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A Review of the Literature: Motor Vehicle Safety Initiatives in the Oil and Gas Extraction Industry

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Abstract

BACKGROUND: Motor vehicle crashes are the leading cause of death in the U.S. oil and gas extraction industry, resulting in approximately thirty worker fatalities every year. Many oil and gas extraction companies have developed comprehensive motor vehicle safety programs; some have described the impact of those programs at industry conferences, in industry magazines, or in trade journals. The purpose of this paper was to conduct a systematic review of the motor vehicle safety initiatives that have been published in this industry. This paper will summarize the reported effectiveness of these initiatives, identify the research gaps in the literature, and describe recommendations to enhance future motor vehicle safety research in the oil and gas extraction industry.

METHODS: To be included in this review, articles had to meet the following criteria: 1) available in an online database; 2) published during 1990-2012; 3) describe a motor vehicle safety initiative within an oil and gas extraction company; and 4) objectively measure the effectiveness of at least one component of a motor vehicle safety initiative.

RESULTS: The authors identified 38 articles that met the criteria above. Oil and gas extraction companies have employed a variety of interventions to improve motor vehicle safety among their workforce; the most common found in this review were in-vehicle monitoring, journey management, driver training and qualification, and driver fitness and alertness.

CONCLUSIONS: There is a need to improve the quality of research articles examining motor vehicle safety in the oil and gas extraction industry. The authors' systematic review found a limited number of published articles describing motor vehicle safety initiatives in the oil and gas extraction industry, particularly in the U.S. In addition, the articles often suffered from a weak study design and did not evaluate the long-term impact of their initiatives over time. There is a continued need for oil and gas extraction companies to evaluate the impact of their motor vehicle safety initiatives and publish their findings in peer-reviewed journals to enhance the dissemination of effective strategies.

Introduction

During 2003-2008, 648 oil and gas extraction workers were killed on the job, resulting in a fatality rate of 29.1 deaths per 100,000 workers – more than seven times the rate for all U.S. workers during the same time period (Retzer and Hill 2011). Motor vehicle crashes were the leading cause of death to oil and gas extraction workers during that time, comprising nearly one-third (n=190, 32%) of all fatalities. Many factors contribute to the risk of operating a motor vehicle in the oil and gas extraction industry,

including driving on rural roads that may lack safety features, the movement of large trucks and equipment, and long work hours (Retzer and Hill 2011) (CDC 2008). To help reduce motor vehicle fatalities globally, the International Association of Oil and Gas Producers (OGP) released a Land Transportation Safety Recommended Practice, Report #365, for the oil and gas exploration and production industry specifically (2005, updated 2011). It is based on best practices for the industry and provides tools to support implementation. The OGP recommendations advise that oil and gas operators address motor vehicle crash risk for their employees on and off of drilling sites. It also advises oil and gas operators to hold their contractors to the same high level of road safety performance. The OGP Recommended Practice contains recommendations for implementing motor vehicle safety practices in nine key areas: seatbelts, driver training and qualification, in vehicle monitoring systems, cellular telephones and two-way communication devices, journey management plans, driving under the influence, driver fitness and alertness, vehicle specifications and management systems. The extent to which these recommendations have been implemented in the U.S. is unknown.

The purpose of this paper was to conduct a systematic review of the motor vehicle safety initiatives in the oil and gas extraction industry and to summarize their reported effectiveness. The gaps in current research and recommendations to enhance future motor vehicle safety research in the oil and gas extraction industry will also be described.

Methods

The authors conducted a search using several online databases, including PubMed, SafetyLit, World of Knowledge and OnePetro for all articles published on motor vehicle safety initiatives in the oil and gas extraction industry worldwide during 1990-2012. Several combinations of search terms were used to identify potential articles, including ‘oil and gas’ or ‘oil’ or ‘gas’ or ‘petroleum’ along with the terms ‘motor vehicle’ or ‘vehicle’. Articles were only found in the OnePetro database; no relevant articles were found in any of the databases that include scientific journals. A total of 61 articles written in the English language were identified for potential inclusion in the review. However, to be included in the review, articles had to include a description of the effectiveness of a motor vehicle safety initiative by reporting at least one measure (e.g., change in the frequency or rate of motor vehicle crashes). Twenty-three of the articles did not evaluate the effectiveness of a motor vehicle safety initiative and were excluded. The remaining articles met all of our criteria and were included in this review.

The authors abstracted information from each article using a standardized data collection form. Each article was categorized by the type/s of motor vehicle safety intervention that was described in the paper. These interventions were categorized according to the nine key areas addressed in the OGP Recommended Practice. The authors developed tables to summarize the type and frequency of interventions and their reported effectiveness.

Results

The authors identified 38 articles that met the selection criteria. None of the articles were published in peer-reviewed, scientific journals; all of the articles were Society of Petroleum Engineers (SPE) numbered articles, written as a condition by SPE to present at one of their professional conferences. Half of the articles (n=19) were published by Schlumberger, followed by Halliburton and Chevron with four and three articles, respectively. Multiple articles were published on initiatives in the Middle East, Latin America, and Africa. Several articles reported on results of global initiatives. Only five (13%) of the articles described a motor vehicle safety initiative based in the United States.

Table 1 categorizes each article by intervention type. More than half of initiatives included more than type of intervention (n=22, 58%). The most common types of interventions reported were in-vehicle monitoring systems (n=20), followed by journey management (n=19) and driver training and qualification (n=18). Appendix A provides a description of the most frequent intervention types found in this review. The least common types of interventions reported addressed seatbelt use (n=6), driver fitness and alertness (n=6), and distracted driving (n=5).

Most articles reported the results of a motor vehicle safety initiative by tracking selected measures both before and after interventions were implemented (n=34, 89%). Only two articles used a comparison group (or control group) to evaluate the impact of a motor vehicle safety initiative. There were many different types of measures that were used to report the results (Table 2). Outcome measures (also known as ‘lagging’ indicators) that were reported included the number and rate of motor vehicle crashes and fatalities, costs associated with motor vehicle incidents, the number and rate of lost time incidents, the rollover incident rate, the number of Department of Transportation (DOT) recordable accidents, and the number of fatigue-related incidents. Impact measures (also known as ‘leading’ indicators) reported included speeding, harsh braking and acceleration, number of night

journeys, seatbelt violations, driver 'out of service' rate, and non-compliance with company policy. Process measures reported included the number of journeys tracked and the number of behavioral-based observations conducted. All of the articles reported some degree of success as a result of the initiative.

Conclusions and Recommendations

There is a need to conduct more rigorous evaluation on motor vehicle safety initiatives in the oil and gas extraction industry. This review found several oil and gas extraction companies that have implemented and evaluated interventions to improve motor vehicle safety. The articles that have been published suffer from several limitations. First, few of the articles reported using a comparison group in the research. A comparison group would help researchers better understand the impact of an intervention by allowing comparison of results between two groups of workers: 1) the group that received the intervention, and 2) the group that did not receive the intervention. Consideration should be given to making the two groups as similar as possible with regards to factors such as age, experience, job duties, and training to ensure that any differences detected between the groups is a result of the intervention rather than other factors. Second, many of the articles evaluate the effect of multiple interventions, which makes it difficult to ascertain the effectiveness of any single type of intervention. Researchers can help address this by: 1) implementing only one intervention at a time, or 2) implementing interventions among different groups of workers so that not all groups of workers receive the same combination of interventions (similar to comparison groups).

This review also found weaknesses in the methods used to evaluate motor vehicle safety initiatives. Few of the articles evaluated the impact of motor vehicle safety initiatives over time to identify trends. Longer-term evaluation of initiatives is necessary to adequately assess trends over time. Similarly, many articles did report on the effectiveness of an initiative by describing a reduction in the number of motor vehicle fatalities (instead of a rate). There are a few limitations with using solely this measure. First, typically the number of fatalities is small, and therefore a reduction in the number (e.g., from 3 deaths to 1 death) may make it difficult to attribute a decrease to the initiative instead of random fluctuations or a downturn in operations. Using a measure which may have a larger number of incidents would be more useful, such as all motor vehicle crashes. Secondly, evaluating a change in motor vehicle crash rates (e.g., crashes per million miles driven) will account for any changes in miles driven over time, as well as differences in miles driven between the business units being evaluated. Tracking the number of crashes by miles driven is preferred to tracking crashes by number of drivers, as the number of miles driven per driver may vary. The use of exposure-based measures is supported by the OGP Recommended Practice, which advocates the use of motor vehicle crash rates (# of crashes/million kilometers driven) in four severity categories: catastrophic, major, serious, and light.

All of the articles examined showed positive results. This suggests that companies that have implemented motor vehicle safety initiatives, but were not able to demonstrate an improvement in driving safety, did not publish their findings. Reports of initiatives that failed to reach their desired outcome (or were not able to objectively measure any change in their desired outcome) are not commonly found in peer-reviewed scientific journals. However, making this information available to other researchers will help them understand why a particular intervention may have failed and will help other safety and health professionals who may attempt to implement a similar initiative at their company.

Finally, this review found that the majority of articles focused on motor vehicle safety initiatives from large companies and on operations outside the U.S. More research and scientific publications describing U.S. motor vehicle safety initiatives in the oil and gas extraction industry are needed. Workers in small and medium sized establishments (<100 workers) have been found to be at higher risk of fatality than those workers from large establishments (>100 workers) (Hill et al. 2009). In an environment of scarce resources and limited safety personnel, it would be useful for more publications to be available from smaller companies that can share the practices that work for them. Lastly, the lack of initiatives to improve seatbelt use (just six articles described interventions to increase seatbelt use) is concerning given that previous NIOSH work found that at least half of all fatally injured oil and gas extraction drivers were not wearing a seatbelt at the time of their crash (Retzer and Hill, 2011). The industry could benefit from more scientific research focused on improving seatbelt use among oil and gas extraction workers.

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Tables

Table 1. Frequency of Motor Vehicle Safety Interventions in the Oil and Gas Extraction Industry, 1990-2012

Year	Authors	In-vehicle Monitoring Systems	Journey Management	Driver Training and Qualification	Management Systems	Driver Fitness and Alertness	Seatbelts	Distracted Driving	Other
1994	Ritchie and Greene		x						
1998	Cocianni and Taviansky	x							
2000	Twilhaar et al.	x		x					rewards based on drivers' score from IVMS
2000	McKay et al.	x	x	x	x		x		
2002	Tan and Sany			x	x				
2002	Silverstone	x	x	x			x		
2002	Torifio		x	x	x				
2002	Jutten et al.	x	x	x			x		
2004	Tate	x	x	x	x	x	x		convoy procedures, incident reporting system, resource web page
2004	Speer			x	x				
2004	O'Regan and Ikerodah	x							
2004	Baltz et al.			x	x				guidance documents, policies, tools; network of experts
2004	Campbell and Tate								road hazard analysis
2004	Meade and Tate		x	x					
2004	Brandsness and Sealy			x					
2004	Ballard et al.	x							
2005	Kazmi et al.	x							
2006	Karowich et al.	x	x	x		x	x	x	800 number for public, roll bars, studded tires
2006	Lopez et al.	x	x		x				risk based driving improvements

2006	Matusalen et al.	x	x	x	x			x	road improvements
2007	Odunmbaku and Obarewon	x		x					
2007	Chedsey et al.		x	x					
2007	Dhitivara	x		x	x	x			partnerships, road and fleet improvements
2008	O'Connell	x							
2008	Allison et al.		x						vehicle tracking system
2008	Al Kurdi et al.	x	x		x				
2008	Meade et al.			x					
2008	Heinzmann et al.					x			
2010	Velazquez et al.		x						
2010	Allison and Frasineanu		x	x	x		x	x	random alcohol testing
2010	Allen and Fee	x	x						
2010	Denkl and Cocianni		x						
2010	Akhmetov et al.					x		x	communication campaign via web, presentations, posters, etc.
2010	Mora et al.	x	x						
2010	Camargo et al.					x			
2010	Pelly and Pillai							x	passenger observation cards
2011	Gale et al.	x							
2012	Lopez and Zidan	x	x		x				
	Frequency	**20**	**19**	**18**	**12**	**6**	**6**	**5**	

Table 2. Summary of Reported Results of Oil and Gas Extraction Motor Vehicle Safety Initiatives, 1990-2012

Author(s) and Year	Title	Measure 1	Measure 2	Measure 3
Ritchie and Greene (1994)	Journey management: a structured approach to reducing accidents	Auto Accident Rate (AAR) decreased from 48 to 5 per 1000 drivers (90%) over 3 years	Accident costs decreased from $90K to $50K with increased miles driven over 3 years	Saving from journey management was $375K after 3 years
Cocianni and Taviansky (1998)	Driving monitor, another spanner in a manger's toolbox for safety management	Serious MV accidents decreased from 8 in 1995 to 0 in 1997 (100%)	Max speed, time over speed limit, distance, harsh decelerations and accelerations-'downward trend over time'.	
Twilhaar et al. (2000)	Making in-vehicle monitoring systems work	Average speed 55km at baseline and 52km at 12 weeks (5%)	Avg. km traveled 550 per week at baseline and 375 at 12 weeks	
Mckay et al. (2000)	Driving: a systematic approach and culture change yield improving results	Fatalities decreased from 6 in 1997 to 3 in 1999 (50%)		
Tan and Sany (2002)	Road transport safety management-a successful transformation journey	Preventable fatal accidents decreased from 7 in 1997 to 2 in 2000 (71%)		
Silverstone (2002)	Assessing the effectiveness of a corporate driving safety program by studying the correlation between frequency and severity of motor vehicle accidents and compliance with corporate policy	Increased percentage of noncompliance with company policies was correlated to increased accident severity		
Torifio (2002)	Journey management in Colombia	Recordable vehicle accident rate decreased from 23.35 in 1997 to 1.88 in 2001 (92%)		
Jutten et al. (2002)	Working toward zero automotive accidents in the Niger Delta	Number of accidents decreased from 14 in 1998 to 2 in 2001 (86%)	Crash rate per 1,000 vehicles decreased from 44.7 in 1998 to 9.7 in 2001 (78%)	
Tate (2004)	Building a global driving program that delivers superior results	Company/contractor incidents per 1,000 drivers decreased from 15.6 in 1998 to 6.3 in 2003 (60%)		
Speer (2004)	A multifaceted approach to reducing driving incidents	Fatalities decreased from 3 in 2001 to 2 in 2002 (33%)	Days away from work decreased from 13 in 2001 to 8 in 2002 (38%)	

O'Regan and Ikerodah (2004)	IVMS-behind the scenes, making it work	Driving fatalities decreased from 7 in 1999 to 2 in 2002 (71%)		
Baltz et al. (2004)	Motor vehicle safety: a comprehensive approach to complex problem	Number of fatal crashes decreased from 23 in 2001 to 8 in 2003	Number of fatalities decreased from 30 in 2001 to 9 in 2003	Crash rate decreased from 5 to 2.5 (50%)
Campbell and Tate (2004)	Reducing vehicular incidents with a road hazard analysis	Incidents per million km for 1 quarter in 2003 was 0 ; comparison location was 11.2 in 2002		
Meade and Tate (2004)	Specialized driver training: elevation defensive driving from a simple awareness to a proactive, crash-free reality	MV accident rate decreased from 19.1 in 2001 to 11.2 in 2002 (41%)		
Brandsness and Sealy (2004)	Drive-through driver training	Vehicle incident rate per 1,000 drivers decreased from 27 in 2000 to 8 in 2003 (70%)	Vehicle rollover incident rate per million miles driver decreased from .3 to .11 (63%)	
Ballard et al. (2004)	Driver monitors: improving transportation safety and enhancing performance through behavioral change	Out of service rate decreased from 28% in 2000 to 12% in 2003	Driver out of service rate decreased from 8% in 2000 to 2% in 2003	
Kazmi et al. (2005)	Vehicle data recorders for addressing “driving behavior”	Over-speed time decreased from >350 minutes in 2001 to 0 in 2005 (100%)	Road incidents decreased from 31 in 2001 to 4 in 2004	Cost savings of $2200/month, maintenance costs decreased 30%
Karowich et al. (2006)	Creating a culture of safe driving behaviors	Vehicle incident rate per million miles decreased from 2.58 to 0.58 (78%)	Behavioral based observations from 96 in 2004 to 291 in 2005	
Lopez et al. (2006)	Risk-based driving improvement plan (beyond traditional approaches)	Driver performance score (top speed plus harsh accelerations and decelerations) decreased from 1.75 in Qtr. 1 of 2004 to 0.9 in Qtr. 1 of 2005. (49%)	AAR for all types of events decreased from 30 in Qtr. 1 of 2004 to 12 in Qtr. 4 of 2005. (60%)	Losses decreased from $59K in 2004 to $8K in 2005
Matusalen et al. (2006)	Development of a successful motor vehicle safety process for western Venezuela	Number of crashes decreased from 58 in 2000 to 12 in 2005	Number of in-field infractions decreased from 91% in 2000 to 24% in 2005	
Odunmbaku and Obarewon (2007)	Reducing road traffic fatalities through driver education: a major oil-producing company’s approach	Serious MV accident rate decreased from 23 per 1000 in 2004 to 10 in 2005 (57%)		

Chedsey et al. (2007)	Focused Oilfield-Specific Training Reduces Accident Costs by nearly 10 Times	Average cost of accidents decreased from $5,250 in 2005 to $2,200 in 2006 for a new driver (58%); From $101,450 in 2005 to $28,700 in 2006 for existing driver (72%)	Number of preventable accidents for new drivers increased from 4 in 2005 to 5 in 2006 for new drivers (25%); and decreased from 11 in 2005 to 10 in 2006 for existing drivers (9%)	DOT reportable accidents increased from 0 in 2005 to 1 in 2006 for new drivers; and decreased from 3 in 2005 to 1 in 2006 for existing drivers
Dhitivara (2007)	Land transport safety management practice of crude evacuation, greater s1 assets, PTT E&P	Motor vehicle fatalities decreased from 5 during 1998-2002 to 1 during 2003-2006		
O'Connell (2008)	Driving monitors-the ultimate behavior based safety tool?	% of contractor drivers with green (good) driver score increased from 70% to 90%; yellow decreased from 25% to 1%.		
Allison et al. (2008)	Real time journey management	Number of reported journeys increased from 0 in October 2006 to approximately 4,300 in September 2007		
Al Kurdi et al. (2008)	Improving Road Safety in Corporate Fleet Settings—Engaging Technology, People, Government Organizations (Police) and Non-Government Organizations (NGOs)	Motor vehicle fatalities decreased from 3 in 2004 to 0 in years 2005-2007.	"Sizable decrease" in speeding and no seatbelt violations	
Meade et al. (2008)	The evolution of a driving simulator program	Annual MV crash rate decreased from 0.6 in 2006 to 0.2 in 2007 (67%)		
Heinzmann et al. (2008)	Using technology to eliminate drowsy driving	Only 1 out of 5 vehicles were not tampered with. 3 Microsleeps detected in driver and 46 false microsleeps detected.		
Velazquez et al. (2010)	Online journey management system	Annual vehicle incident rate decreased from 2.1 in 2001 to .6 in 2009 (71%)	night journeys reduced 30% between 2004 and 2009	300,000 journeys total have been tracked
Allison and Frasineanu (2010)	How the OGP land transportation safety recommended practices led company to significantly reduce fatalities in just 18 months	Number of motor vehicle fatalities decreased from 5 in January-October of 2008 and 0 after intervention		
Allen and Fee (2010)	Driving to real-time compliance in land transport	Number of Catastrophic, Major or Serious crashes decreased from 15 in		

		2007 to 4 in 2009 (73%).		
Denkl and Cocianni (2010)	Electronic journey management- a web based approach to journey management	50,000 journeys were logged into system in 7 month period.		
Akhmetov, et al. (2010)	“Lives in my hands”-a driving safety campaign for transport contractors	There was a 30% reduction in the motor vehicle crash rate between 2008-2009.		
Mora et al. (2010)	Vehicular gprs and journey management system in Latin America	Lost Time Incident rate decreased from 2.41 in 1997 to 0.18 in 2009 (92%)	Recordable vehicle accident rate decreased from 9.39 in 1997 to 0.63 in 2009 (93%)	Safety interventions increased from 307 in 1997 to 2884 in 2009 (839%)
Camargo et al. (2010)	Implementing driving fatigue management in oil and gas operations in Brazil	Percent of accidents that are fatigue related decreased from 35% in 2008 to 9% in 2009		
Pelly and Pillai (2010)	Behaviour based safety behind the wheel	Number of driving observations increased from 600 in Qtr. 1 of 2009 to 950 in Qtr. Of 2010. (58%)		
Gale et al. (2011)	Case study: successful implementation of driving safety and IVMS program	MV incident rates decreased by 49%	Speeding decreased by 50%	Harsh accelerations decreased from 1.0 to 0.4 (60%) and harsh decelerations decreased from 2.3 to 1.5 (35%).
Lopez and Zidan (2012)	Step change in driving performance: a case study	Number of accidents decreased from 23 in 2010 to 15 in 2011 (35%)	Number of rollovers decreased from 18 in 2010 to 5 in 2011 (72%)	

Appendix A: Description of the most common motor vehicle safety interventions identified in the review, 1990-2012.

Intervention Type	Description
In-Vehicle Monitoring Systems (IVMS)	In-Vehicle Monitoring Systems refer to electronic devices that record data such as date, time, speed, acceleration, deceleration, and safety belt use of a driver/vehicle. IVMS measures driver performance against a predetermined set of parameters. IVMS can be used to track a wide variety of indicators; the most common are speeding events, and harsh accelerations and decelerations. Other common indicators include driver rest times or off-duty time periods and well site working times. Companies may also use IVMS to track indicators for purposes other than safety, including vehicle movement outside of location limits, fuel consumption and idling time.
Journey Management (JM)	The key objective of a journey management initiative is to minimize unnecessary trips and distances driven and to minimize the risks associated with necessary trips. A general risk assessment conducted prior to a trip as a part of JM procedures includes an assessment of the driver, the vehicle type, roads to be traveled, weather, time of day and distance. The assessment of the driver commonly includes a verification of minimum qualifications for the journey, hours of sleep and hours of service. The assessment of the vehicle commonly includes a verification that the appropriate vehicle is selected for the journey and a pre-trip vehicle inspection was completed. Road hazard assessments are commonly completed on main routes and are subsequently reviewed prior to each trip.
Driver Training and Qualification	Driver training and qualification activities may be conducted in the classroom as well as hands-on training at the wheel. Training is commonly focused on defensive driving, although night driving, winter driving, and pre-trip vehicle inspection are also used. In some cases, driving simulators may be used for more extensive training. Commentary drives, or 'ride-along' with an experienced driver, where feedback is given and the driver explains his driving actions verbally is another training tool. Refresher training is important; many companies require that a driver repeat driver training on an ongoing basis and whenever an employee is required to drive a different type of vehicle.
Management Systems	Management systems include company policies that address motor vehicle safety. Elements of these policies may include mandatory seatbelt use, a prohibition on cell phone use while driving, electronic monitoring (IVMS), journey management, driver training, and zero tolerance of substance abuse. A policy describing both rewards and penalties for violations is also part of the management system. Some of the rewards included financial incentives. Other oversight activities include vehicle inspections of company and contractor vehicles, and an accident review committee that conducts root cause analysis of motor vehicle crashes.
Driver Fitness and Alertness	Driver fitness and alertness is generally assessed via medical exams to ensure fitness of the driver prior to driving. These exams typically include vision tests and physical exams. Interventions to promote driver alertness and manage fatigue may include management commitment and leadership workshops, contracting of hotels in strategic locations, preparation of night driving maps, the transfer of night driving approval from local to regional level, introduction of a pre-job fatigue evaluation process, and enforcement of journey management policies, which may include a driver rest evaluation, fatigue management awareness training for all employees, and the tracking of behavior change through observations and interventions.

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