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Advances in occupational traumatic injury research

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Advances in occupational traumatic injury research

In this issue of the *Scandinavian Journal of Work, Environment and Health*, the results of two original studies are published highlighting the continued advancement of scientific research in occupational injury epidemiology. The study by Østerlund et al (1) presents the first use of case–crossover study in occupational injury in Europe to identify potentially modifiable “transient” risk factors for occupational acute traumatic injury. The second study by Yu et al (2) uses a large, cluster randomized, controlled intervention trial to demonstrate successfully for the first time the benefits of participatory training in occupational health and safety to reduce workplace injury.

Current researchers and those beginning their careers in the field of injury epidemiology have undoubtedly been inspired by the ground-breaking work of Dr William Haddon in the 1960s (3, 4). He was responsible for markedly advancing the field beyond the purely descriptive approaches that were commonly employed at that time. He strongly believed in and encouraged applying etiologic approaches to risk factor identification to prevent injury. He also recognized the multiple dimensions (individual, equipment, and environment) of injury prevention where interventions would be most effective. As a new member of the SJWEH’s editorial staff, and follower of this philosophy, my goal is to continue to seek out and encourage publication of innovative, high quality, and impactful occupational injury epidemiology research.

There have been several important contributions to injury research published in the Journal since its inception in 1975 (the first year the journal was published in English). One of the earliest, was a 1976 laboratory-based study focused on reducing the physiological effects of acceleration and vibration induced forces transferred to the “hand-arm” system when using vibrating hand tools (5). Traumatic vasospastic disease (TVD), a condition referred to at the time as vibration-induced white finger, is a disabling disorder and mainly associated with the use of pneumatic hammers at work. While this study was limited to five subjects (two lumberjacks and three of the study investigators), it is still cited as an important contribution in the development and testing of potential prevention strategies for TVD, such as using anti-vibration gloves (6).

Most research for occupational injury published in the Journal up to that time was primarily lab-based, however one notable study was published in 1981, entitled “Epidemiologic principles applied to injury prevention” that helped to introduce field-based occupational injury epidemiology to the readers (7). The author, a researcher from the US Division of Safety Research at the National Institute for Occupational Safety and Health (NIOSH), described the paucity of field-based injury research (almost 13 years after Haddon’s charge) and provided a synopsis of the epidemiological methods in most injury studies of the time. To further illustrate these methods, the results of his own recent investigation of risk factors for ladder-related injuries were presented, referred to at the time as a case–referent study design (ie, case–control study). The critical concept of control selection in this study was defined as the “extent that today’s referent could have been yesterday’s case” and exposures were defined as “the dynamic, day-to-day changes and circumstances that are not predictable from the fixed structural features of the work” (7, p96). To the best of my knowledge, this may be the earliest mention of “transient” exposures as risk factors for occupational injury. In 1998, approximately 17 years later, NIOSH in their National Occupational Research Agenda (NORA) on the needs and priorities of traumatic occupational injury research, called for an expansion of traditional epidemiological designs and methods to include the identification of potentially modifiable “transient risk” factors in occupational injury (8). This led to the first application of the case-crossover study in occupational injury epidemiology (9).

As noted, two studies are published in the current issue that contribute to the advancement of occupational injury epidemiology research. The first study by Østerlund et al (1) uses the case-crossover design, and like its predecessors (9, 10) examines several potential modifiable transient risk factors to estimate the short-term risk of a work-related acute traumatic injury. This study sought to answer the questions (i) “when work tasks are repeatedly performed, why does an injury occur at one point in time and not at earlier or later times?” and (ii) “does some set of unusual conditions in the work environment and in the individual act to increase or decrease the short-term risk of an injury?”. This epidemiological design, used for almost 25 years now, investigates the generic question, “Did anything unusual or different take place before the onset of the event?” by examining the transient effects of an intermittent exposure on the onset of acute outcomes (11). Seminal case-crossover studies published in the 1990s, include an investigation of the immediate determinants of myocardial infarction (MI) onset (12) and an evaluation of potential associations between cellular telephone use and the risk of a motor vehicle collision in real-world circumstances (13).

The factors (exposures) examined in the study by Østerlund et al (1) represent three domains including worker-related factors (time pressure, mobile phone use, disagreement with someone, feeling sick and being distracted by someone), work-practice factors (non-routine task and altered surroundings), and equipment-related factors (working with broken machinery or materials). Each meets the requirements of this design that (i) the exposure is intermittent and exhibits transient effects (ie, the case moves across periods of varying exposure) (11, 14, 15) and (ii) the onset of the outcome is sudden (or acute) and time of onset is known. Cases were defined as patients who were treated at one of two emergency departments in Denmark (over a one-year period) for an acute traumatic work-related injury.

In choosing the case-crossover design, a self-matched approach, the investigators likely saved valuable resources (ie, costs, time) by not having to recruit and interview a separate control group. This advantage cannot be overestimated as participation rates in conducting epidemiological research in the past few decades have significantly declined due to difficulties finding subjects and increased rates of refusal for participation (16). To successfully recruit and enroll healthy or hospital-based controls, with similar periods of atypical activities and exposures as those experiencing a work-related traumatic injury can be extremely difficult and in some cases almost impossible.

Another advantage of using this self-matched (within-subject) design, is the elimination of confounding associated with between-subject differences in stable characteristics (both measured and unmeasured) (11). Statistical comparisons are made between hazard and control periods contributed by the same subject, thus each subject forms their own stratum and fixed-subject characteristics (such as work or task experience, job risk, injury severity) do not vary within strata, thus there is independence from between-subject confounding (11, 14, 15).

Occupational injury epidemiology studies using the case-crossover design have generally used two approaches to control-period selection, one is the matched-pair interval approach and the other the usual frequency approach (9, 10, 15). Although matched or unmatched control recruitment is not an issue in this design, a new challenge is the selection of an appropriate matched control period (or if using the usual-frequency approach, estimating, for each exposure, the person time exposed to each factor and person-time at risk). In the case of the matched-pair interval approach used here, two distinct time intervals for each case needed selection: the hazard (referred to here as the case period or exposure window) and the control period. This was operationalized for each factor as worker exposure status “just before the injury” (case period) and exposure status “on the previous day at the same time of the injury” (control period). Critical to this selection is the sampling of a sufficient number of informative pairs or workers, where the exposure status is discordant or different in the case and control periods to have adequate statistical power to detect an association. Non-informative pairs would be concordant matched pairs, having similar exposure status at both time periods. Estimating the proper sample size for conducting a

case-crossover study can be complex and involves the calculation of the lower bound of detectable effects (17). Like this study, several previous case-crossover studies examining risk factors for occupational injury have enrolled a thousand or more cases to achieve adequate statistical power to detect significant effects. As seen in the current study, to evaluate potential effect modifiers, 95% confidence intervals can become quite wide if the number of informative pairs is small. Pilot studies (or simulations) are thus highly recommended before launching a full-scale case-crossover study to accurately estimate the proper “hazard period”, which is defined as the period from the occurrence of the “trigger” to the point in which the event occurs (14, 18).

One limitation discussed by the study investigators is that the exposure data collected used similar case and control periods for each factor. It may be unlikely that the length of hazard period is similar for all factors, for example those such as “feeling sick” and “being distracted by someone”. The inability to characterize the hazard period in a case-crossover study accurately could lead to several pitfalls, such as misclassification of exposure and the inability to provide reliable estimates of risk due to too few matched discordant pairs (11, 14, 15). In the current study, this was observed for several worker-related risk factors (eg, feeling sick or time pressure), where it is noted that the hazard period exceeded the case period, potentially leading to an underestimation of the relative risk.

Another challenge in implementation of this design is the control of within-person confounding, which is possible for multiple, correlated transient factors that change together over time within a subject (14, 15, 18). For example, the investigators calculated that 38% of subjects were simultaneously exposed to a combination of at least two factors at the time of injury (the most frequent being “malfunctioning machinery and material” and “altered surroundings”). Prudently, a series of sensitivity analyses were conducted to demonstrate that, after controlling for these factors independently, there was little change from the overall risk estimates. Despite the limitations described here and other challenges that have been previously well documented (14, 15, 18), investigators successfully identified and confirmed several important potential modifiable transient factors related to work equipment and practices that increase the risk of an occupational injury.

The second study by Yu et al (2) presents the results of a successful participatory training approach based in occupational health and safety (OHS) designed to reduce the incidence of acute traumatic work-related injuries and prevent re-injury. This study is especially valuable in that the literature contains few large, well-controlled, randomized studies to prevent work-related acute traumatic injury (“accidents”). Additionally, this is the first study to provide statistically significant evidence of the efficacy of a participatory training intervention in reducing the incidence (and recurrence) of workplace injury. Previous participatory training studies, including one by the authors to prevent musculoskeletal disorders/low-back and neck pain, have not provided evidence for their effectiveness (19).

In summary, this cluster randomized controlled trial of frontline Chinese industrial workers initially randomized 30 matched pairs (same industry, similar employment sizes and production processes) of participating factories into experimental and control factories (N=1706 workers) and then further randomized 1932 workers from the experimental factories into an intervention (N=966) and control group (N=966). Thus, experimental factories (N=30) consisted of workers allocated to intervention plus control training, and control factories (N=30) consisted of workers allocated only to control training. As described in detail by the authors, the three groups shared similar training contents and materials, however, the control groups received only a brief presentation of these materials, whereas the participatory training group used active group discussions, games, checklists, and workplace visits to reinforce learning and implementation of the occupational health and safety (OHS) training materials.

The primary outcome, “accidental” work-related injury events, was defined as self-reported acute traumatic injuries occurring at work either requiring medical attention or treatment or which interfered with work activities. The nature of these injuries were primarily machine-related, slips, and falls, hit by

and against objects, and from manual handling. After a 12-month follow-up period, the intervention group showed a statistically significant reduction of 41.7% from baseline, in the person-incidence rate of injury (from 89.3 to 52.1/1000 workers). This effect was significantly different than the smaller reductions in injury incidence observed in either control group. The intervention also significantly reduced event-based injury rates and re-injury rates at 12 months.

These two successful studies published in the latest issue of the *Scandinavian Journal of Work, Environment and Health* share a focus on acute injury as the primary outcome of interest rather than chronic injury. Although occupational injury has been defined in several ways, Hagberg et al (20) defined it as “any damage inflicted on the body by energy transfer during work with a short duration between exposure and the health event” (21, p110). In this case, energy transfer over the course of milliseconds could produce traumatic injury to the body, whereas more gradual energy transfer would more likely be associated with a musculoskeletal or cumulative trauma disorder. The short induction – latency period involved in acute traumatic injury – may have allowed for a cleaner examination of the exposure in both studies (in the first case transient risk factors, whereas in the second the participatory intervention).

Finally, as an indication of the global burden of injury (21), it has been estimated that, in a single year, worldwide, there were 4.8 million persons fatally injured and an additional 973 million persons who sustained injuries needing some form of healthcare. Clearly, there is still quite a bit of work to do in identifying important modifiable risk factors causing work and non-work related injury and implementing and designing effective interventions to prevent injury and disability.

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