year to a projected 18. Unlike the case study, the sample area is mostly residential. Capacity based on Synchro results showed a reduction if an acceptable one (Wahed & Arellano, 2020).

3.3. Florida

During a 2001-2002 resurfacing project, a 1.5-mile portion of Edgewater Drive in Orlando, Florida was converted from a four-lane roadway to a three-lane to allow for wider sidewalks and an area which is more friendly to pedestrians (Tan, 2011). The road operated on the high side with an ADT of 20,000 vehicles per day and the road also saw the introduction of bike lanes (Arms, 2012). The road diet saw reductions in crashes by 34% and injury rates by 68% (Tan, 2011). Other sources list these improvements as 40% and 71%. Two of the three sections showed significant reductions in excessive speeders and volumes, which initially declined after implementation, normalized, and increased not long after (Urban Land Institute, 2016). Pedestrian and bicycle traffic also increased by 23% and 30% respectively while on-street parking increased from 29% to 41% (Tan, 2011; Urban Land Institute, 2016). Looking back ten years after installation, Property values in the corridor rose by 80% while they rose by 70% within a half mile of the improvement compared to 58% in the county. Both pedestrians and bicyclists heavily use the street while crash rates and injury rates remain down 45% and 44% respectively. A parallel street was forced to install traffic calming to deal with increased volumes as a possible result of the project, but this appears to have been successful (Arms, 2012).

In Tampa, there have been at least 16 road diets completed since 2004. These projects have been of the four to three-lane, six to four-lane, and three to two-lane varieties with features including bicycle facilities, parking, bus bays, and wider sidewalks installed in place of the removed lanes. Even the bicycle facilities have varied including shared lanes, bike lanes (buffered and not), and cycle tracks (City of Tampa, 2020). This effort has been aided by a citywide walk-bike plane which was created as a partnership between the City of Tampa and the local Metropolitan Planning Organization. These projects are then funded using money from resurfacing projects, Transportation Alternatives Program funding, and Highway Safety Improvement Program funding (Florida Department of Transportation, 2018).

One of these projects is a 3.2-mile stretch of Nebraska Avenue which was converted from four lanes to three with two bike lanes and bus loading zones added in their place. The sidewalks, medians, signals, and midblock crossings were also redesigned as part of the project. This minor arterial saw a drop in ADT from 17,900 to 14,600 vehicles per day in the before and after conditions, though this may be explained by an improvement in a nearby interstate since other local streets saw no increase. Crashes were reduced by 68% and the corridor became a new home for a transit route (Schlossberg et al., 2013). In addition, the fatal/incapacitating crash rate was reduced by 33%, sideswipe crash rate by 90%, angle crash and left turn crash rate by 64%, pedestrian crashes by 62%, and bicycle crashes by 47% (Project for Public Spaces, 2013). While all the other improvements associated with this design made for a more major and more expensive redesign than many of the other case studies, this study is a fitting example of how to use a road diet as part of a greater plan. The road diet is not responsible for all the improvements in safety in the corridor, but it made certain ones, including the new bus route, possible and aided the mission.

3.4. Illinois

As part of a 2011 initiative by Chicago, Illinois to implement 100 miles of separated bicycle lanes, several road diets were implemented throughout the city. One of these was an 0.8-mile, four-lane segment (with on street parking) on 55th Street along the University of Chicago campus. A major concern for this project was the existing major Chicago Transit Authority bus line. This issue was addressed with a dedicated bus stop which was shared with the bike lane.

The bike lane is six-feet wide with a separation from the travel lane thanks to eight-foot-wide parking lanes and a three to five-foot buffer zone. Speeding was also an issue in part due to unneeded capacity on the street which makes for a prime spot for a road diet. As a result of the road diet, in the 20-month span following its implementation, vehicle crashes were reduced by 31%, bicycle crashes by 33%, and pedestrian crashes by 45%. Pedestrian crossing distance was reduced by 32 feet which saw a reduction of time to cross from 19 seconds to 9 seconds (Chicago Department of Transportation, 2016). Land value along the street also saw an increase of 18% (Project for Public Spaces, 2020).

3.5. Iowa

Iowa has been one of the states at the forefront of road diet implementation and analysis (Knapp et al., 2014). Starting in 1996, the state began to convert several four-lane roadways to three lanes (Welch, 1999). A 2005 study in Iowa established that road diets in the state generated a 25.2% decrease in crash frequency per mile and an 18.8% overall decrease in crash rate. These results were obtained based on 15 road diets performed in the region in comparison to 15 control sites (Pawlovich et al., 2006).

In 1999, the city of Sioux Center, Iowa performed a road diet on a four-lane corridor of US 75. As a result of this conversion to a three-lane roadway, peak hour travel times increased by 36% while speed was reduced by 25% - 29%, largely thanks to issues with right turns and parking. Excessive speeders decreased from 43% to 13%. Crash results yielded a reduction of 57% (Knapp, 1999).

In 2010 in the city of Des Moines, a 2-mile stretch of Ingersoll Avenue was converted from a four-lane roadway to a three-lane roadway with both parking and bicycle lanes on both sides of the street. The parking lanes were replaced with right turn lanes at signalized intersection (Federal Highway Administration, 2015). During the six-month trial period, a 50% reduction in total crashes and a 30% reduction in injury crashes was noted. Average speeds saw a reduction of 10% and 23% of business owners saw an increase in business because of the road diet (Project for Public Spaces, 2020). Unlike many of the roadways surveyed here, the traffic remained flat most of the day with a 5% increase in traffic between the hours of 11:00 AM and 1:00 PM (Federal Highway Administration, 2015). A less successful Des Moines project was performed on Hubbell Avenue. The project was attempted in 2012 converting four-lanes to the standard three arrangement. This road diet lasted less than a year faced with 93% public disapproval. One plausible reason for its failure was the lack of connectivity with other bicycle facilities and less of a downtown environment than exists on Ingersoll Avenue (Aschbrenner, 2015).

3.6. Kentucky

In Kentucky, a series of five road diets, all four to three-lane were studied. A 2000, 1.13-mile, road diet in Fayette County saw a 56% reduction in crashes and a 2200 vehicle per day reduction in traffic, though this could possibly be explained by mitigating factors in the decline in traffic, and some congestion issues. This decline would also make the crash rate difference much less severe a drop off. A 2005, 0.93-miles road diet in Floyd County saw a 55% reduction in crashes and minimal change in volumes. A 2006, 0.82-mile road diet in Mercer County saw a 41% reduction in crashes accompanied by a 1300 vehicle per day drop in ADT. A 2008, 0.83-mile road diet in Woodford County had a 25% increase in crashes primarily associated with a poorly designed transition to the road diet and no change in ADT. Finally, a 2008, 1.4-mile road diet in Campbell County saw a 68% reduction in crashes but a corresponding 30% reduction in ADT (Stamatiadis et al., 2014).

It is important for each project to be studied to ensure that they are implemented correctly. These road diets spanned a wide variety of lane widths (from 11-foot to 15-foot through lanes and 11-foot to 14-foot two-way left turn lanes) and bike lane widths (five-foot to seven-foot with some having none or just parking added) which indicates that success is independent of the needs of the roadway design (Stamatiadis et al., 2014).

3.7. Michigan

In many locations, a road diet is merely one aspect of a Complete Streets program. Complete Streets methodology is to incorporate into design, planning, and operation the safety and mobility for all users. This includes accessibility concerns and the many types of transportation beyond driving including pedestrians, bicyclists, and public transit (U.S. Department of Transportation, 2015). Michigan is one such location where the implementation of such a program, in 2009, led to the evaluation of the feasibility of road diets as well as their implementation. In Genesee County, a before and after analysis of seven road diets was performed and yielded crash rate reductions of between 32% - 58% for distinct types of crashes (Federal Highway Administration, 2015). Another study of

18 four-lane to three-lane road diets in the county (which did not count nine cases with insufficient data), totaling 26.62 miles in length, saw an average crash reduction rate of 32.1% compared to 13.8% for roads county wide (Genesee County Metropolitan Planning Commission, n.d.).

The county also identified crash data, lane width, speed limits, surface type, average daily traffic count, number of traffic signals, and land use as the key components to identifying suitable road diet sites (Federal Highway Administration, 2017). Specifically, they listed an ADT of 10,000 vehicles per day as "highly likely as feasible" and that 10,000 - 20,000 vehicles per day may also be feasible (Genesee County Metropolitan Planning Commission, n.d.).

In Grand Rapids, road diets were attempted to improve the business environment and increase parking. On Division Street, a one-mile stretch of four and five-lane roadway was converted into a three-lane roadway with the existing lanes converted to bicycle lanes and shared lanes. The project was first implemented on a trial basis because of conversations with the public. The trial proved successful in terms of increasing parking, reducing vehicle speeds (1-4 mph), and increasing bike flow while decreasing volumes. There were a few downsides, however. Head-on left turns (by 38%), angle (17%), and sideswipe crashes (20%) all saw reductions, but rear-end crashes nearly tripled (Federal Highway Administration, 2022). Pedestrian crashes also saw a reduction of 7% despite increases in pedestrian and bike traffic of 13% in the AM and 57% off-peak (Project for Public Spaces, 2020). In addition, the corridor saw increased delay with longer queues and travel times with increased emissions. Diversion from the corridor was also noted if not statistically shown including an existing bus route was rerouted by the bus company (City of Grand Rapids, 2013).

Another road diet was conducted in Grand Rapids on a two-mile stretch of Burton St. This road diet was done with the intent of installing bicycle lanes, improving safety, and accommodating the needs of buses. The last need wound up dictating the chosen design to allow for transit bus operations to be maintained in the corridor. As a result, the buses were permitted to use the bike lanes at their stops. In addition, traffic signals were optimized throughout the corridor (Federal Highway Administration, 2022). The results of this process are mixed depending on the source. According to one source, 85th percentile speed was reduced by 8 - 9 mph while crashes were reduced by 67 percent (Smith, 2019).

A 2012 study of 24 different four-lane to three lane road diets in the state yielded mixed results overall. The CMF for the projects was calculated to be 0.63, or a 37% reduction in crashes, however, this rose to 0.91 when adjusting for overall city-wide trends, a process very few CMF calculations perform. This value was significantly different between sites, which indicates that not all road diets are as successful in this regard and emphasizes the need for context specific solutions. Residential areas performed better than commercial and mixed-use sites in this regard. Even with this variation, they are still almost universally successful at achieving some reduction. The study also indicated that delay increases start to become significant on a four-lane to three-lane project when the road ADT is greater than 10,000 vehicles, which is much lower than the typical 20,000 vehicle limit prescribed by planners, or the peak hour volume is greater than 1,000 vehicles. At a peak hour of 1500 vehicles and corresponding 15,000 vehicle ADT, traffic noticeably degrades, typically past an acceptable level (Lyles et al., 2012).

Site visits indicated that there was a direct correlation between road diet success and factors such as pedestrian and bicycle facilities, commercial and pedestrian attractions, and effective traffic calming. There also was a pervasive misuse of the features installed by the road diet, especially when the markings were not clear or there was inadequate signage (Lyles et al., 2012).

3.8. Nevada

In Reno, Nevada, a pair of road diets was installed on California Avenue and Wells Avenue. The California Avenue segment was a 1.4 mile four-lane roadway converted to a three-lane road with bicycle lanes and parking in each direction. Simulation analysis indicated a minor but acceptable drop in intersection performance and the project resulted in a 42% drop in total crashes. The 1-mile Wells Avenue project converted also converted a four-lane road into a three-lane one with several noticeable differences. While both projects added bike lanes, five-foot lanes for Wells, the Wells Avenue project also used the extra space from removing a lane and reducing lane width in the two travel lanes from 12 feet to 11 feet to expand the sidewalks from 8 feet to 10 feet. As part of this change, curb extensions, increased crosswalks, medians, and pedestrian refuge islands were installed (Federal Highway Administration, 2015).

The project yielded a 31% reduction in crashes including a 54% reduction in pedestrian crashes. Traffic speeds also saw a 14% - 24% reduction, no change in service level, and a 10% reduction in traffic volume, an undefined amount shifting to nearby streets (Federal Highway Administration, 2015). The success of the project, illustrated in **Table 2**, emphasizes the reduction of crashes before and after its implementation.

Table 2. Crash frequency before and after road diets treatment (Federal Highway Administration, 2015).

Roadway Segment	Crash Frequency		
	Before	After	Variation
Wells Ave	123	85	−31%
California/Mayberry	33.5	19.4	−42%
Arlington	18.6	10	−46%
Mill St	10	4.4	−43%

a. The numbers of crashes have been annualized to show a direct comparison between the locations.

3.9. New York

In 2008, the New York City Department of Transportation performed a road diet on a 0.3-mile stretch of Ninth Avenue in Manhattan. This section of roadway was a four-lane, one way road with parking in both directions which was converted into a three-lane, one way road with parking in both directions and a single buffered bicycle lane on the left side of the road. Pedestrian refuge islands were also installed which reduced crossing distance by nearly 30 feet. In addition, the parking was modified to allow for dedicated commercial loading zones and dedicated zones for taxi drivers. Left turn bays were added next to the bicycle lane with protected turn phases to increase safety at intersections with permitted left turns (Federal Highway Administration, 2015). The project resulted in a 58% reduction in injuries to street users and a 49% increase in retail sales where the average Manhattan-wide was 3% (New York City Department of Transportation, 2012).

In 2009, the city implemented a road diet on a 1.4-mile stretch of Empire Boulevard in Brooklyn. The four-lane road with two parking lanes was converted to a two-lane roadway with parking, bidirectional bicycle lanes, and a divided, striped median. The goal of the project was to modify a road with excess capacity to combat speeding and pedestrian safety concerns. The latter was addressed with pedestrian refuge islands which shortened the distance pedestrian were required to cross the street. The project resulted in a reduction of overall injuries by 27% and 19% for pedestrians. Bicyclist injuries increased by 133%, but it is unclear if this is because of additional bicycle usage or not (Federal Highway Administration, 2015).

In 2010, also in Brooklyn, a 1.5-mile stretch of West Sixth Street was converted from a four-lane undivided roadway to and two-lane divided road with 12-foot painted medians. The project was in response to a string of pedestrian deaths but suffered from a few issues. The corridor maintained excess capacity and the considerable number of pedestrians were forced to deal with long crossing distances and insufficient crosswalks (Federal Highway Administration, 2015). Pedestrian refuge islands and new crosswalk markings were installed while left turns were banned in certain sections and left turn bays added at key intersections (New York City Department of Transportation, 2011). The project resulted in an 8% - 12% reduction in speeds, 30% - 40% reduction in speeders, and a 24% reduction in injury crashes with significant reductions for both motor vehicles users and pedestrians (Federal Highway Administration, 2015).

Elsewhere in Brooklyn in 2010, one of three one-way lanes was removed from 0.9 miles of Prospect Park West and replaced the lane with a parking lane protected, two-way bike lane. The signals were also retimed and loading zones added. Two years later, pedestrian islands were also added as well as bike rumble strips. This process resulted in stable traffic volumes while bike volumes nearly tripled on weekdays and more than doubled on the weekends while eliminating almost all the bicyclists using the sidewalk instead of the road. In addition, total crashes declined by 16% and injury crashes by 63% while the percentage of speeders fell from 74% to 20% (Project for Public Spaces, 2013).

In 2010, the city performed a road diet on a four-lane stretch of Luten Avenue in Staten Island, converting it to a less standard two-lane roadway with a ten-foot median, dedicated left turn lanes, and parking lanes. The area is a heavy pedestrian area and as part of the project, pedestrian refuge islands were installed. The number of vehicles exceeding the speed limit decreased by 34% in the southbound direction and 21% in the northbound direction with reductions in both injury crashes and pedestrian crashes (Federal Highway Administration, 2015). Overall traffic speeds and crash rates for the corridor also saw a reduction (New York City Department of Transportation, 2011).

Starting in 2009, Broadway in Manhattan was updated over a 2.3-mile stretch. Times Square and Herald Square were closed to vehicle traffic in favor of pedestrian plazas. Between 23rd Street and 59th Street, bike lanes were added in several places, but more major changes were made between 14th Street and 23rd Street. Here, the existing two vehicle lanes, two parking lanes, and an on-street bike lane were converted to one vehicle lane, two parking lanes and a median protected bike lane with curb extensions and pedestrian refuge islands also added. Nearby East 17th Street was also converted from two-way to one way and added separated bicycle and pedestrian lanes. Between 23rd Street and 59th Street, travel times mostly improved while injury crashes declined by 63% and pedestrian injuries declined by 35% despite an 11% increase in volume. Between 14th Street and 23rd Street, speeding decreased in certain sections while median speed increased by 14%. Bike volumes increased by 16% on weekdays and 33% on weekends without causing any impact on traffic volumes for either Park Ave or Broadway (Project for Public Spaces, 2013). Later updates were made adding a car-free block, five slow-street or shared-street blocks, and more improvements planned to be implemented in the future (Kessler, 2021).

3.10. North Carolina

Charlotte, North Carolina was the site of a road diet along a 1.6-mile stretch of the East Boulevard arterial (Schlossberg et al., 2013). The road diet was completed in three phases from 2006 to 2011 to allow for public input between each, two of which reduced from a four-lane roadway to a three-lane and a third which started as five lanes. The goal of the project was to convert the roadway into a main street, reduce speeds, improve conditions for bicyclists and pedestrians, and reduce rear-end and left turn collisions. Two bike lanes were added as well as 17 pedestrian refuge islands which reduced crossings from a max of 70 feet to 17 to 28 feet. ADT fell from 20,500 to 17,500 vehicles per day in one section yet rose from 18,600 to 19,700 vehicles per day in another. The road also achieved the main street feel with an increase in outdoor dining along the corridor (Project for Public Spaces, 2013).

The 85th percentile speed decreased from 43 mph to 40 mph on a 35-mph road with only a slight increase in peak hour travel time (Schlossberg et al., 2013).

3.11. Virginia

Virginia modified its legislation to encourage the completion of road diets in 2017 which permitted the conversion of movement lanes to bike lanes with no loss of funding. Despite this, only 8 of the 113 surveyed municipalities indicated that this change resulted in any modification of planning for road diets with a limited penetration of knowledge about it. A sharp spike in road diets which were completed in 2018, reaching a peak of 10. 12 of the 25 completed road diets were of the four-lane to three-lane variety though there was a variety of other options including four lanes to two (4), six lanes to four (3), seven lanes to five (1), two lanes to one (1), and three lanes to two (3). In general, four lanes replaced with three lane is the most common road diet modification across the board. The road diets were implemented primarily to accommodate pedestrians and improve safety, but also for traffic calming, bike travel and on-street parking with 72% of projects achieving success in meeting the goals. From 2010 to 2018, 39 miles of road diets were implemented across 66 projects. Though these lack concrete data, based on surveys, these road diets did not create congestion issues (Ohlms et al., 2020).

Difficulties from the projects include drivers occasionally using the bike lane as a passing lane, issues with the bike lanes not being integrated to existing networks or in areas with trip generators, lanes lacking in certain directions, decreased speeds in certain areas. The number of speeders was significantly affected but, in some areas, this was a positive increase and in others a negative. Largely, however, mean speed remained unchanged because of the road diets. On the observed segments, bicycle traffic appeared to be largely unchanged however a greater increase was noted in pedestrian traffic and less of both partaking in unsafe practices (Ohlms et al., 2020). Two 2009 road diets in Reston, Virginia, which were converted from four-lanes to three saw crash reductions of 70% with 47% of respondents indicating that they used bicycles on the roads more frequently (Federal Highway Administration, 2015). Another study found Crash Modification Factors (CMFs) for Road Diets of 0.62 (a 38% reduction) for Total Crashes and 0.36 for Fatal and Injury Crashes along segments in Virginia between 2009 and 2018. The study also found CMFs for 0.65 for Total Crashes and 0.54 for Fatal and Injury crashes at all intersections though there was no benefit specifically noted at unsignalized intersections (Lim & Fontaine, 2022).

In 2019, the City of Alexandria implemented a road diet on Seminary Road to improve safety and accessibility as a project identified as a possibility in their Transportation Master Plan. The four-lane road was converted into a three-lane one with buffered bicycle lanes and an on-street shared use path. New pedestrian crossings and refuge islands were also installed while the signal timing was updated. Average annual crashes declined by 41% with injury crashes and property damage only crashes declining by 14% and 8% respectively. 85th percentile speed remained unchanged but there was a reduction from 11% to 7% in excessive speeders. Volumes decreased by 11 to 17% while peak period travel times decreased by 35 to 60 seconds. Some of that may come down to changes in traffic patterns because of the COVID-19 pandemic as most nearby streets also saw decreases in volumes. The Ft. Williams Parkway saw an increase in volume of 12 to 33%. Bike ridership saw a 300% peak hour increase, but pedestrian volumes went down by 22% and these changes were minimal in absolute terms (City of Alexandria, 2022).

3.12. Washington (State)

Seattle has been at the forefront of road diet adoption with its first implementation of a road diet being North 45th street in 1972. This roadway saw a reduction of collisions by 49% (Welch, 1999). The city requires the DOT to provide improvements for pedestrians, bicyclists, and transit and for a road diet, the city considers them if traffic volume is less than 25,000 vehicles per day (Federal Highway Administration, 2022). A series of nine road diets performed on Seattle roads between 1972 and 1995 (with all but the first of these conducted between 1991 and 1995) yielded total crash reductions of 34%. In addition, the ADTs on the sections largely stayed the same and no individual site saw a rise in collisions or a fall in vehicles per day (Welch, 1999).

The city performed a two-stage road diet on a two-mile section of Dexter Avenue. At first, in 1991, the four-lane roadway with parking in both directions was converted to a three-lane with center two-way left turn lane and expanded shared parking/bicycle lanes. In 2011, the two-way left turn lane was removed in favor of dedicated, buffered bike lanes in each direction, bus bulbs, and load zones. This second change was brought on by a low volume of left turns being made. This roadway is heavily used by bicyclists with a peak of approximately 300 heading Southbound compared to 850 vehicles. The second change maintained a consistent travel time while the addition of the bus bulbs helped lead to a 30% increase in bus ridership. Public opinion also remained positive about the decision (Federal Highway Administration, 2015).

Another road diet, which was performed in 2010 on Nickerson Street, converted a four-lane roadway with parking to a three-lane one with parking, a dedicated bicycle lane in one direction and a sharrow in the opposing direction. Before the road diet was implemented, 90% of vehicles were speeding (Federal Highway Administration, 2015). The diet led to an over 90% decrease in speeders traveling 10+ mph over the speed limit while crashes saw a dip of 23% 85th Percentile Speed was reduced by 18% - 24% and speeders by 63% - 64%. Traffic saw a 10% reduction in the AM peak, but otherwise remained largely unchanged. Similarly, a nearby potential diversion route saw 25% reductions in AM peak traffic and minimal the rest of the day and another saw a reduction of daily volumes from 8000 to 7000 vehicles per day (Seattle Department of Transportation, 2012). This reduction assuages some fears of the traffic just being rerouted, but the overall reductions in the area may point to a lack of causation between the road diet and traffic reductions. At the very least, traffic demand appears to be handled by the new roadway alignment. As of 2013, the city of Seattle alone has performed 35 road diets (Schlossberg et al., 2013).

Outside of Seattle, the city of University Place conducted a road diet to promote safety and to create more of a town center feel. The 1.5-mile section of Bridgepoint Way was a five-lane road including a two-way left turn lane. Along with other cosmetic improvements, the two-way left turn lane was replaced by a landscaped median and turn bays while one mile of the corridor saw the introduction of planter strip separated bike lanes and wide sidewalks over a three-phase period. The project led to a 13% decrease in speed to 32.6 mph where the speed limit is 30 mph, crashes decreasing by 60%, and sales increasing by 7% vs 5% elsewhere in the city (Project for Public Spaces, 2013). This design required right of way that is not always available in these types of projects, but it allowed for more improvements without removing any through lanes than just modifying the center two-way left turn would have allowed.

4. International Road Diets

4.1. Australia

While the United States has a long and expansive history regarding the implementation of road diets, there have been much fewer examples internationally and far less data on their implementation. Still, several countries have started to dabble with the technique with even more opening themselves up to the possibility in the future.

A study of various road diets in Victoria and New South Wales, Australia yielded mixed results hampered by a lack of statistically significant changes. The changes in crashes, 85th percentile speed, and volume were compared to those at comparable sites over the same period. There was a 19% reduction in overall crashes, a 71% net reduction in fatal and serious crashes (with a bit of an increase in crashes resulting in minor injury), net increases in speed at most sites, and for most sites, there was a minimal change in net volume (Makwasha & Turner, 2017).

4.2. Canada

In Canada, a before and after study of six road diets was performed in British Columbia. The results were then compared to control sites with similar lanes, proximity, land use, intersection and access density, and segment length. The results were mixed, but each came with important clarifications. Three of the sites yielded decreases of 31% - 47%. Another yielded a minimal 2% decrease but was performed on a 21,000 vehicle per day roadway, a figure beyond the recommendation of most studies. Another saw a 20% increase in an area with high development growth. These figures averaged out to a reduction in crashes of 40% versus 13% for the control while fatal and injury crashes fell be 42% versus 9% for the control (Rocchi & Craik, 2011). A point brought up in the study is the sample size, something that is also an issue with road diet analysis elsewhere. While the sum of these studies yields a better and more consistent picture, there does exist great variation which is not helped by inconsistent evaluation methods. The potential for outliers both positive and negative is very real and can greatly skew results. Still, while road diets as a group could use a better and more standardized method of evaluations, it is still important to additionally evaluate their implementation in context specific manners.

In the city of Toronto in 1997, a 1.8 kilometer (1.1 mile) long, 14 meter (45.9 foot) wide section of St. George Street was converted from four to two lanes. This space was used to widen the sidewalks from an existing width of 1.5 - 2 meters (4.9 - 6.6 feet) to a width of 2.5 - 5+ meters (8.2 - 16.4+ feet). Additional pedestrian crossings were also installed as part of the project. The existing bike lanes were extended though narrowed to also help increase pedestrian space. This project was intended to increase pedestrian use and calm traffic while also expanding the amount of greenspace in the area. As a result of this road diet, crashes were reduced by 40% over a six-year period while traffic volumes remained unchanged which is consistent with greater Toronto trends. There was also a 10% increase in daily cyclists, but this is less than the 23% increase seen on comparable roads in the area, perhaps tied to the reduction in lane width. While the goal of increasing greenspace was achieved, the other two goals were not even analyzed as part of the project. Still, the project was considered enough of a success to inspire the implementation on other roadways in the area and anecdotal information is cited as to speed reducing on the corridor (Transport Canada, 2005).

Elsewhere in Toronto, Richmond Street and Adelaide Street are parallel roadways with heavy streetcar traffic. Both roadways saw the removal of a lane in favor of new one direction cycle tracks separated from the roadway by planters and bollards. Most of the roadways were reduced from four one-way through lanes to three, though some saw the loss of an additional lane in favor of off-peak parking and construction staging areas. Adelaide Street saw the number of bikes rise from 529 to 1573 during an eight-hour period while Richmond Street saw these counts rise from 504 to 1296 in those hours. On most sections of the road, travel times were reduced for vehicles as well. Queens Quay, an important tourist area, was reduced from four lanes in two directions to two lanes with dedicated turning lanes and places for vehicles to stop. The speed limit also dropped from 50 km/h to 40 km/h. These modifications allowed for a redesign of the streetcar section as well as an expanded promenade and multiuse trail which serves as a connection to existing trails. The improvement led to an 888% increase in bike traffic with almost 6000 daily weekday riders (Transport Canada, 2005).

4.3. Indonesia

A study in Jakarta found a road diet can increase walkability by 38.98% and increase public transportation users by 15.41%. While the road diet is only one aspect of changing policies in the city, it was part of a reduction of the city from 4th most congested in the world to 46th. Walkability increased by up to 38.98% because of the improvements. Improvements to the walkability including those associated with road diets, transit passengers in the associated area increased by 15.41% (Mulyadi et al., 2022).

4.4. Netherlands

The Netherlands is well known for its culture of bicycling, a culture hard fought for with years of city planning to reverse heavy car use and congestion. Perhaps the defining city for this is Utrecht. 51% of the city of Utrecht bicycles and it is often considered the most bike friendly city in the world (Balgaranov, 2022). In 2019, the average daily bike trips were 125,000 in a city of 330,000 (Bliss, 2019). Vredenburg, a road with 33,000 bicyclists per day, only permits bicycles, buses, and pedestrians links together the city center and train station.

Croeselaan was a four-lane roadway which was overhauled with a large section replaced with a bike lane and extended sidewalks while another portion removed a travel lane and a lane for parked vehicles for a wide bike lane. Mariaplaats, located at the entrance to the old city center replaced 75 parking spaces with a pedestrian and bike friendly section (Streetfilms, 2019). One 12-lane motorway, which had been constructed starting in 1969 in place of an existing moat, has even been replaced by a new canal, the Catharijnesingel, as well as several features on either side (Boffey, 2020).

Several streets have also been closed completely or in one direction for vehicle traffic to allow for more room for pedestrians and bicyclists. Redesigned roads are designed and intended to be shared by cars and bikes on equal footing with red coloring and signage to denote this (Streetfilms, 2019). Looking to replicate the more extreme programs of the Netherlands in the United States directly would be an unlikely occurrence, but they offer plenty of lessons. An important part of ensuring the success of all these improvements is ensuring that they all tie into each other and providing plenty of bike parking, including some particularly large facilities. A road diet which increases pedestrian and bicycle facilities in a specific corridor but does not connect elsewhere can leave these improvements underused. A complete streets program in the United States needs to be persistent and strategic to appropriately transform an area.

4.5. Norway

An interim road diet in Trondheim, Norway where the lanes were reduced from four to two with a 1.8 km two-way bike path were added in the space where the lanes had been and separated from traffic variously by pavement markings and by concrete traffic barriers. Elevated bus stops between the traffic lanes and bike path were also added. A preference was shown by users for more separation and a preference was had for bike paths that were red surfaced, which is the standard in Norway, as opposed to those with a raised curb. Whether the red surface is something that would translate equally into areas which do not have such standards is unclear, but it does point to familiarity and continuity with existing methodology is something valued by consumers? The raised curb design was thought of as less desirable to users than those which used planter boxes with the use of standard bike lanes thought of the lowest of the options (Vasilev, Pritchard, & Jonsson, 2022).

4.6. United Kingdom

The COVID-19 pandemic forced a lot of changes, but some of these changes were opportunities to try new things. One of those was the closing of roads or vehicle lanes for use by pedestrians or bicyclists. This technique has existed for many years, as exemplified by the Netherlands and other examples through Europe. Most of these pandemic-inspired road modifications were short lived. 84% were only ever meant to be temporary and within six months 94% were gone in the United States, and the ones that were kept longer remained controversial, even more so than typical road diets (Fenston, 2022).

One that has persisted thus far is Park Lane in London. In June of 2020, the city instituted a protected two-way cycle lane along with a bus and taxi lane on the roadway. A general vehicle lane was reintroduced a year later and, in the time since, several modifications have been made to better serve bus riders, pedestrians and bike riders including the reduction in speed limit from 40 mph to 20 mph. The lane is intended to pull cyclists from nearby Broad Walk in Hyde Park to allow for that path to be more heavily used by pedestrians, reduce vehicle traffic, reduce morning peak freight transport, and help grow the cycle network. Bus travel times have varied but have been broadly consistent with pre-pandemic times. Travel times for general vehicles are up one to two minutes (around five minutes total) for the corridor though this is at least in part due to the reduction in speed (Transport for London, 2022).

5. Conclusion

Over the past 50 years, the road diet has proven itself to be an effective strategy for improving safety over a corridor. The reasons for implementing them vary greatly, from trying to reduce crashes, traffic calming, to creating space to implement bicycle and pedestrian facilities. This usage is increasing as more American states and other countries begin to consider and implement them.

While the four-lane to three-lane conversion is the most common, there are many variations available with successful examples. In addition to being the most common, reducing two through lanes in each direction to a single through lane in each direction with a two-way left turn lane is by far the most studied arrangement. The FHWA's current standards suggest a 29% crash reduction in vehicle crashes, a 19% crash reduction in for pedestrian accidents in urban areas, and a 47% crash reduction for pedestrians in suburban areas, but the actual results can vary greatly (Crash Modification Factors Clearinghouse, n.d.). When determining an expected crash reduction or analyzing the actual reduction, there are many other factors to consider. Rates can vary greatly between various states and even within the state or locality. This can be because of different goals, different roadway characteristics, or quality of implementation. As part of the analysis, it is also important to compare with overall traffic trends and to analyze rates instead of raw changes in crashes. Citywide reductions in crashes or reductions in volume can make the improvements look far better than they are and too many studied cases included here neglect this factor in favor of juicier results. Mean speed, 85th percentile speed, and percent speeders all have their usage in evaluation. There appears to be no set assumption for what reduction in speed can be expected because speed is so project specific, but results have been positive for most sites.

The methodology currently exists to effectively pick prospectives sites. ArcGIS and related applications can be used to cross reference existing data to look for key factors in a successful design. While there is a large range of ADT values accepted by various states for what makes an acceptable road diet candidate, some as high as 25,000 vehicles per day, road diets are more effective at maintaining flow when the volume is under 15,000 vehicles per day. Maintaining the current rate of flow is not essential as there are many reasons to implement a road diet, but it can be very helpful when trying to sell a program to politicians and a populace which can be skeptical of the procedure. Looking at upcoming resurfacing projects can also cover most of the costs associated with a basic road diet aside from design cost. The affordability of a road diet remains one of its greatest strengths.

Context specific design is needed to consider how the road diet fits into the greater traffic environment. Bicycle facility connectivity both enhances overall access in an area and helps to promote usage of any new facilities added. Main streets and entertainment districts can provide plenty of destinations for bicycles and pedestrians and encourage new multimodal usage. Bus bulbs, designated pull over lanes, and other such facilities can promote bus usage and ensure that the reduction in lanes does not negatively affect existing transit usage. Flexibility in design is crucial to best serving all users whether it is by car or not. Incorporating a road diet as one aspect of a complete streets program can yield additional benefits and maximize the impacts of both in achieving the desired goals.

The analysis of a road diet cannot just look at the specific area, it must also consider the region and mitigations that may need to be provided there in preparation for a changing user base. Diversions, which can be particularly noticeable when a lane is removed from a higher ADT road, can lead to unwanted vehicles and speeding on lanes that were not designed to handle such traffic. These roads may require traffic calming too to discourage usage or a high diversion rate may indicate that the road is not able to properly handle losing a lane. More studies going forward should collect volumes and speeds from surrounding roads to better assess this impact even though this would expand the scope of the project.

A lack of data is a frequent enemy of these types of project analyses. Higher ADT roadways tend to have more existing data than lower ADT ones, which means that many retrospective analyses naturally focus on those with a higher ADT which introduces bias. Low sample sizes also introduce their own issues including the possibility that a road diets success would be less noticeable over a longer period. Consideration of the context of each road diet and the ways they succeeded or failed is needed to refine implementation and better perform similar projects later. There is also a major lack in data for road diets away from basic four-lane to three-lane variety.

Equity also needs to be considered as part of any road diet. For example, several road diets have been shown to increase surrounding property value which can price out the very users who most need alternate transit. Engaging with the public is an important part of the engineering design process, but when removing a lane, this becomes even more important. Road diets are often controversial and ensuring proper communication with the public about goals and results can help address if not always solve this issue. The results tend to improve public perception, but successful road diets have been rolled back because of public disapproval.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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