Evaluating the Impact of Mining and Construction Employment on Highway Crashes

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ABSTRACT

A comprehensive safety study is being preformed to compare crash statistics, human factors, roadway geometry, and safety features between Wyoming and North Dakota. Over the past ten years, the rate of fatal crashes in North Dakota has been approximately 30% less than the rate of fatal crashes in Wyoming. Because Wyoming and North Dakota are similar in terms of terrain, weather, motor vehicle miles traveled, and population, these two states initiated this study to attempt to determine the source behind the lower fatalities in North Dakota and apply those findings to Wyoming roadways. Some aspects being investigated in that study are: the level of enforcement, traffic safety laws, specific highway improvements, and miles of highway by functional classification. In the course of that study, it was found that North Dakota experienced a sharp gain in fatal crashes in 2009. It is thought that this is attributed to the increase in drilling and mining activities that have begun in the western part of the state over the past two years. Because Wyoming employment is very much dependent upon mining and drilling exploration and extraction, it is thought that the reason for the higher fatal crash number could be due to the number of migrant workers employed in these fields. This paper investigates the relationship between areas of employment and crashes in Wyoming.

Certain Wyoming counties were identified as having large amounts of mining and drilling activities while others have been selected because of low levels of employment in this industry. This study compares the employment rate in the fields of Mining and Construction to the number of Fatal, Injury, Serious, PDO, and Total crashes in Wyoming counties. This comparison shows that where there is high mining and construction related employment, there are a larger number of crashes. The findings in this paper also suggest that Wyoming is experiencing high fatality rates because of high employment in these areas. Using the results of this paper, Wyoming will be able to focus efforts for further safety initiatives.

KEYWORDS: employment, crashes, safety, construction, mining

INTRODUCTION

The comparative study between North Dakota and Wyoming was initiated because of the large difference fatal crashes between the two states. Wyoming and North Dakota are also considered part of the northern rocky mountain region, and have similar climates, roadway geometrics, populations, and geographies. From the time the study was started until the present, more crash information has become available, specifically for 2009, and this information revealed very different figures for fatal crashes in that year. North Dakota began experiencing more fatalities and an equal amount of fatal crashes than Wyoming for the first time since reliable records are available. Many reasons were speculated for this sharp change in trends, but the most relevant and believable explanation was the increase drilling activity in North Dakota that began in 2008. The addition of one drill site attracts over 2000 truck trips and cumulatively have resulted in a 600% increase in traffic in certain areas of northwestern North Dakota (Wetzel 2010). Figure 1 illustrates these crash numbers.

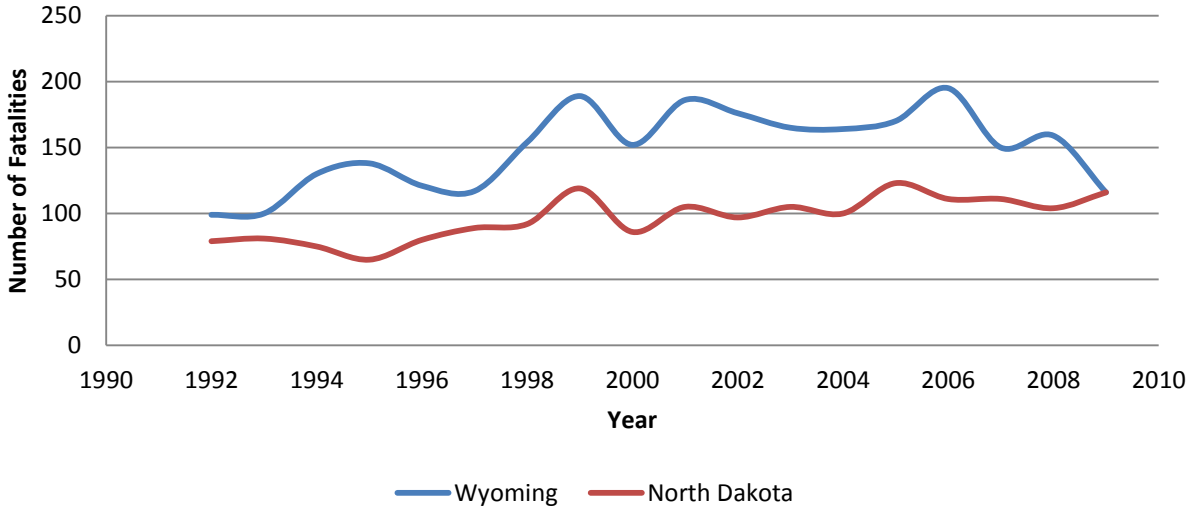

Figure 1 Wyoming and North Dakota fatalities

The purpose of the overarching study is to identify the source of higher fatalities in Wyoming and work to mitigate those fatal crashes. With the increase in fatal crashes was found in North Dakota and the determination the onset of the higher crash levels could be caused by increased drilling, this study was began to investigate this possibility. A closer look at fatality rates in the two states, normalized per 100 million vehicle miles of travel (MVMT) shows even more of a disparity in the trend. Wyoming experienced 1.43 fatalities per 100 MVMT while North Dakota has 1.76 fatalities per 100 MVMT up 28% from 2008. Figure 2 illustrates those trends compared to the national trend for 1998-2009.

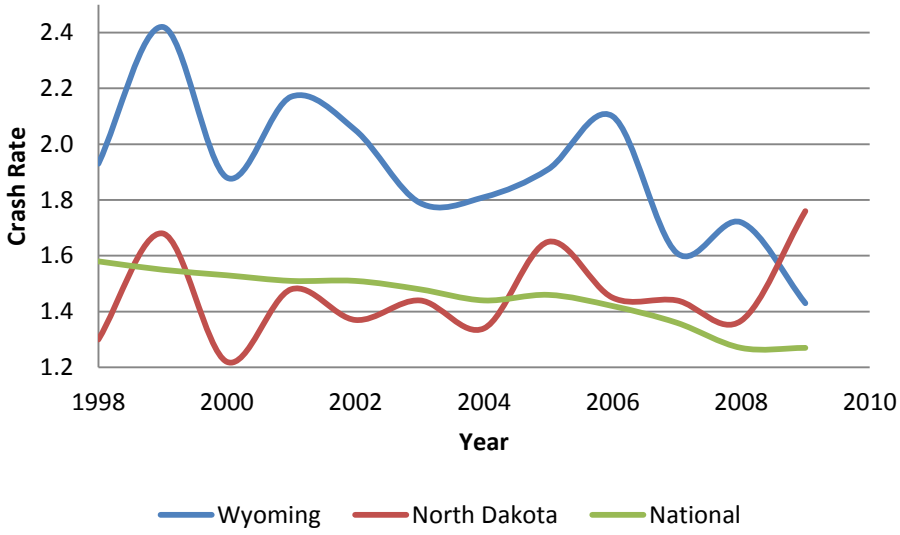

Figure 2 Fatality Rate per 100 Motor Vehicle Miles Traveled

Figure 3 illustrates the increase in employment for both construction and mining in North Dakota and Wyoming. The employment numbers have decreased in Wyoming over the past two years consistent with the number of fatalities in that state. In North Dakota the employment in both mining and construction has increased and this corresponds to the increase in fatalities in that state. The time period of 2001 through 2009 was selected because it provides for 4 years prior to and four years after the implementation of the 2005 strategic highway safety plan in Wyoming as well as that is the period in which the employment data is the most consistent and collected in a uniform manner.

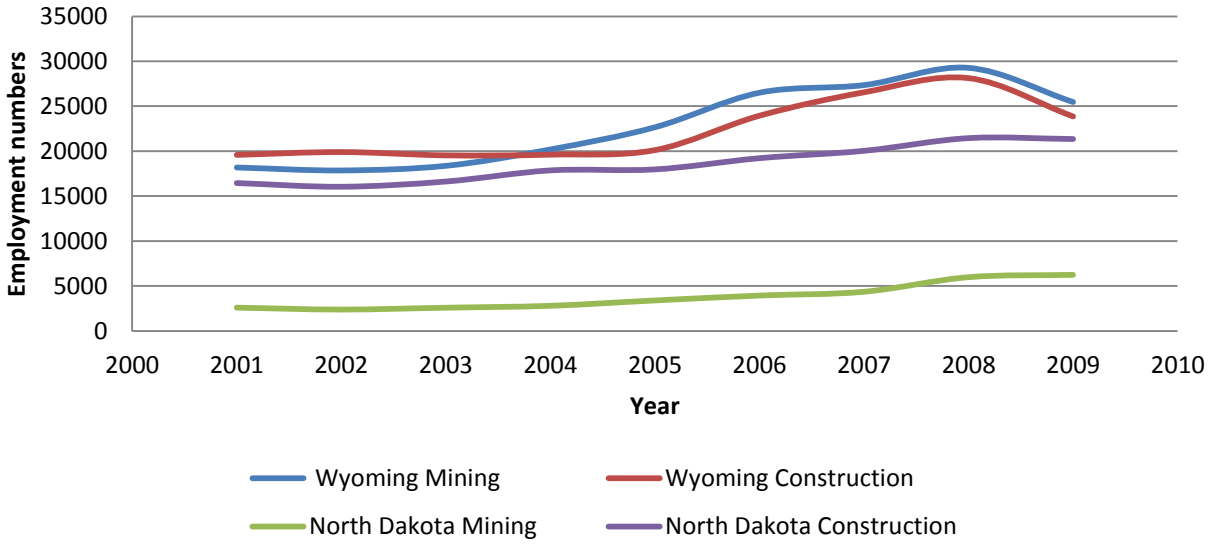

Figure 3 Wyoming and North Dakota Employment

With the safety study already being conducted and the effect of drilling on fatalities being so evident in North Dakota it was decided to include this as part of the study using Wyoming data. If a correlation could be found between the employments in certain fields and the amount of crashes in that area, new initiatives for education and safety should be implemented to mitigate this rise in crashes.

There have been minimal research studies evaluating the effect of employment in certain fields on highway crashes. Some work has been done using spatial modeling to determine land use and its effect on roadway safety. However, the literature is somewhat silent on the subject of employment in resource extraction related industries and its effects on regional crash rates. In Wyoming, the largest employing industry outside of local, state, and federal governments is the area classified as drilling and mining. The next largest employment group is construction which attracts workers from the same demographic profile. A brief look at fatal crashes in two counties show that the employment in those two industries statewide has risen 25 percent from 2002-2008. As can be seen in Table 1, the fatal crash trend from 2002-2008 has been decreasing in Laramie County, where there is little employment in the mining industry. The largest mining and extraction employing county in the state is Campbell County. Table 1 shows how Campbell County has seen an increase in fatal crashes of 70 percent in the same period. Wyoming statewide has experienced a decrease in total fatal crashes, while in counties where drilling and mining activities are taking place fatal crashes are increasing.

Table 1 Yearly fatal crashes in Wyoming

Year	Statewide	Laramie County*	Campbell County
2002	151	23	4
2003	141	6	9
2004	142	22	9
2005	147	13	6
2006	169	16	15
2007	136	7	13
2008	139	3	14

*Mining is not currently very large in Laramie County

The state of Wyoming is interested in determining if there is a difference in crashes in areas where employment in mining and construction is high. In this research, counties were identified as either having large amounts of resource extraction or as having little to no amount of mining. The counties with high levels of extraction are: Carbon, Campbell, Sublette, Natrona, and Sweetwater. Counties identified as having small amounts of mining are: Albany, Big Horn, Laramie, and Weston. The distinction between large and small amounts of employments was made when employment in the mining sector was over 1000 people on average per month.

OBJECTIVES

The main objective of this study is to determine whether or not employment in the fields of mining and/or construction has an effect on the crashes within the state of Wyoming.

DATA COLLECTION

Crash data was collected for the nine counties identified for the study from the Critical Analysis Reporting Environment (CARE) 9 database program. CARE 9 is a program used by the state of Wyoming to store, access, and sort crash data for every roadway within the state. Data was extracted for every quarter from January 2002 through December 2009. It was then sorted into three crash classifications: fatal, injury, and property damage only (PDO). Fatal and Injury crashes were later combined to make serious category which is simply the sum of the two. The data was further broken down into the Interstate Highway System and non-interstate or Other. The crashes were sorted by month initially. They were then aggregated into quarters similar to the employment data.

Employment data was collected from the Wyoming at work website which holds data for every industry called the "Wyoming Quarterly Census of Employment and Wages (QCEW)". This information was collected by quarter using the average monthly employment figure for the chosen county and year. This information was logged into a database which also held the crash data for that county and quarter. Employment figures were collected for the mining and construction categories as well as total employment within that county for the given quarter. Mining is the official term used for extraction of natural resources of any kind, including drilling for oil and natural gas as mining for coal and other minerals. Employment in both construction and mining is cyclical due to the weather in Wyoming, which is in contrast to crashes which is cyclical as well but is lowest in the summer where mining employment is largest in the summer. To remove this effect from the data, the employment and mining numbers were pooled on a yearly basis and there for weather impacts could be negated.

DATA ANALYSIS

The crash and employment data were combined in a comprehensive database for each quarter. Once the data set was complete, the amount of employment in each county was graphed against the number of crashes in each severity level to evaluate the relationship between the two variables. Figure 4 is one such graph that shows the employment in Campbell County which has the highest number of people employed in mining.

On the vertical axis is the total number of crashes in Campbell County while the horizontal axis is number of people employed in mining in that county. There is a data point for every quarter of each year within the study period of 2002-2009. As can be seen the interstate showed a low number of crashes as well as no trend or increase for the increased number of people employed in the mining field. It is suggested that this is because most interstates in Wyoming are used for through movements and not as access roads for people going to and from work in these areas. These fields use more local roads that are classified as non-interstate or Other. The Other category does show an increase in crashes with an increase in employment. Construction is not so different in the fact that it too shows an increase in crashes in the Other classifications. A graph of those trends can be seen in Figure 5.

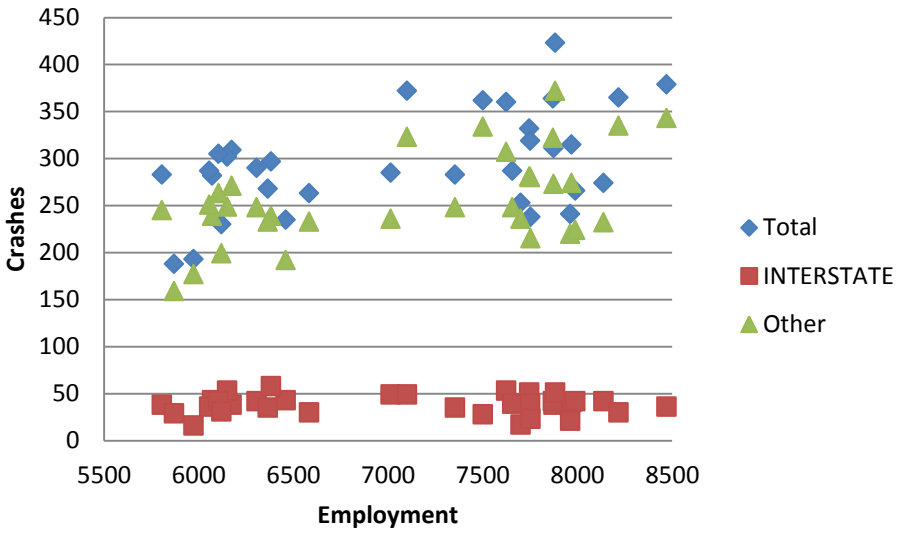

Figure 4 Mining employment vs. crashes in Campbell County

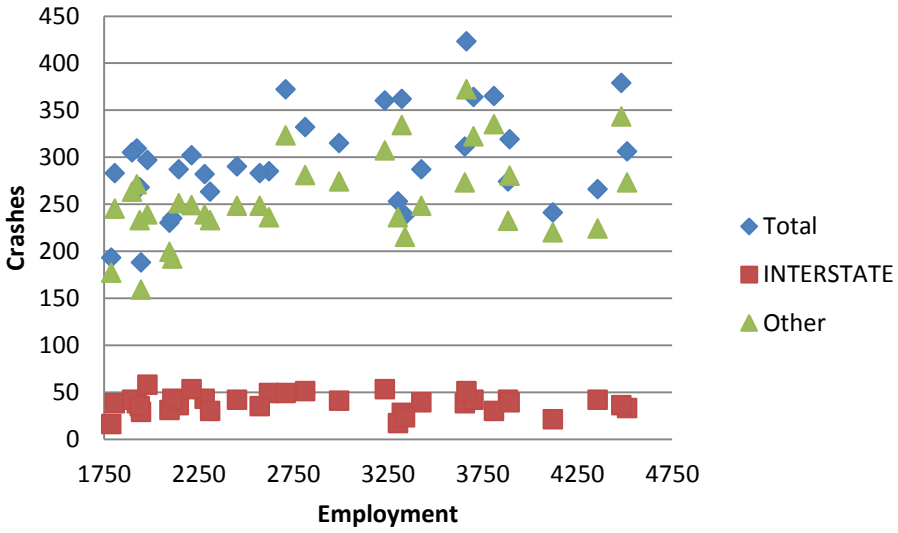

Figure 5 Construction employment vs. Crashes in Campbell County

Figure 5 shows that for construction employment there is an increase in crashes with an increase the number of persons employed in that category. As shown in Figure 6, in Carbon County, a trend in the crashes compared to number of people employed in mining is not evident. This is most likely due to the fact that there is never more than 475 people employed in the mining area over the eight year study period.

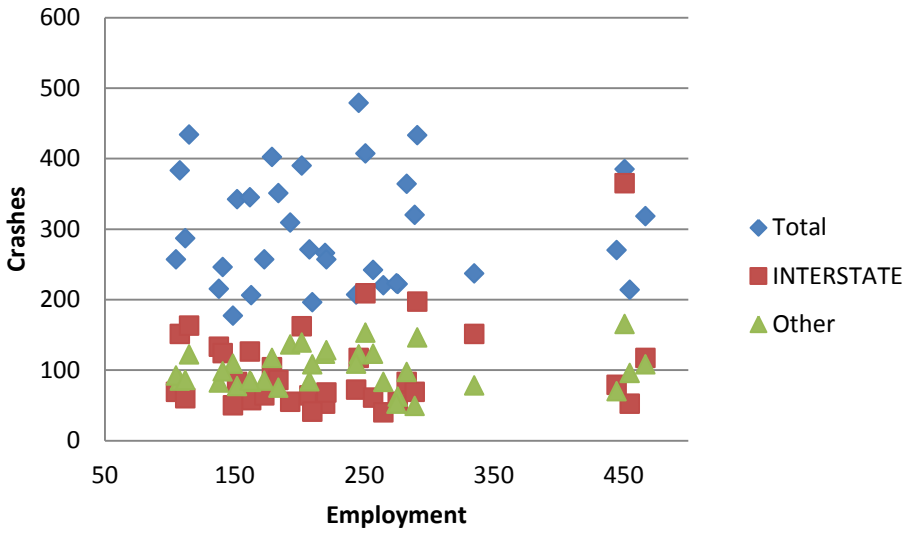

Figure 6 Mining employment vs. Crashes in Carbon County

Sweetwater County has high employment numbers in both construction and mining. As can be seen in Figure 7, there is an increase in crash numbers as the employment in construction increases. The interesting attribute about Sweetwater County is that as employment increase, the interstate crashes increase, which does not happen in many other counties.

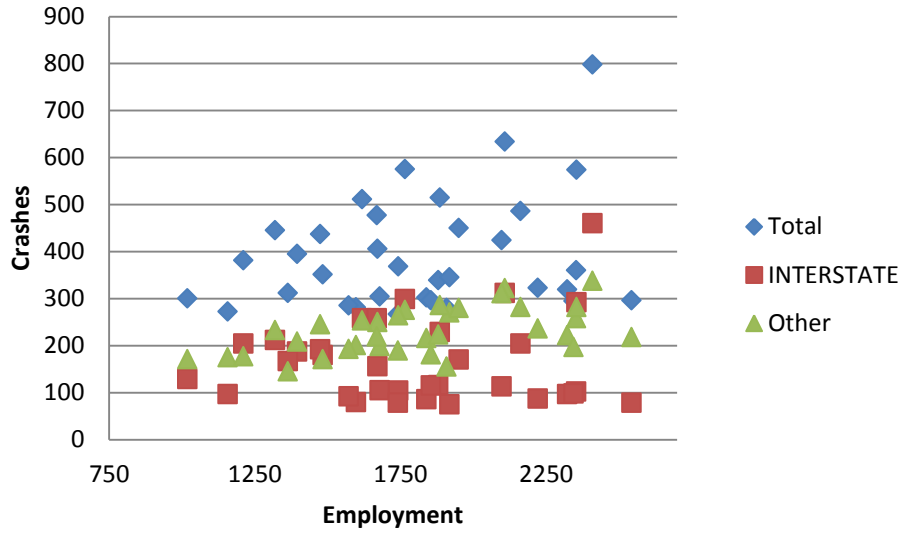

Figure 7 Construction employment vs. crashes in Sweetwater County

Data representation was similar for most counties. Only those counties with high employment numbers over five hundred in either mining or construction revealed of trends between the crash numbers and the employment rates.

The findings using the graphical method were an excellent initial step in determining if there was a relationship between employment levels and crashes. To more concretely establish whether or

not there is a relation between employment and crashes, it was decided to conduct a statistical t-test on the data from the counties included in this study.

Statistical T-Test

A statistical t-test is used to determine whether a sample is statistically different from another sample. This is helpful in this study because it could be used on separate parts of the same data set to determine if there was a difference on the data. The data for each county was sorted based on the number of people employed from smallest amount to largest amount. It was then split at the median employment value to produce two different samples from the same county. One set represented those data points with employment values less than the median and the second set represented those data points with employment figures higher than the median.

The t-test was then used on the crash numbers for the county to determine if the number of crashes in the set below the median was lower than the number of crashes in the set above the median. A test was completed for all crash types for both roadway classifications. The level of significance applied to this test was .05 and it was assumed that the variances were unequal.

Each sample was also graphed to show visually the difference in the means between the lower employment set and the higher. Figure 8 shows the mining crash means for all crash severities on both of the samples for Natrona County. The figure shows that the means for each of the crash severity categories is higher in the sample with higher employment than in the sample with lower mining employment. Note that the average number of fatalities in Natrona County was so low that it could not be represented on the current scale of the graph.

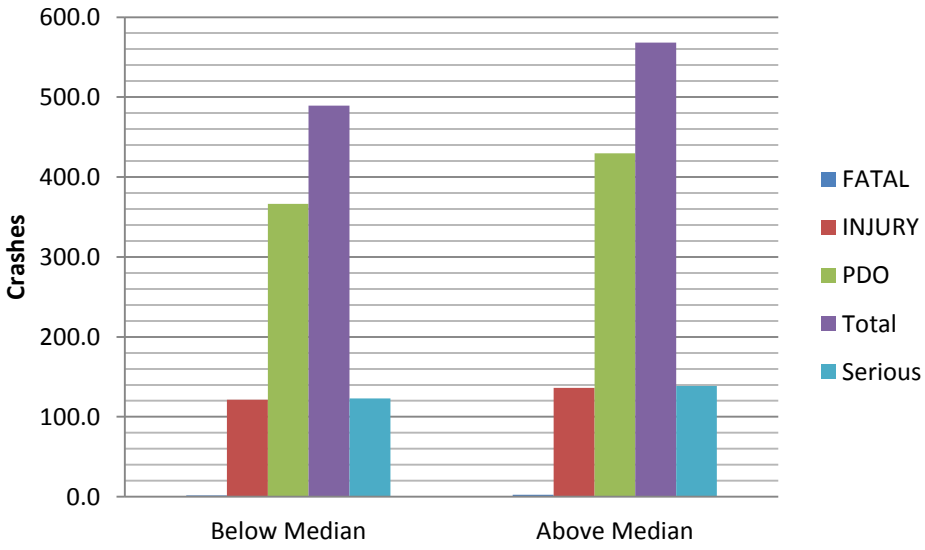

Figure 8 Sample means for Natrona County mining on non-interstate roadways

A similar graph was created for every county for both the interstate and non-interstate classifications as well as for mining and construction. All data for every county was also combined into a larger set and sorted around the median of the entire set. It is even more evident that when all of the data is combined that when the employment is higher, there is a larger number crashes in every category on average.

The results for construction employment were even more pronounced at the interstate and other classification level. Figures 9 and 10 show the total construction employment and the difference in the mean crashes for employment values above and below the median. For the other classification, the difference is so evident that one could conclude graphically that the two samples are significantly different and therefore more crashes happen on roadways in counties where employment construction is high.

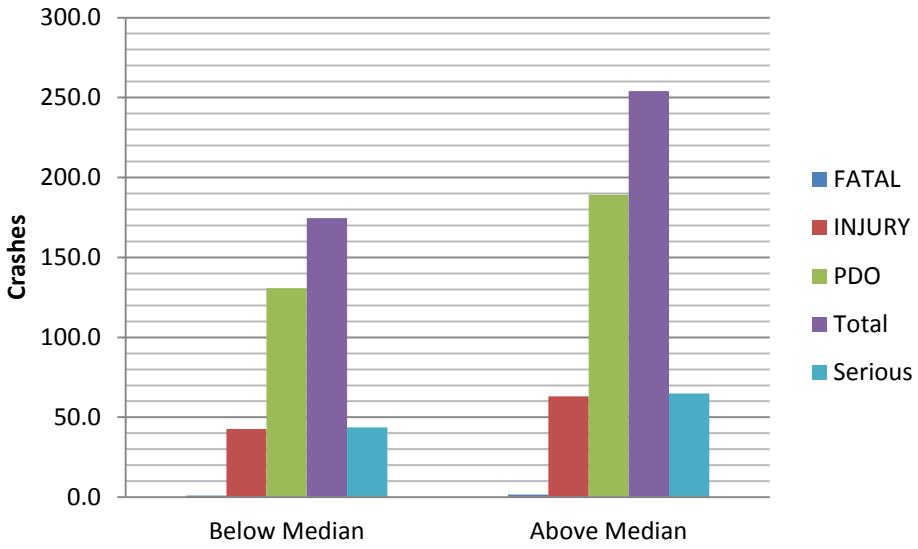

Figure 9 Sample means for entire study mining on non-interstate roadways

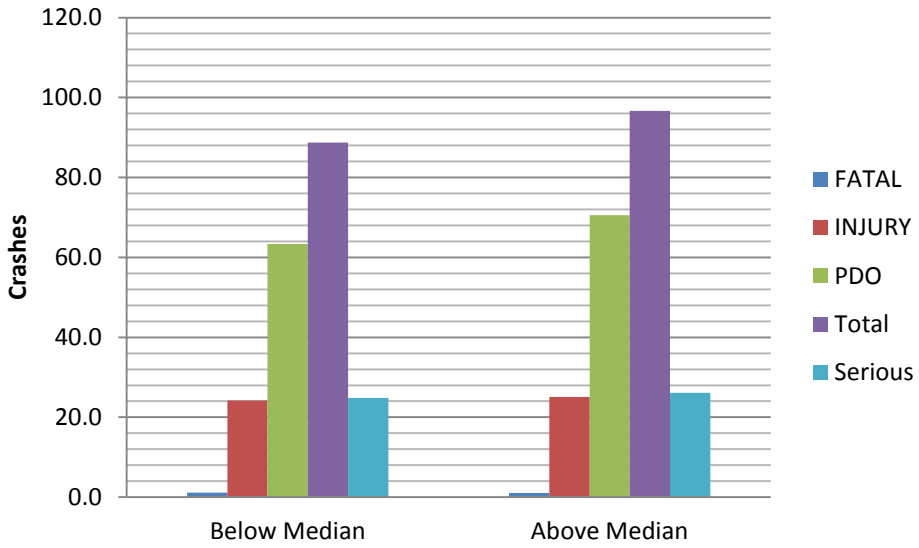

Figure 10 Sample means for entire study construction on interstate highways

Figure 11 is the most clear in showing that the average for the sample below the median employment is much lower than the average crash numbers for the sample above the median employment number. The average total crashes on all roads in the nine counties in the study below the median employment was 85 crashes while the average for data above the median employment was significantly higher at 343.

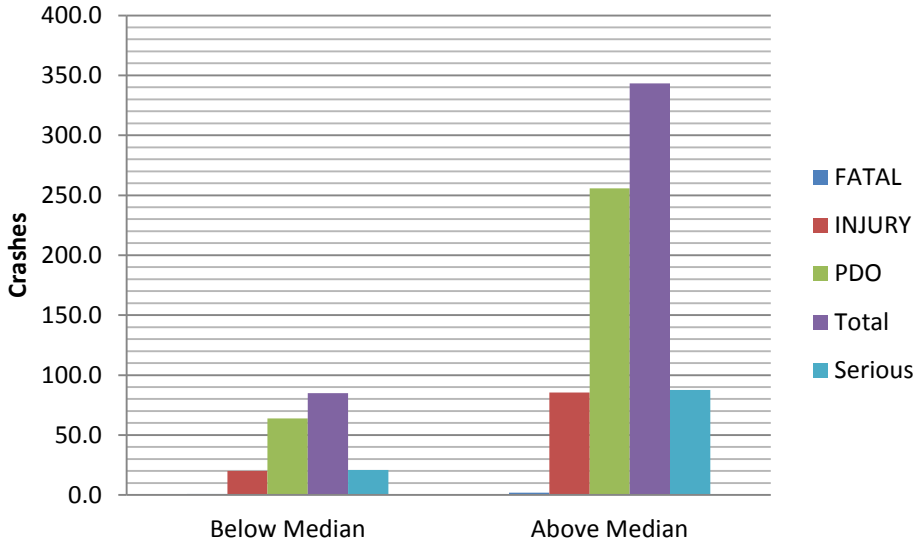

Figure 11 Sample means for entire study construction on non-interstate highways

The t-test is one method to quantify the difference between the two populations. If the t-test value is higher than .05, the two samples are considered the same. The two samples in this case are the crash data above and below the median employment level for each of the counties. Table 2 summarizes those values for each county for the different levels of crash severity. Some counties had no interstate roadways and therefore have no statistical information for crashes.

There are several values less than .05 in the non-interstate category. Notice that the values for all counties show that the information for every crash severity is statistically different. When analyzing the entire data set the counties with no mining employment were excluded. This is because they still had crashes but were included in the sample blow the median employment. It was just not applicable to include those counties in the overall test.

The data is sorted into the counties identified as having high levels of mining employment and this makes it even clearer that those counties are seeing more of an effect on their crashes from mining and drilling activities. Those values are represented in Table 2 as well. There is a significantly larger amount of statistically different crash values in the counties where there is more mining.

Similar results were found when the crashes were separated based on construction employment rather than mining employment. Interstate values were not as conclusive as those statistics from the non-interstate system, most likely because workers in this field use more local roads to get to and from there work rather than the larger roadways. Table 2 summarizes the T values for construction crashes in the counties studied. The counties are separated differently than mining because some counties considered low in mining employment are much higher in construction employment.

Table 2 T values for mining employment

Mining										
County	Interstate					Other				
	Total	PDO	Injury	Fatal	Serious	Total	PDO	Injury	Fatal	Serious
Albany	0.37	0.47	0.14	0.50	0.15	0.21	0.18	0.28	0.21	0.31
Big Horn						0.14	0.40	0.01	0.38	0.01
Laramie	0.33	0.50	0.09	0.29	0.09	0.17	0.14	0.48	0.18	0.49
Weston						0.10	0.32	0.04	0.31	0.04
Campbell	0.25	0.48	0.02	0.16	0.02	0.00	0.00	0.10	0.05	0.08
Carbon	0.26	0.18	0.35	0.21	0.33	0.27	0.16	0.20	0.27	0.22
Natrona	0.11	0.25	0.00	0.03	0.01	0.00	0.00	0.00	0.11	0.00
Sublette						0.31	0.32	0.34	0.35	0.48
Sweetwater	0.13	0.08	0.47	0.25	0.45	0.12	0.17	0.17	0.01	0.10
All counties	0.01	0.01	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.00

Table 3 T values for construction employment

Construction										
County	Interstate					Other				
	Total	PDO	Injury	Fatal	Serious	Total	PDO	Injury	Fatal	Serious
Albany	0.03	0.06	0.02	0.01	0.01	0.14	0.15	0.31	0.31	0.30
Big Horn						0.28	0.05	0.02	0.03	0.01
Sublette						0.07	0.09		0.20	0.91
Weston						0.94	0.22		0.05	0.12
Campbell	0.25	0.48	0.02	0.16	0.02	0.00	0.00	0.10	0.05	0.08
Carbon	0.22	0.16	0.49	0.21	0.47	0.03	0.02	0.29	0.38	0.28
Laramie	0.07	0.11	0.05	0.29	0.04	0.24	0.07	0.07	0.46	0.07
Natrona	0.11	0.08	0.31	0.21	0.34	0.18	0.28	0.04	0.22	0.04
Sweetwater	0.47	0.47	0.27	0.07	0.23	0.01	0.03	0.00	0.23	0.00
All Counties	0.16	0.13	0.34	0.39	0.27	0.00	0.00	0.00	0.00	0.00

It is clear from the t-test values that the majority of the counties have higher crash rates when mining and construction employment is high. It is even clearer when using all of the collected data that the data below the mean employment for all severities is different than the data above, especially using the mining employment.

CONCLUSIONS

There are many variables that can have an effect on the number of crashes in a region. Human, roadway, weather, and usage could all have different contributions to the amount and severity of crashes on a single roadway. This study investigates employment as a factor in crash numbers in several counties across the state of Wyoming. When employment in mining is increased in a county the number of crashes increase. This can be seen in Campbell County where mining and extraction employment is the highest and the t values for total, fatal, and PDO crashes are less than .05. The number of fatal crashes in that county has increased over the past eight years as has the mining employment.

Several other counties have shown the similar results. Natrona, a county rich in petroleum produced T values of 0.00 for all severities but fatal for non-interstate roadways. Interesting enough the same cannot be said for construction in the same county where only non-interstate injuries has a value less than 0.05.

It cannot be said that mining does not also have an effect on the crashes in other counties as well. It just cannot be proven using this method. It could be that the other counties have some other factors that are more prevalent and therefore masking the effect of mining employment. Weather could be the most limiting factor because when mining employment is high, weather is the most favorable for roadway conditions. When employment is down in the winter, weather creates the most roadway problems and therefore crashes go up.

Statewide fatal crash trends have been decreasing or remaining constant since 2000. Employment in mining and construction has been increasing over those years until 2007. This indicates that on a statewide level mining employment does not have an effect on roadway fatalities. However, in counties where mining is a prominent source of employment, crashes

have been increasing. This is further supported by the statistical analysis shown above. In those counties where mining is not increasing, neither are crashes.

The data does not suggest that only those employed in the mining or construction industry are the individuals in the crashes, just that in areas where these types of employments are high, so are the crashes. Any kind of economic growth brings in more workers, and therefore more families, this increase in people requires an increase in services. With new persons in the area as well as large amounts of development there is an increase of trips. It is this increase in activity that is contributing the higher crash rates.

It is more evident that construction employment has an effect on crashes. Figure 11 visually shows the difference in the mean crashes above and below the median. The T values are also well below 0.05 and suggest that the two samples are significantly different.

The data provides that in Wyoming there are more crashes in counties where there is more mining and construction. Wyoming has always had high levels of employment in these fields and therefor has not seen an increase but it also confirms why the crashes in Wyoming have been higher. With the increase in crashes in drilling in North Dakota, there has been an increase in crashes which directly relates to the results of this study.

RECOMMENDATIONS

Both mining and construction work can attract workers from other regions who are not familiar with the roads or the area. These two lines of work also regularly require those employed to be out on the roads traveling to and from job sites. These types of activities can lead to serious consequences for both the employer and the employee. A roadway crash, no matter the severity, is expensive and is sometimes preventable. It is recommended that the states of Wyoming and North Dakota take measures to mitigate the number of crashes where employment in these fields is significant.

The Occupation Safety & Health Administration (OSHA) has published a joint document in collaboration with the Network of Employers for Traffic Safety (NETS) and the National Highway and Traffic Safety Administration (NITSA) intended to insist employers to provide a safe and healthful workplace. This documents the costs to an employer of a work or non work related vehicle crashes and steps to decrease those crashes. (OSHA)

NETS outlines a 10 step program to minimize crash risk through managing, educating, and training not only employed drivers but all employees. The ten steps are:

1. Senior management commitment and employee involvement
2. Written policies and procedures
3. Driver agreements
4. Motor vehicle record checks
5. Crash reporting and investigation
6. Vehicle selection, maintenance, and inspection
7. Disciplinary action system
8. Reward/incentive program
9. Driver training/communication

10. Regulatory compliance

Details outlining these ten steps as well as employer related safety information can be found in the OSHA document *Guidelines for Employers to Reduce Motor Vehicle Crashes.* If employers in both mining and construction in Wyoming follow the recommendations outlined in that report, they will be able to decrease the likelihood of crashes and save money. (OSHA)

Education is the first step in decreasing crashes. If the states require employers to educate the workforce so that they know that by even commuting in these areas, crashes are more likely to occur, many workers would drive more cautiously which can hopefully reduce crashes. It is recommended that a safety program similar to the one described above be implemented to decrease the number of crashes, specifically fatalities in these states.

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REFERENCES

Kim, K., M. Brunner, and E. Yamashita. Influence of Land Use, Population, Employment, and Economic Activity on Accidents. In Transportation Research Record: Journal of the Transportation Research Board, No 1953, Transportation Research Board of the National Academies, Washington D.C., 2006

Guidelines for Employers to Reduce Motor Vehicle Crashes. *Occupational Safety and Health Administration - Home*. U.S. Department of Labor. Web. 24 Apr. 2011. <http://www.osha.gov/Publications/motor_vehicle_guide.html>.

Wyoming at Work. Wyoming Quarterly Census of Employment and Wages (QCEW). *Wyoming Department of Employment*. Web. 1 Mar. 2011. <http://doe.state.wy.us/lmi/toc_202.htm>.

Wyoming Highway Safety Analysis System, Care 9, Wyoming Crash Data. 2011

Wetzel, Dale. "$900 Million Needed for North Dakota Oil Patch Roads, Study Shows." *Fargo ND INFORUM*. Web. 6 Apr. 2011. <http://m.inforum.com/article.cfm?id=301277>.