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Impacts of COVID-19 on Motor Vehicle Crash Frequency and Severity by Functional Classification and Land Use Context

NICHOLAS N. FERENCHAK, PH.D., P.E.

University of New Mexico; Department of Civil, Construction & Environmental Engineering; Albuquerque, NM 87131, USA

ABSTRACT: Reduced traffic exposure due to COVID-19 lockdowns may have resulted in changes to both the frequency and severity of motor vehicle crashes. In order to better understand the impact of COVID-19 lockdowns on traffic safety outcomes in US DOT Region 6, we explored the role of vehicle, user, and built environment factors on fatalities, injuries, and total crashes before and during COVID-19 lockdowns in Oklahoma and Texas. Findings suggest that while crash counts in Region 6 were 45%-50% lower during the COVID-19 lockdowns than the previous five-year averages, crashes were more severe. Fatal pedestrian crash counts decreased 3.9% during COVID-19 and fatal bicyclist crash counts increased 22.0%. These Region 6 outcomes were worse than the US as a whole. COVID-19 crashes were more likely single-vehicle fixed-object or rollover crashes involving unsafe speeds. In Texas, suburban areas saw the most crashes before and during COVID-19. Rural Texas crashes were most likely to result in a serious or fatal injury, and that likelihood got worse during the COVID-19 lockdowns.

KEYWORDS: Traffic Safety; COVID-19; Resilience; Functional Classification; Land Use

1. INTRODUCTION

Early COVID-19 lockdowns in the first half of 2020 largely kept people at home, thereby reducing motor vehicle traffic levels. Theoretically, reduced traffic exposure should have resulted in reduced motor vehicle crashes. However, a variety of factors may have complicated this relationship. More consumption of alcohol and drugs during lockdowns could translate to more driving while intoxicated. Public transit trips decreased by 85% in some cities, with many of these trips converting to less-safe personal vehicles (Hughes, 2020). Similarly, higher levels of vulnerable road users such as pedestrians and bicyclists may have led to worse safety outcomes. Emergency services were often stretched thin during the lockdowns, so enforcement and emergency response times to motor vehicle collisions may have decreased (Vingilis et al., 2020).

The overall goal of this work is to understand how the COVID-19 pandemic's early lockdowns impacted collision frequencies and collision severities in US DOT Region 6, which includes Arkansas, Louisiana, New Mexico, Oklahoma, and Texas. We hypothesize that overall decreases in traffic exposure will have resulted in decreases in crash frequency but increases in crash severity. A key goal of this work will be to understand in which roadway and land use contexts this is true.

To accomplish the research goals, we examine fatal and non-fatal safety outcomes comparing before versus during the COVID-19 lockdowns in Oklahoma and Texas in terms of built environment, person, vehicle, and situational factors. Doing so illuminates whether collision frequencies, collision severities, or both frequency and severity differed during the COVID-19 lockdowns. In other words, it is possible that overall collisions were less frequent but more severe. If this turns out to be the case, was it consistent across all urban/rural contexts and road networks? We therefore look at functional classifications in urban, suburban, and rural contexts.

Findings are relevant in two regards. First, the findings inform actions for future epidemics, pandemics, economic downturns, and natural disasters where we might expect similar traffic volume changes as we saw during COVID-19. Second, our findings will further reveal the intrinsic safety of street and network typologies. Our findings will thusly provide important contributions to the body of knowledge on traffic safety even outside of pandemics.

2. BACKGROUND

We first examine existing research that has explored traffic safety outcomes during COVID-19 in other locations. We then examine how travel behavior, infrastructure, and other relevant factors (such as driving under the influence and emergency response times) relate to traffic safety outcomes and how they may have been impacted by COVID-19.

2.1. Traffic Safety Outcomes During COVID-19

In general, researchers have found that overall crash counts decreased during the early COVID-19 lockdowns. In Louisiana, the stay-at-home order led to a 47% decrease in traffic collisions and a 46% decrease in injury collisions (Barnes et al., 2020). Total crash counts in Connecticut decreased by 54.9% after the lockdowns were initiated compared to pre-lockdown conditions (Doucette et al., 2021). In Missouri, motor vehicle crashes resulting in no injuries or minor injuries saw significant decreases with the lockdowns, while crashes resulting in serious or fatal injuries saw non-significant increases (Qureshi et al., 2020).

However, traffic volumes also decreased during the lockdowns, so the above drops in collision counts would be expected. Once accounting for a 43% decrease in traffic volumes, researchers in Connecticut found that single-vehicle crash rates increased 2.29 times and single-vehicle fatal crash rates increased 4.10 times when compared to pre-lockdown conditions (Doucette et al., 2021). This suggests that not only were the drivers that were still on the road at elevated risk for collision, but those collisions also became more severe.

Backing up those severity findings, researchers found that while traffic volumes decreased across the US, fatality rates

increased (Meyer, 2020). Overall across the country, early fatality data indicated that while road death counts decreased 3.3% during the 2nd quarter of 2020, after accounting for the fact that vehicle miles travelled (VMT) decreased 26%, fatality rates actually increased 31%, indicating that for the drivers still out there, our roads got significantly less safe (NHTSA, 2020). Fatality rates in Massachusetts also increased (GHSA, 2020). In Texas, the proportion of collisions with at least one fatality rose by 14% for single-vehicle collisions and 59% for multi-vehicle collisions (Kellett, 2020). For motor vehicle users in general during the lockdowns, it appears that collision counts decreased, but collision rates increased slightly and those collisions were more likely to be serious or fatal.

From an international perspective, Yasin et al. found in a global analysis that road fatality counts decreased between April 2019 and April 2020 in 32 of 36 countries studied, with a decrease of 50% or more in twelve of them (Yasin, Grivna, & Abu-Zidan, 2021). Interestingly, three of the four countries with increases in road fatality counts were Denmark, the Netherlands, and Sweden, which are among the safest countries on Earth in terms of road safety. However, 66.7% of the countries studied actually had larger decreases in traffic volumes, suggesting that individuals still using the streets were less safe on the scale of the individual road user.

The European Commission similarly found that fatality counts decreased significantly for Europe as a whole during lockdowns (European Commission, 2020). Researchers in India examined trauma data from patients reporting to a tertiary care hospital in the Delhi National Capital Region, comparing patient data from the lockdown to patient data from one year previous (Jain, Goyal, & Varma, 2021). The researchers found that the lockdowns correlated with significant decreases in traffic-related injuries and fatality and disability-adjusted life year (DALY), a 72.6% decrease in minor injuries and a 62.5% decrease in head injuries (Jain, Goyal, & Varma, 2021). In Tarragona Province of Spain, overall mobility during COVID-19 lockdowns declined 62.9%, traffic collisions fell 74.3%, and the relative occurrence of severe collisions diminished (Saladié, Bustamante, & Gutiérrez, 2020). These findings from Spain appear to fundamentally differ from those in the US as collision rates and severity improved during COVID-19.

2.2. Travel Behavior During COVID-19

As seen above, while collision counts may have decreased during COVID-19 lockdowns, collision rates often appear to have increased. Shifting exposure includes both changes in overall trips and mode shift. The National Highway Traffic Safety Administration (NHTSA) estimates that trips per day in the U.S. decreased about 30% beginning in April 2020 and stayed at approximately the same level throughout the remainder of the year (NHTSA, 2021). These trips likely became shorter, with 71% of respondents' trips in a global online snowball survey reported as between 0 and 10 km during COVID-19, whereas only 45% of trips were this distance before COVID-19 (Abdullah et al., 2020). Exposure appears to have decreased both in terms of lower trip counts and shorter trip distances.

Mode shift away from public transit and toward walking, biking, and personal automobiles has been hypothesized. In Buenos Aires, bike use increased 129% with the COVID-19 lockdown and a similar increase was observed on China's bikeshare systems (Goetsch & Quiros, 2020). In the same global online snowball survey referenced above, significant drops in public transit usage were converted primarily to a reduction in overall trips, then to private cars and walking, and less to bicycles (Abdullah et al., 2020). In a study administered to over 10,000 respondents across 20 European cities, significant decreases in public transit use were consistently observed across the study cities (Christidis et al., 2020). University of North Carolina researchers have tracked 920 pedestrian and bicycle infrastructure improvements that were implemented as a result of COVID-19, but usage is still unclear (Combs, 2020).

Because several prior safety studies hinted that vehicle speeds may have increased on empty roadways, we will study travel behaviors such as speeding and aggressive driving in this paper. In the U.S., the number of speeding violations increased with the lockdowns even though vehicle volumes decreased (Meyer, 2020). The proportion of ejections rose markedly at the beginning of the COVID-19 pandemic in the US, hinting at an increase in vehicle speed (NHTSA, 2021). However, the data suggest that vehicle speeds in the U.S. have increased in urban areas while staying relatively stable in rural areas (NHTSA, 2021). Urban increases in speed appear to be concentrated on larger roads such as interstates and arterials and impact the 1st percentile of speeds but not the 99th percentile, indicating that the increases are a result of relatively few outliers speeding on large roadways, likely because less congestion leads to the perception of more space for speeding on the road network (NHTSA, 2021).

In Greece and the Kingdom of Saudi Arabi, COVID-19 lockdowns led to decreases in vehicle volumes but 6-11% increases in speed and 12% increase in harsh acceleration and braking events (Katrakazas et al., 2020). Cell phone data from Greece, Saudi Arabia, and Brazil similarly found an increase in average vehicle speed and harsh driving behavior (Michelaraki et al., 2021). We will thusly explore contributing factors and speeds of collisions during the COVID-19 lockdowns.

2.3. Infrastructure and Land Use During COVID-19

There are two aspects of the built environment that are especially important for traffic safety that we will explore with this work: transportation infrastructure and land use. In terms of transportation infrastructure, a key part of this study is aimed at identifying how traffic safety outcomes are related to road design and network configuration. Researchers have shown that road networks have significant impacts on traffic safety outcomes, with low street network density being correlated with high risk of fatal or severe crashes (Dumbaugh & Rae, 2009; Ferenchak & Abadi, 2021; Marshall & Garrick, 2010; Marshall & Garrick, 2011). Similarly, urban arterials and their associated arterial-oriented commercial developments have been linked to increased incidences of traffic-related crashes and injuries (Dumbaugh & Rae, 2009; Mohan, Bangdiwala, & Villaveces, 2017). Many cities implemented changes to their infrastructure to provide residents with more space to walk and/or bike during the lockdowns. This may have impacted safety (both real and perceived) as past research has found that appropriate bicycle facilities correlate with improved safety for all road users (Ferenchak & Marshall, 2019a; Ferenchak & Marshall, 2019b; Ferenchak & Marshall, 2020; Marshall & Ferenchak, 2019).

Land use is another important aspect of the built environment that has been correlated with traffic safety outcomes. Past research suggests that higher density development is generally related to improved safety outcomes (Ferenchak, 2022; Ferenchak & Marshall, 2017; Long & Ferenchak, 2021). While we do not anticipate that land use changed significantly during the COVID-19 lockdowns, we would expect varying traffic safety outcomes based on land uses and urban/rural contexts.

3. METHODS

For Oklahoma, we defined our lockdown period as March 26th, 2020 through May 6th, 2020 (inclusive). This provides us with a six-week study period. Oklahoma's Governor Stitt

did not announce his "Safer at Home" executive order until March 24th, 2020. By May 1st, 2020, Oklahoma could reopen dine-in restaurants (excluding bars), cinemas, gyms, sports venues, and places of worship.

Our study period for Texas was March 23rd, 2020 through May 3rd, 2020 (inclusive), also providing us with a six-week study period. On March 13th, 2020, Texas' Governor Abbott declared a state of disaster for all counties in Texas and ordered state employees to work from home, and trips took a week to reach their lowest levels. By May 5th, 2020, Governor Abbott had established a reopening timetable.

3.1. Data

For motor vehicle crash data in Oklahoma, we obtained reported motor vehicle crash data covering the study period from the Oklahoma Department of Transportation (ODOT). For the motor vehicle crash data in Texas, we obtained crash data from the Crash Records Information System (C.R.I.S.) Query tool hosted by the Texas Department of Transportation (TxDOT). All motor vehicle crash data available through the C.R.I.S. Query tool represents reportable data collected from Texas Peace Officer's Crash Reports (CR-3) received and processed by the TxDOT.

Since we examined longitudinal changes to crash injury severity, it was important that injury severity definitions were consistent over the study period. While the Model Minimum Uniform Crash Criteria (MMUCC) changed in 2017, the definition changes did not have a substantial impact on the analysis results for any of the states studied in this report.

For data regarding roadways in Texas, we used a spatial dataset maintained by TxDOT of roadway polylines for planning and asset inventory purposes. This dataset covers the state of Texas and includes on-system routes (those that TxDOT maintains), such as interstate highways, U.S. highways, state highways, and farm and ranch roads, as well as off-system routes, such as county roads and local streets. Every road segment in the state of Texas has data regarding that segment's functional classification. TxDOT updates the dataset monthly.

In order to derive population density for our urban/suburban/rural analyses, we used data from the Smart Location Database (SLD) from the US Environmental Protection Agency (EPA). Although there is no perfect definition of urban, suburban, and rural, population density on the block group level can provide a good approximation. We defined rural block groups as those with less than 1,000 residents per square mile, suburban block groups as those with between 1,000 and 5,000 residents per square mile, and urban block groups as those with more than 5,000 residents per square mile. This rural/suburban/urban definition provided us with a relatively even distribution of block groups in each category with 27.5% of block groups being rural, 40.5% being suburban, and 32.0% being urban.

3.2. Data Analysis

To start our Region 6 analysis, we derived descriptive statistics for all reported motor vehicle crashes in Oklahoma during the COVID-19 lockdowns (March 26th through May 6th, 2020) and compared those results to the means from the previous five years (March 26th through May 6th, 2015-2019). We explored person, vehicle, and situational characteristics of crashes, plotting the values for the COVID-19 lockdowns and the five preceding years on scatterplots to illustrate longitudinal trends for all crashes. We explored changes to injury severity based on changes to total counts of different injury severities and proportions of injury severities.

For our analysis of motor vehicle crashes in Texas, we geocoded all the crashes from our study period (March 23rd through May 3rd, 2015-2020) into GIS that had latitude and longitude coordinates provided by TxDOT. Latitude and longitude coordinates were provided for 367,432 of the 409,050 (89.8%) crashes over the study period. Once the crashes were in GIS, we used a spatial join to determine the population density of each crash's block group. We also used a spatial join to join each Texas crash to the road segment that it occurred on so we could understand the functional classification of each crash's roadway. The previous analysis of Oklahoma did not include results by standard functional classification designations because that data was not available for all crashes. Categorized by roadway functional classification and urban/suburban/rural context, we then graphed the changes to the overall number of motor vehicle crashes, the changes to the number of motor vehicle crashes that resulted in a serious or fatal injury, and changes to the proportion of crashes resulting in a serious or fatal injury. We do not provide maps in our Results section because the wide geographic range of the study area would make maps difficult to interpret.

4. RESULTS

4.1. Oklahoma Results

4.1.1. Crash Count Trends - Oklahoma

Between March 26, 2020, and May 6, 2020 (inclusive), there was a 48.3% decrease in reported motor vehicle crashes across Oklahoma relative to the average over the same time frame for the five preceding years (Table 1). There was a significant drop in the proportion of crashes occurring in urban areas meaning that, given Oklahoma's binary data definition that each crash occurred in either an urban or rural area, there was a higher proportion of crashes that occurred in rural areas during the COVID-19 shutdowns than in preceding years.

	Reported Motor Vehicle Crashes (3/26 - 5/6)	% In Urban Areas
2015	25,902	73.9%
2016	24,216	73.6%
2017	25,794	73.6%
2018	25,749	71.5%
2019	27,201	69.5%
2015-2019 Average	**25,772**	**72.4%**
2020	13,315	60.9%

Table 1. Reported Motor Vehicle Crashes in Oklahoma for March 26 through May 6 (inclusive) in the years 2015 through 2020.

Collisions during the COVID-19 lockdowns were more severe (Figure 1a). Specifically, the proportion of property damage-only crashes and possible injury crashes decreased in 2020 while the other more serious types of injury severity crashes increased, with non-incapacitating injuries seeing the largest increase. Interestingly, while the total number of crashes decreased 48.3% in 2020, the number of fatalities only decreased 12.3%. A higher proportion of crashes involved pedestrians or bicyclists in 2020, although the proportions were still relatively low at 0.8% and 0.4%, respectively (versus an average of 0.6% and 0.3% over the five preceding years) (Figure 1b).

4.1.2. Crash Infrastructure - Oklahoma

In terms of roadways, a higher proportion of crashes occurred on county roads (8.8% in 2020 versus 5.3% over the preceding five years) while the proportion on city streets and interstates saw the largest decreases (46.0% in 2020 versus 48.1% over the preceding five years for city streets; 16.4% in 2020 versus 18.4% over the preceding five years for interstates) (Figure 2a). This aligns with the findings from Table 1 suggest-

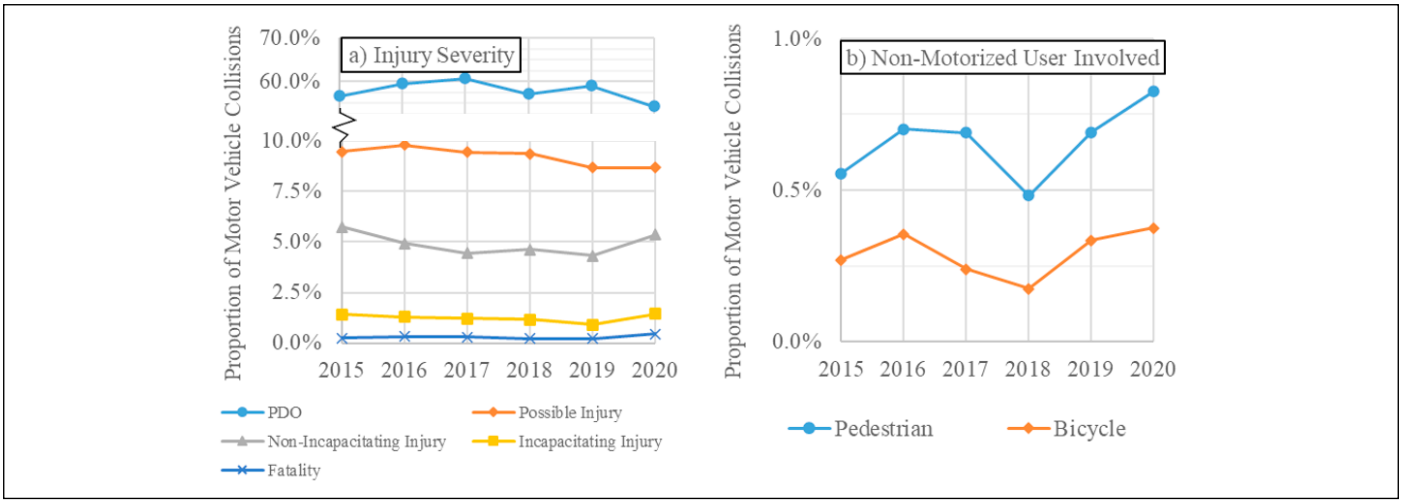

Figure 1. Proportion of Reported Motor Vehicle Crashes in Oklahoma During the Study Period (March 26 through May 6) Between 2015-2020 by a) Injury Severity and b) Non-Motorized Users Involved.

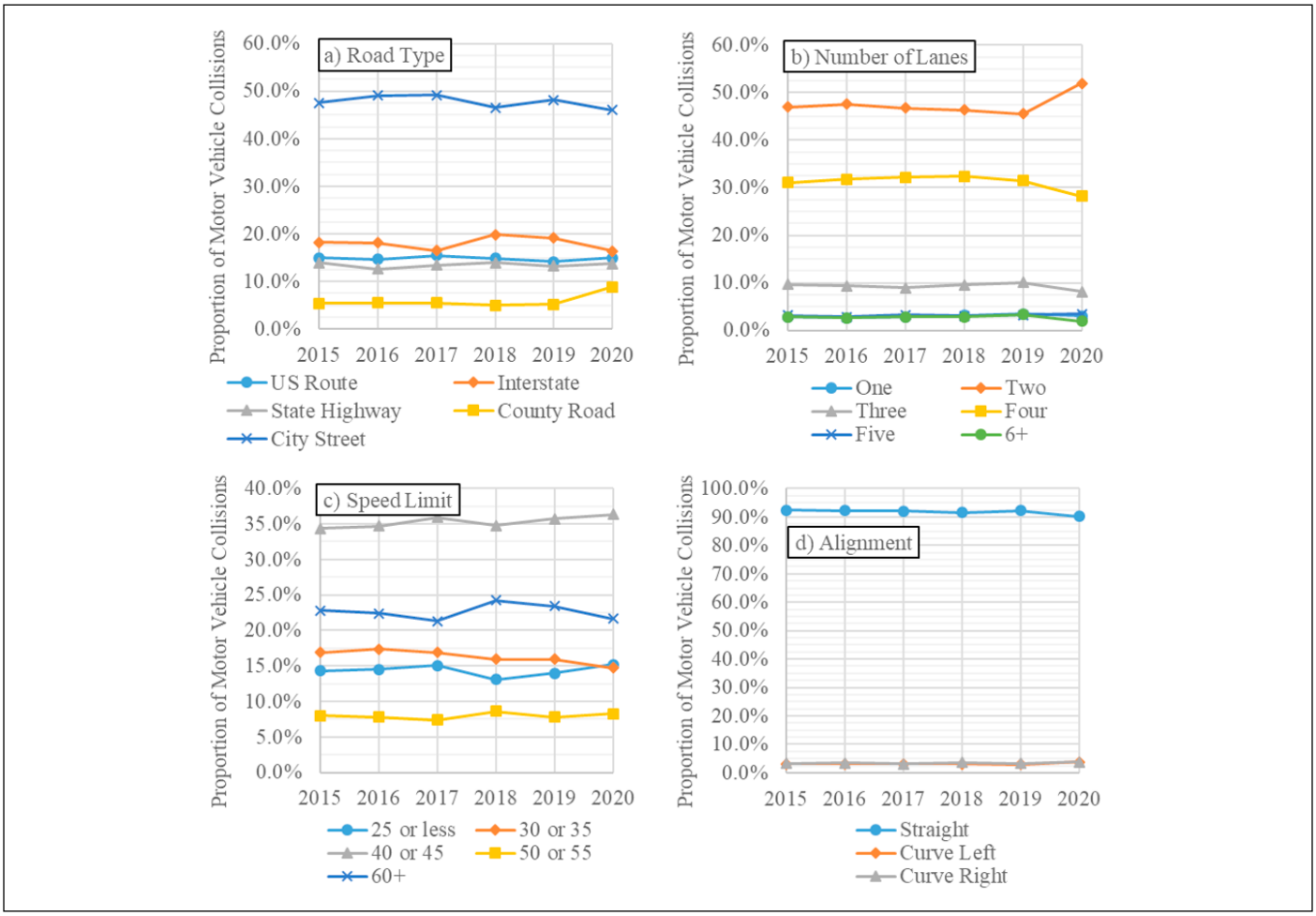

Figure 2. Proportion of Reported Motor Vehicle Crashes in Oklahoma During the Study Period (March 26 through May 6) Between 2015-2020 by a) Road Type, b) Number of Lanes, c) Speed Limit, and d) Alignment.

ing that crashes were more likely to occur in rural areas. The roads in 2020 crashes were more likely to be two lane roads and signed at 40-45 mph (Figure 2b and Figure 2c). While the vast majority of crashes still occur on straight segments of roadways, the proportion of crashes occurring on curves in 2020 increased (Figure 2d).

4.1.3. Crash Vehicles - Oklahoma

In terms of vehicles, there was a drastic increase in crashes that only involved a single vehicle (Figure 3a). Single-vehicle collisions increased from 14.2% over the five preceding years to 22.5% in 2020. The proportion of crashes involving pickup trucks increased while the proportion involving sport utility vehicles (SUVs) decreased (Figure 3b).

4.1.4. Persons Involved - Oklahoma

In terms of users, there was a surprising decrease in the proportion of crashes involving male drivers. Male drivers were involved in 29.6% of crashes in 2020 versus 34.4% in the five preceding years (Figure 4a). However, it is worth noting that the proportion of drivers with unknown gender increased by approximately 3% in 2020, which accounted for some of

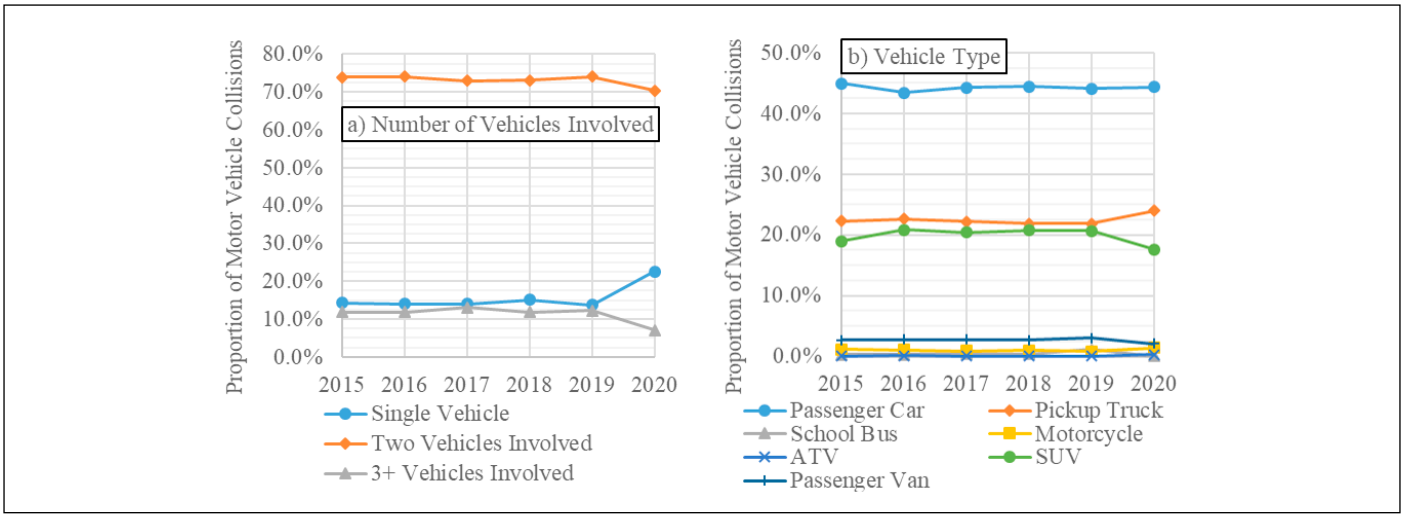

Figure 3. Proportion of Reported Motor Vehicle Crashes in Oklahoma During the Study Period (March 26 through May 6) Between 2015-2020 by a) Number of Vehicles Involved and b) Vehicle Type.

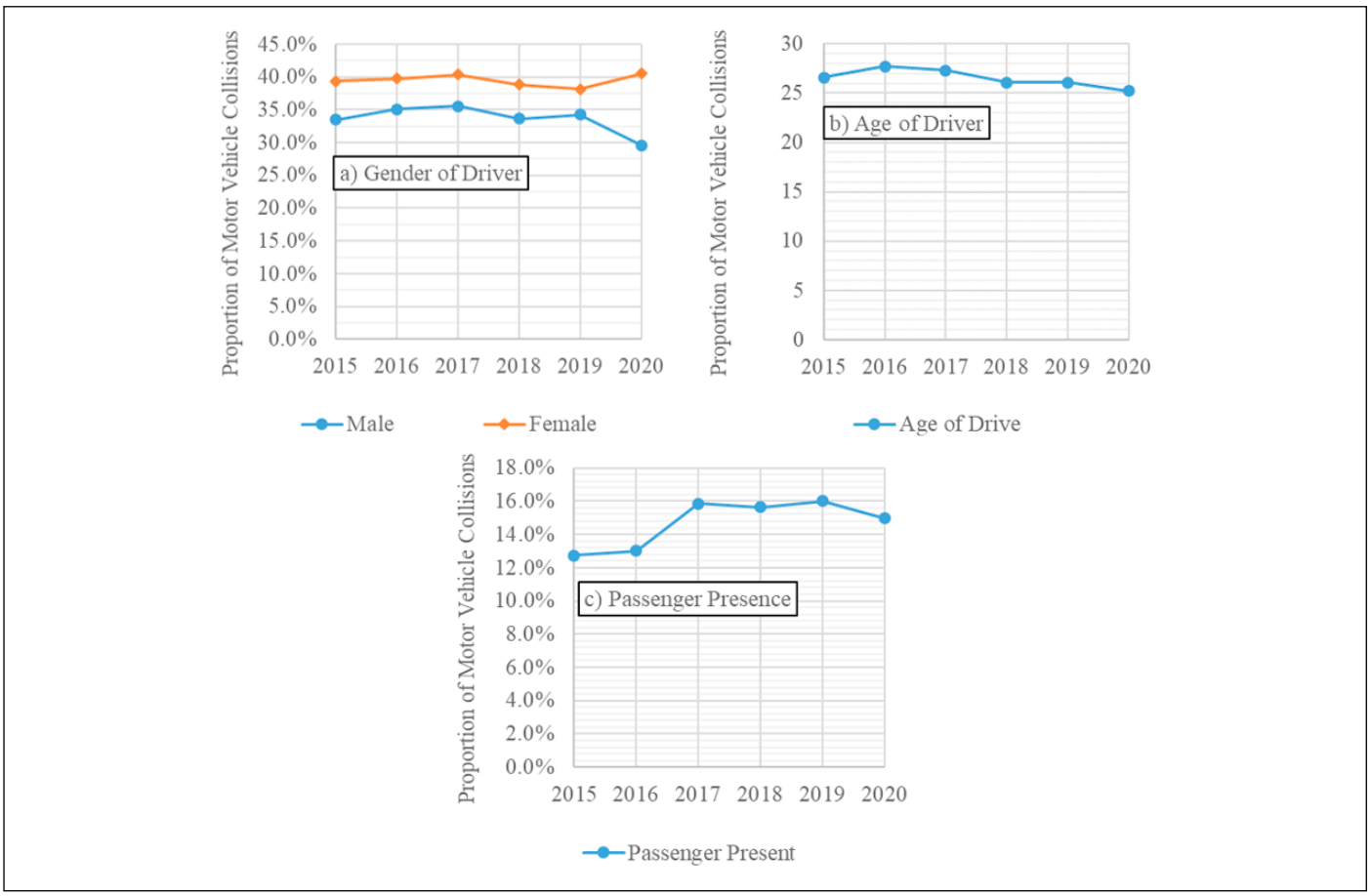

Figure 4. Proportion of Reported Motor Vehicle Crashes in Oklahoma During the Study Period (March 26 through May 6) Between 2015-2020 by a) Gender of Driver, b) Age of Driver, and c) Passenger Presence

the male decrease. Drivers were younger in 2020 than in the preceding five years, but this largely followed a consistent pattern throughout the study period (Figure 4b).

4.1.5. Other Characteristics - Oklahoma

In terms of behaviors, the proportion of crashes involving alcohol or drugs increased significantly in 2020 and was higher than any of the five preceding years (Figure 5a). The proportion of fixed object crashes saw the strongest increase (Figure 5b). This increase was coupled with a significant decrease in rear-end crashes (Figure 5b). Correspondingly, crashes involving "unsafe speed" increased significantly while "followed too closely" decreased significantly (Figure 5c). Restraint use decreased in 2020, but this generally followed a trend present over the preceding five years (Figure 5d).

Overall, Oklahoma saw a 48.3% decrease in total collisions in 2020 relative to the five preceding years. However, these 2020 collisions were more likely to be more severe. This was a result of a higher proportion of crashes being single vehicles running into fixed objects at high speeds. These crashes were more likely to occur at curves on county roads (two lane roads signed at 40-45 mph) in rural areas. Alcohol and drugs were also more likely to be involved in 2020 crashes.

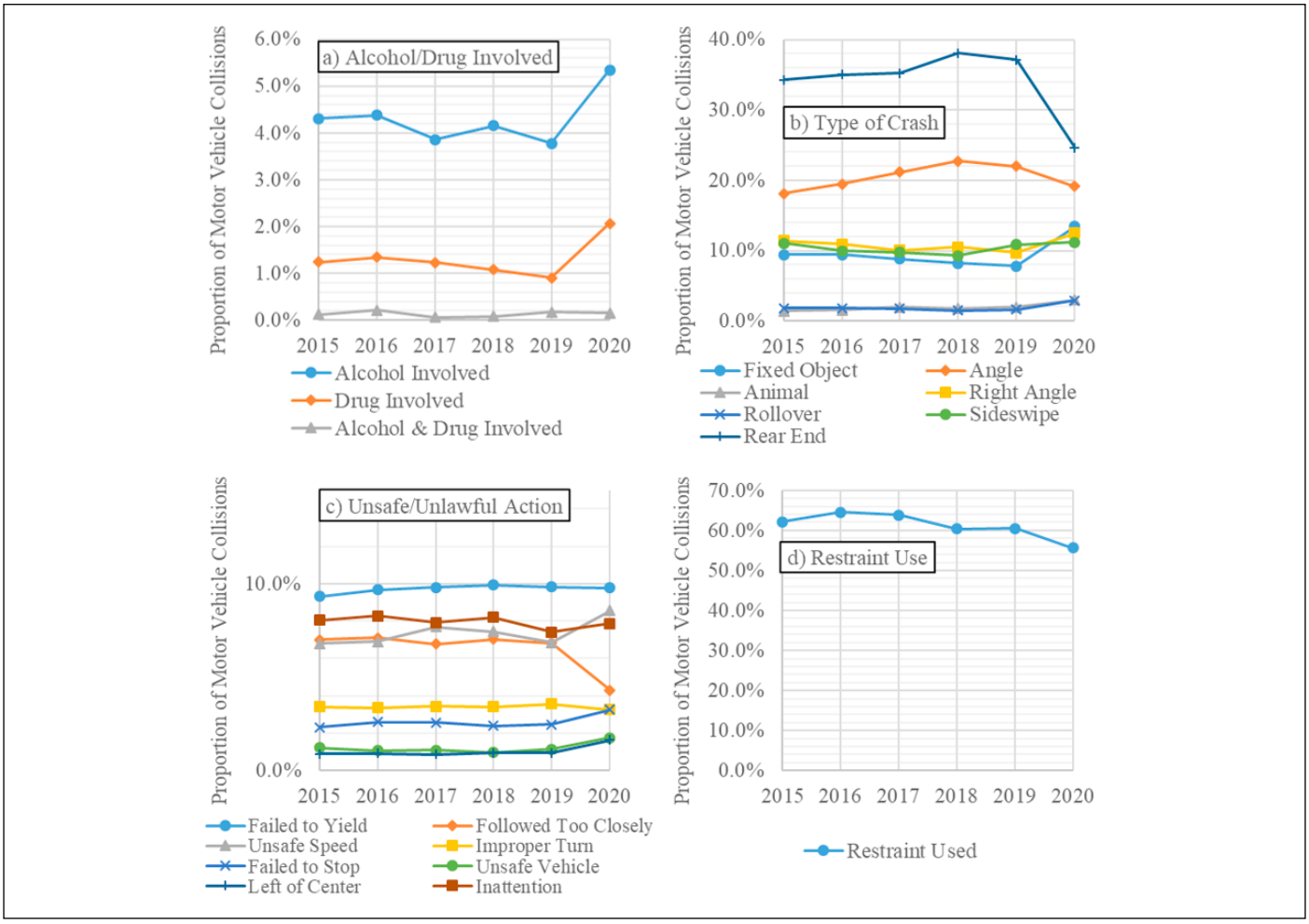

Figure 5. Proportion of Reported Motor Vehicle Crashes in Oklahoma During the Study Period (March 26 through May 6) Between 2015-2020 by a) Alcohol/Drug Involvement, b) Type of Crash, c) Unsafe/Unlawful Action, and d) Restraint Use.

	Reported Motor Vehicle Crashes (3/23 - 5/3)	Fatal Crashes	Serious Injury Crashes	Minor Injury Crashes	Possible Injury Crashes	No Injury Crashes	Unknown Severity
2015	68,971	354	1,602	6,682	11,633	44,634	4,066
2016	73,678	383	1,708	7,108	12,700	47,588	4,191
2017	74,567	353	1,747	7,694	12,456	48,068	4,249
2018	73,181	367	1,433	6,713	12,491	47,929	4,248
2019	78,336	398	1,538	6,879	13,421	51,548	4,552
2015-2019 Average	**73,747**	**371**	**1,606**	**7,015**	**12,540**	**47,953**	**4,261**
2020	40,317	325	1,028	3,781	6,047	26,008	3,128
% Change (2015-2019 versus 2020)	-45.3%	-12.4%	-36.0%	-46.1%	-51.8%	-45.8%	-26.6%

Table 2. Reported Motor Vehicle Crashes in Texas for March 23 through May 3, 2015-2020.

4.2. Texas Results

4.2.1. Crash Count Trends - Texas

Between March 23, 2020, and May 3, 2020 (inclusive), there was a 45.3% decrease in reported motor vehicle crashes across Texas relative to the average over the same time frame for the five preceding years (Table 2). Similar to Oklahoma, crashes were more severe in 2020. While the overall crash count decreased by 45.3%, fatal crashes decreased by only 12.4% and serious injury crashes decreased by only 36.0%.

4.2.2. Crashes by Land Use - Texas

A key goal of the Texas analysis was to gain a better understanding of where changes to crash counts and severities occurred spatially in 2020 relative to the preceding five years. We accomplished this by analyzing crash outcomes based on functional classification and population density on the block group level. There was a total of 15,811 block groups in Texas used for the analysis with 4,347 (27.5%) being designated as rural, 6,404 (40.5%) suburban, and 5,060 (32.0%) urban.

Suburban block groups in Texas had significantly more crashes in 2015-2019 (8.6 crashes per block group), while rural and urban block groups had lower, but relatively similar, crash frequencies over the same period (6.5 and 6.1 crashes per block group, respectively) (Figure 6). In 2020, crash frequencies for all categories decreased, as was expected. Rural and suburban block groups had similar crash frequencies in

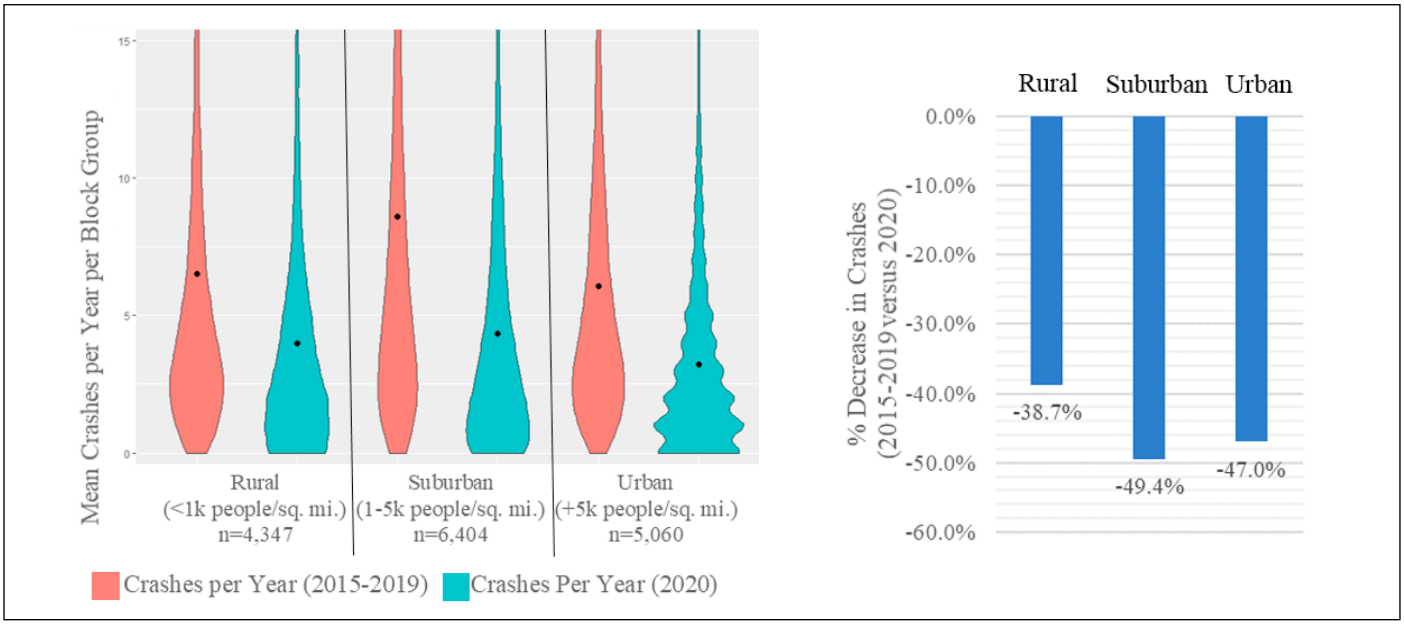

Figure 6. Crashes per Year per Block Group in Texas During the Study Period (March 23 through May 3) Between 2015-2020 by Population Density.

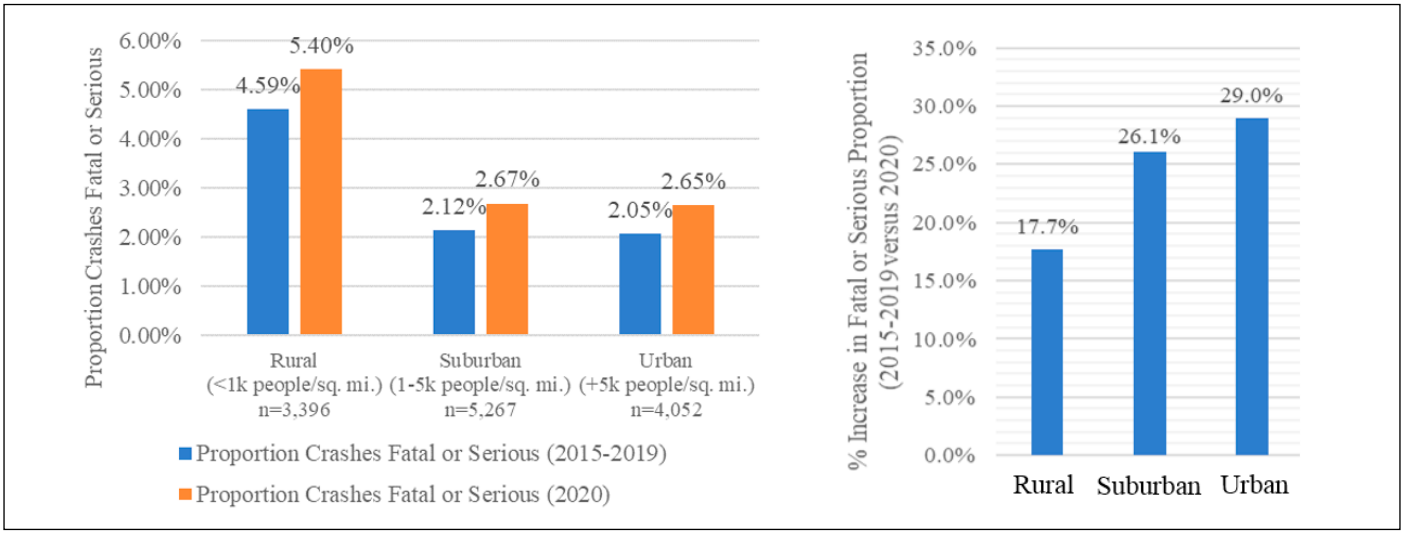

Figure 7. Proportion of Crashes Resulting in a Fatal or Serious Injury in Texas During the Study Period (March 23 through May 3) Between 2015-2020 by Population Density.

2020 (4.0 and 4.3 crashes per block group, respectively) while urban block groups had significantly lower crash frequencies (3.2 crashes per bock group in 2020).

While suburban and urban crash frequencies decreased by approximately 50% in 2020, rural crash frequencies only decreased by 38.7% (Figure 6). This might be expected given the higher proportion of rural crashes previously reported in neighboring Oklahoma and the significant decrease in rear-end collisions that we would expect in urban and suburban areas.

How and where did crash severities change? It is important to note that, since we examined severity proportions, we removed all block groups with less than ten collisions in the 2015-2019 period due to high variability. The 3,096 block groups (19.6% of the total) removed from the following analysis because of small sample sizes were relatively well distributed across the population density categories (951, 1137, and 1008 block groups were removed from the rural, suburban, and urban categories, respectively).

The proportion of crashes that resulted in a fatal or serious injury increased across all population density categories during the COVID-19 lockdowns, meaning that crashes were more likely to result in more severe injuries (Figure 7). Rural crashes were significantly more likely to result in a fatality or serious injury than higher population density areas before COVID-19 and remained that way during COVID-19 lockdowns. However, urban areas saw the largest relative percentage increase in the proportion of fatal or serious crashes at 29.0%. Rural areas saw the smallest relative percentage increase at 17.7%. This means that urban and suburban areas saw disproportionately large increases in crash severity relative to rural areas, although they remained safer than rural areas overall.

In an effort to more fully understand where crashes were occurring during COVID-19 lockdowns, we further divide our results by functional classification while keeping the same rural, suburban, and urban classifications as before. On average between 2015-2019, principal arterials had the most crashes with 27.3% of all crashes, minor arterials had the second most at 18.4%, and local roads had 17.8% (Table 3). In 2020, principal arterials remained the highest at 25.4%, but local roads had the second most crashes at 20.7% while minor arterials decreased to 16.9%.

		Average 2015-2019	2020	2015-2019 to 2020 Change	2015-2019 to 2020 % Change
Rural	Interstate	2,998	1,820	-1,178	-39.3%
	Freeway	1,094	575	-519	-47.5%
	Principal Arterial	5,214	2,933	-2,281	-43.8%
	Minor Arterial	3,174	1,858	-1,316	-41.5%
	Major Collector	3,486	2,430	-1,056	-30.3%
	Minor Collector	385	277	-108	-28.1%
	Local	2,332	1,774	-558	-23.9%
	TOTAL	**18,684**	**11,667**	**-7,017**	-37.6%
Suburban	Interstate	5,234	2,603	-2,631	-50.3%
	Freeway	2,798	1,377	-1,421	-50.8%
	Principal Arterial	8,970	4,325	-4,645	-51.8%
	Minor Arterial	5,787	2,698	-3,089	-53.4%
	Major Collector	3,590	1,838	-1,752	-48.8%
	Minor Collector	127	69	-58	-45.8%
	Local	5,216	3,108	-2,108	-40.4%
	TOTAL	**31,722**	**16,018**	**-15,704**	-49.5%
Urban	Interstate	1,732	1,004	-728	-42.0%
	Freeway	822	401	-421	-51.2%
	Principal Arterial	3,900	1,903	-1,997	-51.2%
	Minor Arterial	3,238	1,543	-1,695	-52.4%
	Major Collector	1,861	943	-918	-49.3%
	Minor Collector	59	36	-23	-38.8%
	Local	4,251	2,578	-1,673	-39.4%
	TOTAL	**15,862**	**8,408**	**-7,454**	-47.0%
Grand Total		**66,268**	**36,093**	**-30,175**	-45.5%

Table 3. Reported Motor Vehicle Crashes in Texas for March 23 through May 3, 2015-2020 by Rural/Urban Context and Functional Classification (green signifies large drops and red signifies small drops in crash frequencies).

		Average 2015-2019	2020	2015-2019 to 2020 Change	2015-2019 to 2020 % Change
Rural	Interstate	113	87	-26	-23.3%
	Freeway	42	25	-17	-40.2%
	Principal Arterial	249	153	-96	-38.5%
	Minor Arterial	159	113	-46	-28.9%
	Major Collector	212	152	-60	-28.4%
	Minor Collector	26	19	-7	-28.0%
	Local	102	104	2	2.4%
	TOTAL	**903**	**653**	**-250**	**-27.7%**
Suburban	Interstate	124	89	-35	-28.0%
	Freeway	68	43	-25	-37.1%
	Principal Arterial	189	98	-91	-48.1%
	Minor Arterial	125	62	-63	-50.2%
	Major Collector	69	49	-20	-29.4%
	Minor Collector	2	5	3	150.0%
	Local	98	80	-18	-18.4%
	TOTAL	**675**	**426**	**-249**	**-36.9%**
Urban	Interstate	32	44	12	36.6%
	Freeway	20	13	-7	-33.7%
	Principal Arterial	82	52	-30	-36.9%
	Minor Arterial	62	48	-14	-22.3%
	Major Collector	41	24	-17	-41.5%
	Minor Collector	1	0	-1	-100.0%
	Local	73	49	-24	-33.1%
	TOTAL	**311**	**230**	**-81**	**-26.1%**
Grand Total		**1,889**	**1,309**	**-580**	**-30.7%**

Table 4. Reported Motor Vehicle Crashes in Texas for March 23 through May 3, 2015-2020 Resulting in a Fatality or Serious Injury by Rural/Urban Context and Functional Classification (green signifies large drops in crash frequencies and red signifies small drops in crash frequencies).

Large roadways saw the largest decrease in total crashes (Table 3). Specifically, principal and minor arterials in suburban and urban areas saw the largest decreases (51-54% decreases). Interstates and freeways in these areas saw approximately 42-50% decreases. Collectors and locals in suburban and urban areas saw about 38-50% decreases. The worst performers were small rural roads (collectors and locals) which only saw 24-30% decreases in crashes. The largest decreases in total crash counts during COVID-19 lockdowns were on larger suburban and urban roadways and the smallest decreases in crashes were on smaller rural roadways, likely because of the reduction in minor fender benders.

Although rural areas had relatively few total crashes, rural areas had the most crashes that resulted in either a serious or fatal injury for both 2015-2019 and 2020 (Table 4). Suburban areas had the second most crashes resulting in a serious or fatal injury while urban areas had the least. Suburban areas saw the largest percentage decrease in crashes resulting in a serious or fatal injury (-36.9%) while rural and urban saw similar decreases (-27.7% and -26.1%, respectively).

Between 2015-2019, arterials were home to many crashes resulting in a serious or fatal injury (Table 4). In 2020, arterials still saw many serious and fatal crashes, but local roads and interstates both had relatively small decreases or even increases in serious and fatal crashes (urban local roads were an outlier as they saw a relatively large decrease of -33.1%). Road types that performed particularly poorly in 2020 included urban interstates (which went from 32 serious or fatal crashes to 44, a 36.6% increase in 2020) and rural local roads (which went from 102 serious or fatal crashes to 104, a 2.4% increase in 2020). Note that we did not analyze minor collectors in suburban or urban areas because of small sample sizes.

Urban interstates are worth highlighting because they experienced a 42.0% decrease in total crash counts during COVID-19 lockdowns but a 36.6% increase in serious and fatal injury crashes (Table 4). Freeways and arterials saw large decreases in terms of both total crashes and serious or fatal crashes while interstates, collectors, and local roads performed relatively poorly for both types of crashes.

Crashes became more severe during the COVID-19 lockdowns. 2.9% of crashes resulted in a serious or fatal injury in 2015-2019 while 3.6% did in 2020 (Table 5). Rural areas had the highest proportion of crashes that resulted in a serious or fatal injury. However, since rural areas had a high proportion of crashes resulting in a serious or fatal injury to begin with, they did not experience a relatively large change in 2020 (only a 15.4% relative increase). Urban crashes had the largest relative increase in severity (39.4%) while suburban was in the middle (25.1%). That being said, the proportion of crashes resulting in a serious or fatal injury was still twice as high in rural areas (5.6%) than suburban or urban (2.7% and 2.7%) in 2020.

		Average 2015-2019	2020	2015-2019 to 2020 Change	2015-2019 to 2020 % Change
Rural	Interstate	3.8%	4.8%	1.0%	25.7%
	Freeway	3.8%	4.3%	0.5%	13.3%
	Principal Arterial	4.8%	5.2%	0.4%	9.1%
	Minor Arterial	5.0%	6.1%	1.1%	20.9%
	Major Collector	6.1%	6.3%	0.1%	2.3%
	Minor Collector	6.9%	6.9%	0.0%	-0.1%
	Local	4.4%	5.9%	1.5%	34.6%
	TOTAL	**4.8%**	**5.6%**	**0.7%**	**15.4%**
Suburban	Interstate	2.4%	3.4%	1.1%	45.3%
	Freeway	2.5%	3.1%	0.7%	27.2%
	Principal Arterial	2.1%	2.3%	0.2%	7.7%
	Minor Arterial	2.1%	2.3%	0.1%	6.9%
	Major Collector	1.9%	2.7%	0.7%	38.1%
	Minor Collector	1.6%	7.2%	5.6%	351.8%
	Local	1.9%	2.6%	0.7%	37.0%
	TOTAL	**2.1%**	**2.7%**	**0.5%**	**25.1%**
Urban	Interstate	1.9%	4.4%	2.5%	135.7%
	Freeway	2.4%	3.2%	0.9%	36.0%
	Principal Arterial	2.1%	2.7%	0.6%	29.1%
	Minor Arterial	1.9%	3.1%	1.2%	62.9%
	Major Collector	2.2%	2.5%	0.3%	15.5%
	Minor Collector	1.7%	0.0%	-1.7%	-100.0%
	Local	1.7%	1.9%	0.2%	10.4%
	TOTAL	**2.0%**	**2.7%**	**0.8%**	**39.4%**
Grand Total		**2.9%**	**3.6%**	**0.8%**	**27.1%**

Table 5. Proportion of Reported Motor Vehicle Crashes in Texas for March 23 through May 3, 2015-2020 that Resulted in a Fatality or Serious Injury by Rural/Urban Context and Functional Classification (green signifies small increases in crash proportions and red signifies large increases in crash proportions).

Interstates and freeways had large increases in the proportion of crashes resulting in a serious or fatal injury in nearly all land use contexts (except for rural freeways) (Table 5). Suburban and urban interstates had especially large increases. Interestingly, arterials had large increases in severity in urban areas but small increases in severity in suburban areas. Local roads saw large increases in rural and suburban areas (although they were still relatively safe), but a small increase in urban areas.

The roads with the highest proportion of their crashes resulting in a serious or fatal injury (for both 2015-2019 and 2020) were rural collectors, where 6-7% of crashes resulted in a serious or fatal injury (Table 5). In suburban and urban areas, collectors and local roads actually had some of the lowest serious or fatal injury proportions. We again do not analyze suburban or urban minor collectors because of the small sample sizes.

Of particular note, the largest increases in severity occurred on urban interstates, which went from one of the safest of all road types in 2015-2019 (only 1.9% of crashes resulted in a serious or fatal injury) to one of the least safe of all road types in 2020 (4.4% of crashes resulted in a serious or fatal injury) (Table 5). Other concerning increases were seen on urban minor arterials (from 1.9% to 3.1%) and suburban interstates (from 2.4% to 3.4%). Rural local roads also had a concerning increase in severity, although they were already unsafe to begin with so the relative change was not as pronounced as the aforementioned functional classifications.

Overall, crashes in rural areas had high proportions of serious or fatal injuries before COVID-19 and remained unsafe in 2020. Urban areas saw troubling increases in the proportion of crashes resulting in a serious or fatal injury on larger roads such as interstates, freeways, and arterials (likely because of the drop in the fender benders that were so prevalent before COVID-19). Suburban areas saw particularly large increases on interstates.

5. DISCUSSION

Thanks to reductions in exposure, crash counts in Region 6 were 45%-50% lower during COVID-19 lockdowns in 2020 (Table 6). Lower-severity crashes saw larger reductions during 2020, meaning that the crashes that occurred during the COVID-19 lockdowns were more likely to be more severe. Based on fatality counts (which is the only data that is comprehensively available on the national level), Region 6 performed worse than the country as a whole. This may be because of the rural nature of Region 6.

	All Crashes			Pedestrian Crashes		Bicyclist Crashes	
	All	Fatal or Serious Injury	Fatal	All	Fatal	All	Fatal
National			-18.3%		-19.0%		3.6%
Region 6							
OK	-48.3%	-33.6%	-12.3%	-31.6%	*LSS*	-29.4%	*LSS*
TX	-45.3%	-31.6%	-12.4%	-47.3%	-3.9%	-30.4%	22.0%

Table 6. Change in crash counts from five-year average (2015-2019) to 2020 COVID-19 lockdowns (LSS signifies that results were left out because of low sample size).

Pedestrian fatalities decreased 19.0% nationally (569 to 461) and decreased 3.9% in Texas (56.2 to 54.0). Oklahoma averaged less than ten pedestrian fatalities per year and thus had large variance. Bicyclist fatalities increased 3.6% nationally and increased 22.0% in Texas. This may reflect more biking activity, although we do not have comprehensive exposure data to substantiate that hypothesis.

In Oklahoma, crash severities got worse during COVID-19 lockdowns and crashes were more likely to be single-vehicle crashes and involve unsafe speeds. Fixed object and rollover crashes were more likely during COVID-19 lockdowns while rear-end crashes were less likely. Crashes were more likely to occur in rural areas on two-lane county roads. Alcohol and drug involvement increased in Oklahoma, with about 5.4% of all crashes involving alcohol and 2.1% involving drugs.

In Texas, while most crashes happened in suburban areas both before and during COVID-19 lockdowns, these suburban areas experienced the largest drop in overall crash counts. Rural areas had the highest proportion of crashes resulting in a serious or fatal injury before COVID-19, and that rural proportion got significantly worse during the COVID-19 lockdowns.

Texas arterials were the functional classification that saw the most crashes while crashes on interstates and freeways were most likely to result in a serious or fatal injury in urban and suburban areas. Of particular note are urban interstates and rural local roads. These are the two functional classifications that actually saw increases in the number of serious and fatal injury crashes during COVID-19 lockdowns. Although urban interstates and rural local roads saw decreases in total crash counts of 42.0% and 23.9%, respectively, the total

number of crashes that resulted in a serious or fatal injury increased by 36.6% and 2.4%, respectively.

These Region 6 findings resonate with past research on COVID-19 traffic safety. For instance, although there were fewer overall crashes during the COVID-19 lockdowns in California and Utah, the rate of fatal and severe crashes got worse (Gong et al., 2023; Grembek et al., 2022). Similarly, an international analysis of news articles suggests that severity rates got worse across the US and in Colombia, India, and Japan (Das & Sarkar, 2022). These results suggest that it is possible to experience a reduction in overall crashes without making the system safer in terms of fatal and severe crashes, which is the key metric for efforts such as Vision Zero. This important finding is supported by our own work. The primary mechanism behind the worse severity outcomes across the US and internationally appears to be more speeding, followed by more driving under the influence of drugs and/or alcohol and less seat belt use (Das & Sarkar, 2022; Gong et al., 2023). As was present in Region 6, outcomes were worse for vulnerable road users in Utah, across the US, and internationally (Das & Sarkar, 2022; Gong et al., 2023). In terms of land use, while our work was the only research we found exploring the rural/urban continuum, our findings may be mirrored in research that found that COVID-19 crashes were likely to migrate from higher-income areas to lower-income areas in New York City and Los Angeles, which may be related to the migration we saw to more rural areas (Lin et al., 2021).

The findings have road safety implications not only for future pandemics and other similar events where we would expect decreases in motor vehicle volumes (such as natural disasters and economic downturns), but findings also have implications for a future where cities are pursuing mode shift away from personal automobiles and toward alternative modes of transportation. The first major implication of the work is the need to focus on improving safety of urban and suburban interstates and freeways. For urban and suburban contexts, crashes on these large and fast roadways had the highest likelihood of resulting in a serious or fatal injury before COVID-19 lockdowns and the roadways got even less safe when volumes dropped during the lockdowns. The second major implication is the need to improve rural road safety. Most crashes resulting in a serious or fatal injury happened on rural roads in Region 6, and rural roads got less safe during the COVID-19 lockdowns.

6. CONCLUSIONS

A limitation of the current work is a lack of exposure data, primarily because longitudinal exposure data on such a wide geographic scale was not feasible. While we believe the current work presents important findings regarding crash frequency (based on total crash counts) and severity (based on injury severity proportions), future work might focus on smaller geographies or specific corridors so that the research can account for exposure.

This paper highlights the importance of accounting for the complex relationship between exposure, behavior, and safety outcomes when planning and designing our transportation systems. In the pursuit of improving safety for all road users, specific focus may be given to rural roads, interstates and freeways in urban and suburban areas.

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