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Impact of Energy Sector Growth on Perceived Transportation Safety in the Seventeen-County Oil Region of Western North Dakota: A Follow-Up Study

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Impact of Energy Sector Growth on Perceived Transportation Safety in the Seventeen-County Oil Region of Western North Dakota: A Follow-Up Study

Andrew Kubas, Associate Research Fellow
Kimberly Vachal, Ph.D.

Rural Transportation Safety and Security Center
Upper Great Plains Transportation Institute
North Dakota State University
Fargo, North Dakota

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ABSTRACT

The sharp increase in travel volumes, shift in traffic mix, and large increases in crashes have transformed the travel environment in the oil region of western North Dakota. Roads once used for local access and agricultural purposes now mostly serve expanding oil production. Oil companies, workers, commercial trucks, and industrial equipment associated with oil extraction use these roads to access oil drilling and production sites. This has led to a larger number of overweight and oversized vehicles on the road. A survey questionnaire was sent to drivers to better understand perceptions and behaviors of road users in this region. County-level crash data were gathered for the state of North Dakota to understand changes in driving conditions during the latest oil boom – specifically between 2004 and 2013. This study addresses two goals for improving traffic safety in the region: first, to examine public perceptions of traffic safety issues and priorities; and, second, to address crash trends and possible intervention strategies. Survey results indicate that drivers perceive the region to be dangerous. Crash data reveal that overall crash events are growing at near exponential rates, and some metrics are worsening even when factoring for changes in vehicle miles traveled and population growth.

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1. INTRODUCTION

Road usage in western North Dakota has changed over time. Interstate, highway, and low-volume unpaved roads have been used with greater frequency due largely to an expanding energy sector. This evolution is especially prominent in a 17-county region where new oil extraction methods such as hydraulic fracturing have improved production economics. Roads once used only for local access and agricultural purposes are now being utilized at high volumes to serve oil production needs. Oil companies, oil workers, commercial trucks, and heavy-duty industrial equipment associated with oil and gas development all rely on these roads to access oil drilling and production sites. This has led to not only an increase in the traffic volume, but an increase in the number of overweight and oversized vehicles on the road as well. As such, a number of roads are now in poor condition and many others are deteriorating rapidly.

The oil region of North Dakota occupies 17 counties in the western part of the state: Billings, Bottineau, Bowman, Burke, Divide, Dunn, Golden Valley, McHenry, McKenzie, McLean, Mercer, Mountrail, Renville, Slope, Stark, Ward, and Williams (Figure 1.1). This region is home to three of the largest cities in the state: Minot, Dickinson, and Williston, which are located in Ward County, Stark County, and Williams County, respectively. Because of the expanding energy sector, the region has experienced various social, economic, and environmental changes – many of which stem from rapid population growth, an influx of labor and job-seekers, and improved economic development.

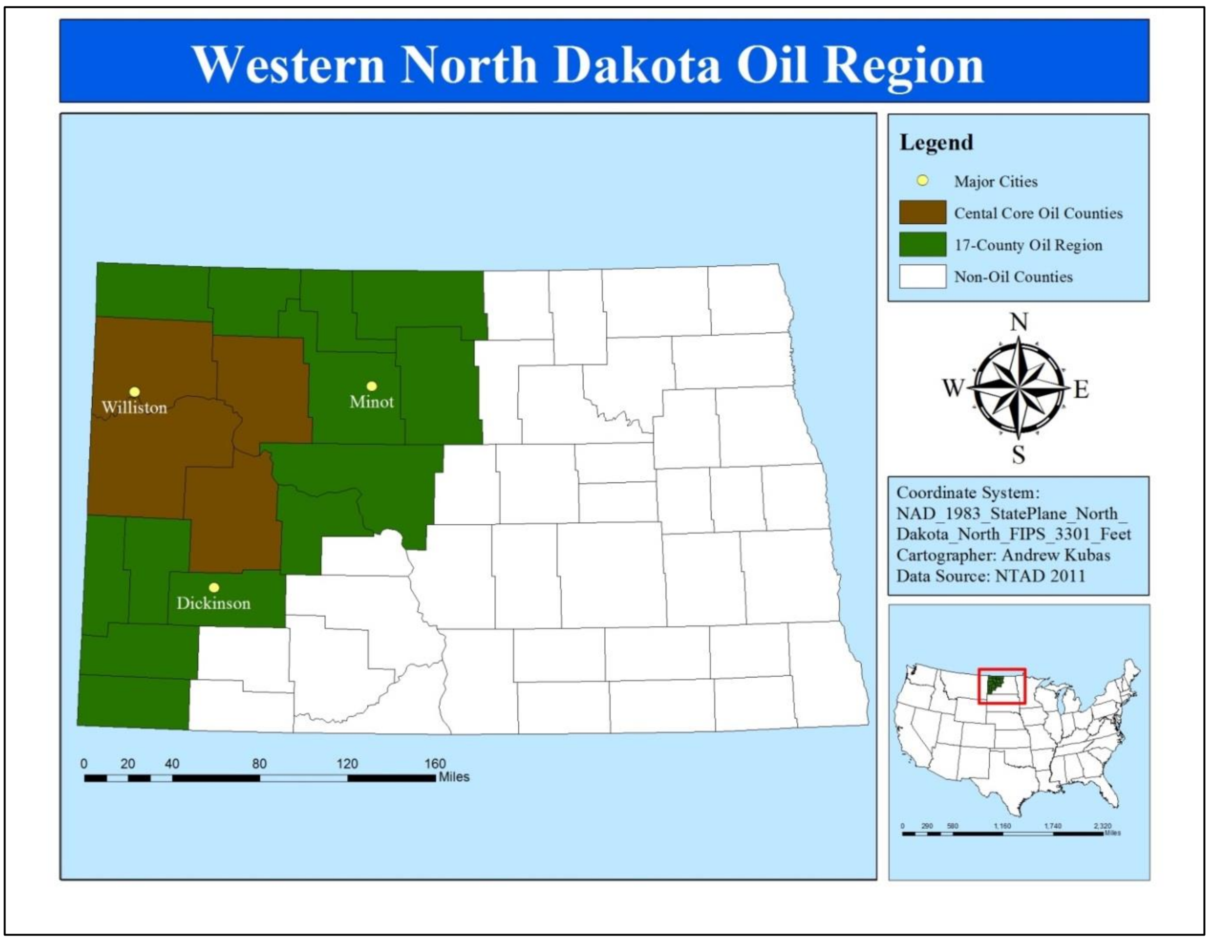

Figure 1.1 Western North Dakota Oil Region

It is undeniable that the expanding oil industry in North Dakota has resulted in many benefits. The state currently has the lowest unemployment rate in the nation, largely due to the success of the oil region (Bureau of Labor Statistics 2014). The oil boom has also played a direct role in North Dakota's budget surplus, which "continues to grow" throughout the current biennium (Wahpeton Daily News 2014). Despite these economic benefits, an increased public safety risk associated with increased traffic is evident when examining the number and severity of crashes in the region. An example is illustrated in Figure 1.2, where crash incidence trends in the central core of the oil region show exponential growth, especially for more serious crashes. The central core consists of the four highest producing oil counties as defined by the North Dakota Industrial Commission: McKenzie, Mountrail, Dunn, and Williams (Department of Mineral Resources 2014) (see Table 2.1). The vehicle miles traveled (VMT) in these four counties is generally much higher than most other areas in the oil region. However, in 2013, McLean, Stark, and Ward counties did have comparable VMT figures to the four central core counties. This implies that increased oil activity in these four counties is amplifying the number of miles traveled by drivers in this part of the state. Consequently, when more miles are driven, there is a greater chance of a crash. This may partially explain why crash rates in these four counties are considerably higher than in other portions of North Dakota.

When these four counties are compared to other areas of North Dakota, it becomes apparent that driving conditions in the central core are more dangerous than in other parts of the state. Using 2004 as a base year, Figure 1.2 highlights how the number of fatalities, injuries, and crashes that resulted in property-damage-only (PDO) increased considerably in recent years. When compared to other parts of the state, it is clear that the rate of injuries and fatalities in these four counties is higher than in other parts of North Dakota.

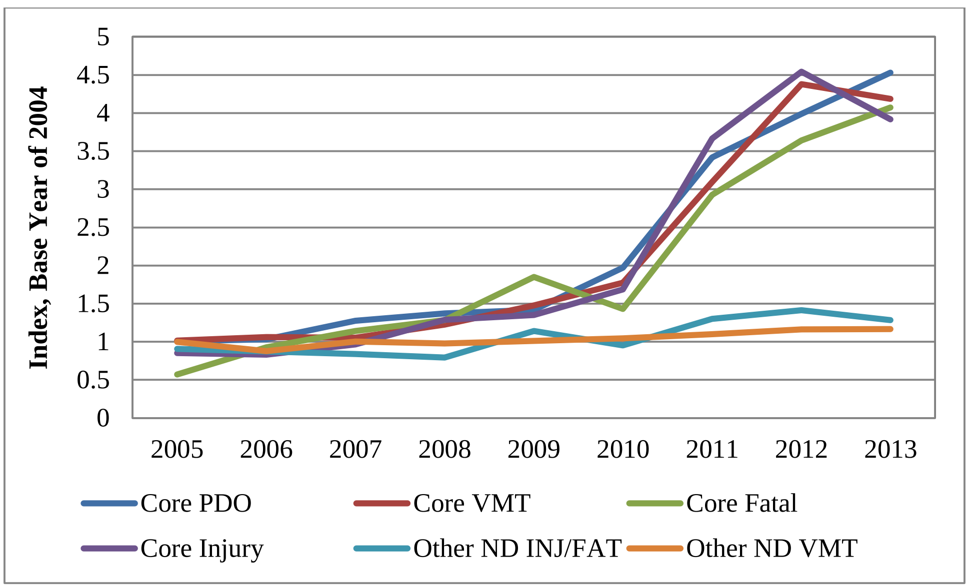

Figure 1.2 Crash Trend for Central Core Oil Counties and Other Areas

Large truck crashes are another contributing factor that can be examined to compare and contrast counties. The counties in the central core have had similar trends during the study period. In all four counties, the number of large trucks involved in crashes remained relatively stable from 2004 through 2009. After 2009, however, the number of large trucks involved in crashes in those four counties rose significantly (Figure 1.3). Large truck crash rates have not grown as sharply since 2011, but the overall trend has clearly moved upward between 2004 and 2013.

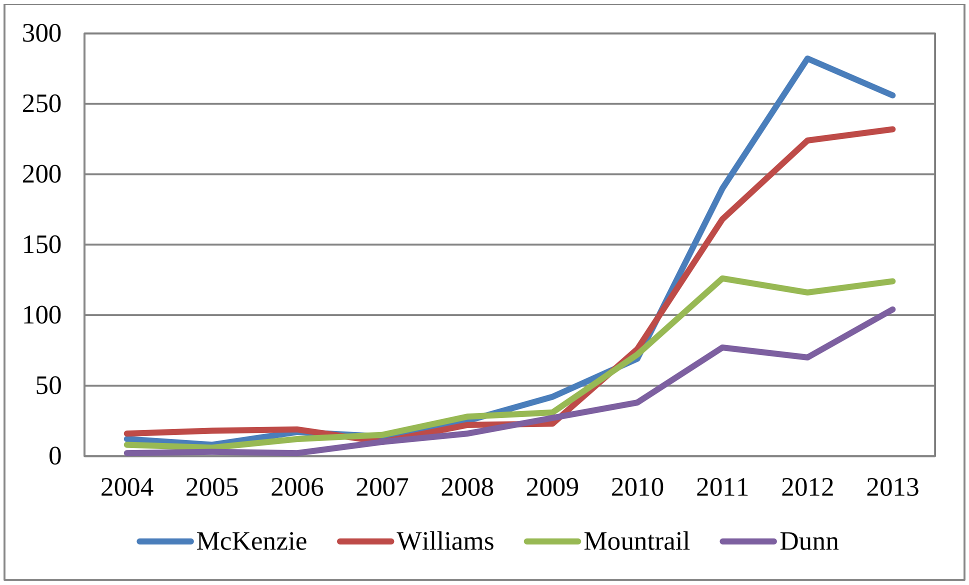

Figure 1.3 Large Truck Crash Involvement, by Central Core Counties

When factored together, the change in large truck crashes for the central core slightly resembles an exponential growth curve (R^2=0.939) (Figure 1.4). These four counties increased from just 38 large truck crashes in 2004 to 716 in 2013, an increase of 1,784%. This percentage increase is slightly exaggerated due to the small number of truck crashes in the base year and a noticeable rise in VMT. Nonetheless, the rate at which truck crashes have increased clearly outpaces the rate at which VMT has grown in the central core counties, and is a contributing factor to perceptions of danger in the region. The prevalence of large truck crashes may be a factor in negative perceptions of traffic safety as heavy-duty trucks are more likely to be involved in serious crashes (Braver et al. 1992), especially when speeding (Neeley and Richardson 2009; Islam and Hernandez 2013; Vadlamani et al. 2011). It should be noted that heavy-duty trucks are not necessarily the root cause of danger in the region as drivers of passenger vehicles can be at fault in a crash for attempting to pass a large truck in an unsafe situation.

Driving factors such as these have prompted stakeholders such as the North Dakota Department of Transportation (NDDOT), the North Dakota Petroleum Council (NDPC), and the North Dakota Highway Patrol (NDHP) to take action to encourage safety on the roadway. One awareness campaign – *ProgressZone: Moving Forward Safely* – was created in 2012 as an intervention strategy to improve driver safety. In 2014, the *Code for the Road* safety campaign was rolled out as a safety initiative. Various safety messages have been promoted on billboards, newspapers, radio advertisements, television broadcasts, and online advertisements to alert drivers about safe driving practices. Education and outreach have also been utilized, and funding has been allocated for additional safety personnel and law enforcement to patrol the oil region (Grand Forks Herald 2013).

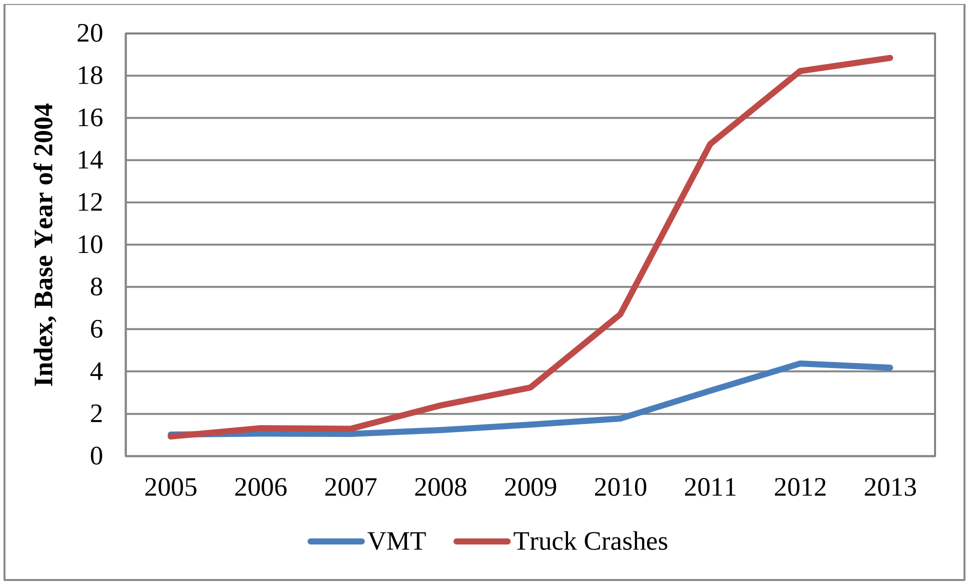

Figure 1.4 Large Truck Crash Growth Trends in Central Core Counties

The sharp increase in travel volumes, shift in traffic mix, and large increases in traffic crashes have transformed the travel environment in the oil region of western North Dakota. This research report aims to address a few key goals related to improving traffic safety in the region: (1) to longitudinally examine public perceptions of traffic safety issues and priorities in the state's oil producing region; (2) to discover trends in large truck/passenger vehicle interaction among oil county drivers; and (3) to understand the efficacy of public education, specifically *ProgressZone: Moving Forward Safely* in 2012 and *Code for the Road* in 2014, as safety intervention strategies focusing on large truck/passenger vehicle interaction. The following section provides context for the survey discussion that is presented in section five. Sections three and four provide information on the method and survey response. Some crash facts that are related to the survey focus are provided in section six. The final sections are the conclusion and discussion for the survey.

2. BACKGROUND

2.1 Western North Dakota Oil Region Geography

The 17-county oil region is defined by its proximity to economically viable oil formations (Figure 2.1). Currently, the two main formations that define the oil region are the Bakken Formation and the Three Forks Formation, though the recently discovered Birdbear Formation is expected to augment oil activity further. All have different levels of drilling and production. The Bakken Formation covers a significant portion of North Dakota, South Dakota, and Montana, and extends northward into Saskatchewan and Manitoba as well. It is estimated that the Bakken Formation has a mean undiscovered volume of 3.65 billion barrels of oil (Pollastro et al. 2008). The Three Forks Formation is directly below the Bakken Formation, and is roughly two miles below the surface of the ground (Beitsch 2010). It has been estimated that there are two billion barrels of recoverable oil in this formation (Sonnenberg, Gantyno, and Sarg 2011). Presently, North Dakota produces just over one million barrels per day from these two formations (Helms 2014), a number which was predicted by geological experts just a few years ago (St. Anthony 2011).

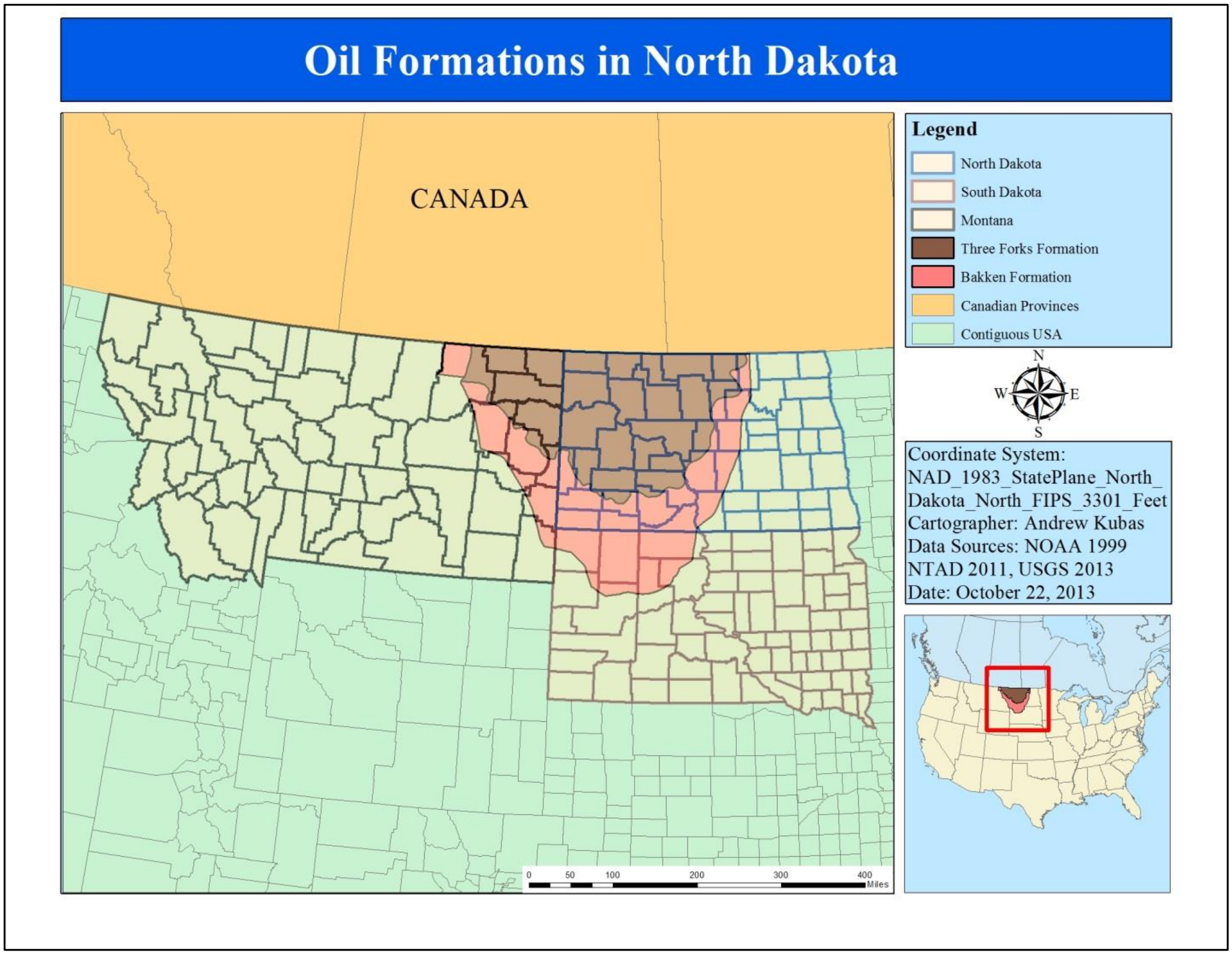

Figure 2.1 Oil Formations in North Dakota Oil Region

The Birdbear Formation lies farther underground beneath the Three Forks Formation (LeFever 2009). Drilling and oil production is newer to this formation, with only 37 active wells producing as of 2010

(Yang and Kent 2010). Although the three formations share similar geographic and geologic properties, the drilling and production activity that takes place varies from formation to formation.

2.2 Growth and Development of the Oil Industry

Oil development in North Dakota has expanded rapidly, particularly since the latest "boom" in activity began in 2004 (NDIC 2014) (Figure 2.2). The North Dakota Industrial Commission's Department of Mineral Resources, Oil and Gas Division reports that there are 10,892 actively producing oil and gas wells, a considerable spike from the 3,339 that were producing in 2004.

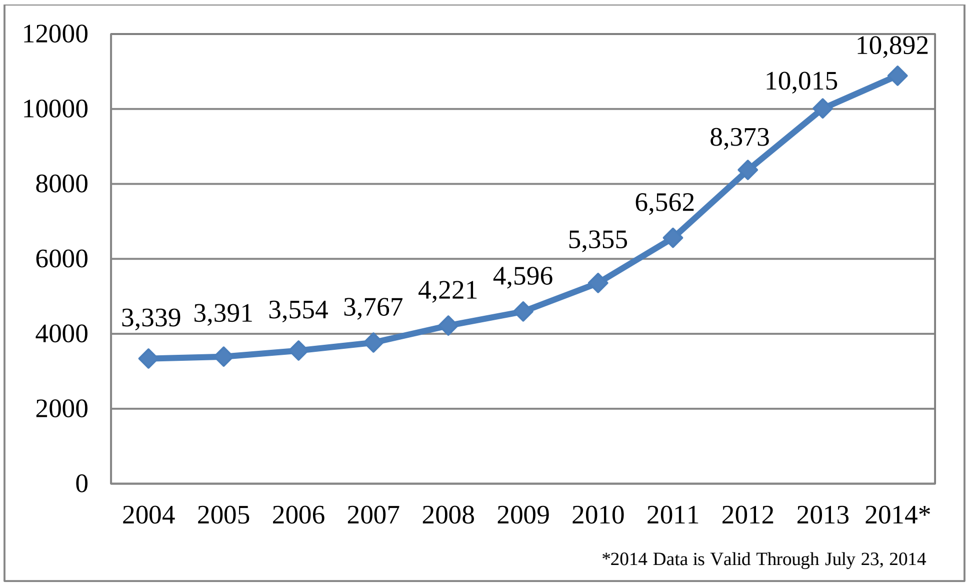

Figure 2.2 Active Oil Wells in North Dakota

The 17 western oil counties vary considerably in terms of oil production (Table 2.1). McKenzie County has the highest volume of barrels of oil produced (9,134,166), the greatest number of actively producing oil and gas wells (2,392), and the highest average production per well (3,819 barrels). These numbers represent a stark contrast from Mercer County, which did not have any wells producing in May. It was producing oil as recently as December 2013.

These 17 counties also face unique impacts with regard to state and local roads due to oil development (Table 2.2, Table 2.3). As demand for oil has increased, so too has the use of local low-volume and high-volume roads. Many of these roadways were not designed for heavy oil truck traffic. The most common reason that infrastructural problems arise is because of the sheer volume and weight that the vehicles place on each axle, which is especially prominent in oil development (Rosendahl 2011). NDDOT estimates that for each vertical oil well drilled, 400 truck loads are needed throughout implementation and maintenance (NDDOT 2008). Additionally, for each horizontal well drilled, anywhere from 600 to 1,000 truck loads are required (NDDOT 2008).

Based on extensive analysis of surface and base layer thickness, the materials of those layers, the amount of cracking and deterioration of the surface layer, underlying soil conditions, and the graded width of the road, a study from the Upper Great Plains Transportation Institute concluded that approximately 958 miles of paved roads and 12,718 miles of unpaved roads are impacted by oil development (UGPTI 2010). These impacts include additional maintenance costs, unforeseen maintenance costs, surface cracking, road deterioration, damages to grading, damages to drainage, and overhead expenditures (UGPTI 2010).

Table 2.1 Western North Dakota Oil Production, March 2014

COUNTY	RANKING	BARRELS	WELLS	AVERAGE PRODUCTION PER WELL
McKenzie	1	**9,134,166**	**2,392**	**3,819**
Mountrail	2	6,961,402	1,883	3,697
Dunn	3	4,630,141	1,357	3,413
Williams	4	4,259,962	1,582	2,693
Divide	5	1,228,980	582	2,112
Bowman	6	704,394	369	1,909
Burke	7	482,711	485	996
Stark	8	437,787	206	2,126
Billings	9	384,576	497	774
Bottineau	10	179,004	551	325
McLean	11	102,811	49	2,099
Golden Valley	12	87,694	89	986
Renville	13	73,022	270	271
Slope	14	43,299	19	2,279
Ward	15	2,806	11	256
McHenry	16	2,119	15	142
Mercer	17	0	0	0
TOTAL		28,714,874	10,357	2,773

Bold: Leading county in category
Source: North Dakota State Industrial Commission 2014

Table 2.2 Conditions of Paved Roads Affected by Oil Development

Road Condition	Miles	Percent Miles	Cumulative Miles	Cumulative Percent
Very Good	60.8	6.3%	60.8	6.3%
Good	496.1	51.8%	556.9	58.1%
Fair	333.6	34.8%	890.5	92.9%
Poor	38.2	4.0%	928.7	96.9%
Very Poor	29.7	3.1%	958.4	100%

Source: Upper Great Plains Transportation Institute 2010

Table 2.3 Conditions of Unpaved Roads Affected by Oil Development

Road Condition	Miles	Percent Miles	Cumulative Miles	Cumulative Percent
Very Good	118.2	0.9%	118.2	0.9%
Good	4,601.9	36.18%	4,720.1	37.1%
Fair	7,374.2	57.98%	12,094.3	95.1%
Poor	574.3	4.52%	12,668.6	99.6%
Very Poor	49.3	0.4%	12,717.9	100%

Source: Upper Great Plains Transportation Institute 2010

In general, truck loads consist of heavy-duty vehicles and objects that are significantly over the size and weight limits of low-volume rural roads (NDDOT 2008) (Table 2.4). The main impacts of the overweight loads and heavy-duty vehicles on rural road networks are damages to the crown and rutting (Skorseth and Selim 2000). The weight of the vehicles gradually diminishes the crown. As the crown decreases, water accumulation and traffic can soften the crust, create a rut, develop potholes, and eventually result in washboard conditions that make the road dangerous year round.

Table 2.4 Overweight Loads During Oil Development and Maintenance

Load Type (and number needed)	Weight (lbs.)
Generator House (3)	111,180
Shaker Tank/Pit	122,000
Suction Tank	131,000
Mud Pump (2)	164,000
Shaker Skid	111,760
Draw Works	130,880
Hydraulic Unit	127,640
Tool Room Junk Box	124,140
BOP Skip	138,680
Top Dog House	117,000
Crown Section	140,000
Derrick	159,000
VFD House	130,100
Mud Boat	114,380
Substructure	136,000
Centerpiece	139,440
Choke Manifold	126,000
MCC House	145,160
BOP Setting Machine	145,160

Source: North Dakota Department of Transportation 2008

A study by Mitra, Tolliver, and Dybing (2012) analyzed three main data sources – oil production forecasts, traffic data, and county road surveys – to assess the present situation in the state. Presently, there is greater traffic volume, more overweight vehicles, and more oversized trucks on the road due to energy sector growth. All these variables contribute to deteriorating road conditions. As such, the authors estimate that an investment of $900 million will be needed during the next 20 years for transporting oil and allowing travelers to have acceptable roadway use in western North Dakota.

2.3 Community-Level Changes due to Oil Extraction and Development

Early research regarding the impacts that oil extraction have on a region shows a similar situation to that currently being experienced in North Dakota. Affolter (1976) studied the implications that oil development had in Scotland with regard to ecological, planning, and general environmental considerations. There was an obvious link between human activity and growing pressures on the built and natural environments. Oil extraction in the North Sea created noise, safety hazards, increased traffic volumes, altered landscape, construction camps, and localized changes to infrastructure – all of which are presently occurring in western North Dakota.

Near Coastal Louisiana, environmental consequences from oil extraction in the Gulf Coast were augmented by hurricanes and tropical storms. Laska et al. (2005) performed a social impact assessment to gauge which human activities in the region would be impacted by various proposed projects aimed at restoring barrier islands. The authors noted that such projects could threaten transportation modes such as road networks, ports, and airports; issues that would not have arisen without demand for oil extraction.

Prowse et al. (2009) discuss the implications that oil development has had in northern Canada. The researchers discuss that such development has made noticeable changes to infrastructure and transportation, particularly in terms of designing pipeline networks to deliver oil and gas to market. The study does shed light on the relationship between oil extraction and transportation safety, but it focuses extensively on future responses due to predicted climate change instead of present issues stemming from oil development.

A recent study by Kubas and Vachal (2014) indicates that drivers in western North Dakota do not feel safe when traveling via automobile. Residents from the oil region generally are fearful during large truck-passenger vehicle interactions. Most drivers would be willing to drive out of the way during a typical commute to avoid roads with heavy truck traffic or to drive on roads with better signage and surface conditions. The study also tracked crash rates, noting that conditions in the western oil counties were actually more dangerous than in the rest of the state.

2.4 Studies Relating to Perceived Safety

Some studies have attempted to measure perceptions of safety in various situations. Naveh, Katz-Navon, and Stern (2005) gave a questionnaire to doctors and nurses at two separate hospitals to identify patient safety within the hospital building. A major finding from the study was that when employees perceived that the safety procedures were congruent with their daily work demands and were realistic given their available resources, the priority given to safety was high and overall safety thus improved. This was further augmented when information flow was clear and sufficient from all employees in the hospital. In western North Dakota, it can be argued that daily travel demands have exceeded capabilities of the roadway, and this may influence how road users perceive safety in this region.

A survey of workers at British Rail focused on understanding perceptions of the importance of safety issues within the transportation organization (Clarke 1999). Three types of workers – train drivers, supervisors, and senior managers – were asked to participate in the survey. All three groups rated safety as being important, but each group varied on how they perceived other groups rate the importance of safety at British Rail. This finding parallels some of the literature on risk taking: humans tend to perceive themselves as being safer than others. In general, a sense of "otherness" emerges when one is asked to compare one's self to one's peers or colleagues. In this instance, a hierarchy of transportation management officials rated the importance of safety differently when compared with others at the same institution.

2.5 Driver Behavior as a Determinant of Roadway Safety

Driver behavior directly impacts safety. Operating a vehicle while impaired, speeding, and choosing not to wear a seat belt contribute to danger on the roadway. Drivers have different underlying mechanisms that determine whether one commits an emotional or reckless driving violation. For example, Martinussen et al. (2013) gave a survey questionnaire to 4,335 Danish drivers. It aimed to understand driver behaviors while operating a motor vehicle. The study found a differentiation between how drivers with emotional violations and drivers with reckless violations change their driving styles. The changes stem from different underlying mechanisms, such as errors or lapses while unfocused, emotional arousal, reckless behavior, and confusion. Given the large volume of vehicles on western North Dakota's roadways, a lapse in judgment, loss of focus, or confusion on the roadway could prove deadly.

Strayer and Drews (2007) focused on cell phone use as it related to driver distraction. The authors tested drivers by using a simulated screen to see if hands-free cell phone use resulted in any lost information while driving. It was found that drivers who use a hands-free cell phone failed to see some information in the driving scene. It was believed that drivers do not encode information adequately, even when using a hands-free device. The authors indicate that the best driving scenario is one in which the driver is not distracted whatsoever.

Individuals behave differently after being in a crash (af Wahlberg 2012). A study of drivers at the bus company Gamla Uppsalabuss (BUG) in Uppsala, Sweden, attempted to explain if drivers operate vehicles in a safe manner after having been in a crash. Although the study by af Wahlberg showed there is no large effect on general driving behavior after a crash, the researcher noted that drivers may change specific behaviors. For example, an individual who experienced a crash at a junction may use extra caution when at junctions in the future.

Drivers also exhibit more stress, worry, and exhaustion after a crash. A survey of 124 drivers from the Atlanta metropolitan area found that 42 had been in at least one motor vehicle crash in the last five years. When studying if there were any differences between those that did and did not have a crash, Lucas (2003) showed that drivers reporting having been in at least one crash had greater personal safety concerns, worries about driving, stress, exhaustion, and negative physical symptoms. These experiences may directly relate to overall perceptions of safety on the roadway.

Although drivers who have experienced a crash exhibit more fear and worry on the roadway, these motorists nonetheless tend to have higher levels of risk-taking, even after the crash has occurred (Lin et al. 2004). A 20-month study was conducted in Taiwan in which the impact of motorcycle crash experiences was investigated. As expected, students with prior crash involvement had higher risk-taking levels than those without a crash experience. However, involvement in a previous crash did not change one's reported levels of risk taking. This indicates that risk taking among drivers varies individually and that danger on the roadway can stem from individual behavior.

2.6 Large Truck-Passenger Vehicle Interaction

National fatalities from large truck crashes decreased from 1975 to 1999, likely due to safety improvements to truck and passenger cars (Lyman and Braver 2005). The authors analyzed U.S. truck crash rates and truck crash fatality rates by querying FARS data for the study period. Over the time frame examined, fatalities in large truck crashes per 100 million truck miles traveled decreased. Similarly, truck driver deaths per 10,000 truck registrations also decreased over the same period. The number of fatalities in large truck crashes, however, has not changed per 100,000 population. It is hypothesized by the authors that across-the-board safety advances to truck and passenger cars may explain the overall crash rate improvement.

A study by Jermakian (2012) posits that further safety improvements, such as side view assist, forward collision warning, lane departure warning, and vehicle stability control, would be relevant to approximately one-fourth of all large truck crashes in the United States. The author extracted data from two sources – the National Automotive Sampling System General Estimates System (NASS GES) and FARS – to identify which safety features were relevant to different crash types. This was accomplished by factoring for the crash type and manner of collision and then separating individual crash events as they related to each of the four crash avoidance technologies. It was found that such technology could be applicable to tens of thousands of large truck crashes annually.

Aghabayk et al. (2011) showed that large trucks execute lane changes more smoothly on arterial roads and freeways than do shorter vehicles. The researchers applied different models to lane changing techniques by large and heavy trucks. They attributed the smoothness of large-truck drivers to the fact that heavy vehicles apply lower acceleration or deceleration when executing a lane change maneuver. Although the authors have a limited sample size, they also present preliminary findings which suggest that large-truck driver behaviors are typically safer than the behaviors of drivers of passenger vehicles.

The Upper Great Plains Transportation Institute analyzed the impacts that oil and gas development have had on western North Dakota's roads (UGPTI 2010). The analysis revealed that trucks make up a significant portion of traffic in oil counties in the western part of the state. Table 2.5 outlines truck traffic on major county roads for this region. The table shows that – of the 15 western North Dakota oil counties studied – the mean number of trucks on the road each day is 61 (UGPTI 2010). Table 2.6 reveals that – above and beyond volume – the number of trucks on the road in western North Dakota is also a significant proportion of the traffic. As a whole, in the 15 oil counties that were studied, trucks comprised an average of 42% of the average daily traffic (UGPTI 2010).

Table 2.5 Average Trucks per Day on Major County Roads

County	Road Segments Observed	Minimum	Mean	Maximum
Billings	9	4	31	80
Bottineau	3	48	68	86
Bowman	6	30	125	233
Burke	6	4	22	66
Divide	3	28	96	172
Dunn	10	12	61	198
Golden Valley	5	23	38	50
McHenry	4	7	21	40
McKenzie	12	14	97	253
Mercer	3	1	3	6
Mountrail	12	12	65	252
Slope	4	7	17	34
Stark	5	9	26	62
Ward	6	24	105	217
Williams	11	10	68	312
All	**99**	**1**	**61**	**312**

Source: Upper Great Plains Transportation Institute 2010

The same study from the Upper Great Plains Transportation Institute discussed a 2008 survey which analyzed 2007 truck traffic data to establish a baseline of average ADT and percent truck traffic on roads in North Dakota's oil region. The survey found that between 2008 and 2010 the percentage of trucks on collector roads – roads designed to move traffic from local roads to arterial roads – increased from 18% in 2008 to 39% in the same counties by 2010 (UGPTI 2010). This is a considerable increase in a relatively short span of time, especially when considering that a majority of western North Dakota residents do not feel safe passing or being passed by heavy-duty trucks (Kubas and Vachal 2012).

Table 2.6 Percent Trucks and Multi-Unit Trucks on Major County Roads

County	Trucks as a Percent of ADT	Multi-Units as a Percent of Trucks
Billings	49	23
Bottineau	24	38
Bowman	62	24
Burke	43	72
Divide	54	63
Dunn	46	46
Golden Valley	42	31
McHenry	51	52
Mercer	14	8
Mountrail	49	49
Slope	37	28
Stark	24	42
Ward	26	35
Williams	51	56
All	**42**	**44**

Source: Upper Great Plains Transportation Institute 2010

2.7 Perceived Risk on the Roadway

Drivers often perceive themselves as being safer than others. Out-of-state oil workers perpetuate the "self-versus-other" dynamic in western North Dakota. A study by DeJoy (1989) asked 106 college students to compare their risk of being involved in 10 different crash scenarios compared to other drivers at their school. Subjects consistently viewed their chances of being involved in a crash as significantly less than their counterparts. Delhomme, Verlhiac, and Martha (2009) had similar results in a study of 3,002 young French drivers. These individuals took part in a survey questionnaire in which they were asked to rate perceptions of one's self compared to other drivers with regard to tendencies and expectations when operating a vehicle. Like the study by DeJoy, drivers rated themselves as safer than other drivers. Additionally, this study factored for various emotional states. It found that drivers who exhibited comparative optimism tended to take less risk on the roadway and were safer drivers than those who were categorized as exhibiting comparative pessimism.

Certain demographics are more prone to taking risks on the roadway than others. In North Dakota, young male drivers are a particularly dangerous driver group. They are more likely to engage in dangerous driving activity, less likely to partake in safe driving behaviors, and are less likely to be positively influenced by traffic safety messages (Vachal, Benson, and Kubas 2010 – 2014). A study utilizing the U.S. National Household Travel Survey estimated the individual driver risk for crash involvement (Ouimet et al. 2010). Just as is taking place in North Dakota, on a national scale the study indicated that young male drivers have the highest risk of any driver group. Additionally, young drivers with passengers in the vehicle were found to engage in high-risk behavior on the roadway.

2.8 Safety Strategies/Campaigns as Intervention and Prevention Tools

Traffic safety interventions are generally formed under four approaches: policy (Shults et al. 2004), enforcement (Houston and Richardson 2006), education (Hedlund et al. 2008), and media (Nichols and Ledingham 2008). All intervention approaches have been used with varying degrees of success in addressing issues such as seat belt usage, impaired driving, and speeding. These strategies are primarily associated with public education and perceptions, and have been proven in past applications.

For example, the *ProgressZone: Moving Forward Safely* campaign launched by NDDOT in 2012 utilized a combination of education and media strategies to alert drivers in western North Dakota oil counties about safe driving behaviors (North Dakota Petroleum Council 2011a, North Dakota Petroleum Council 2011b). The campaign had four main messages displayed on large yellow billboards: “Pass With Caution,” “Be Patient. Slow Down,” “Buckle Up. Every Time,” and “Roads Shared. Lives Spared” (Wehrman 2011). The campaign proved successful: roughly 42% of all drivers that had viewed the safety messages positively changed their driving habits (Kubas and Vachal 2012). Understanding the safety impacts of this campaign is important in future traffic safety resource decisions (Donovan 2011).

Local, state, regional, and federal safety campaigns have been waged in an attempt to promote safer driving habits and discourage driving activity. Safety tools such as *What’s the Hurry?* in northeastern Tennessee (Whittam et al. 2006), Hawaii Opportunity Probation with Enforcement (Hawken 2011), the South Dakota 24/7 Sobriety Project (Loudenburg, Drube, and Leonardson 2010), the *Checkpoint Strikeforce* program in NHTSA’s Region 3 (Lacey et al. 2008), the annual nationwide *Drunk Driving: Over the Limit, Under Arrest* Labor Day crackdown (Solomon et al. 2008), the *Target Zero Team Project* in Washington State (Cicchino 2012), the *Saving Lives* program in Massachusetts (Hingson et al. 1996), the *Strategic Evaluation States* initiative in Alaska, Georgia, and West Virginia (Syner et al. 2008), the *Better Driver Campaign* in Florida (Lee et al. 2010), and the national *Click It Or Ticket* campaign (Kim and Yamashita 2003) are geared toward improving safety on the roadway and have been studied extensively. Many of these programs emphasize preventing impaired driving, and some do so specifically targeting young males (Murry, Stam, and Lastovicka 1993).

2.9 Gaps in the Literature

Although these topics have been studied widely by academics and transportation safety personnel, none have focused solely on North Dakota oil development. Moreover, none have given priority to rural road segments. The goal of this project is to measure driver behaviors, perceptions, priorities, and risk given rapidly changing road networks in western North Dakota and worsening crash trends. This will be achieved by (1) measuring public perceptions of traffic safety issues and priorities in the state’s oil producing region; (2) determining perceived driver risk and its relation to danger on the roadway; and, (3) querying rural crash data to parallel the data with on-road driving experiences as reported by oil county drivers. These crash data will be compared with the non-oil producing part of the state in an attempt to quantify if the perceptions of dangerous driving conditions are simply perceived or occurring in reality.

3. METHOD

A mail survey was selected as the method for obtaining data from western North Dakota residents. A draft survey was designed by blending questions related to traffic safety, *ProgressZone: Moving Forward Safely* goals (in 2012), *Code for the Road* goals (in 2014), and issues directly related to oil traffic and oil development. Industry partners provided input regarding questions to include in the final survey. The mailing to drivers included a cover letter, which invited participation and explained the goals of the survey. The survey was first mailed to drivers on April 6, 2012, and was open to response until May 1, 2012. In 2014, the second mailing for a follow-up study was mailed to drivers on April 1, 2014, and was open to response until May 5, 2014. After multiple conversations with transportation safety officials, it was recommended that a longitudinal study be conducted to identify changes in perceptions and behaviors over time. Thus, the 2012 data will be used as a baseline and will be augmented by forthcoming data. It is anticipated that this questionnaire will be mailed annually through the year 2016.

The state driver licensing division used the 17-county oil region driver population for the sampling. Initially, the 2012 mailing list provided by NDDOT consisted of 2,700 driver addresses. Prior to mailing, 41 addresses were removed from the list because they were in counties outside of the 17-county oil region focus area. Thus, 2,659 addresses were verified for a final mailing list. Of these, 10 were flagged as addresses of individuals who had moved and had not provided a new forwarding address, 2 were flagged as "unmailable," and 22 were flagged as "problem" addresses that were not mailed. Ultimately, 2,623 surveys were mailed. Three of the 2,623 initial surveys that were mailed were unable to be forwarded to a current address and were subsequently returned by the Post Office. Of the 2,620 successfully mailed, 781 responses were obtained. From the 781 responses, 2 responses had Zip codes that were either out of state or unverifiable. Of the useable survey responses received, 779 were verified as North Dakota responses and form the valid driver response sample used as the baseline year in the analysis.

In 2014, a slightly larger mailing list of 2,720 driver addresses was provided by the state driver licensing division. Before mailing the survey, 54 addresses were removed because they were either addressed to out-of-state drivers or North Dakotans living in counties outside the target study area. None of the remaining addresses were flagged as "unmailable," "problem addresses," or sent to individuals who had changed residency. A total of 2,666 surveys were mailed. Two of these were returned as undeliverable. Of the 2,664 successfully mailed, 710 responses were acquired. Of these, 14 responses had Zip codes that were either out-of-state addresses, unverifiable, or from counties outside the 17-county target region. Thus, 696 surveys comprise the final sample for the 2014 follow-up study.

The sample size was based on a 95% confidence interval, with a 5% confidence level. The expected response rate was estimated at 20%. Although mail survey response is generally low – 10% is not uncommon – a slightly better response rate was expected due to the parameters used in the survey design and administration. These parameters included keeping the survey to a single page, including "Upper Great Plains Transportation Institute, North Dakota State University" letterhead, and using UGPTI mail envelopes. Moreover, given the timeliness of the topic at hand, it was expected that an above-average response would be obtained.

A proportionate stratified random sample was used to select drivers. The North Dakota driver population was stratified by county boundaries. Individuals living in the 17 western oil counties had no greater than a 3.5% chance of receiving a survey. The greatest number of surveys was sent to Williams, Stark, and Ward counties, respectively. This aligns with the fact that these three counties are home to the three largest cities in the oil region: Williston, Dickinson, and Minot.

Although a random sample of the 17 western oil counties was obtained from the survey mailing, the sample was not representative of the population in those counties (Table 3.1). Males were overrepresented in the 2012 mailing and underrepresented in the 2014 follow-up study. Whereas the adult (18+) population in the 17 western North Dakota oil counties is 51% male and 49% female, the sample used in 2012 had rates that were 62% male and 38% female and the 2014 follow-up study had rates that were 42% male and 58% female.

Moreover, the proportion of drivers in each age cohort did not always mirror the real-life proportion of drivers in the oil counties. In 2012, the sample was underrepresented in terms of drivers 44 years of age and younger. In contrast, drivers over age 55 and under age 74 were overrepresented in the sample when compared with their actual proportion of the population in the counties. In 2014, a comparable situation occurred: drivers under age 34 were underrepresented in the sample and drivers between ages 55 and 74 were once again overrepresented. Some age cohorts – such as the 45-54 age group in 2012 and the 35-44 age cohort in 2014 – were accurately represented in the mailing sample.

Table 3.1 Mailing Samples and State Driver Population by Age

Age Group	Surveys Mailed 2012	Surveys Mailed 2014	Percent of Sample Mailed 2012	Percent of Sample Mailed 2014	Oil County Population	Percent of 18+ Oil County Population
18-24	86	150	3.2	5.6	17,486	13.4
25-34	285	249	10.7	9.3	21,976	16.9
35-44	212	375	8.0	14.1	18,087	13.9
45-54	584	609	22.0	22.8	24,914	19.1
55-64	637	652	24.0	24.5	21,292	16.4
65-74	488	358	18.4	13.4	12,730	9.8
75+	366	273	13.8	10.2	13,637	10.5

Source: US Census Bureau 2010 Census

Survey responses were entered into a database using SPSS Statistics 22 software (see Table 5.1 and Table 5.2 for quantitative scale definitions). Initially, a factor analysis was performed to identify possible components linked to constructs developed by the researchers. After the factor analysis was conducted, different statistical analyses – such as measures of association, Chi-Square tests, and 1-way ANOVAs – were performed to identify differences in response distributions and differences across target groups. Many of the questions on the survey were posed at ordinal levels of measurement, though some were presented and subsequently coded as dichotomous "dummy" variables. Some variables, such as length of residency, were recoded based on the prior studies from the literature to ordinal scales. Key driver groups – gender, age, newcomers/long-term residents, high-risk young drivers, and those exposed to the *Code for the Road* safety campaign – were treated as independent variables in the analysis. Driver knowledge, attitudes, behaviors, and beliefs were most often treated as dependent variables in the statistical analyses.

4. RESPONSE

Survey response rate was 29.7% in 2012, with 779 valid responses from the sample mailing to 2,620 drivers. The response rate was 26.1% in 2014, with 696 valid surveys obtained from a mailing to 2,666 drivers. As expected, the proportion of responses by age cohort increased with age: there were more responses from older drivers in both years than there were responses from drivers under the age of 45 (Table 4.1). This was likely because a smaller proportion of younger drivers received the survey compared with the higher proportion of older drivers who received it. Note that the valid responses obtained from this study are not representative of the 17 western North Dakota oil counties: a much lower proportion of drivers under the age of 45 are in the sample than are in the population. Similarly, the portion of drivers over age 45 and under age 74 is much higher than the actual proportion of individuals in this age group in the 17-county oil region. The 75+ age cohort comprised 10.3% of responses in 2012 and 10.6% of responses in 2014, numbers that accurately reflect their proportion (10.5%) of the oil region population. Also consider that the total number of responses from the 18-24 age cohort is not large enough to be extrapolated to fit the 17 western North Dakota oil counties. In general, at least 30 valid responses are required for data to be considered representative of a particular demographic. Thus, any conclusions made for the 18-24 age cohort cannot be considered indicative of the entire 18-24 year-old population in this portion of the state.

Table 4.1 Valid Survey Responses and State Driver Population by Age

Age Group	Valid Surveys 2012	Valid Surveys 2014	Percent of Sample Received 2012	Percent of Sample Received 2014	Oil County Population	Percent of 18+ Oil County Population
18-24	12	17	1.5	2.4	17,486	13.4
25-34	49	40	6.3	5.7	21,976	16.9
35-44	55	55	7.1	7.9	18,087	13.9
45-54	193	186	24.8	26.7	24,914	19.1
55-64	220	198	28.2	28.4	21,292	16.4
65-74	168	124	21.6	17.8	12,730	9.8
75+	80	74	10.3	10.6	13,637	10.5

Source: US Census Bureau 2010 Census
Frequency Missing 2012 = 2; Frequency Missing 2014 = 2

When factoring for both gender and age, it becomes apparent that multiple demographic groups have less than 30 responses for their respective cohorts. Responses obtained in 2012 cannot be extrapolated to fit the entire population of 18-24 year-old males, 18-24 year-old females, 25-34 year-old females, and 35-44 year-old males (Table 4.2).

Table 4.2 Survey Response by Age and Gender, 2012

Age	Male	Female	Total
18-24	6 (50.0%)	6 (50.0%)	12
25-34	30 (61.2%)	19 (38.8%)	49
35-44	24 (43.6%)	31 (56.4%)	55
45-54	113 (58.5%)	80 (41.5%)	193
55-64	137 (62.3%)	83 (37.7%)	220
65-74	104 (62.7%)	62 (37.3%)	166
75+	38 (47.5%)	42 (52.5%)	80
Total	**452 (58.3%)**	**323 (41.7%)**	**775**

Frequency Missing = 4

A similar pattern emerges for 2014 responses (Table 4.3). Yet again, both males and females in the 18-24 age cohort did not have at least 30 responses; thus, information obtained for these groups will not be considered representative. Males in the 25-34 and 35-44 year-old age cohorts also did not have 30 responses. There were only 27 responses from females over age 75; this represents another group for which responses must be interpreted critically.

Table 4.3 Survey Response by Age and Gender, 2014

Age	Male	Female	Total
18-24	0 (0.0%)	17 (100.0%)	17
25-34	5 (12.5%)	35 (87.5%)	40
35-44	24 (44.4%)	30 (55.6%)	54
45-54	69 (37.5%)	115 (62.5%)	184
55-64	86 (43.9%)	110 (56.1%)	196
65-74	55 (45.1%)	67 (54.9%)	122
75+	45 (62.5%)	27 (37.5%)	72
Total	**284 (41.5%)**	**401 (58.5%)**	**685**

Frequency Missing = 11

5. RESULTS

Survey responses offer important insight into driver perceptions, attitudes, and behaviors regarding traffic conditions in the oil region. Simple frequency analysis of ordinal and dichotomous survey responses provides a baseline of driver views and behaviors. Quantifying responses allows for statistical testing of relationships, means, and tests of significance. Quantitative scale definitions are provided in Table 5.1 (for questions that were unchanged in 2012 and 2014) and Table 5.2 (for questions on the survey unique to 2014).

Table 5.1 Quantitative Scale Definitions: Identical Questions in 2012 and 2014

Q#	Question	Scale	Conversion Values
1	Safety Now vs. 5 Years Ago	1-5	1=Much Less Safe to 5=Much Safer
3	Sudden Brake/Swerve	0-1	0=No, 1=Yes
4	Law Enforcement Presence	0-1	0=No, 1=Yes
5	Meet/Pass Large Trucks	1-5	1=Never to 5=Daily
6a	Safety Passing Large Trucks	1-5	1=Very Unsafe to 5=Very Safe
6b	Being Passed by Trucks	1-5	1=Very Unsafe to 5=Very Safe
7a	Extra Driving to Avoid Oil Trucks	1-4	1=No Change to 4=20+ Minutes Extra
7b	Extra Driving for Better Surface/Signs	1-4	1=No Change to 4=20+ Minutes Extra
8a	Seat Belt Use in Town	1-5	1=Never to 5=Always
8b	Seat Belt Use Over 30 MPH	1-5	1=Never to 5=Always
9	Speeding on 65 MPH Road (Over 70 MPH)	1-5	1=Never to 5=Always
13a	Signage of Traffic Rules	1-4	1=Least Important to 4=Most Important
13b	Law Enforcement Presence	1-4	1=Least Important to 4=Most Important
13c	Driver Awareness	1-4	1=Least Important to 4=Most Important
13d	Truck/Car Interaction	1-4	1=Least Important to 4=Most Important

Table 5.2 Quantitative Scale Definitions: Questions Unique to 2014 Survey

Q#	Question	Scale	Conversion Values
10	Expected Future Injury Car Crash	0-5	0=None to 5=5 or more times
11a	Safer Driver Than Others	1-5	1=Strongly Disagree to 5=Strongly Agree
11b	Out-of-State Are More Dangerous	1-5	1=Strongly Disagree to 5=Strongly Agree
11c	Risking My Life in Western North Dakota	1-5	1=Strongly Disagree to 5=Strongly Agree
11d	See Crash, Drive Route Less Often	1-5	1=Strongly Disagree to 5=Strongly Agree
12	Multi-Vehicle Crash in Past Year	1-3	1=No, 2=Else’s Fault, 3=My Fault

The survey questionnaire was designed to measure certain constructs within transportation safety. The researchers wanted to learn about key latent variables that are not easily measured. When applied to residents living in western North Dakota, these factors include perceptions of danger, perceptions of risk, travel behavior, safety priorities, and attitudes toward large truck-passenger vehicle interaction. Factor analysis was utilized to determine which variables had similar patterns of responses. Initially each variable (with the exception of demographic information) was correlated with one another to identify variables that may be unrelated to any underlying factor. A total of 17 variables were used in the factor analysis, and six components emerged as having an Eigenvalue greater than 1. A scree plot of the components, however, visually displays that the first four components explain a significant percentage of the total variance, and that the fifth and sixth components have an Eigenvalue slightly larger than 1, and are plausibly the “beginning point” of the scree plot’s plateau (Figure 5.1).

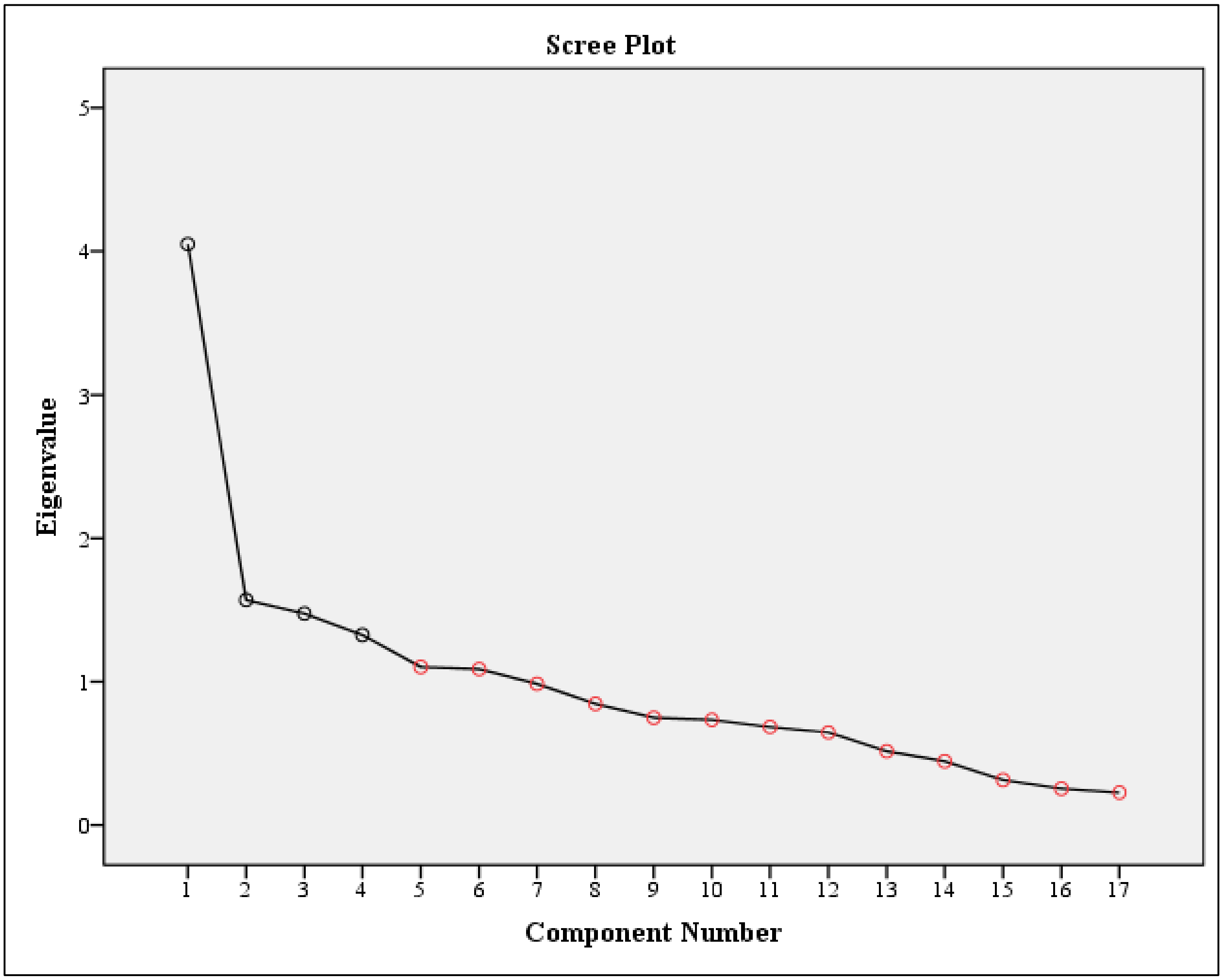

Figure 5.1 Scree Plot of Factor Analysis

These four components were subjected to a Varimax rotation with Kaiser Normalization, and factor loads were sorted by size. Only factor loads greater than 0.40 were considered. The four main components appear to be linked to the constructs identified by the researchers. The first factor relates to perceptions of danger. The second factor can be described as those choosing to avoid danger. The third factor encompasses safe driver behaviors. The fourth factor highlights large truck-passenger vehicle interaction. The relationships of driver responses to these themes will be the focal point of the following data analysis.

5.1 Perceptions of Danger

Multiple survey questions focused on safety conditions in the 17 western North Dakota counties. Response frequencies for three of these general safety questions are provided in Table 5.3. Responses show that a majority of drivers do not feel safer driving now than they did five years ago. A majority of respondents chose the worst option on the Likert scale – "Much Less Safe" – in both 2012 and 2014. Just 1.1% of respondents in 2014 indicated that driving conditions had improved in the last five years by answering that they either feel "much safer" or "somewhat safer" when driving. This was a slight decline from the 1.4% of respondents who held this view in 2012. With regard to braking suddenly, treated here as a crash avoidance maneuver measure, the proportion of respondents revealing that they have had to brake or swerve suddenly to avoid a crash remained the same over time at roughly 73%.

Table 5.3 Perceptions of Danger Responses

Question Number		Survey Question	Responses		
1	How safe do you feel driving in your area compared to five years ago?				
	Much Safer	Somewhat Safer	Same	Less Safe	Much Less Safe
2012	0.8%	0.6%	9.7%	33.2%	55.6%
2014	0.1%	1.0%	10.6%	36.2%	52.0%
3	Have you had to brake or swerve suddenly to avoid a crash in the past 3 months?				
	Yes	No			
2012	73.3%	26.7%			
2014	72.7%	27.3%			
12	Have you been in a multi-vehicle car crash in the past 12 months?				
	Yes, it was my fault	Yes, it was someone else's fault	No		
2014	0.0%	2.6%	97.4%		

Interestingly, 17 respondents (2.6%) reported that they had been in a multi-vehicle crash within the past year, but none of them indicated they were at fault for the crash. This could plausibly be true, but this percentage may also be due to response error as some respondents may not want to admit they were culpable. Nonetheless, being in a multi-vehicle collision is a strong barometer of fear and danger on the roadway, and may contribute to some perceptions and behaviors.

1.1.1 Danger: Perceptions of Self and Other

One common theme that emerged from the literature review was that of a "self-versus-other" complex. In general, humans perceive themselves as being safer and more responsible than others. This is also evident in situations related specifically to transportation safety (see DeJoy 1989 and Delhomme, Verlhiac, and Martha 2009). This theme prompted three questions on the final survey questionnaire to highlight self-versus-other perceptions as it relates to safety on the roadway (Figure 5.2). Surprisingly, there was not a notable correlation between those thinking they are safer than other drivers and those thinking that out-of-state drivers are more dangerous than North Dakota drivers (Pearson Correlation=0.232, $p<0.001$, n=689). These questions are essentially inverse of one another; and, therefore it would logically be expected that a strong correlation should exist. Instead, the correlation measure shows that only about 5.4% of their variability is shared. These two questions did have comparable skewed distributions: a majority (74.6%) either agreed or strongly agreed that they were safer than other drivers and a similar sized majority (71.5%) held the same viewpoints that out-of-state drivers were more dangerous than North Dakota drivers.

When respondents were asked if they drive a route less often when seeing a crash on the road, responses followed somewhat of a normal distribution. Feelings about this type of danger on the roadway were most commonly neutral (42.4%), though a greater percentage (35.3%) tended to be in disagreement with the prompt than in agreement (22.3%) with it. Drivers in western North Dakota are more likely to continue driving on routes after a crash has a taken place. This may be due to limited route availability in some rural areas of western North Dakota.

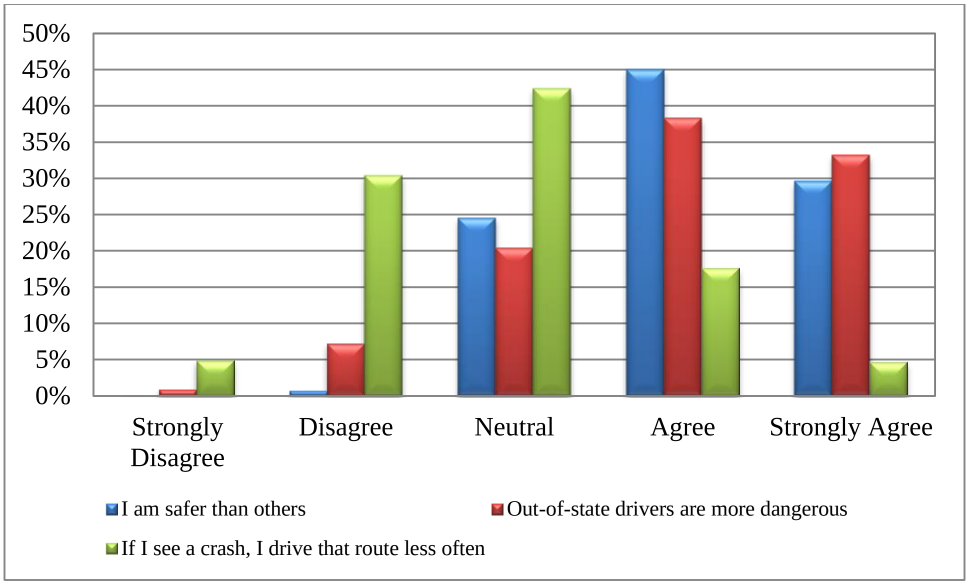

Figure 5.2 Self-versus-Other Danger on the Roadway

5.1.2 Danger: Risk on the Roadway

Roughly seven out of 10 drivers (71.2%) indicated that they feel as though they are risking their lives when driving in western North Dakota, based on those who answered that they "agree" or "strongly agree" with that prompt, respectively. Less than one in 10 (9.8%) either disagreed or strongly disagreed with the belief that they were risking their lives when driving in this part of the state. Despite the aforementioned perceptions of danger, when drivers were asked to predict how many times they expected to be injured in a car crash in the future, a majority (54.2%) believed they would not be injured at all (Figure 5.3). However, this leaves a high proportion of residents believing that they will be injured in a car crash at some point in the future. This perception of danger may underlie some survey responses and may explain some travel behavior. A one-way ANOVA of these risk factors shows that the two variables are undeniably linked: expectations for future crash events depend on whether or not drivers feel as though they are risking their lives traveling on western North Dakota roadways ($F=15.927$, $df=4$, $p<0.001$). Drivers perceiving a greater risk of their lives believe they will be involved in more injury-causing crashes in the future.

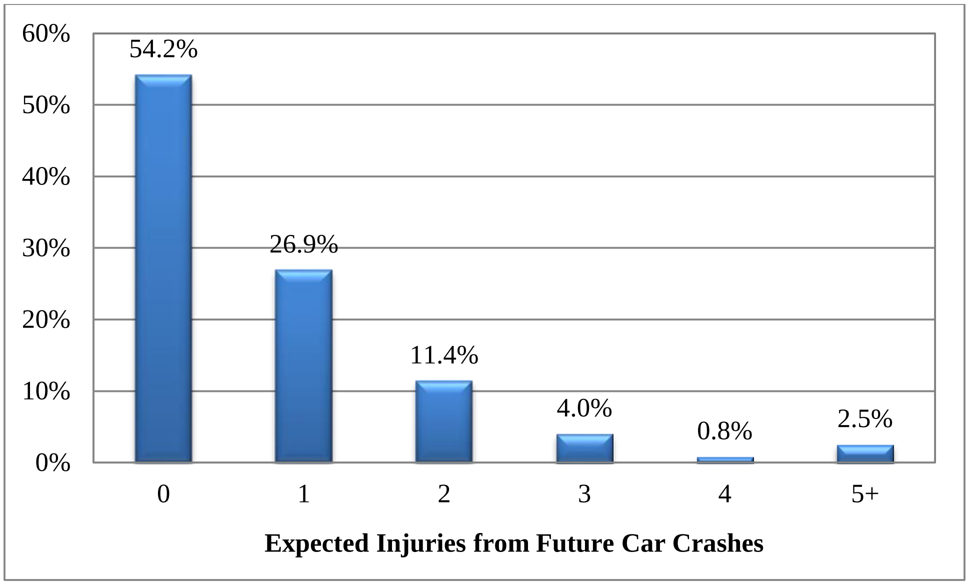

Figure 5.3 Anticipated Future Car Crash Injuries

5.2 Danger Avoidance

Some drivers actively attempt to avoid danger on the roadway. Other drivers may not have this chance considering the remote, rural areas prevalent in some North Dakota counties. Drivers in the target region were asked if – during a typical 20-minute commute – they would drive out of the way to avoid large oil trucks and/or travel on roads with better surface conditions. Roughly three-quarters indicated they would travel at least five additional minutes for these improved conditions (Figure 5.4 and Figure 5.5).

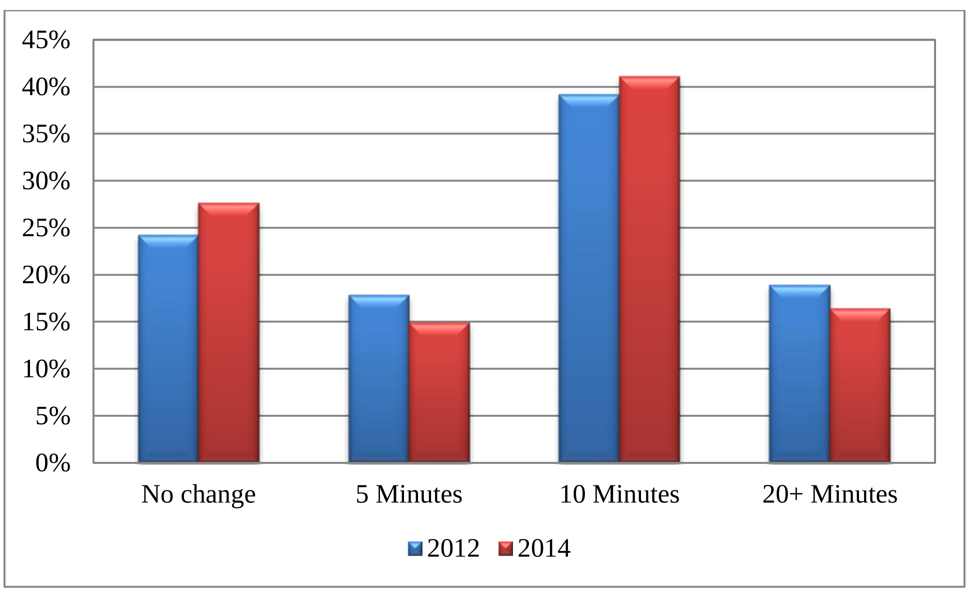

Figure 5.4 Willingness to Travel Out of the Way for Roads with Fewer Oil Trucks

Roughly one-fifth of drivers surveyed would more than double their current commute time and add an additional 20 minutes to travel roads with better traffic conditions. One's willingness to travel out of the way is linked to how safe one feels today compared to five years ago. Those who feel less safe will drive farther to avoid oil trucks ($F=17.692$, $df=4$, $p<0.001$) or for better surfaces ($F=11.586$, $df=4$, $p<0.001$).

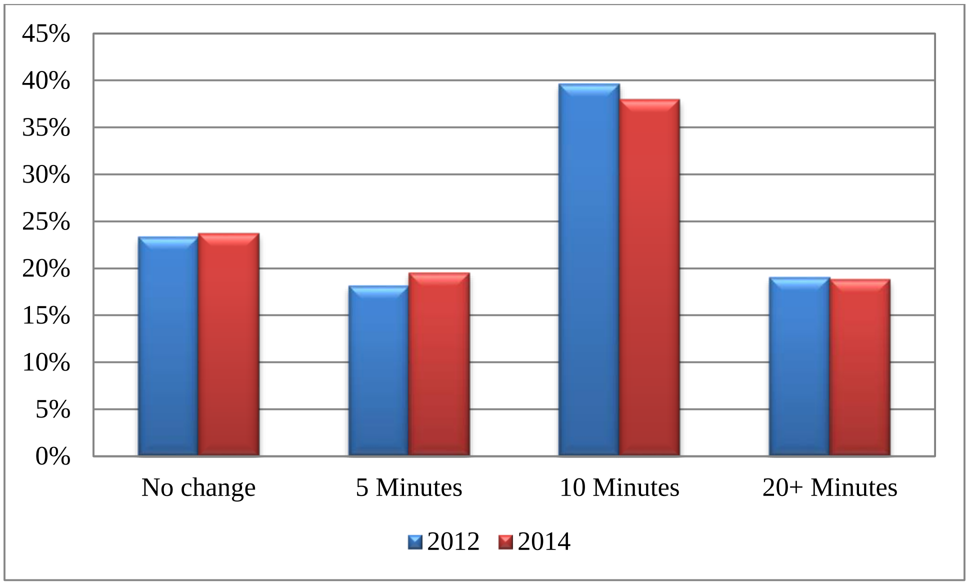

Figure 5.5 Willingness to Travel Out of the Way for Roads with Better Surface Conditions

5.3 Driver Behavior

Driver behavior behind the wheel directly impacts safety on the roadway. Drivers control some roadway safety via seat belt use, obeying the speed limit, and never choosing to operate a vehicle when impaired. External factors, such as law enforcement presence, also influence driver behavior, often positively.

Two questions examined driver behavior as related to seat belt use and speeding. Based on driver response indicating that they "always" or "nearly always" wear a seat belt, 86.9% of drivers use a safety belt regularly while driving in town. A higher proportion, 95.0%, either "always" or "nearly always" wear a seat belt when traveling in a vehicle going over 30 miles per hour (Figure 5.6). Only 5.6% of drivers reported "rarely" or "never" wearing a seat belt while in town, and an even smaller portion, 2.2%, reported "rarely" or "never" using a safety belt while driving in a vehicle traveling at least 30 miles per hour. As expected, there was a strong, positive correlation between the two seat belt use variables (Pearson Corr.=0.673, $n=682$, $p<0.001$) indicating that those who use a seat belt in town are more likely to also use a safety belt in a car going at least 30 miles per hour. This is logical as seat belt use is often considered habitual in nature.

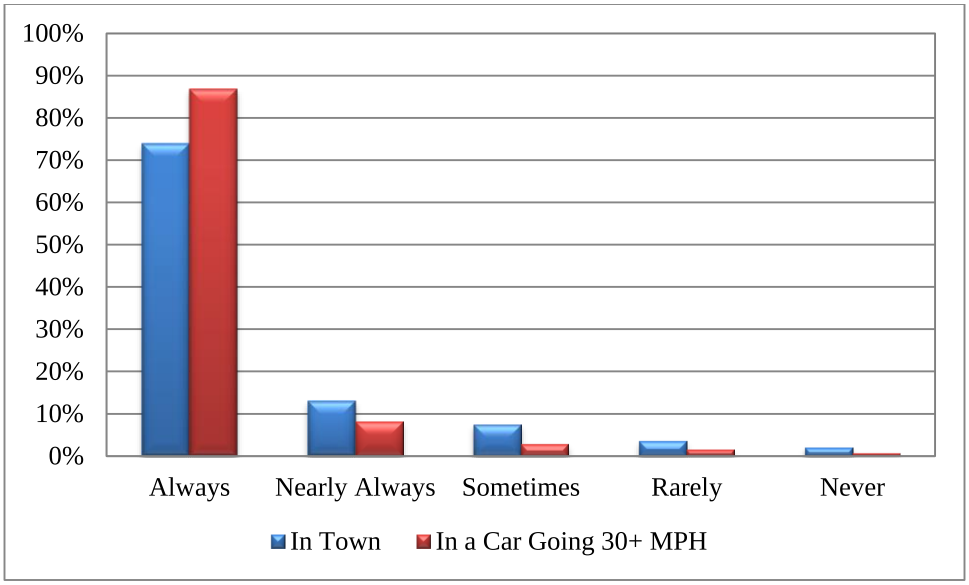

Figure 5.6 Driver Behavior Response: Seat Belt Use

Speeding tendencies in 2014 mirrored those of drivers in 2012 (Figure 5.7). In 2014, 5.5% of drivers reported that they “always” or “nearly always” have the dangerous driving habit of traveling at least 70 miles per hour in a 65-mile-per-hour zone. A majority of drivers, 75.7%, reported that they “rarely” or “never” engage in this dangerous driving habit. A noticeable contrast between seat belt use and speeding tendencies is that the median value of “sometimes” is much more prominent for speeding than it is for using a safety belt; roughly one-fifth of drivers “sometimes” drive more than 70 miles per hour in a 65-mile-per-hour zone. Based on these frequencies, in western North Dakota, drivers make safer choices regarding seat belts than they do speeding.

A majority of respondents (69.2%) believed that greater law enforcement visibility reduces crashes on North Dakota roadways. Those drivers who held this viewpoint were more likely to wear a seat belt in town ($F=9.484$, $df=1$, $p=0.002$), more likely to wear a seat belt in a vehicle traveling over 30 miles per hour ($F=8.942$, $df=1$, $p=0.003$), and were less likely to speed on a 65-mile –per-hour road ($F=14.025$, $df=1$, $p<0.001$).

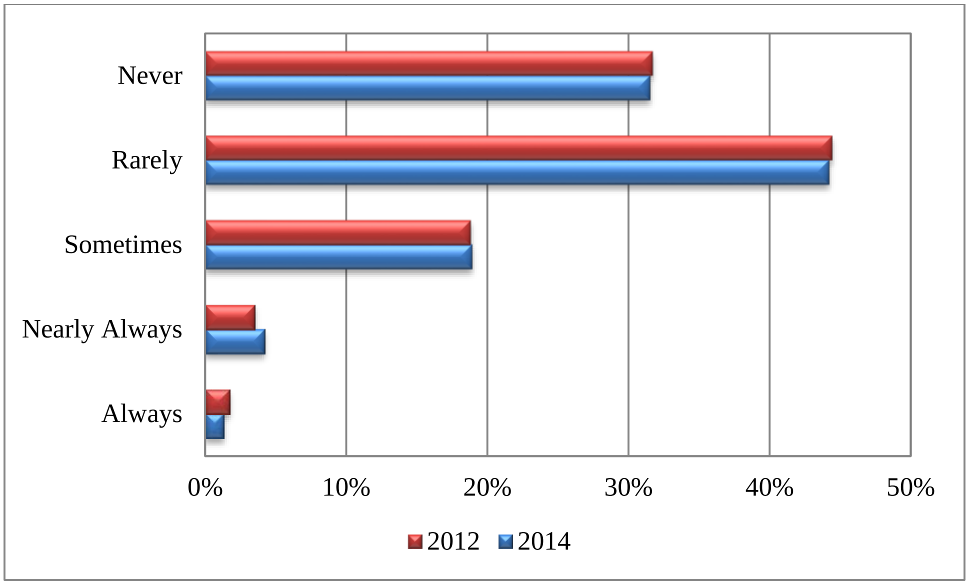

Figure 5.7 Driver Behavior Response: Speeding

5.3.1 Driver-Reported Priorities

Drivers were asked to rank their priorities for four issues that may be targeted in traffic safety: improved road signage, increased law enforcement presence, heightened driver awareness, and education for truck/passenger car interaction. Road signage is important in providing drivers information needed for navigation and vehicle control (Rasanen and Hornberry 2006). Increased law enforcement presence has been proven as a traffic safety intervention that reduces crime, reduces the fear of a crime occurring, and provides the public with a greater sense of security and safety (NHTSA 2001). Driver awareness is also a critical element in traffic safety. Driver expectations, perceptions, and distraction can create a significant risk for both the driver and others on the road. The size/mass relationship of large trucks and passenger vehicles, along with operational differences such as acceleration/deceleration times and turning radiuses, heighten the risk of a crash taking place (UGPTI 2012). The survey asked drivers to rank these four issues on a scale of one to four, with one being least important and four being most important.

Results show that driver awareness is clearly seen as the most important issue to drivers. Over three-fifths (62.8%) ranked it as most important of the four issues presented. Similarly, the lowest proportion, 5.9%, ranked driver awareness as least important. This congruity suggests that driver awareness is, in fact, the most important issue facing North Dakota drivers in the oil region (Figure 5.8).

A majority of drivers perceived three issues to be important, based on the proportion of those who ranked the issues as a 3 or 4, respectively. Over three-fifths (62.7%) rated law enforcement presence as being either most important or second-most important. A similar proportion, 61.7%, ranked passenger vehicle/large truck interaction as their most important or second-most important issue. A clear majority, 83.0%, believed that driver awareness was a top priority.

Unlike these three issues, a majority of drivers did not think that signage related to traffic rules was of the highest priority. Over half (53.8%) of those sampled ranked signage related to traffic rules as either least important or second-least important among the issues presented to them. The proportion of individuals who ranked signage last (33.1%) was noticeably higher than law enforcement presence (12.3%), driver awareness (5.9%), and passenger vehicle/large truck interaction (20.6%).

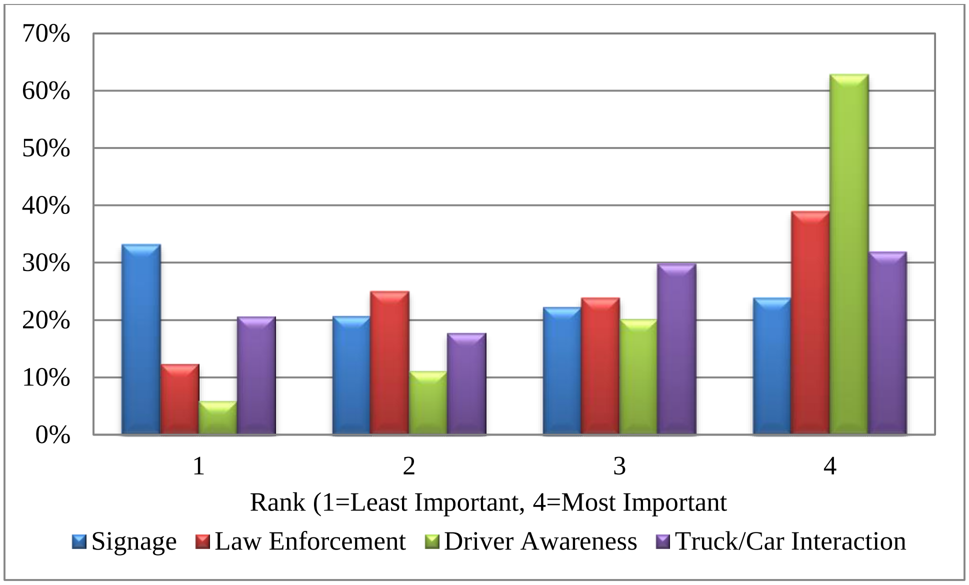

Figure 5.8 Driver Safety Priorities for Traffic Safety

5.4 Large Truck-Passenger Vehicle Interaction

Based on driver response, roughly three in four (74.5%) drivers in the 17 western North Dakota oil counties meet or pass a large truck on a daily basis (Table 5.4). Only 1.3% of drivers reported meeting trucks on the roadway less than once per month or not at all. In terms of perceived safety, a majority of drivers felt unsafe when passing or being passed by large trucks. Over half (51.1%) of all drivers indicated that they felt either "unsafe" or "very unsafe" while passing large trucks in the 17 western oil counties, and two-thirds of drivers felt the same way while being passed by large trucks. There was an obvious link between these two variables: drivers who felt safe passing large oil trucks were more likely to also feel safe when being passed by large trucks (Pearson Corr.=0.742, n=675, $p<0.001$). Perceptions of safety when passing and being passed by large trucks appear to be contingent upon how often one interacts with large oil trucks. Drivers who meet/pass large trucks frequently are more likely to feel safe passing trucks ($F=2.390$, df=4, $p=0.050$) and are also more likely to feel safe when being passed by trucks ($F=6.363$, df=4, $p<0.001$). Thus, interaction with large trucks on the roadway may determine some views and opinions about safety on the roadway.

Table 5.4 Responses to Large Truck/Passenger Vehicle Interaction Questions

Question #	Question	Response				
5	How often do you meet/pass large trucks while driving?					
		Daily	Few/Week	Few/Month	<1/Month	Never
	2014	74.5%	15.2%	9.1%	0.9%	0.4%
	2012	79.4%	12.5%	6.0%	1.5%	0.5%
6a	How safe do you feel when passing large trucks?					
		V. Safe	Sw. Safe	Neutral	Unsafe	V. Unsafe
	2014	2.8%	20.2%	26.0%	34.2%	16.9%
	2012	4.0%	20.4%	21.8%	32.4%	21.3%
6b	How safe do you feel when being passed by large trucks?					
		V. Safe	Sw. Safe	Neutral	Unsafe	V. Unsafe
	2014	1.6%	14.6%	17.1%	38.8%	27.9%
	2012	2.8%	12.9%	18.7%	37.4%	28.3%

5.5 Driver Groups

In addition to general population insight, the potential to focus traffic safety efforts for more efficient resource use may be possible. For instance, some significant differences were found when factoring for various driver groups. These driver groups – the independent variables used in this portion of the analysis – include gender, age, length of residency, and high-risk young drivers.

5.5.1 Gender

Some differences between males and females were found related to safety and driver behaviors (Table 5.5). Compared to men, women generally rated driving conditions compared with five years ago as less safe (F=12.763, df=1, p<0.001). Perceptions of safety were also lower for women when rating how safe it is passing large oil trucks (F=14.983, df=1, p<0.001) and being passed by large oil trucks (F=7.576, df=1, p=0.006). This is a slight change from 2012 when there was no difference in how men and women perceived safety when being passed by large oil trucks.

Women exhibit behaviors that are safer than men, especially with regard to seat belt use. In this survey, females were more likely than men to wear a seat belt when driving in town (F=10.113, df=1, p=0.002) and when in a vehicle traveling over 30 miles per hour (F=21.486, df=1, p<0.001). This continues a trend that initially occurred in 2012. Other research studies of North Dakota driver behaviors have found similar differences between seat belt use rates among men and women (Vachal, Benson, and Kubas 2010 – 2014).

Table 5.5 Differences in Mean Driver Views and Behaviors, by Gender

QUESTION	SCALE[1]	ALL DRIVERS	MALE	FEMALE	SIG.
Safety Now vs. 5 Years Ago	1-5	1.61	1.73	1.53	**
Read, Seen, Heard *Code for the Road*	0-1	0.19	0.18	0.19	
Changed Driving After *Code for the Road*	0-1	0.30	0.25	0.35	
Sudden Brake/Swerve	0-1	0.72	0.72	0.72	
Law Enforcement Visibility	0-1	0.69	0.66	0.72	
Meet/Pass Trucks Frequency	1-5	4.62	4.64	4.61	
Safety Passing Trucks	1-5	2.58	2.77	2.45	**
Safety Being Passed by Trucks	1-5	2.23	2.36	2.14	**
Seat Belt Use in Town	1-5	4.53	4.40	4.63	**
Seat Belt Use 30+ MPH	1-5	4.79	4.66	4.88	**
Drive > 70 on 65 MPH Road	1-5	1.99	2.01	1.98	
Expected Future Injuries	0-5	0.77	0.67	0.85	
Safer Driver than Others	1-5	4.04	4.06	4.02	
Out-of-State are Dangerous	1-5	3.95	3.97	3.94	
I'm Risking My Life	1-5	3.89	3.83	3.94	
Drive Route Less After Seeing Crash	1-5	2.86	2.82	2.90	
Signage to Traffic Rules	1-4	2.37	2.40	2.34	
Law Enforcement Presence	1-4	2.89	2.95	2.85	
Driver Awareness	1-4	3.40	3.43	3.38	
Truck/Passenger Car Interaction	1-4	2.72	2.65	2.78	

**Significant difference at the 1% level for 1-way ANOVA
[1]Nominal/Ordinal scales require different tests of significance
Please refer to Table 5.1 and Table 5.2 for quantitative scale definitions for responses

5.5.2 Age

Like results from 2012, many differences in views and behaviors exist across age groups. Table 5.6 highlights mean response values by the seven age groups studied in this survey. The table suggests that extreme values tend to be associated with the youngest and oldest age cohorts, respectively. Perceptions of safety are skewed, with older drivers generally feeling safer on the roadway than those in younger age cohorts. For example, older drivers feel more safe now compared with five years ago than younger drivers ($F=5.764$, $df=6$, $p<0.001$), feel safer being passed by large oil trucks ($F=4.120$, $df=6$, $p<0.001$), and expect to be injured in a car crash fewer times than younger drivers ($F=2.611$, $df=6$, $p=0.017$).

Traffic safety priorities tend to be viewed as more important by older drivers. Higher values are clustered near the 65-74 and 75+ age cohorts. The driver-rated importance of signage related to traffic rules ($F=7.255$, $df=6$, $p<0.001$), law enforcement presence ($F=7.938$, $df=6$, $p<0.001$), and large truck/passenger vehicle interaction ($F=3.391$, $df=6$, $p=0.003$) increases with age.

Younger drivers are more likely to speed ($F=6.865$, $df=6$, $p<0.001$), more likely to interact with trucks on the roadway ($F=13.195$, $df=6$, $p<0.001$), and are more likely to have had to brake or swerve suddenly to avoid a crash (Chi-Sq.=56.608, $df=6$, $p<0.001$). Some of these experiences may be due to how often one drives. In North Dakota, younger drivers typically drive more miles annually than their elderly counterparts (Vachal, Benson, and Kubas 2010 – 2014).

Table 5.6 Differences in Mean Driver Views and Behaviors, by Age

QUESTION	SCALE$_1$	AGE GROUP AND CORRESPONDING MEAN VALUE						
		18-24$_2$	25-34	35-44	45-54	55-64	65-74	75+
Safety Now vs. 5 Years Ago	1-5	1.8**	1.6**	1.5**	1.5**	1.5**	1.7**	2.0**
RSH *Code for the Road*	0-1	0.2	0.2	0.1	0.2	0.2	0.2	0.2
Changed *Code for the Road*	0-1	0.2	0.4	0.1	0.4	0.3	0.4	0.2
Sudden Brake/Swerve	0-1	0.9##	0.7##	0.9##	0.8##	0.8##	0.6##	0.5##
Law Enforcement Visibility	0-1	0.4##	0.5##	0.6##	0.7##	0.7##	0.8##	0.7##
Meet/Pass Trucks	1-5	4.7**	4.7**	4.7**	4.8**	4.7**	4.5**	4.0**
Safety Passing Trucks	1-5	2.7**	2.6**	2.7**	2.5**	2.5**	2.5**	3.1**
Safety Passed by Trucks	1-5	1.9**	2.2**	2.2**	2.1**	2.1**	2.3**	2.8**
Seat Belt Use in Town	1-5	4.7	4.5	4.7	4.5	4.5	4.5	4.5
Seat Belt Use 30+ MPH	1-5	4.8	4.8	4.8	4.8	4.8	4.8	4.8
Drive >70 on 65 MPH Road	1-5	2.4**	2.6**	2.2**	2.1**	2.0**	1.7**	1.8**
Expected Future Injuries	0-5	0.6*	0.9*	0.7*	1.0*	0.8*	0.7*	0.4*
Safer Driver than Others	1-5	3.9**	4.2**	4.2**	4.1**	4.1**	3.9**	3.8**
Out-of-State Dangerous	1-5	3.4*	3.7*	3.9*	4.0*	4.1*	4.0*	3.9*
I'm Risking My Life	1-5	3.2**	3.6**	3.9**	4.0**	4.0**	3.9**	3.7**
Drive Route Less	1-5	2.5	2.7	2.7	2.9	2.9	3.0	3.0
Signage to Traffic Rules	1-4	2.2**	2.2**	2.2**	2.2**	2.2**	2.7**	3.0**
Law Enforcement Presence	1-4	2.2**	2.3**	2.8**	2.8**	2.9**	3.2**	3.3**
Driver Awareness	1-4	3.7	3.3	3.4	3.3	3.3	3.5	3.5
Truck/Car Interaction	1-4	2.6**	2.5**	2.5**	2.6**	2.7**	3.1**	2.9**

*Significant difference at the 5% level for 1-way ANOVA
**Significant difference at the 1% level for 1-way ANOVA
##Significant difference at the 1% level for Chi-Square test
$_1$Nominal/Ordinal scales require different tests of significance
$_2$Estimate uncertain due to limited sample size from this age cohort
Please refer to Table 5.1 and Table 5.2 for quantitative scale definitions

5.5.3 Newcomers and Long-Term Residents

Some studies have shown that newcomers and long-term residents have differing attitudes toward land use (Smith and Krannich 2000). This difference becomes more prominent when environmental issues are taken into consideration. Differences may stem from political ideology, urban/rural background, and the amount of time one has lived in the community. From an environmental context, oil development in western North Dakota is not without controversy. The advent of hydraulic fracturing has pushed some residents against energy sector development altogether. Given the latest boom in oil development, it is prudent to investigate if attitudes toward oil traffic safety differ between long-term residents and those who have moved to the region recently.

An important question to investigate is how one should classify newcomers as opposed to long-term residents. Some studies comparing newcomer and long-term resident attitudes arbitrarily use 10 years as a cutoff point to differentiate between attitudes (Graber 1974; Fortmann and Kusel 1990). An accepted idea is that the length of residence in a community is vital for developing one's sense of social integration within the community (Kasarda and Janowitz 1974).

Other studies postulate that it is best to identify newcomers and long-term residents by examining the year in which substantial in-migration to the community began (Blahna 1985). Using that year as a baseline, one can then confidently distinguish between residents who have relocated to the community due to pull factors (newcomers) and those who had established roots in the community before a major event took place (long-term residents).

Coincidentally, the most recent oil boom began in 2004, which creates a newcomer designation of 10 years. This aligns with both the arbitrary 10-year cutoff point suggested by some authors and the beginning date of in-migration to the community suggested by others. One question posed in the survey asked drivers how long they had lived at their residence. As such, anyone living in the area fewer than 10 years was coded as a "newcomer" and anyone who had been in the area for more than 10 years was identified as a "long-term resident."

Results were mixed when comparing newcomers to long-term residents (Table 5.7). Newcomers were more likely to use a seat belt when driving in town (F=8.141, df=1, p=0.004) and when traveling in a car going at least 30 miles per hour (F=4.280, df=1, p=0.039). Despite engaging in this safe behavior, newcomers were more likely to speed on a 65-mile-per-hour road (F=8.012, df=1, p=0.005).

Long-term residents rated law enforcement presence as being a more important traffic safety priority than did newcomers (F=7.596, df=1, p=0.006). This may be due to the changing community conditions that long-term residents have experienced firsthand. Long-term residents were also more likely to think that out-of-state drivers are more dangerous than North Dakota drivers (F=5.430, df=1, p=0.020). This viewpoint could be influenced by a number of factors, but one can speculate that the influx of oil workers may create a sense of "self-versus-other" between local residents and those living in the area created temporarily for the oil industry. Logically, it is plausible that many of the newcomers sampled in this survey may have moved to the region specifically due to the growth of the energy sector. As such, these individuals may be used to different driving conditions and may not be accustomed to what rural driving in western North Dakota was like more than 10 years ago.

Table 5.7 Differences in Mean Driver Views and Behaviors, by Length of Residency

QUESTION	SCALE[1]	ALL DRIVERS	NEWCOMERS	LONG-TERM RESIDENTS	SIG.
Safety Now vs. 5 Years Ago	1-5	1.61	1.57	1.62	
RSH *Code for the Road*	0-1	0.19	0.17	0.20	
Changed *Code for the Road*	0-1	0.30	0.25	0.32	
Sudden Brake/Swerve	0-1	0.73	0.74	0.72	
Law Enforcement Visibility	0-1	0.69	0.67	0.70	
Meet/Pass Trucks	1-5	4.62	4.69	4.59	
Safety Passing Trucks	1-5	2.57	2.55	2.57	
Safety Passed by Trucks	1-5	2.22	2.24	2.22	
Seat Belt Use in Town	1-5	4.53	4.69	4.46	**
Seat Belt Use 30+ MPH	1-5	4.79	4.87	4.75	*
Drive > 70 on 65 MPH Road	1-5	2.00	2.15	1.94	**
Expected Future Injuries	0-5	0.79	0.79	0.79	
Safer Driver than Others	1-5	4.04	4.06	4.03	
Out-of-State Dangerous	1-5	3.96	3.83	4.01	*
I'm Risking My Life	1-5	3.90	3.91	3.90	
Drive Route Less	1-5	2.86	2.86	2.87	
Signage to Traffic Rules	1-4	2.37	2.32	2.38	
Law Enforcement Presence	1-4	2.89	2.71	2.96	**
Driver Awareness	1-4	3.40	3.34	3.42	
Truck/Car Interaction	1-4	2.72	2.64	2.76	

*Significant difference at the 5% level for 1-way ANOVA
**Significant difference at the 1% level for 1-way ANOVA
[1]Nominal/Ordinal scales require different tests of significance
Please refer to Table 5.1 and Table 5.2 for quantitative scale definitions for responses

5.5.4 High-Risk Young Drivers

In North Dakota, 18- to 34-year-old drivers exhibit explicitly different behaviors and attitudes from the rest of the driver population (Vachal, Benson, and Kubas 2013 – 2014). Other studies show that young drivers in North Dakota are more likely to speed, less likely to wear a seat belt, and are more likely to operate a vehicle after consuming alcohol (Vachal, Benson, and Kubas 2013 – 2014). These same drivers are less likely to have had recent exposure to safety messages. Interestingly, this target group generally has higher familiarity with safety campaigns targeting impaired driving, yet this group is still more likely to operate a vehicle after consuming alcohol.

In this survey of western North Dakota drivers, those between ages 18 and 34 were once again more likely to speed on a 65 mile per hour road ($F=21.586$, $df=1$, $p<0.001$). There were no statistically significant differences regarding seat belt use.

Some studies have found that social situations, peer pressure, and the perceived invincibility of youth result in younger drivers making dangerous decisions on the roadway (Nygaard et al. 2003; NCADD 1988). This perceived invincibility is evident when young drivers rate certain driving situations. For example, these drivers are less likely to feel as though they are risking their lives when driving in western North Dakota than their older counterparts ($F=9.599$, $df=1$, $p=0.002$). They are also less likely to drive a route less often if they see a crash on the road ($F=4.716$, $df=1$, $p=0.030$). These responses show some disconnect between when crash events happen and when crash events happen *to me*. High-risk young drivers may be cognizant of such events taking place, but these individuals believe that they are not at risk

Table 5.8 Differences in Mean Driver Views and Behaviors, by High-Risk Driver Group

QUESTION	SCALE$_1$	ALL DRIVERS	HIGH-RISK	OTHERS	SIG.
Safety Now vs. 5 Years Ago	1-5	1.61	1.64	1.61	
RSH *Code for the Road*	0-1	0.19	0.19	0.19	
Changed *Code for the Road*	0-1	0.30	0.31	0.30	
Sudden Brake/Swerve	0-1	0.73	0.77	0.72	
Law Enforcement Visibility	0-1	0.69	0.47	0.71	##
Meet/Pass Trucks	1-5	4.62	4.70	4.62	
Safety Passing Trucks	1-5	2.58	2.60	2.58	
Safety Passed by Trucks	1-5	2.23	2.15	2.24	
Seat Belt Use in Town	1-5	4.53	4.61	4.52	
Seat Belt Use 30+ MPH	1-5	4.79	4.82	4.79	
Drive > 70 on 65 MPH Road	1-5	2.00	2.52	1.95	**
Expected Future Injuries	0-5	0.78	0.80	0.78	
Safer Driver than Others	1-5	4.03	4.09	4.03	
Out-of-State Dangerous	1-5	3.96	3.56	3.99	**
I'm Risking My Life	1-5	3.90	3.51	3.93	**
Drive Route Less	1-5	2.87	2.61	2.89	*
Signage to Traffic Rules	1-4	2.37	2.16	2.38	
Law Enforcement Presence	1-4	2.89	2.25	2.95	**
Driver Awareness	1-4	3.40	3.39	3.40	
Truck/Car Interaction	1-4	2.73	2.51	2.75	

*Significant difference at the 5% level for 1-way ANOVA
**Significant difference at the 1% level for 1-way ANOVA
##Significant difference at the 1% level for Chi-Square test
$_1$Nominal/Ordinal scales require different tests of significance
Please refer to Table 5.1 and Table 5.2 for quantitative scale definitions for responses

for these crashes; it is other drivers who are being involved in these collisions. Nonetheless, this sense of otherness was only prevalent when related to risk and crash events; high-risk young drivers thought that out-of-state drivers were less dangerous than did the rest of the North Dakota driving population (F=10.825, df=1, p=0.001).

Another difference between high-risk young drivers and all other North Dakota drivers is the perceived value of law enforcement presence. Young drivers were less likely to think that additional law enforcement visibility reduced crashes (Chi-Sq.=14.269, df=1, p<0.001) and rated law enforcement presence as a traffic safety priority as less important than did other North Dakotans (F=24.029, df=1, p<0.001). This parallels other North Dakota studies which have found that young drivers are less likely to think that greater police presence increases seat belt use among drivers (Vachal, Benson, and Kubas 2014). It is clear that this target driver group holds explicitly different views about law enforcement than North Dakota drivers age 35 and older.

5.6 Impact of Public Awareness as a Safety Strategy: *Code for the Road*

The survey highlighted familiarity with the *Code for the Road* safety campaign. *Code for the Road* was targeted at high-risk (18- to 34-year-old) males and emphasizes safety messages such as buckling up, driving sober, and slowing down. It is a statewide campaign, but given the demographic of generally young, male oil workers moving into the western part of the state for employment, it was believed that the campaign would improve road safety in the targeted area. These safety messages have been displayed on television, radio, and Internet advertisements in 2014. The Internet advertisements are optimized to play more frequently on certain websites when visited by the target demographic (Heidle, Horton, and Lerman

2014). The survey included two questions addressing exposure to the safety initiative. Drivers were first asked whether they had recently read, seen, or heard the safety messages being promoted by the *Code for the Road* initiative. Drivers were then asked if they had subsequently changed their driving behavior after seeing such ads. As a whole, 18.6% of respondents indicated that they had recent exposure to the advertisements. Of these, 29.9% reported positively improving their driving after being exposed to the safety messages. Thus, among all of the drivers within this sample, roughly 8.5% of respondents positively changed their driving behaviors as a direct result of the *Code for the Road* ads.

Detail beyond the targeted online advertising was not available about the deployment of the *Code for the Road* safety campaign. Approximately half (49.6%) of all drivers who had seen a *Code for the Road* advertisement lived in Ward, Stark, and Williams counties. The safety initiative may have targeted those three counties, though it should be noted that they are home to the three largest cities in the oil region: Minot, Dickinson, and Williston, respectively. Moreover, if Bottineau, McKenzie, and McLean counties are included with the three aforementioned counties, the total proportion of drivers who saw the *Code for the Road* ads increases to 73.2%. In other words, approximately three out of every four drivers who saw a *Code for the Road* advertisement lived in only 6 of the 17 western North Dakota oil counties.

5.6.1 Exposure as a Determinant of Views and Behaviors

Like the other driver groups highlighted in this study, it is plausible that exposure to safety messages, such as the one put forth by *Code for the Road*, may influence drivers positively to hold views that are different from those individuals who have not been exposed to safety messages. Education influence is powerful, and has been found to be linked to behavior changes among drivers in North Dakota (Vachal, Benson, and Kubas 2010 – 2014). A dummy variable was created based on responses to the second question of the survey. The variable categorized drivers into two groups: those who had recent exposure to the safety messages and those who did not. When these two groups were compared with one another, the results were largely unexpected (Table 5.9).

Table 5.9 Differences in Mean Driver Views and Behaviors, by *Code for the Road* Exposure

QUESTION	SCALE$_1$	ALL DRIVERS	SAW AD	DID NOT SEE AD	SIG.
Safety Now vs. 5 Years Ago	1-5	1.61	1.74	1.59	*
Sudden Brake/Swerve	0-1	0.73	0.74	0.73	
Law Enforcement Visibility	0-1	0.69	0.75	0.68	
Meet/Pass Trucks	1-5	4.62	4.65	4.61	
Safety Passing Trucks	1-5	2.58	2.50	2.60	
Safety Passed by Trucks	1-5	2.23	2.09	2.26	
Seat Belt Use in Town	1-5	4.53	4.51	4.54	
Seat Belt Use 30+ MPH	1-5	4.79	4.85	4.78	
Drive > 70 on 65 MPH Road	1-5	1.99	1.94	2.01	
Expected Future Injuries	0-5	0.78	0.89	0.76	
Safer Driver than Others	1-5	4.04	4.08	4.03	
Out-of-State Dangerous	1-5	3.95	4.03	3.94	
I'm Risking My Life	1-5	3.90	3.91	3.89	
Drive Route Less	1-5	2.86	2.93	2.85	
Signage to Traffic Rules	1-4	2.36	2.54	2.31	
Law Enforcement Presence	1-4	2.89	2.85	3.08	*
Driver Awareness	1-4	3.40	3.41	3.35	
Truck/Car Interaction	1-4	2.73	2.73	2.73	

*Significant difference at the 5% level for 1-way ANOVA
$_1$Nominal/Ordinal scales require different tests of significance
Please refer to Table 5.1 and Table 5.2 for quantitative scale definitions for responses

Overall, drivers in western North Dakota held similar viewpoints regardless of whether or not they had recently read, seen, or heard a *Code for the Road* advertisement. There were two significant differences between the two groups, though they were only significant at the 5% level. On average, drivers who had recent exposure to the *Code for the Road* safety messages rated driving conditions today compared with five years ago as safer than those who did not see the safety messages (F=4.521, df=1, p=0.034). It is unknown why these two variables are linked, though it can be postulated that drivers with exposure to safety messages have been educated from the advertisement to drive in a safer manner. One unexpected result is that drivers who had recently read, seen, or heard a *Code for the Road* advertisement rated the importance of law enforcement presence as a traffic safety priority lower than those who had not had recent exposure to the initiative (F=4.938, df=1, p=0.027). This is perplexing since some of the advertisements feature law enforcement, and all the advertisements advocating adopting behaviors that follow the law. It is unknown why this disparity exists between how these two groups rate the importance of law enforcement presence on North Dakota roadways.

6. CRASH DATA

In addition to survey data, crash reports were collected for the 17 western North Dakota oil counties from 2004 to 2013. Rural road data were queried specifically to track the total number of crashes, the number of vehicles involved in each crash, large truck crash rates, and crash severity – including injuries, fatalities, or property-damage-only (PDO) crashes. The results of the crash data are compelling: almost every crash statistic has increased considerably since 2004, and major spikes occurred in 2009 and 2011.

6.1 Oil Counties Compared to the Rest of the State

Fatal crashes rose 188.9% from 2004 to 2013 in the oil counties and the largest number (78) occurred in 2013 (Figure 6.1). This outpaced the 115.7% growth in VMT in the same time period. Although there were instances from 2006-2007 and from 2009-2010 in which the number of fatal crashes decreased from the previous year, the overall trend in western North Dakota shows that fatal crashes have risen with the increase in oil development. This may explain why many respondents in the survey indicated that they felt less safe driving presently compared with five years ago.

Traffic fatality trends in the oil region differ from other North Dakota counties: statistically based linear trend lines are included to illustrate the contrast. Whereas fatal crashes in the oil region nearly tripled compared with 2004 and peaked in 2013 (R^2=0.7598), the number of fatal crashes in the rest of the state remained relatively stable, peaking in 2005 (R^2=0.3664). Beginning in 2011, there were more fatal crashes in the oil counties than in the remainder of the state.

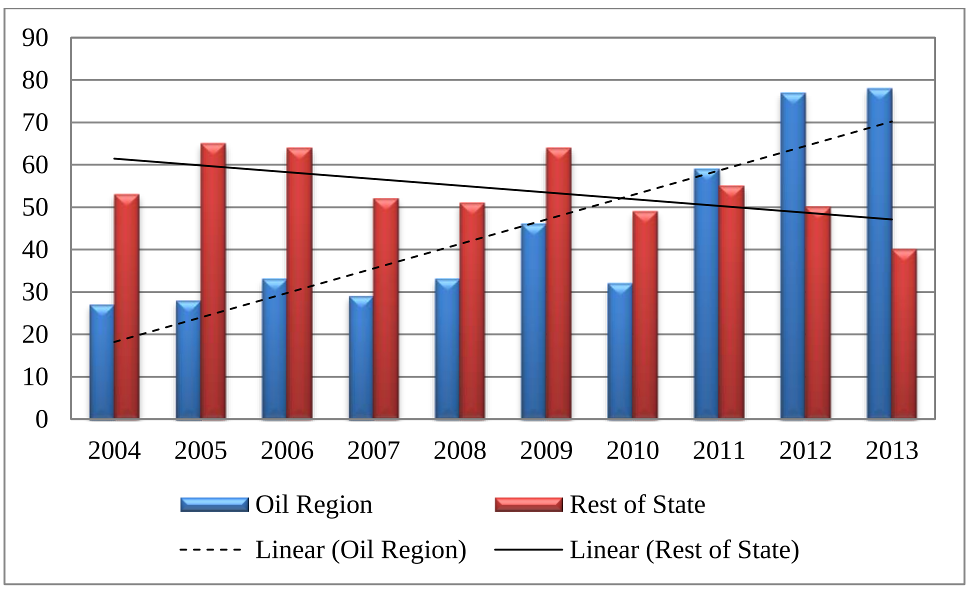

Figure 6.1 Total Number of Fatal Crashes, 2004–2013

The fact that – starting in 2011 – the total number of fatal crashes in the oil region outpaced fatal crashes in the rest of the state is especially alarming given the annual VMT attributed to the two groups and their respective populations. Between 2004 and 2013, the 17 oil counties had a smaller share of North Dakota's annual rural VMT compared with the rest of the state, yet the oil region experienced higher rates of fatal crashes every year in the study period (Figure 6.2). For example, in 2013, the study area's rural VMT (3.489 billion miles) was smaller than the rest of the state (4.107 billion miles), yet the region experienced 2.236 fatal crashes per 100 million VMT in 2013, a rate that was more than twice as high as the 0.974 fatal crashes per 100 million VMT in the rest of North Dakota.

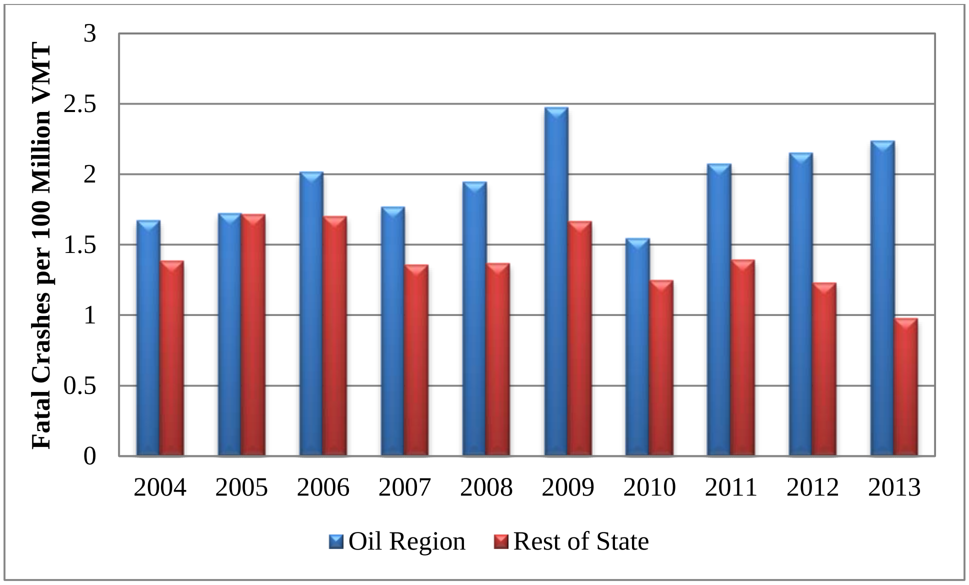

Figure 6.2 Fatal Crashes per 100 Million Rural VMT, 2004–2013

With regard to population, fatal crashes in the oil counties have been higher than in the rest of the state in each year of the study period. The U.S. Census Bureau (2014) estimates the oil counties to have had a 2013 population of 194,216, which is roughly one-third the size of the rest of the state (529,177); yet in the oil region there were 40.161 fatal crashes per 100,000 individuals, a rate that is more than five times higher than the 7.559 fatal crashes per 100,000 individuals in the rest of the state. In terms of fatal crashes, both of these metrics show that driving has been more dangerous in the oil counties than in the rest of North Dakota. Note that fatal crashes, while increasing, are still largely episodic in nature and are difficult to use for assessing traffic safety issues and strategies.

Like fatal crashes, crashes resulting in injuries have also increased during the study period, though the growth has been moderate by comparison (R^2=0.3410) (Figure 6.3). During the time frame studied, the total number of non-fatal injury crashes in oil counties increased 26.4% from 295 to 373. Non-fatal injury crashes in the 17 western oil counties increased noticeably between 2010 and 2011, though it should be noted that there was a slight decrease in the most recent annual interval. Nonetheless, the overall growth in injury crashes may be a direct factor in why some drivers feel less safe and favor increased driver awareness or more law enforcement presence as strategies to reduce crashes. In contrast, the number of non-fatal injury crashes in the rest of the state decreased noticeably (R^2=0.8532).

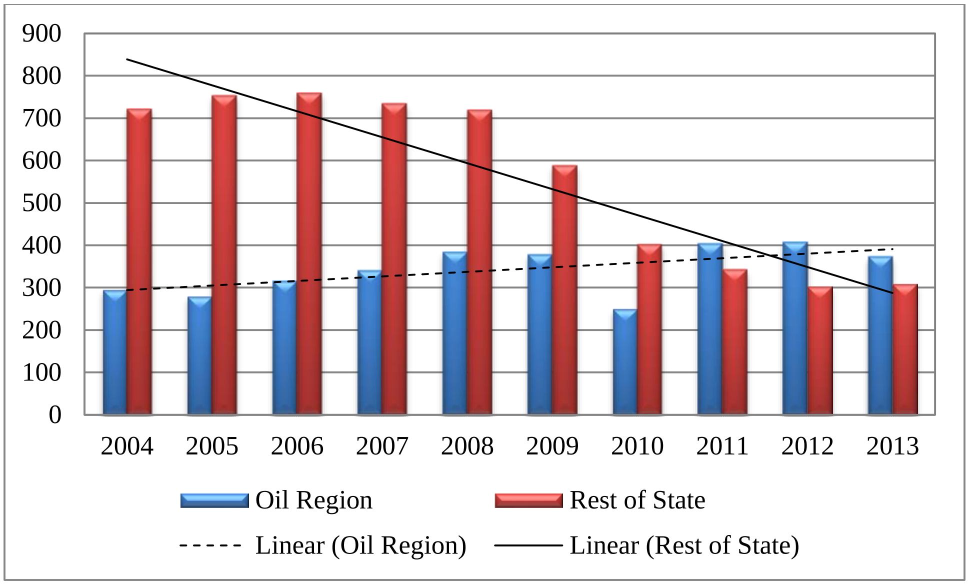

Figure 6.3 Total Number of Non-Fatal Injury Crashes, 2004–2013

Beginning in 2011, there were more injury crashes by volume in the oil region than in the remainder of the state. When injury crashes are normalized by 100 million VMT, it becomes apparent that the rates of injury crashes in the oil patch have exceeded injury rates in the rest of the state each year since 2007 and were comparable near the beginning of the oil boom (Figure 6.4). In 2013, there were 10.691 injury crashes per 100 million VMT in oil counties, a higher rate than in other parts of the state (7.499 injury crashes per 100 million VMT). When injury crashes are normalized by population, the rate at which injury crashes occur in the oil region have outpaced injury crashes elsewhere in North Dakota during each year of the study period. Using data from the most recent year, there were 192.054 injury crashes per 100,000 population in oil counties in 2013. By comparison, there were just 58.204 such crashes per 100,000 population in the rest of the state. These numbers parallel previous statements about fatal crashes in the oil region: individuals living in this part of the state have a higher likelihood of being involved in a crash resulting in a serious injury.

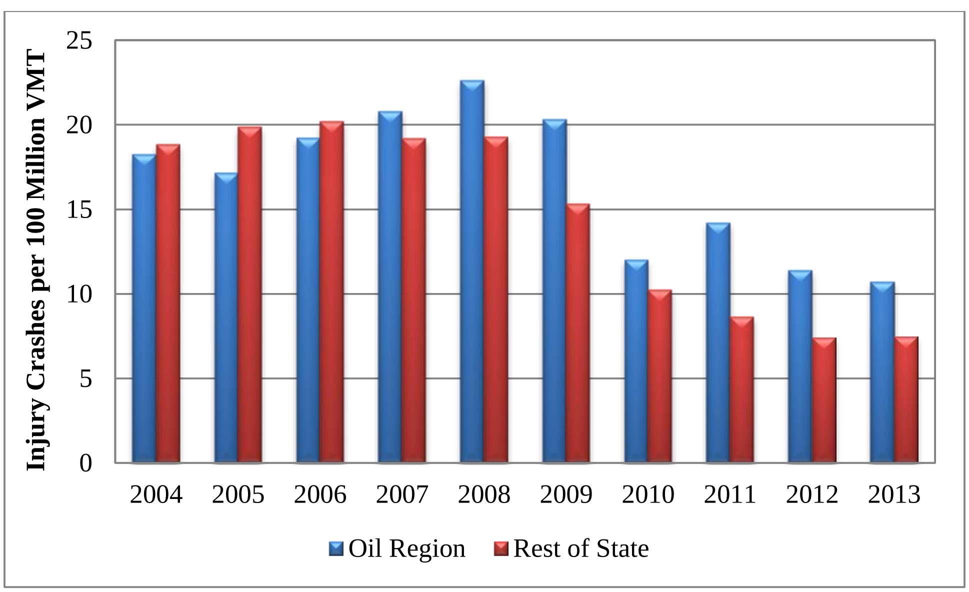

Figure 6.4 Injury Crashes per 100 Million Rural VMT, 2004–2013

With increases in oil development come growing numbers of large trucks and heavy-duty machinery required to extract and transport natural resources. This has resulted in a higher propensity for trucks to become involved in traffic crashes; large truck crash involvement in the oil region appears to be growing exponentially (R^2=0.9341) but has less variability in the rest of the state (R^2=0.5371) (Figure 6.5). From 2004 to 2013, the total number of large trucks involved in crashes in oil counties increased over 575%. This may explain drivers' fears of passing and being passed by large trucks. Within the last five years alone there has been a 217.6% increase in the total number of trucks involved in a crash.

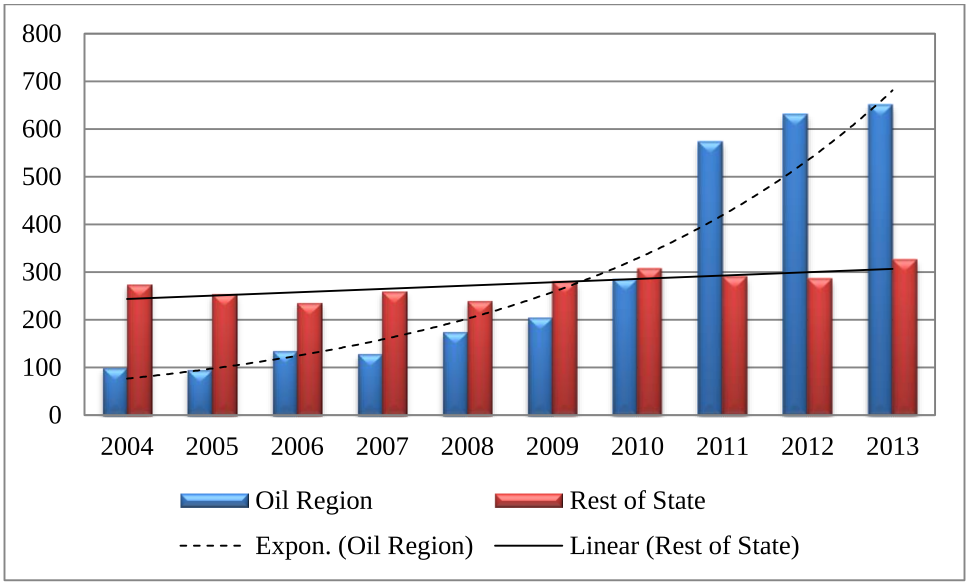

Figure 6.5 Total Number of Large Truck Crashes, 2004–2013

When normalizing large truck crash rates per 100,000 population, the oil region has once again outpaced crash rates in the remainder of North Dakota (Figure 6.6). There were 335.194 crashes involving large trucks per 100,000 population in oil counties and just 61.605 per 100,000 individuals elsewhere in 2013. The representation in terms of traffic exposure is not known since VMT is not reported by vehicle class for the oil counties, so the population exposure measure is reported.

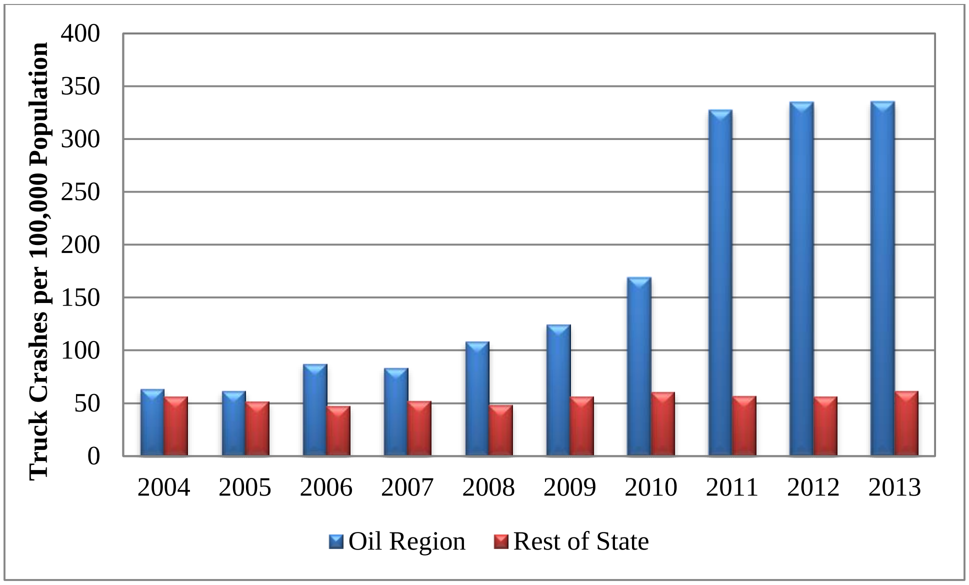

Figure 6.6 Large Truck Crashes per 100,000 Population, 2004 – 2013

6.2 Individual Oil Counties

In addition to examining all 17 western oil counties collectively, one can investigate how crash trends differ among counties within the region. Given changing travel trends and population growth in the region, crash rates were once again normalized by 100 million VMT and per 100,000 population. Five oil counties increased crash rates per 100 million VMT between 2004 and 2013. Considering all traffic crash events, McKenzie, Williams, Divide, Burke, and Golden Valley all saw moderate increases in crashes per 100 million VMT in the time period studied (Figure 6.7). McKenzie County had the highest crash rate increase from 161.4 crashes per 100 million VMT in 2004 to 239.5 crashes per 100 million VMT in 2013.

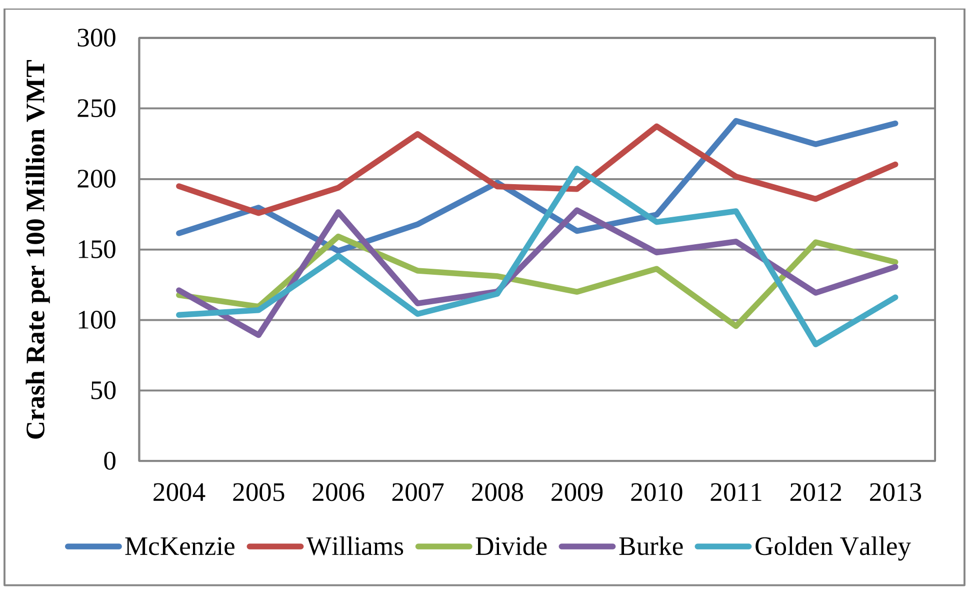

Figure 6.7 Crash Rate per 100 Million VMT Increases in Selected Counties

The other 11 counties decreased overall crash rates per 100 million VMT. In some cases, this occurred despite the total number of crashes increasing over time; many counties had substantial changes in VMT between 2004 and 2013. For example, Dunn County nearly quadrupled its total number of crashes – there were 103 in 2004 and 378 in 2013 – yet its crash rate per 100 million VMT declined from 194.2 in 2004 to 187.8 in 2013. Slope County was the only county during the study period in which both the total number of crashes and VMT declined between 2004 and 2013. As a result, it had the most noticeable improvement in crash rates per 100 million VMT between 2004 and 2013; the county declined from 164.8 to just 88.0. Although the total number of crashes – including those that result in fatalities, injuries, or involve large trucks – has grown considerably since 2004 in the oil region, the subsequent growth in VMT in these counties has kept crash rates relatively stable. Crashes are still more prevalent in this portion of the state, but individual oil counties have had relatively consistent crash rates per 100 million VMT during the latest oil boom.

6.3 Overall Trends in the Entire Oil Region

Using 2004 as a base year, it is obvious that one crash metric – large truck crashes – have grown at a faster pace than other crash types (Figure 6.8). The number of fatal crashes in the oil region has outpaced VMT growth, suggesting that increased VMT in the region is not the sole factor influencing traffic safety near oil extraction. Fatal crashes are perhaps more prevalent due to the type of traffic associated with the oil industry. Injury crashes in the oil region remained on par with changes in VMT until 2009, but then began to lag behind VMT growth in 2010 and beyond. As a whole, it is clear that the crash metrics analyzed in this study are more common in the oil region than in the rest of North Dakota, indicating that driving conditions are more dangerous than elsewhere in North Dakota.

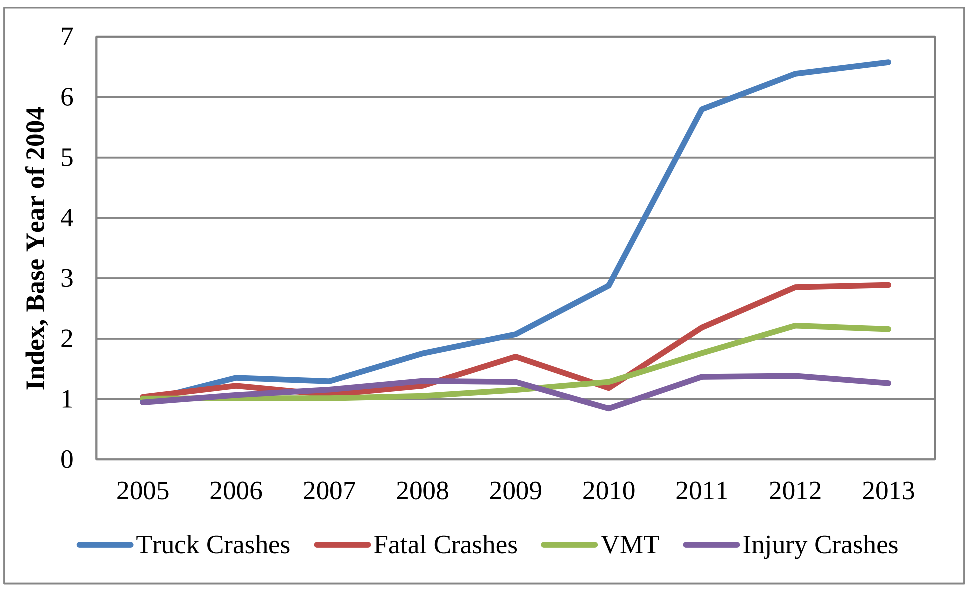

Figure 6.8 Driving Trends in Entire Oil Region, 2004 – 2013

7. CONCLUSION

It is evident that the driving environment in the 17 western North Dakota oil counties is noticeably different than in other parts of the state. Whereas other parts of the state have experienced traffic growth related to many different factors, this particular area of the state has seen extensive growth surrounding one specific issue: the development of the oil industry. This development has coincided with drastic increases in population, job opportunities, and economic prosperity. As individuals flock to the 17 western oil counties, increased traffic, including more personal vehicles, large trucks, oil trucks, and heavy-duty machinery, is being experienced.

As a whole, responses from the survey show that local residents in the oil region perceive driving conditions to be unsafe. Most drivers believed that improving safety on oil roads is contingent upon multiple factors, such as increasing driver awareness or utilizing greater law enforcement presence on the roadway. In addition to perceptions, responses indicate that some behaviors, such as seat belt use and speeding, can be improved via greater compliance. It is undeniable that *Code for the Road*, an initiative geared specifically at encouraging safe driving behaviors, has had some positive influence. Although not widely recognized by its target audience of high-risk young males, drivers did reportedly change behaviors after exposure to this safety campaign.

There were some important differences in responses when factoring for specific driver groups. Knowing these differences exist can be crucial for practitioners and safety personnel when planning future safety campaigns, intervention strategies, or prevention efforts.

An examination of crash data in the 17-county oil region revealed that the total number of crashes, injuries, fatalities, PDO crashes, and the number of large trucks involved in crashes has increased substantially since 2004. Some crash patterns, such as the total number of large trucks involved in crashes, appear to be increasing at a rate comparable to that of an exponential growth curve. Moreover, every major crash statistic has seen a considerable spike, either in 2009 or 2011. This likely has a direct impact on driver views, attitudes, behaviors, and perceptions and may go hand-in-hand with why many drivers view roads in the oil region as being unsafe. Crash data reaffirm results obtained by the survey and validates that negative driving experiences reported by drivers are not just perceived, but are actually taking place on western North Dakota roadways.

It should be reiterated that not all individual counties within the oil region had worsening crash statistics from 2004 to 2013. This was more evident when normalizing data by 100 million vehicle miles traveled, per 100,000 population, or when using 2004 as a baseline year. Some counties showed moderate improvements between 2012 and 2013, and others showed crash rates that were beginning to curtail relative to crash rate growth in recent years. This may be the first sign of improved crash trends in the region, though it is still much too early to make this claim. Even with these moderate improvements, crash rates among North Dakota drivers are still higher in these 17 counties than in the rest of the state, especially when factoring for vehicle miles traveled and for population. For individual drivers in certain counties, it may be difficult to perceive that crash rates are improving when factoring for vehicle miles traveled and population growth as these metrics are difficult to assess by mere firsthand observation. Local residents may be more familiar with changes in numbers and volumes of crashes as they are more easily interpreted. This may explain why responses to the survey indicate that driving conditions are dangerous and worsening, even if they are improving moderately in individual counties when normalized by VMT and population.

Based on projections for continued oil drilling and extraction, the higher-density, industrial driving environment is expected to continue into the future. Therefore, rising VMT figures and a growing population base may continue for many years. In this projected scenario, even if crash rates remain stable, the total number of crashes will continue to rise. This may prolong the current trend of some crash types growing exponentially. Therefore, public safety efforts focused on traffic safety are necessary to slow and reverse current trends in crash injury and economic loss.

8. DISCUSSION

Future research can be improved by integrating more responses from specific groups into the survey. Although the survey was mailed to numerous residents in the 17 western North Dakota oil counties, responses varied greatly from county to county. Billings, Bowman, Burke, Divide, Dunn, Golden Valley, McHenry, Renville, and Slope counties all had fewer than 30 responses. Thus, the responses obtained from these areas could not be extrapolated to fit the rest of the population and should not be considered representative of the true sentiments and perceptions held by drivers from those respective counties. Similarly, there were not enough responses from the 18-24 year-old cohort to consider their responses as representative of the entire 18-24 year-old population in the oil region. Future research could benefit by intentionally over-sampling these groups in order to ensure that all demographics within the oil region are included. Moreover, focus groups with communities or businesses may be useful in gaining additional insight.

In addition, future research may benefit from integrating non-North Dakota residents into this survey through creel techniques or private company participation. The oil industry boom in western North Dakota has attracted temporary workers and businesses from Canada, Montana, South Dakota, eastern North Dakota, Minnesota, and other areas as well. Including non-western North Dakotans would provide an outside voice to better understand if perceptions of poor driving conditions are accurate across all residents or if they are simply a product of locals experiencing changing driving conditions firsthand.

While new insights may be gained with future driver contact, it seems prudent to expand or discuss alternative strategies for increasing travel safety in the oil region. Public health outreach using the *Code for the Road* platform may be one outlet for delivering the message, especially to target driver groups. Work with private companies in educating their workers about safe practices for maneuvering in traffic with increasing truck density may be another beneficial endeavor. If not already identified in the deployment, school and community events may also be strong venues for reaching young drivers with messages specific to oil region traffic safety issues such as how to safely interact with trucks.

Beyond the public awareness and education strategies, deterrence methods may be considered based on successful experiences elsewhere. For instance, traffic surcharges may be useful in discouraging risky driving behavior such as driving too fast, tailgating, and improper passing. Some jurisdictions have successfully instituted surcharges on existing traffic fees for moving violations. The surcharges collected are generally then dedicated to an associated cause such as emergency medical services or traumatic brain injury fund. An example is Douglas County, Colorado, where a Victim Assistance and Law Enforcement (VICE) surcharge is assessed on each traffic violation – Douglas County Ordinance 999-002 (Douglas County Sheriff 2012). If a driver is cited for three traffic violations on a citation, the assessment totals $30 with a surcharge of $10 applied for each violation. All surcharges collected are dispersed to local programs that provide services to crime victims. If one of the violations is speeding, an additional surcharge applies. The State of Colorado collects a $12 surcharge for each speeding citation. These funds are dedicated to the Colorado Traumatic Brain Injury Fund (U.S. Department of Health and Human Services 2006). In Texas, the Driver Responsibility Program is governed by the Texas Transportation Code, Chapter 708. An annual surcharge of $100 is assessed for three years following offenses such as impaired driving, driving with an invalid license, and driving without insurance. The Trauma Center and Texas General Revenue Funds receive 99% of the funds collected, 1% is provided to the Transportation Department for Program Administration (Texas Department of Public Safety 2012). Another example of the driver responsibility assessment is found in New York where anyone convicted of an alcohol or drug related traffic offense must pay $250 for three years (New York Department of Motor Vehicles 2012).

Operational solutions may also be discussed. Given that about three-quarters of drivers were willing to increase the distance driven to avoid trucks, passenger- or truck-only routes or one-way traffic may be useful in certain situations or during selected time intervals. Public education and awareness regarding this type of change would be crucial. In addition to operational interventions, increased use of roadway safety enhancements, such as clear zone, intersection lighting, edge lines, and rumble strips, could also be considered. The ability of counties to pool needs in contracting as a group or joining into a state services contract may accelerate these types of investments.

Finally, the ability of counties to share best practices and supplement efforts to manage heavy trucks in order to maintain roads in good condition may contribute to longer-term road safety. Road degradation, both on paved and gravel roads, is widespread. While enforcement efforts are led by the state, several counties have begun their own efforts. In North Dakota, state, county, and city law enforcement are presently working together to increase visibility for road maintenance and beyond. Sharing best practices and standards related to these efforts may be useful for those already engaged and for counties or locales that are considering similar strategies.

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