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“...IT IS...USEFUL TO TAKE STOCK AT REGULAR INTERVALS OF WHO WE ARE, WHERE WE HAVE COME FROM, AND WHAT HAS HAPPENED TO OUR LUGGAGE.”

-- NEIL PEARCE, 2007, INTERNATIONAL JOURNAL OF EPIDEMIOLOGY

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ABSTRACT

Objective: The January 2013 meeting in Trondheim, Norway of representatives from the Nordic countries and the U.S. provided the opportunity for participants to reflect on a number of challenges that we face as we seek to understand and control occupational injuries. The meeting also allowed consideration of how we might structure our work and communicate findings in ways that could help us improve occupational safety both within and beyond our own borders.

Methods: Four challenges are presented here in the context of how they might influence the practice of public health injury control in the workplace. Emphasis is predominantly on control of non-fatal workplace injuries although the methodological issues certainly have application to fatalities as well.

Results: The challenges are posed as four questions. 1) First, do we really know the extent of workplace injury problems and are we able to track occupational injuries accurately or even reliably? 2) Do the methodologies being used, both for the study of injury etiology and intervention evaluation, fit the problems we seek to understand and ameliorate? 3) Why don't we focus on the Public Health Hierarchy of Hazard Control to address occupational injuries? 4) And lastly, have we forgotten the importance of context?

Conclusions: Attention to each of these issues could enhance our knowledge and improve workplace safety for populations of workers through improved injury surveillance that more actively includes workers, use of more appropriate research approaches, actions at the more efficient tiers of the public health hierarchy, and enriched understanding of injury etiology and control.

Keywords: Occupational injury, Workplace injury, Evaluation research, Injury surveillance, Injury prevention, Research methods

BACKGROUND

The basic assumption framing this discussion is that occupational injury epidemiology is a science of public health and, as such, it is an applied science with a focus on workplace safety in *populations* of workers. The goals of occupational injury epidemiology are viewed as seeking to: 1) understand why workers are injured, 2) prevent the injuries and their sequelae, and 3) evaluate interventions designed to accomplish the latter.

CHALLENGES

Current challenges in occupational injury epidemiology are presented as four questions. The questions raise concern about the state of injury surveillance, our selection of methodologies for the study of work-related injury, as well as the conceptual frameworks we use, or do not use, in the design of intervention efforts. The focus is non-fatal injuries although the methodological issues have application to fatalities as well.

1. First, do we really know the extent of workplace injury problems and are we able to track occupational injuries accurately or even reliably?
2. Next, do the methodologies being used, both for the study of injury etiology and intervention evaluation, fit the problems we seek to understand and ameliorate?
3. Why don't we focus on the Public Health Hierarchy of Hazard Control to address occupational injuries?
4. And lastly, have we forgotten the importance of context?

Question 1: What is the extent of the occupational injury problem and can we track it?

The Centers for Disease Control and Prevention in the United States define surveillance as “the ongoing, systematic collection, analysis, and interpretation of health data essential to the planning, implementation, and evaluation of public health practice, closely integrated with timely dissemination of those data to those who need to know” [US DHHS, 1987]. As such, surveillance is viewed as central to public health practice.

In the U.S. the primary federal source of information on work-related injuries is the Bureau of Labor Statistics Survey of Occupational Injuries and Illnesses (SOII). These data, compiled yearly and based on Occupational Safety and Health Administration (OSHA) logs of workplace injuries and illnesses, come from a probability sample of U.S. employers. Coverage is not complete or entirely representative with, for example, small employers and self-employed workers excluded [[US Department of Labor, Occupational Safety & Health Administration 2001](#)]. Another source of information on non-fatal occupational injuries and illnesses in the U.S. is the Consumer Product's Safety Commission's occupational supplement to the National Electronic Injury Surveillance System (NEISS-Work). Collected from a probability sample of U.S. hospital emergency departments, these data allow national injury estimates of nonfatal work-related injuries and illnesses treated in U.S. hospital emergency departments [Derk, Marsh, and Jackson, 2007; NIOSH, 2009]. While these surveillance sources have improved our understanding of occupational injuries, alone they do not appear to be adequate.

Given that the capture of injuries is different across various sources, including these two, it is not surprising that we see different injury estimates depending on the source. Striking, however, is the variability in even broad patterns over time by source. For example, while the BLS data show marked declines in rates of non-fatal workplace injuries over the last 20 years, the NEISS-Work data, which do not require an event be reported to workers' compensation or on an Occupational Safety and Health Administration (OSHA) employer log in order to be captured, do not show the same reductions [Derk et al., 2007].

Injury rates based on reports of workers are consistently higher than those captured through traditional surveillance efforts based on sources that require employer involvement, such as BLS or WC [Lipscomb et al., 2007; Morse, Dillon and Warren., 2000; Azaroff et al., 2013]. In the U.S. [Azaroff et al., 2002; Rosenman et al., 2000 and 2006; Biddle et al., 1998; Fan et al., 2006; Welch et al., 2003; Welch et al., 2007; Leigh, 2004; Azaroff et al., 2004], and increasingly across the globe [Shannon and Lowe, 2002; Moore et al., 2013], public health practitioners and researchers share concern regarding the under-counting and non-reporting of occupational injuries. Recently in the U.S., Mendelhoff and Burns [2013] reported that states with high fatal injury rates had low rates of non-fatal injuries and vice versa. Several issues many contribute to this negative correlation, but the observed relationship should be a cause for concern about factors that may be influencing these findings [Lessin and McQuiston, 2013].

A number of influences on non-reporting of work-related injuries have been described in the U.S. including the down-turn economy which has resulted in job insecurity and, perhaps, an evolving norm not to report work-related injuries among the employed as well as willful neglect on the part of employers [Azaroff,

Levenstein and Wegman, 2002; Friedman and Forst, 2007]. Workers describe pressures not to report injuries from employers as well as their peers and behavioral-based safety programs that end up rewarding non-reporting instead of safety [Lipscomb et al., 2013; Lipscomb et al., 2010]. Previously reported comments of union carpenters [Lipscomb et al., 2013] provide a clear demonstration of these issues.

“In today’s economy more people are likely not to report injuries due to fear of termination.”

“[Supervisors] say report all injuries... but we know you have it happen more than once and you’re gone.”

“The incentive programs for crews and foremen with low injuries often lead to accidents or injuries being hidden. ‘Don’t report it and we’ll get a bonus at 100 days.’ This allows the employer to later refuse benefits to employees.”

Such vulnerability is created by inequitable power structures regarding access to benefits and resources. The failure to use resources that are theoretically available – in this case workers’ compensation – demonstrates how workers’ compensation in the U.S. is not a no-fault system as even predominantly white men with union membership in the U.S. can be vulnerable workers under certain conditions. Documenting behaviors such as these does not provide insight into the magnitude of the problems or the significance they hold for the science of occupational injury epidemiology. The significance of these issues will depend on how reporting practices might vary based on the type of injury (acute vs musculoskeletal, for example), as well as size of worksites and the prevalence of risk and injury, as well as whether the behaviors are systematic with respect to variables such as age, job tenure, work exposures and current economic conditions, which they very well may be [Lipscomb et al., 2013]. They do present an alternative to the focus on moral hazard as a source of error or built-in bias in workers’ compensation data.

Question 2: Are we using the right methods to study occupational injury?

The study of injury is sometimes considered to be underdeveloped as a science or the “stepchild” of epidemiology. Methods developed for the study of infectious or chronic diseases may fall short in the study of injury events. Addressing the goals of injury epidemiology – to understand and prevent injury – may, at first, seem straightforward. Traumatic injuries occur because of energy transfer [Robertson; 1992]. The proximal cause is often easy to identify and temporality is rarely an issue. Furthermore, in the study of acute traumatic injury we are not dealing with prolonged latency between the exposure and injury inducing event. We should recognize, however, that injuries result from a complex mix of factors including social, environmental, equipment/tool and human agents [Haddon, 1968; Runyan, 1998]. Specific to the workplace, these factors include not only personal behaviors of workers, but also those of their co-workers and supervisors, as well as business owners and regulators. Their injuries can result from faulty design of tools or equipment as well as the physical environment in which the work gets done and the broader economic and social environments. The latter includes both formal and informal policies that influence the work people do, how that work is done, and consequently, their exposures as well as their acceptance of potential control measures.

Epidemiologists spend considerable effort trying to improve the accuracy and precision of effect measures. We seek clear definitions and measures of outcome, exposures, and other variables of interest and we have become enamored with analytical techniques that more precisely define the strength of associations. While there is clearly merit in these efforts, this focus is propagated in systematic reviews and meta-analyses of occupational injury interventions with rigid inclusion criteria and, consequently, what Andrew Watterson [IJOEH 2007] referred to as a ‘paralysis by analysis.’ Furthermore, from the standpoint of public health, we may be doing a disservice to workers – and to science -- by reducing the study of occupational injury, including the evaluation of interventions, to one of pure statistical inference. We certainly need to measure effects in unbiased ways, but we also need to understand them, interpret them, and communicate what they really mean [Lipscomb et al., 2009].

Study designs

Randomized controlled trials (RCTs) are considered the “gold standard” study design for measuring intervention effectiveness. The perceived strength of this design comes largely from the biomedical literature assessing the value of therapeutic agents. The goal of randomization in this context is to have similar control and experimental groups at the initiation of the study, with respect to unmeasured factors that could confound the association of interest if not equalized.

As Zwerling et al. note [1997], the “paucity of randomized controlled trials (*in the field of occupational injury prevention*) has many reasons – historical, social and political, as well as methodological. The

methodological reasons often interact with the social and political context of the intervention.” In the context of occupational injury intervention evaluations, consideration must be given to the often complex and highly dynamic nature of workplaces. Trials are not always feasible or even possible. Furthermore, the validity of randomization may be challenged with threats to external validity [Lipscomb et al., 2009; Lipscomb and Dement, 2009]. The very controlled nature of trials poorly control for a multitude of social factors and may be prone to contamination in the workplace. To study rare events large samples would be required. If an intervention is expected to have a delayed effect then longer follow-up time is needed. It would be difficult to maintain a truly controlled workplace trial for extended periods, making their use in understanding sustained effects of little use.

Observational studies provide an alternative means of evaluation and yet we seem to have lost sight of an important fact clearly articulated by Michel Coleman [2007]. “Observational data on human disease and mortality (*and injury, we contend*) are not intrinsically frail. On the contrary, they are our most crucial source of information on the patterns, causes and trends of disease and death in human beings in their natural habitat – human society. For that, experiments are useless.”

Analytical approaches

There may also be situations where those of us who study injury have failed to use traditional epidemiologic techniques that could enhance our work. Latency of effect is important in cancer epidemiology when there can be extended periods between exposure and onset of disease and these critical periods may vary among different carcinogens [Checkoway, Pierce, and Kriebel, 2004]. Failure to look for effects in appropriate time windows can lead to biased conclusions. As mentioned earlier, latency of effect is not an issue in understanding the most proximal cause of injury but it is potentially very important in evaluating workplace interventions. Consideration should be given to when the intervention is anticipated to have an effect and the theoretical underpinnings of that assumption. A change in machinery on a production line might be expected to be effective immediately, whereas that would not be the case for adoption of lift equipment on a hospital nursing unit [Schoenfisch et al., 2013]. Lagging techniques that allow exploration of when effect measures are maximized could be very useful in injury intervention evaluations, particularly.

Measures of attributable risk including attributable risk percent (AR%) and population attributable risk percent (PAR%) are important if we are going to focus efforts where we are more likely to have impact on populations of workers [Rothman and Greenland, 1998] yet these are rarely emphasized in the study of injury or the interpretation of the potential impact of findings. They can be useful as we evaluate effects of interventions for injuries caused by more than one factor of interest [Lipscomb et al. 2008]. These measures can help us assess whether observed effects – even if significant from a statistical standpoint – are actually meaningful to workers. Will they matter on the shop floor?

Question 3: Why don't we focus on the Public Health Hierarchy of Hazard Control to address occupational injuries?

The basic tenet of industrial hygiene is control of health hazards in the working environment. To do so, an ordered public health hierarchy of hazard control has been described [Herrick and Dement, 1994]. The primary means of hazard control is through prevention or containment of hazards. A secondary approach is to remove or isolate the hazard from the pathway between the worker and source. Lastly, control of exposures may be sought through barriers or use of personal protective equipment. This same hierarchical approach has been described for control of physical hazards that can cause acute injury in the workplace. Namely, the hierarchy in this case first focuses on elimination of hazards through design, followed by use of safeguards that limit exposure, administrative type controls such as training workers to protect themselves, and finally use of personal protective equipment [Castillo, Pizatella, and Stout, 2006]. While this paradigm is often presented as an upward-pointed triangle, we have intentionally inverted it to emphasize that intervention at the upper tiers of the hierarchy are more efficient means of injury control [Figure 1].



Figure 1. Public Health Hierarchy of Hazard Control Applied to Injury Prevention

The U.S. has a long history of tension between public health and individual liberty or responsibility that ignores social justice [Beauchamp, 1980]. Failure to embrace the concept of the public health hierarchy of control in occupational injury prevention fosters a focus of prevention efforts on the individual worker. This emphasis on human agency dangerously ignores the more efficient tiers of the public health hierarchy of control that are more likely to have lasting effects on larger populations of workers.

The behavioral-based safety movement provides such an example through use of incentives to workers or supervisors for enhanced production speed and lower rates of (reported) injury in the U.S. construction industry. However, hazardous conditions due to speed of work need to be addressed, not by rewarding workers for being more careful when they are pushed, but rather by stopping unsafe levels of production pressure [Lipscomb et al, 2013]. Dekker, Nyce and Myers [2012] described the danger in our tendency to focus on human agency in injury prevention: “safety researchers are informed by ... and also a formative part of ... the Western moral enterprise which elevates responsibility, choice and autonomy above almost any considerations... and in so doing we fail to consider systematic issues that broadly influence the safety of workers.”

Similarly, failure to recognize the complexities behind occupational injuries and the exposures that cause them has led to short-cited interpretation of risk and prevention needs. For example, the attribution of higher risk among new or young workers to inexperience has steered attention away from recognition that the exposures of inexperienced workers may be quite different from those of experienced workers, resulting in attempts to “empower” workers through training instead of by addressing more difficult social issues that influence their work exposures and injury experiences [Lipscomb et al. 2009; Lipscomb et al., 2010].

Question 4: Have we forgotten about the importance of context?

As we seek to improve the quality of occupational injury research we need to remind ourselves that nothing we study occurs in a vacuum. The context surrounding the study of injury at any given point in time will influence what we observe, including the etiology of the injuries we seek to ameliorate, how the intervention is thought to prevent injury events, whether (and under what circumstances) intervention components were actually delivered to and adopted by the target audience, and broad influences outside of the worksite (e.g. economic and regulatory climate). When we speak of context we are embracing a broad construct of historical context. Namely, we refer to “the interrelated conditions in which something exists or occurs, such as the environment or setting” [Merriam-Webster, 2014]. For example, because safety interventions – in the workplace and elsewhere - - can be triggered by particularly untoward events, or even catastrophic ones, it is important to know what may have led up to the intervention. Similarly, if there are reasons why workers may be hesitant to report injuries they sustain, those are part of the relevant context in understanding their injury rates. Context involves broader social conditions that might influence why a low-wage industry ends up in an impoverished area. We essentially mean recognizing the importance of knowledge or information which Merriam-Webster’s definition goes on to say “can throw light on meaning.”

Furthermore, for injury prevention science to be more useful it must revolve around more than simply knowing whether an intervention works; we also need to know why that is the case. In this realm, RCTs, meta-analyses and many observational studies fail miserably as they do not provide potentially important context

surrounding experiments in the workplace. Capturing relevant intermediate measures can be essential in understanding what is really happening in an intervention designed to work in a dynamic workplace.

Contextual factors are as important to our true understanding of injury cause and control as the basic principles of epidemiology that have historically guided us to focus on improving effect measures through clarity in measurement of exposures and outcomes, as well as through care in reduction of bias. However, relevant context is not simple to assess and it is not captured through traditional epidemiologic methods. Qualitative methods are valuable, and sometimes the only way to get at important contextual details. Despite concerns that qualitative data are not generalizable and do not always lead to appropriate inferences, they can add an important dimension to injury science that can help us understand what we observe and seek to measure and interpret. Furthermore, qualitative resonate with people in ways that effect measures do not. They can enhance credibility of the researcher in the eyes of workers and others who are not epidemiologists. Policy is not always driven by science and the process of “telling the story” matters. Quantitative data, though often assumed to be superior, do not always measure what we think they are, their analysis is not always straightforward, and interpretation of resulting measures of effect and association is not an entirely objective process [Lipscomb et al., 2009].

CONCLUSIONS

Obviously, the challenges provided here are only a few that we face in the study of occupational injury. However, attention to these four issues -- as an ongoing process rather than one with a solution -- could significantly enhance our efforts as occupational injury scientists. The knowledge of injury risk for populations of workers could certainly be advanced through improved injury surveillance strategies and use of more appropriate research approaches that actively include workers as partners and consider factors that are pertinent to the workplace. However, it seems unlikely to us that there will ever be one answer to these problems. There is no perfect surveillance system and considerations must be given to the purpose for which each was developed. We need to embrace the importance of examining multiple sources of data. Strength will come from ongoing questioning of the limitations of each source we choose to use. Similarly, there is no perfect research design.

A focus on actions at the upper tiers of the public health hierarchy would serve to protect more workers from harm with greater efficiency. When we, as injury scientists, find ourselves recommending training as a primary approach to occupational injury prevention, or focusing on individual remedies, we should reflect carefully on the importance of social justice. Likely rooted in political and economic reasons, our failure to embrace remedies at the higher levels of the hierarchy of control perpetuates an acceptance of what should be unacceptable risk.

And lastly, as scientists, we should strive to enrich our understanding of occupational injury etiology, its control and the evaluation of preventive efforts. It is here where we must seek an understanding of the context in which work and injuries occur. Obviously, this is a never-ending task, and we accept that one never knows all he or she should about context. But this does not mean that the construct should be dismissed or we should forget the strength we gain through embracing the variety of quantitative and qualitative methods that help us view a larger picture. Measurement alone - no matter how precise - cannot adequately replace analytical thought, synthesis, and judgment, all of which are important as we seek to structure occupational injury science in ways that will most efficiently promote empowerment of workers through policies that foster safe work environments, tools and conditions.

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