Public Health Model of Injury Prevention: Practical Application in the Environmental Drilling Industry

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Abstract

According to the Bureau of Labor Statistics (BLS) the environmental water well drilling industry averaged 10 fatalities per year between 1990 and 1997. Recent BLS data suggests that similar statistics are true today. Current industry health and safety practices include Risk Assessment and Risk Management. These practices lack much of the research and data required to design and implement successful injury prevention strategies. The Public Health Model of Injury Prevention (PHMIP) is a tool which, when used appropriately, creates effective injury prevention strategies which can be implemented on an industry-wide basis. The PHMIP can be used alongside existing health and safety practices in the environmental drilling industry to greatly reduce the number of fatal and nonfatal injuries that occur. Components of the model include Surveillance, Risk Factor Identification, Intervention Development and Evaluation, and Implementation. It is critical that all four components be implemented as they must work together to create successful injury prevention strategies. Limitations to the model exist and should be taken into consideration during its application. One limitation is that the model relies on data from injuries that have already occurred. Would it not be better to prevent these injuries from ever occurring? Another problem is the cost of collecting and analyzing data as well as designing and implementing certain injury prevention strategies. Careful budgetary review should be conducted prior to implementing the model. Additionally, organizational management may present some barriers to using the model. There needs to be complete buy-in from management or injury prevention
efforts will fail at the workers level. A review of literature indicates that the PHMIP is being used sporadically across the industry however wider and more consistent application is necessary to achieve measurable results in injury prevention. Wider dissemination of information on the PHMIP will serve to increase awareness amongst industry leaders and foster dialogue that will stimulate further interest in proactively preventing injuries in the drilling industry.
Introduction

According to the Bureau of Labor Statistics (BLS) the environmental water well drilling industry averaged 10 fatalities per year between 1990 and 1997. Recent BLS data suggests that similar statistics are true today. This is a fairly significant number when you consider that the construction industry, under which they are categorized, accounts for only 5% of the total labor force in America (Matetic RJ, 1999). Based on statistics gathered by the BLS from 1992 to 2002, electrocution was the leading cause of on-the-job death for water well drillers (Matetic & Ingram, 2001). Other nonfatal recordable injuries included hearing loss, hand injuries, back injuries and slip-trip-fall injuries.

The Environmental Remediation Drilling Safety Guidelines (ERDS guide), 2005 (AntiEntropics, 2005), were developed to summarize some of the best available drilling safety knowledge in the remediation industry. One of the four goals of the guide is to assist in preventing losses due to injury to workers. According to the National Institute for Occupational Safety and Health (NIOSH), multiple factors and risks contribute to injuries to workers, such as hazardous exposures, workplace and process design, work organization and environment, economics, and other social factors (NORA Traumatic Injury Team, 1998). The ERDS guide seeks to address and mitigate the most common safety concerns that arise from the risks outlined above.

The Public Health Model of Injury Prevention (PHMIP) recognizes that in order to prevent injuries, we must first understand their causes. The Public Health approach to injury begins with a series of questions which, when
answered, provide a complete picture of injury causing events that can be better understood, predicted and often prevented altogether. There are some variances to the PHMIP such as the State and Territorial Injury Prevention Directors Association (STIPDA) model for a State Injury Prevention Program (Appendix A) (STIPDA, 2003), however, it generally consists of four core components which work together to create effective injury prevention programs.

This paper looks at current injury prevention practices in the environmental drilling industry as well as how and where the PHMIP might supplement those practices to further prevent injury amongst drillers. It examines to what, if any, extent the PHMIP is currently being applied and suggests methods through which organizations can seamlessly integrate the model into their existing health and safety programs. Also discussed are some of the limitations to implementing the PHMIP in the environmental drilling industry.

**Risk Assessment and Management**

Current injury prevention practices in the environmental drilling industry have been established to ensure worker safety on the job. The establishment of these safety practices stems from organizational safety plans and lessons learned as well as Risk assessment and Risk Management techniques. Risk Assessment is the process of quantifying the probability of a harmful effect to individuals or populations from certain hazards or hazardous activities. Risk Management is activity directed towards the assessing, mitigating (to an acceptable level) and monitoring of these hazards. Risk Assessment and Risk
Management form an integral part of any good health and safety management plan.

**Risk Assessment**

Risk assessments in environmental remediation drilling seek to characterize the nature and magnitude of risks (risk characterization) related to the drilling and direct push methods of intrusive subsurface activities involved in environmental remediation (AntiEntropics, 2005). Studies have previously been conducted on the risks associated with environmental drilling (Matetic RJ, 1999). Two methods of assessing the risks of injury on the job include identifying hazards and analyzing hazards.

- **Hazard Identification (HI)**

  During the HI process, an attempt is made to identify actual and potential hazards associated with completing the scope of work. As part of the hazard identification process, the likelihood of occurrence and potential severity of each hazard will be assessed, for the purpose of prioritization of control measures. HI should be performed at the beginning of work, anytime the scope of work or tasks change, after an incident or near miss, anytime site or weather conditions change, and when performing non-routine tasks or unusual circumstances. Identifying all actual and potential hazards requires planning and training to ensure accuracy and completeness. Hazards identified during environmental drilling activities include:
• Drilling set up and operation
• Below ground/above ground services, such as gas pipes and electric cables (below ground and overhead)
• Falling, swinging tools
• Explosion/combustion
• Contaminated soil or water
• Excavations
• Trips, slips and falls
• Heavy weights both on and off the drilling rig.
• Noise
• Traffic
• Poor access
• Struck by plant
• Chemicals
• Re-fuelling rig engine
• Materials handling (cement, diesel or petrol, bentonite etc.)

(Blackledge & Blackledge, 2007)

An example of a completed HI form is attached as Appendix B

• Job Hazard Analysis (JHA)

The Job Hazard Analysis (JHA) is a safety analysis tool which provides a step-by-step breakdown of each of the task that comprises the job. It is completed in order to outline measures to eliminate or control the identified hazards and
protect workers. It is usually attached as part of the Health and Safety Plan (HASP) prepared for the job. The HASP details site specific hazards associated with known conditions at the site and is a valuable onsite resource. Appendix C contains an example of typical topics addressed in a HASP.

A JHA form is usually prepared by outlining the job description and the individual steps required to execute them effectively. OSHA outlines five questions that need to be asked during a JHA (OSHA, 2002):

- What can go wrong?
- What are the consequences?
- How could it arise?
- What are other contributing factors?
- How likely is it that the hazard will occur?

These five questions, when answered, create a hazard scenario which will ensure that efforts to eliminate the hazard and implement hazard controls help target the most important contributors to the hazard. An example of a good hazard scenario is presented below:

*At the gas station (environment), while pulling augers from a borehole (trigger), a worker's hand (exposure) was pinched between two flights of auger. It broke the bone of his forefinger and lacerated several fingers (consequences) quickly.*
To perform a job hazard analysis on the above scenario, you would ask:

*What can go wrong?* The worker's hand could come into contact with the augers while extracting them from the borehole.

*What are the consequences?* The worker could receive severe injuries to the skin and bones of his hand.

*How could it happen?* The accident could happen as a result of the worker trying to pull augers from the borehole as part of completion activities during well installation.

*What are other contributing factors?* This hazard occurred very quickly. It did not give the worker much opportunity to recover or prevent it once his hand came into contact with the augers. This is an important factor, because it helps you determine the severity and likelihood of an accident when selecting appropriate hazard controls. Unfortunately, experience has shown that training is not very effective in hazard control when triggering events happen quickly because humans can react only so quickly.

*How likely is it that the hazard will occur?* This determination requires some judgment. If there have been "near-misses" or actual cases, then the likelihood of a recurrence would be considered high. If the auger consistently presents a pinch point hazard this also increases the likelihood that the hazard will re-occur. In the example, the likelihood that
the hazard will occur is high because there is no guard preventing contact, and the operation is performed while the machine is running.

An example of a completed JHA form is presented in Appendix D.

**Risk Management**

The conclusions found in a risk assessment provide essential information about the severity and extent of specific hazards. This information is used in determining risk management decisions. Risk management refers to those actions taken to control or mitigate exposure to hazards identified in the risk assessment of a job. Risk management involves eliminating or reducing the risk with control measures; and reviewing controls regularly to ensure they remain the optimal solution to the injury risk (WorkCover, 1999).

*Eliminate the risk.* It may be possible to eliminate a risk by not performing a specific activity or using a certain type of equipment. For example, limiting sampling requirements during drilling would eliminate the hazards posed by the use of open face switch blades used to open sampling sleeves. However it is not always possible or feasible to eliminate a risk.

*Reduce the risk.* When a risk cannot be eliminated altogether, it should be reduced by the following:

- Replacing the system of work or equipment with something safer e.g. using retractable knives in place of open faced switchblades.
• Modifying the system of work or equipment to make it safer e.g. moving the location of a soil boring due to its proximity to overhead power lines.

Isolate the Risk. Keeping away from the risk may be an option if it is not a relevant part of the job e.g. staying clear of a hornets nest identified on the worksite during the hazard identification process.

Engineering Controls. Using engineering measures to make work safer e.g. establishing traffic control in high volume traffic areas.

Where none of the above measures is feasible on a job, secondary measures may be instituted to try to minimize the hazards. Secondary measures include the use of Personal Protective Equipment (PPE) and the application of safe work procedures such as posting warning signs and providing safety training. These secondary measures are less effective and must be constantly checked to ensure they are functioning properly. Often, secondary measures will be used in conjunction with the previously listed controls to increase their effectiveness.

The selection of risk management decisions requires careful consideration of technical feasibility, economic sustainability and behavioral factors. Risk management decisions must be based on scientific data which supports the ability of the control to effectively address the hazard. Decisions based on poor technical feasibility will likely fail to prevent the occurrence of a hazard. For example, drillers who are exposed to air pollutants during drilling operations may be provided with half face respirators as an engineering control. If this occurs, it
is necessary to ensure that the correct filter cartridge for the contaminant of concern be used with the respirator. Using an incorrect filter cartridge will fail to provide the desired protection from the hazard rendering the control technically infeasible. Cost is also a major consideration when making risk management decisions. It is necessary to understand the available budget prior to making these decisions. While cost should never deter the implementation of necessary injury prevention practices, understanding financial limitations will provide guidance in making risk management decisions that are cost effective and economically sustainable.

Risk management decisions will be unsuccessful in eliminating or addressing hazards if the drillers are unwilling to implement them. Studies have shown that there is a direct correlation between an individuals' perception of risk and risk behavior (Rundmo, 1996). Ensuring that drillers are aware of the seriousness of the risks presented on the job and willing to implement the measures outlined in the risk management decision are key to successful decision making. Often, involving drillers in the decision making process will ensure greater buy in to the final decisions.

Once the decisions are made and the injury prevention measures have been implemented, they are evaluated to determine whether and how well they are working. Elements of the measures that need to be changed to eliminate difficulties or increase effectiveness are identified and addressed accordingly.
An example of a Risk Assessment-Risk Management paradigm outlining the entire process is presented below. The figure is slightly more complex than that described above:

![Diagram of Risk Assessment and Risk Management Paradigm](image)

**Figure 1. The United States National Academy of Sciences Risk Assessment Paradigm (US EPA, 2008)**

**Public Health Model of Injury Prevention (PHMIP)**

The public health approach to injury prevention is a systematic process that seeks to understand the underlying causes of injury by collecting and analyzing data, deciding what to do about it, and putting in place the programs, infrastructure, trained staff, and policies that will prevent injuries, deaths, and disabilities in the future (STIPDA, 2003). It is the framework upon which intervention strategies are built with the goal of reducing the occurrence of injuries and the burden of these injuries on populations as a whole.
The PHMIP has been widely adopted across government agencies such as the Centers for Disease Control and Prevention (CDC) and the US Army as well as in public and private organizations. These organizations have documented considerable success, such as in the case of the state of Alaska which had the highest rate of acute traumatic occupational injury fatalities of any state in the US from 1980 to 1989. NIOSH developed an Alaska Occupational Injury Surveillance System (AOISS) which incorporated the PHMIP and determined that fishing and logging had the highest occupational fatality rates. Implementing new safety measures after applying the principles of the PHMIP resulted in a 48% fatality rate decrease over a seven year period (Smith, 2001).

At the industry level, the PHMIP can be used in conjunction with any health and safety program to broaden existing injury prevention practices and bridge gaps between what is known and what is done to prevent injury. By applying the public health approach to injury prevention in the environmental drilling industry, we will gain a greater understanding of the causes of drilling injuries, why they occur and what actions can be taken to prevent them. Individual drilling companies will develop and implement their own health and safety programs tailored to the specific needs of the company. Application of the PHMIP industry-wide, however, will help to standardize injury prevention practices and serve as a reference point for setting priorities and developing collaborative efforts for injury prevention within the drilling industry.

The PHMIP consists of four components which work together to create effective injury prevention program (Figure 2). The four components are:
• Surveillance – Problem Identification and Prioritization
• Risk Factor Identification – Analytic Injury Research
• Intervention Development and Evaluation – Identification/Development of Prevention/Control Strategies
• Implementation – Methods to put into practice and evaluate prevention and control programs.

The Public Health Approach to Injury Prevention

![Diagram showing the steps of the Public Health Approach to Injury Prevention]

Figure 2. The Public Health Model of Injury Prevention (Centers for Disease Control and Prevention, 2006)

Applying the PHMIP to the Environmental Drilling Industry

In applying the components of the PHMIP to the drilling industry, it is necessary to take into consideration the existing industry practices for injury prevention, health and safety. Guidelines currently exist to ensure safety of workers in the drilling industry, examples of which include the Environmental Remediation Drilling Safety Guidelines, 2005 and the National Drilling Associations’ Drilling Safety Guide.
• **Surveillance** – This is the first and most important step in the PHMIP. Surveillance involves analyzing databases of information related to injuries in the drilling industry such as can be found at the BLS. According to the BLS database, approximately 50 percent of all fatalities involving water well drilling are attributed to electrocution while the majority of nonfatal injuries are attributed to material-handling accidents (Matetic & Ingram, 2001). This data is vital in helping to determine injury trends and how they may change over time. Near miss and incident reporting are standard procedure in most health and safety programs within the industry. Surveillance can be as simple as monitoring the occurrence of near misses or incidents at a company or as complex as the use of occupational injury surveillance technology at the national level for data analysis. By collecting and analyzing this data, decision-makers can prioritize issues and evaluate the effectiveness of prevention strategies. Also, near miss and incident reporting should be made more detailed to increase the accuracy and completeness of surveillance data and provide further insight into the broad range of risk factors that result in injuries. It should be noted that no single data source can provide all of the information needed in regards to injuries and there are many possible sources of information in addition to near miss and incident reporting. Appendix E presents a table listing some other sources of injury data which are useful during surveillance.
• **Risk Factor Identification** – It is not enough to know that injuries occur in the environmental drilling industry, we also need to understand why. A myriad of factors contribute to any one injury occurrence; behavioral, environmental, social and other workplace organizational factors included. Identifying and studying risk factors will help to quantify and prioritize modifiable risk factors that can be used to develop injury prevention strategies. Current industry practices utilize the Job Safety Analysis and Hazard Identification tools to identify actual and potential hazards associated with completing the scope of work at a jobsite. By supplementing these existing tools with new and innovative approaches such as technology updates or behavioral changes we can better address the various factors that contribute to injury and reduce the burden of these injuries on the environmental industry.

• **Intervention Development and Evaluation** – In this step, the knowledge and technology which have been developed are communicated to workers, management, and industry leaders who can apply this information to prevent drilling injuries from occurring. Using information gathered during surveillance and risk factor identification, strategies are developed to address specific injury occurrences. Injury prevention usually involves a multidimensional approach and intervention strategies may include education, engineering, environmental, enforcement efforts or any combination of such. Where a single strategy may fail, a combination of strategies can result in substantial injury reduction. It is important to note
that intervention strategies must be based upon sound scientific research or prevention efforts may fail or even cause harm (Smith, 2001).

An example of the use of intervention strategies in the drilling industry can be seen in the case of loss of hearing (injury) as a result of noise levels on a drill rig (hazard). Surveillance data indicated that water well drillers are exposed to noise levels above 85 dB(A) during the normal course of drill rig operations (Reinke & Ingram, 2005). NIOSH partnered with the water well drilling industry to develop engineering control technologies and training products to address noise exposure at the jobsite (Reinke & Ingram, 2007). A partial cab enclosure was designed to protect the operator at the rig’s control panel (Figure 3). Used in conjunction with personal protective equipment, it was found to significantly reduce exposure to noise associated with the drill rig. NIOSH ensured development of the partial cab was communicated to stakeholders in the industry through the development of a CD which contained information about noise exposure and the partial cab’s design and implementation. The CD also contained information on noise related hearing loss and hearing protective devices to increase worker knowledge of this occupational hazard.
• **Implementation** – Ultimately, the intervention strategies that are developed must be implemented in order to be effective in preventing injuries. Effective communication is essential in implementing these strategies since lack of knowledge of the value of implementing these strategies will inhibit their application and reduction of injuries. Interventions should be assessed prior to their implementation to ensure they are applicable to the environmental drilling industry and meet the needs of those most affected.
by injuries. They should be tested in a real work setting to demonstrate the value of the strategy on an industry wide level to ensure greater buy-in. In the example above, partial cabs were field tested and found to be effective in reducing noise exposure by 8 dB(A). This rendered the strategy more readily adoptable by industry leaders. Injury prevention efforts that will be most successful will be those that are developed specifically for the industry and that have been clearly communicated to industry decision-makers in a timely and reliable manner.

Evaluation of intervention strategies in the environmental drilling industry must be conducted to determine whether and how well they are working. Evaluation is essential in determining the effectiveness of the intervention; many intervention strategies and programs are implemented without undergoing rigorous evaluation to measure their effectiveness. We can use the information gathered during evaluation to identify elements of the strategy which need to be changed to eliminate problems or increase effectiveness. Even if evaluation indicates that a specific intervention strategy is ineffective, this is still valuable information that can be used to adjust an intervention to ensure greater success in the future.

Application of the PHMIP process is an iterative one which requires continuous monitoring to ensure that intervention strategies implemented actually prevent injuries as the intervention progresses and do not create unacceptable new risks.
Limitations

The PHMIP has been highly successful in its application in injury prevention strategies; however, there are some limitations which may affect its ability to be widely adopted across the environmental drilling industry. One problem is that it relies on statistical data from injuries that have already occurred: Would it not be better to prevent these injuries from ever occurring? Adapting the model to rely on more pre-injury data such as near miss reporting, could result in technologies that can be applied much earlier in the injury occurrence process further increasing the number of injuries that are prevented.

Another problem is the cost effectiveness of implementing the model. A lack of resources, especially amongst the smaller drilling businesses, may hamper the ability to collect and analyze data, develop technologies and evaluate their effectiveness. This is especially of concern when BLS data indicates that 33% of workplace fatalities occur in businesses with fewer than 11 employees (Willet, 2001). Industry leaders such as the NDA and the National Ground Water Association (NGWA) should collaborate on strategy development, training and the provision of educational materials to create a safer industry for all businesses.

Another limitation to the model can come from management and organizational issues. Management's perception and approach to injury prevention are important determinants of injury risk. Ensuring that managers and other decision-makers are knowledgeable about the effectiveness of selected interventions will create greater buy-in amongst workers expected to adopt the
strategies. Leading by example is one of the best ways to set the tone for safety expectations in the workplace. For example, in many small drilling businesses, the company owner may also operate drilling rigs alongside his workers. Exhibiting company safety practices such as wearing the appropriate PPE will make workers more likely to adopt those same attitudes in management’s absence.

Findings

While more needs to be done to develop and evaluate new intervention strategies for injury prevention in the environmental drilling industry, there is much that is already known and can be applied. Despite this knowledge, a gap often exists between what is known and what is actually being applied. Effective communication and transfer of technology are pertinent in bridging this gap and ensuring effective application of intervention strategies. Current injury prevention practices across the industry indicate that the PHMIP is sporadically being applied to some extent however there does not appear to be cohesive and complete buy-in from all relevant stakeholders. Industry stakeholders should be held accountable for applying the PHMIP to current injury prevention practices and should push for industry-wide adoption of the model to enhance these existing practices.

The PHMIP should be presented at major industry conferences and discussions should be initiated regarding increasing its application in the environmental drilling industry. The importance of implementing all phases of the
PHMIP should be stressed and collaborations on research and strategy design should be established in order to ensure the cost effectiveness of implementing the model.

Wider dissemination of information on the PHMIP will serve to increase awareness amongst industry leaders and foster dialogue that will stimulate further interest in proactively preventing injuries in the drilling industry.

Conclusion

Well drilling injuries remain high and the environmental drilling industry is no exception. Most of these injuries are preventable provided proper health and safety practices and injury prevention strategies are being followed. The accepted method of planning to prevent injury is to identify, assess and then control the risk.

Current industry health and safety practices include conducting risk assessment and risk management. Two methods of assessing the risks of injury on the job include identifying hazards and analyzing hazards. During Hazard Identification, an attempt is made to identify actual and potential hazards associated with completing the scope of work. A Job Hazard Analysis can then be completed in order to outline measures to eliminate or control the identified hazards. Risk management refers to those actions taken to control or mitigate exposure to hazards identified in the risk assessment of a job. A Health and Safety Plan is an integral part of all health and safety programs across the
environmental drilling industry and is a valuable resource on the jobsite.

Significant efforts have been made to promote injury prevention in the industry, providing guidance such as that found in the *Environmental Remediation Drilling Safety Guidelines, 2005* and the National Drilling Associations' *Drilling Safety Guide*. However, there is still a considerable gap between what is known as what is actually being applied. Incorporation of the PHMIP alongside existing safety practices can bridge much of that gap provided it is effectively and comprehensively applied. Success in the use of the model will be dependent on the application of all four phases namely; Surveillance, Risk Factor Identification, Intervention Development and Evaluation, and Implementation.

Industry stakeholders must begin the dialogue to ensure industry-wide adoption of this model. The benefits of the model should be presented at major industry conferences and collaborations sought on research and strategy design in order to ensure the cost effectiveness of implementing the model.

It should be noted that the PHMIP is not without its limitations, one weakness is that it relies on statistical data from injuries that have already occurred: Would it not be better to prevent even these injuries in the first place? Another limitation can be the cost of implementing the intervention strategies that result from application of the PHMIP. This may be offset if industry leading associations assume some of the burden of implementation. Finally, organizational and management issues could create barriers to using the model.
especially if management does not appear to “buy-in” to the benefits of the model.

Current industry practices indicate that the PHMIP is sporadically being applied in the environmental drilling industry however wider and more consistent application is necessary to achieve measurable results in injury prevention. Wider dissemination of information on the PHMIP will serve to increase awareness amongst industry leaders and foster dialogue that will stimulate further interest in proactively preventing injuries in the drilling industry.
Appendix B
Appendix C
Appendix D
Appendix E
Bibliography


http://www.osha.gov.libproxy.lib.unc.edu/Publications/osha3071.html


