Risk Factors for Nonfatal Work Injury for Young Workers: A Review of Two Relevant Literatures

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Introduction

The inverse relationship between age and non-fatal work injuries is one of the most consistent associations found in occupational health and safety research [Laflamme and Menckel 1995; Salminen 2004]. Depending on the data source, both teenagers and young adults in developed countries have rates of work injury up to two times those of workers over 25 years of age [Breslin et al. 2003; CDC 2001; Dupre 2001; Laflamme and Menckel 1995; Salminen 2004].

Many of the work injuries youth sustain have clear health and economic consequences. For example, 15 to 26 per cent of injured workers under age 18 have reported permanent impairments such as chronic pain, scarring, sensory loss, and loss of range of motion. [Parker et al. 1994a,b]. In addition, serious injuries such as fractures and amputations though relatively rare (rate of compensation claims with permanent impairment among working 15 to 19 year olds = 0.59 per 1000 fulltime equivalents (FTEs); [Breslin et al. 2003] are clearly a concern because of the long-term health and disability consequences [Breslin et al. 2003]. Labor market trajectories may also be affected given that 16- to 24-year-olds who sustained a work injury have significantly lower earnings – about $1,000 (Canadian dollars) -- in the year after they returned to work than their uninjured counterparts [Breslin et al. 2007c].

This paper reviews the quantitative literatures for two related questions regarding risk factors of work injuries for teenage (15- to 19-years-old) and young adult (20- to 24- years-old) workers: a) What risk factors might account for youth's elevated work-injury rates compared to adult workers; and b) Among young workers, what risk factors are associated with experiencing a work injury? Although the term "risk factor" can have somewhat different meanings in different disciplines, for this paper a risk factor refers to an individual or situational characteristic statistically associated with, although not necessarily causally related to, an increased likelihood of a health event [Stedman 2006], and that is *independent of other potential risk factors*.

The term, "young worker" has been defined both narrowly and broadly. Policy- makers and researchers -- especially in the U.S. -- define young workers as those less than age 18 because most child labor laws only apply to this age group [NRC 1998]. An alternative definition includes young adults up to age 24. This broad definition recognizes that many young adults are often in the same labor market niche as adolescents, and young adults are also more likely than older adults to sustain a work injury. In this review, we used the latter definition.

In terms of review scope, studies focusing exclusively on work injuries occurring in agricultural settings were not included because a recent review covered this literature [Reed and Claunch 2000]. Also, this review does not include studies focusing on specific occupational dis-

eases among young workers, such as asthma or dermatitis. Even though occupational disease is an important topic, published and unpublished reviews of this area exist [Breslin et al. 2006a; Pollack 2001]. In addition, given the chronic course of many diseases, the risk factor issues associated with occupational diseases can be quite different than for acute injuries.

Risk factors and method issues

There are three methodological aspects of risk factors that are highlighted in this paper for their relevance in interpreting the studies and identifying research gaps (see Figure 1). These dimensions are adapted from a systematic review of observational studies of whiplash injuries [Cote et al. 2001].

Data sources

Young worker research draws primarily from three data sources: workers' compensation claims, health records, and self-report surveys. Each of these data sources has its advantages and biases. Under-reporting of injuries may be a particular limitation with workers' compensation claims. For example, Shannon and Lowe found that where workers who had sustained injuries that might qualify for compensation, *not* filing for a claim was more common among those who perceived their injury to be less serious [Shannon and Lowe 2002]. Also, those in temporary jobs or those with multiple jobs did not report the injury. Of these factors, being in a temporary job is common among youth and would make it less likely that they file a claim.

The coverage of work-related injuries through hospital emergency department (ED) records has also been shown to not coincide with injuries reported for workers' compensation [CDC 1998]. Finally, self-report measures may circumvent administrative reporting practices, but recall biases as to the injury date or the interpretation of what is an injury are concerns with this data source. The advantage of an overall review of the relevant studies is that when we see patterns in risk factors from many data sources, this consistency suggests a robustness of the association despite methodological differences.

Relationships between potential risk factors

The types of relationships between potential risk factors, -- namely confounding, mediation, and moderation -- are important to consider when interpreting the results of the young worker and age-difference literatures. A confounder is a factor that produces a spurious association between the outcome and a predictor [Greenland and Robins 1985]. It does so by being associated with both the predictor and the outcome, without being in the causal pathway between the two. Accordingly, multivariate studies were the focus of this paper because univariate, descriptive statistics leave open the possibility of confounding due to a differential distribution of demographic or other factors. However, estimating the true associations between a variable and an outcome in multivariate analyses has its own set of assumptions, such as that none of the other variables in the model lie in the causal pathway [Greenland et al. 1999].

As emphasized in our introduction, identifying a characteristic as a risk factor does not necessarily imply that it is causally related to the likelihood of a work injury. For example, young males show higher rates of acute work injuries than young females. However, the duration and type of hazard exposure, the different ways of carrying out their tasks, and specific physical vulnerabilities to injury may mediate gender differences in the likelihood of work injury (i.e., part of the pathway accounting for observed gender differences) [Messing 1997]. This review reflects the degree to which the methods and analyses of each study were able to rule out potential confounders and characterize possible mediators -- such as hazard exposures -- that underlie the observed association between certain demographic and workplace/job variables with work injury.

A particularly relevant issue for the literature on youth versus adult differences in work injury likelihood is whether age may act as a moderator. A moderator is a variable that changes the relationship between another predictor and the outcome [Baron and Kenny 1986]. A common belief is that cognitive/behavioral/ physiological vulnerabilities unique to youth may make even similar work environments and job tasks more hazardous for youth (i.e., youth specific vulnerabilities). If these youth-specific vulnerabilities had substantial effects and were relatively common among youth, then one would predict that age would moderate the relationship between occupational categories and work injury likelihood. That is, certain occupations would be unusually risky for youth, but there would not be the same elevated risk of work injury among adults in the same occupation. In sum, identifying mediators and ruling out confounding factors are relevant to both risk factor literatures that will be reviewed in this paper. The issue of moderating factors is a potential issue in both literatures, but it is highlighted in this paper in relation to youth's elevated injury risk relative to adult workers.

Type-of-injury dimension

The type-of-injury dimension refers to the notion of an injury pyramid and its implications for risk factor identification [Institute of Medicine 1999]. The injury pyramid is a visual representation of the levels of injury severity, with less severe injuries being of higher frequency than more severe injuries and fatalities. Different injury severities may have different risk factors. For instance, goods producing industries have higher claim rates (compared to service industries) in jurisdictions where a lost-time claim required three or more days of lost time before a claim could be filed. However, rates of injury between goods and service industries are more similar in jurisdictions where fewer days of lost time from work were needed to qualify for a lost-time claim [Breslin et al. 2005]. Another example on how risk changes by injury severity is that, while youth typically show higher rates of non-fatal injuries such as lost-time claims and ED visits, adult workers typically show higher rates of permanent impairments and fatal occupational injuries [Breslin et al. 2003; Castillo et al. 1994].

The nature of the injuries -- regardless of severity -- is also relevant to interpreting the correlates of an aggregate injury outcome. In a previous review [NRC 1998], claims data showed lacerations/cuts to be the most frequent type of injury, with contusions/abrasions and sprains/strains being the next most common among young workers. Information on the mix of injury types in a study's injury outcome variable is useful for cross-study comparisons, especially if young worker studies identify different injury risk factors. If a study has a particularly unu-

sual mix of injuries, this may indicate that the samples of young workers may have encountered different sets of hazards. Such differences in hazard exposure to, for example, sharp objects versus heavy lifting may lead to a different set of risk factors being associated with the aggregate injury outcome. That is, many studies make the assumption that risk factors for various acute injuries are similar, but this is an assumption that has not been systematically examined in the young worker literature.

Two questions pertaining to risk factors for work injuries of young workers

There are two overarching questions pertaining to risk factors for work injuries of young workers: a) What risk factors might account for youth's elevated work-injury rates compared to adult workers? and b) Among young workers, what risk factors are associated with experiencing a work injury?

What risk factors might account for youth's elevated work injury rates compared to adult workers?

The key reason that youth are considered a special or vulnerable population is that descriptive, population-based data show elevated injury rates for adolescents and young adults. From the two most recent reviews focused on age-related differences in work injuries [Laflamme and Menckel 1995; Salminen 2004], there were 14 population-based studies (e.g., studies reporting on workers' compensation claims across multiple industries) that provided descriptive information on work-injury rates for at least one age group under 25-year-olds. In 10 of these studies, adolescent and young adult workers had higher work-injury rates than their adult counterparts. This elevated risk was more marked and more consistent for young males than for young women (for specific citations, see introduction of [Breslin and Smith 2005]).

Four of these studies showed similar or lower rates for young workers. However, a methodological concern in each of these studies was that the denominators used to calculate the injury rates were based on the number of workers in each age group instead of by the number of hours worked. Because young workers are more likely to work part-time or seasonally, injury rates calculated using the former method underestimate the risk of injury for youth [Castillo et al. 1994; Ruser 1998].

Given the consistent findings of elevated work injury rates for young workers compared to adults, a key focus has been determining the degree to which different jobs (as a proxy for hazard exposure) account for this pattern. Hazard exposures are different for young people because the labor market is strongly segregated by age [NRC 1998]. In many developed countries, young people are over-represented in certain industries, such as food, service or retail sales. The jobs that many young workers hold are low-skilled, and are self-reported as more physically demanding than those jobs held by adults [Breslin and Smith 2005].

To date, only four population-based studies of age-related differences in work injury have included both age and work variables such as type of occupation in a multivariate regression model [Breslin and Smith 2005, 2006; Leigh 1986; Mitchell 1988]. Adjusting for work variables such as job title can be seen as an indirect measure of different hazard exposures between jobs [Cole and Rivilis 2004]. This adjustment provides preliminary information on the extent to

which youth being concentrated in certain types of jobs can account for the elevated risk of young workers.

In a cross-sectional study using workers' compensation files from nine U.S. states and corresponding Census data (i.e., denominators), Mitchell [1988] found that young workers' elevated claim rates were somewhat reduced when controlling for occupation and industry, but continued to exhibit significant residual risk, suggesting that elevated youth risk is not entirely a reflection of age differences in jobs held.

In another cross-sectional study of Canadian workers [Breslin and Smith 2005], adjusting for job characteristics substantially reduced -- but did not eliminate -- the elevated risk status of adolescent (15 – 19 yrs) and young (20 – 24 yrs) adult male workers. For females, only young (20 – 24 yrs) adult females continued to exhibit an elevated risk of work injury when job characteristics were controlled for.

In a longitudinal survey, a significant inverse relationship between age and the likelihood of work injury was eliminated when work-related factors such as type of job was controlled [Leigh 1986]. Similarly, a multivariate cross-sectional study of workers' compensation claim rates found that the unadjusted relative risk of 15- to 19-year-old workers decreased by 50 per cent (unadjusted RR = 2.56) when factors such as type of occupation and job tenure were controlled (adjusted RR = 1.28) [Breslin and Smith 2006].

Despite many methodological differences among these studies and some variability in findings, most indicate that a substantial part of the elevated injury risk experienced by youth appears to be due to differences in the types of jobs young people and adults hold (and the associated hazard exposures). There may be other work-related variables that affect hazard exposure where youth and adults differ (e.g., organizational factors), but the current literature most consistently focused on and found differences in the types of jobs youth and adults hold.

Explanations for youth's elevated risk even after controlling for work variables

Two types of explanations may account for the residual elevated risk for youth even after controlling for work-related variables: a) age differences in hazard exposure within jobs; and b) youth-specific vulnerabilities. Each of these will be discussed in more detail below.

Age differences in hazard exposures within jobs

Multivariate studies of age differences in work injury represent an incomplete evaluation of how youth-specific vulnerabilities may elevate their work injury risk because these studies assume similar hazard exposure within similar occupational categories.

Preliminary evidence of this possibility comes from a study of teenage workers that found a wide discrepancy between job titles and job tasks they performed ([Davis and Frank 1997] cited in [NRC 1998]). For example, a cashier in a fast food restaurant may also regularly be asked to cook or clean. These data are only indirect evidence of age-related hazard differences within an occupation because the variability of tasks of adults in similar occupations is not known. In addition, one set of youth focus groups have reported that youth sometimes experience instances of hazards tasks being shifted onto them by senior workers [Workers' Compensation Board of British Columbia 2001]. These differential task assignments within the same job title may translate into additional hazard exposure for young workers in terms of ergonomic demands and using dangerous equipment/tools.

Beyond job content, there may be age differences in workplace cultures that ultimately influence hazard exposures in the same job. A young person's typical position as a temporary or part-time worker may translate into less autonomy or control over work tasks. This decreased control may influence injury risk through work intensification [Quinlan et al. 2001]; work pace pressure; frequency of rest breaks; or the ability to vary tasks to reduce injury risks. These hypothesized relationships between workplace culture and hazards are tentative and need to be further explored, especially given the findings by Mortimer[1] that increased perceived control at work for young people was associated with increased stress.

In sum, the additional hazard exposures not captured by occupational categories may further account for residual risk for young workers and raises the possibility that more refined measures of hazard exposure may lead to even more of youth's elevated risk being accounted for by work-related factors.

Youth-specific vulnerabilities

There is also the possibility that even the same workplace and job tasks are not experienced the same way by youth and adults because of individual differences. Physical developmental issues may be relevant because "tool design, working surface height, and equipment dimensions are designed for adults and make different demands on the body, with the smaller stature of some teenagers leading to lower physical tolerance and awkward postures [Feldman et al. 2002]." Yet the youth-specific vulnerabilities most frequently discussed are different cognitive functioning and different social-emotional issues between youth and adults.

The media often describes aspects of adolescent cognitive functioning as a major contribution to youth work injury. A typical example from an occupational health and safety trade journal is the following: "The vulnerability of younger workers may arise from their well-known sense of invincibility" [Gordon 2005]. As Fischoff and others have noted [Fischhoff 2007; Furby and Beyth-Marom 1992], however, it appears that by about age 16, an individual has the cognitive capability to appraise risk and use decision heuristics similar to adults. Consistent with this notion, many studies of risk appraisal of health events find no age-related differences [Quadrel et al. 1993; Weinstein 1987]. Also, if cognitive factors were a predominant factor in elevated risk, we would expect to see a gradient where young adults would show less elevated risk (after adjusting for work variables) than adolescents, but more often young adults show as much or greater injury risk than teens [Breslin and Smith 2005].

Complicating the picture, there is some evidence that youth may differ from adults in terms of the salience of potential long-term, in addition to short-term, consequences [Nurmi 1991]. Differences in future time perspective may suggest that certain workplace situations, where long-term consequences influence injury risk but are not salient, may evoke a different response among young workers compared to older workers. The mixed findings on cognitive functioning as a plausible mechanism for youth specific vulnerabilities suggest that an inability to process information relevant to assessing risk among youth is not as pervasive and robust as commonly portrayed in the popular media.

[1] *See Mortimer J. Work and its Positive and Negative Effects on Youth's Psychosocial Development in Health and Safety of Young Workers: Proceedings of a U.S.-Canadian Series of Symposia, NIOSH 2013. Page 66 in this document.*

There are, however, certain findings in the research literature on brain development during adolescent/young adulthood that need to be explored for their relevance to specific vulnerabilities for work injury among youth. Although a detailed review of this literature is beyond the scope of this paper, two key changes in the adolescent brain may be relevant to increased risk of work injury. First, changes in reward sensitivity related to developments in the limbic system are thought to underlie the increased novelty seeking and higher levels of stimulation observed among adolescents [Spear 2000; Steinberg 2004]. Second, the relatively slow development of self-regulatory processes -- such as impulse control, foresight, and planning -- are seen to be linked to the slow maturation of the pre-frontal cortical systems [Spear 2000; Steinberg 2004].

Both of these processes could provide a propensity for different behaviors when engaging in similar job tasks as adults at work (e.g., adherence to safety practices), but possibly through other mechanisms than risk appraisal such as social and motivational issues [Erikson 1964]. Social-motivational issues that are more salient during this life stage include particular needs for affiliation, being attractive to others, achievement and independence. For example, teen's acceptance of parental influence declines during adolescence [Berndt 1979]. This change occurs in conjunction with increased susceptibility to peer influence, which appears to peak at around age 14 [Steinberg and Silverberg 1986]. A related developmental issue is social perspective taking, the ability to understand a situation from another person's point of view. According to Selman [Selman 1980], understanding that other's perspectives are influenced by institutional practices and the social roles they play continues to develop during adolescence. This combination of peer influence and difficulty seeing other's perspectives may make workplace interactions with young people qualitatively different from interactions with adults.

Another important aspect of potential youth specific vulnerabilities is their apparent situation-specific nature. For instance, there is recent research on the specific contexts where youth risk-taking is more likely to occur. Contextual factors influencing risk-driving behaviors among youth have also been demonstrated [Gardner and Steinberg 2005]. In this study, risk in a driving simulation was similar among youth and adults when completing the simulation alone. However, when youth and adults completed the driving simulation in the company of friends, youth showed significantly greater risk-taking tendencies.

General evidence of the modifying effect of the social setting on youth injury risk is also provided by a study examining the relationship between risk-taking behaviors (e.g., recreational drug use, failure to use a bike helmet) and injury among youth 11- to 15-year-olds [Pickett et al. 2002]. There was a clear risk gradient, with youth who reported the most risk-taking behaviors exhibiting an injury rate four times those reporting no high risk-taking behaviors. Importantly, the strength of the behavior-injury association varied by setting with the association being attenuated in school settings compared to home and sports settings. This pattern appears to indicate that more controlled contexts inhibit teen risk-taking, with workplaces potentially akin to school settings in terms of being more controlled due to supervision and co-workers, but with workplaces probably varying on this dimension. Consistent with this notion, a study of a fast-food chain with particularly engineered and organized work processes showed lower than average injury rates among youth [Mayhew and Quinlan 2002]. These work processes were so engineered and controlled that "...there was an almost total removal of all conceptual work from execution of tasks" (page 268).

Given this combination of cognitive, social, and emotional factors in adolescence and young adulthood, risk appraisal may be less salient or need to be interpreted in the context of the other factors. For instance, one could hypothesize that, consistent with Fischoff[2], young males are able to accurately appraise the risk, but may still not engage in safe practices due to social-emotional factors (e.g., gender roles)[Harré 2000]. For example, mastery of physical risk has a central position in traditional male gender identity [Kilmartin 1994]. Young males experience pressure to take physical risks at an early age, so as not to be seen as a "sissy" [Kjellberg 1998], or wanting to fit in with their older male co-workers [Breslin et al. 2006d]. Furthermore, mastery of risk can bring with it self-esteem, independence, and peer recognition [Lloyd and Forrest 2001]. These issues particular to the adolescence/young adulthood life stage may lead to, for example, differences in the way workers react to near misses, minor injuries or willingness to engage in certain safety practices.

In sum, the typical discourse in the youth occupational health and safety literature appears to have an implicit assumption that youth-specific vulnerabilities (e.g., cognitive and social-emotional functioning) influence all situations, and an assumption that such vulnerabilities affect all youth to a similar degree. However, studies on adolescent development raise the possibility that social-emotional issues and the motivations arising from them may be more relevant to work injury risk than development aspects of cognitive functioning (e.g., risk appraisal). As noted in the discussion below, this may suggest other targets of intervention besides risk appraisal. Research also indicates that any youth-specific vulnerabilities are highly context dependent. One major implication of this conception is that studies of risk taking in other injury setting may not be generalizable to the work setting. Further, research on young workers reviewed below also suggests that the assumption of vulnerabilities applying to all youth needs to be examined in that specific subgroups of young workers appear to sustain a disproportionate share of the injury burden (e.g., not attending school). Thus, a simple model that developmental factors might be a predominant factor in explaining work injury risk is not tenable and needs to be modified to account for a complex set of research findings and possible mechanisms.

Section summary

Based on the literature concerning youth's elevated risk of injury compared with adults, the following points are noted:

Based on the few multivariate studies examining this issue, youth's elevated injury risk is substantially reduced (and in one study completely eliminated) after work-related variables such as occupation/industry are controlled. Given the amount of the elevated risk of young workers explained by the types of jobs they hold (and by implication the hazards they are exposed to [Hébert et al. 2003; WHSC 2002]), young workers might be conceptualized as similar to vulnerable adult worker subpopulations such as visible minorities who encounter multiple work-related risk factors due to their lack of work experience or low education level. Such populations are selected into work arrangements that lead to a concentration of risk factors that can lead to adverse health outcomes [Frohlich and Potvin 2008].

[2] See Fischhoff B. Assessing adolescent decision-making competence in Health and Safety of Young Workers: Proceedings of a U.S. – Canadian Series of Symposia, NIOSH 2013. Page 46 in this document.

It would be useful to formally evaluate whether age moderates the association between work variables (such as occupational category) and work injury, thereby providing more direct, but preliminary evidence of youth-specific vulnerabilities and their relationship to work injuries.

One possible explanation for any residual elevated injury risk for youth include different hazard exposures within jobs compared to adults. Further exploration of this hypothesis would require more detailed assessments of job- and workplace-related exposures.

Another possible explanation for residual risk for youth are specific vulnerabilities related to cognitive functioning and/or social-emotional functioning. Although research has identified unique aspects of the adolescent brain, research also shows that adolescent risk-taking is sensitive to context. Thus, the simple notions of how developmental factors might affect youth appear untenable.

Among young workers, what risk factors are associated with experiencing a work injury?

The results of risk factor studies among working youth improve our understanding of why some young workers do and others do not experience a work injury. Such information can help identify particularly vulnerable sub-groups of young workers and assist occupational health and safety (OHS) practitioners and policy-makers in making informed decisions about how to best intervene to reduce injury risk. Given the complexity of the problem, risk factor identification requires a multidisciplinary approach to examine both traditional (occupational, hazard exposure) and non-traditional (social, psychological, economic) risk factors.

Previous reviews of non-fatal occupational injuries among youth in the U.S. summarized studies primarily of workers' compensation claims or emergency department records. These data showed that 16- and 17-year-old workers have higher injury rates than younger adolescents [NRC 1998; Runyan and Zakocs 2000]. In addition, adolescent males exhibited injury rates around twice those of adolescent females [NRC 1998; Runyan and Zakocs 2000]. In terms of work settings, injury rates across studies were found to be elevated in industries such as retail trade, manufacturing, construction, public administration (where park maintenance and other manual tasks were common), and trucking/warehousing [NRC 1998]. One review [NRC 1998] also drew on indirect evidence on adolescent development and workplace policies to support the relevance of other risk factors that had not been specifically correlated with work-injury risk. For example, a finding that 80 per cent of adolescents injured at work reported that no supervisor was present at the time of the injury. Whether this rate of supervision differed between injured and uninjured youth was not provided.

Risk factors among working youth review: Methods overview

For this paper, a systematic review of risk factors for young workers was updated to include relevant studies published since that review [Breslin et al. 2007a]. Regarding study inclusion criteria, studies were identified that focused on working youth between ages 12 to 24 who engaged in paid work. The studies needed to have examined unintentional, non-fatal work injuries.

In relation to methodological quality, studies were evaluated based on three criteria: a) the study needed to examine work-injury rates or the likelihood of injury (i.e., information on popu-

lation exposed to possible injury was required); b) the study needed to describe the type or severity of the work injury. Such data on the nature or severity of the work injury provides some indication that the injury measure was assessing nontrivial events and allows for some basis to compare the nature of injury across studies; and c) the study needed to use multivariate analyses that included some combination of individual/demographic characteristics and job/workplace factors as predictors in the regression model.

Studies published between January 1980 and March 2005 were identified through an electronic database search (for details see [Breslin et al. 2006b]). For studies published since then, we searched the archives of SafetyLit, a service that identifies articles published related to injury. Table 1 shows the details of the studies that met these inclusion criteria.

Nature of injuries across studies

Among the multivariate survey studies reviewed, the outcome was defined as whether any type of injury had occurred at work (sometimes with a specified timeframe). Although many studies provided information on the types of work injury sustained (e.g., cut), no study stratified their multivariate analyses by type of injury.

To examine types of injuries reported between studies, each category of injury reported within a study was rank-ordered, that is the most frequent type of injury was ranked first, the second most frequent was ranked second, etc. (i.e., high frequency ranking). Cuts-lacerations were on average the most frequent type of injury reported across four studies [Breslin et al. 2006b; Driscoll and Hanson 1997; Weller et al. 2003a, 2003b]. Fractures/dislocations and sprains/strains were the next most frequent types of injury. This information on which injuries were most frequent is in line with reports from previous reviews [NRC 1998].

Individual/demographic factors

Table 2 summarizes the individual/demographic factors that at least two multivariate studies evaluated. Five of eight studies that included gender in their analyses found no independent association of gender when job/workplace factors were controlled (with all but one study showing a significant crude association with gender). This may indicate that when working in similar situations, young males and females exhibit a similar risk. Studies of the fast food industry are consistent with this, showing comparable injury rates for both men and women [Mayhew and Quinlan 2002]. Of note is that the three studies showing residual gender differences tend to be those that included young people in late adolescence and young adulthood. This raises the possibility that jobs and tasks within jobs become more gender differentiated in late adolescence and young adulthood.

Three of five studies examining visible minority status found elevated risk of injury even after controlling for factors such as work setting/industry. The groups at elevated risk were most frequently Hispanic and Black youth. The finding that visible minority status was associated with work injury may occur because this group encounters more hazards at work even within the same job, or due to other social/environmental factors that could contribute to this residual risk that were not controlled. However, the one Canadian study of the five showed visible minorities at significantly lower risk. Given that Canada has a different mix of visible minorities than the U.S. (i.e. in Canada most visible minorities are Asian), this finding may indicate that

contextual differences and the degree of marginalization minorities experience in the labor market may change their risk of injury.

A positive association between substance use and work injury was found in two studies. However, this association should be explored further before firmer conclusions can be drawn. For example, Shipp and colleagues [Shipp et al. 2005] adjusted for basic demographic factors (e.g., age gender) and only work hours. Thus, whether substance use was independently associated with injury risk, and not a proxy for other personal, socioeconomic, or even workplace factors, is open to question.

Three studies have now examined school status, and two of the three studies found that those youth not in school (with or without a high school diploma) are at an elevated risk for a work injury, even with job/workplace factors controlled. There were indications that those out of school may be encountering a poorer fit between themselves and their work environment compared to their counterparts in school holding the same type of job. For example, those not in school (regardless of high school completion) reported less social support at work. This reduced support could reflect fewer peers as co-workers when working full-time and/or inadequate supervision than their counterparts in school.

Two of the three cross-sectional studies examining length of employment in current job showed a positive association with injury (the fourth, prospective study examining length of employment is discussed below). However, an association between total months on the job and injury in cross-sectional studies obscure the timing of when the injury occurred within the job tenure. That is, length of employment in cross-sectional studies reflects cumulative exposure rather than time varying risk at each month of job tenure (phase specific risk). In studies examining phase specific risk, the findings are mixed. In a longitudinal study of young workers, the month on the job was not associated with risk of a one-week work absence due to injury or illness [Breslin et al. 2007b]. These findings may differ from ecological studies of job tenure and lost-time claim rates [Breslin and Smith 2006] because the former study's outcome reflected a higher level of severity compared to the latter study (where a lost-time claim can be filed after one day of absence in the jurisdiction).

Two cross-sectional studies examined psychosocial traits such as negative affectivity, rebelliousness, impulsivity, and "omnipotence" (e.g., "I honestly think I can do things no one else can")[Frone 1998; Workers' Compensation Board of British Columbia 2001]. Neither study found these traits were significant predictors in their multivariate regressions. However, given the studies' cross-sectional nature, a possible explanation is that the occurrence of a workplace injury might reduce such psychosocial traits post-injury, resulting in smaller differences between groups. This possible explanation underscores the importance of longitudinal studies that clarify the temporal patterning of risk factors and outcomes. A young worker's risk-taking orientation at work was found to be prospectively associated with work injury [Westaby and Lowe 2005]. However, this study did not include occupational variables such as work setting or occupation. Thus, it is unclear whether the risk taking-injury association is due to high risk-taking youth holding more hazardous jobs or whether they carry out similar jobs, but in a way that increases risk.

Workplace and job factors

The type of work setting or occupation (e.g., restaurant and food service work, respectively) is often used as a proxy for measuring the amount of hazard exposure and dangerous tasks that workers engage in [Punnett and Wegman 2004]. Work setting or occupational categories were associated with the likelihood of a work injury in six of seven studies. In the two studies conducted among junior high and high school students, only restaurant work had an injury risk significantly higher than babysitting. Construction work showed significantly increased risk only among high school students.

A study of Canadian youth found that compared to administrative and clerical jobs, all other occupations demonstrated an increased risk of injury, with process/manufacturing and farming/forestry/fishing jobs showing the highest risk [Breslin et al. 2006b]. The other two Canadian studies showed that physically demanding, manual jobs were associated with higher injury risk than non-manual jobs [Breslin et al. 2007b; Breslin 2008]. The only study that did not find work setting to be predictive also included work hazards as a predictor in a multivariate model, which would be expected to be a more proximal measure of exposure than work setting or occupation (i.e., mediator).

Three studies examined the relationship between the number of work hazards encountered in the workplace (e.g., sharp objects, hot objects) and the likelihood of injury. The number of hazards was positively associated in two of the three studies. The number of hazards was typically the strongest predictor of work injury in these studies (largest standardized parameter estimates), compared to demographic/individual variables and other workplace factors.

Perceived work overload or pace pressure was positively associated with injury risk in all four studies that it was examined. In two studies, perceived work pace pressure contributed to the probability of work injury over and above the strong association between number of work hazards and injury. Barling et al. [Barling et al. 2002] found that work overload indirectly increased work injuries by weakening organizational safety climate (defined as the perception the workers have about the importance that safety has in their workplace)[Zohar 2003].

The number of hours worked per week was positively associated with injury risk in only three of nine studies. However, this lack of consistency in finding an hours-injury association may be a methodological artifact related to whether the job information obtained in the study is the actual job where the injury occurred. For example, studies that used information not only about the person's main job, but about any injury event (sometimes even lifetime prevalence) were less likely to find an association.

Supervisor attributes were assessed in three studies for their association with injury risk. Youth perceptions that the supervisor cared about young workers' safety reduced risk for injury indirectly through an association with organizational safety climate [Barling et al. 2002]. Similarly, youth perceptions that their supervisors viewed risk-taking negatively reduced injury risk indirectly through its effect on youth's perceptions of risk-taking at work [Westaby and Lowe 2005]. In contrast, teen workers' perceptions of how closely their supervisors monitored them did not influence the workers' risk for injury.

Section summary

Even though one strength of systematic reviews is their transparency of relevance and quality criteria, this review focused on published studies, with little attention to the non peer-reviewed literature. A further limitation is that while basic methodological features were used to screen study quality, those studies meeting the criteria still had a diversity of ways of operationalizing constructs such as job and workplace characteristics.

Based on the literature concerning risk factors of work injury among youth, the following points are noted:

Workplace/job factors showing consistent evidence of an independent association with youth work injury were work setting, frequency of hazard exposure, perceived work overload, and supervisor attitudes to safety.

Individual/demographic factors showing consistent evidence of an independent association with youth work injury were visible minorities (in U.S. studies) and youth who were currently not attending school.

There are a growing number of multivariate studies on this issue, with an additional four 12-month prevalence studies [Breslin et al. 2006b; Breslin et al. 2007b; Breslin et al. 2008; Westaby 2005] and two lifetime prevalence of work injury studies [Rauscher et al. 2008; Zierold et al. 2006] above the nine studies identified in a recent systematic review.

Discussion: research issues

There are several methodological strengths in the literatures related to risk factors and youth work injury. First, there are several data sources such as compensation claims and ED records that allow one to summarize important population-based information on the work injury burden of young workers by demographics, occupation, and industrial categories as well as the nature of the injuries. Second, the literature on risk factors among youth has an increasing number of studies using multivariate analyses, which aid in disentangling the covariation of individual/demographic and job/workplace factors, thereby helping to clarify potential targets of intervention to reduce work injury risk.

Conceptual and methodological gaps

Even though these literatures show solid progress, there are several needs or gaps that would further improve these literatures' utility in informing OHS interventions and policy. Implicit in these recommendations is a view of what counts as sufficient evidence that a situational or individual characteristic is a risk factor for work injury. Ideally, what counts as evidence should include constructs clearly delineated in a conceptual model, direct measurement of the construct, control for potential confounders, in a rigorous study design.

The need for more theory-driven research

The awareness that multiple, diverse factors influence young workers' injury risk helps prevent a narrow focus on a single intervention approach. At the macro level, the ecological frameworks [Bronfenbrenner 1979] are essential for providing broad categories of factors and

for positing important linkages between the social and economic context in which youth work (e.g., family, school) and occupational injury.

Meso-level conceptual models, models that specify interrelationships and pathways broadly alluded to in macro-level frameworks, are particularly needed to guide variable selection and analyses for youth work injury risk. The domains of individual/demographic, job and workplace factors used in previous reviews and the current review of the young worker literature are generally in line with conceptual frameworks employed in other OHS literatures [DeJoy and Southern 1993; Hale and Hovden 1998]. The diversity of etiological factors presents a challenge in that this can lead to a literature that tests only parts of the overall framework, a situation that did occur to a certain extent even in some of the multivariate studies reviewed above. Accordingly, it would be useful if future studies that assessed less established risk factors (e.g., psychosocial variables) would also include more established risk factors, such as hazard exposure or job type.

A useful meso-level conceptual model also includes details of the pathways of influence that identify which factors are proximal (more direct, immediate) determinants in the injury process and which are more distal (e.g., mediation of effects). Proximal determinants of work injury such as exposure to work hazards show strong association with work injury. This finding naturally evokes questions about what workplace, worker, economic, and societal factors lead to some teens being exposed to more hazards than others. In exploring the distal factors that influence the more proximal ones, more potential levers for change can be identified. Accordingly, future studies should specify a model of proximal and distal constructs and test these hypotheses of mediation in their analyses.

A clearer notion of what constitutes a proximal determinant of injury would also be useful in the current etiological literature. Certain studies have included constructs that overlap so substantially with the injury outcome (e.g., coworker injured; [Zierold et al. 2004], that they are more of a proxy for the outcome than a proximal determinant of injury risk. That is, while these proxies for a young worker's injury event may be highly associated with the actual event, such variables provide less information on potential intervention strategies. Accordingly, variables that are essentially proxy outcomes should be distinguished in conceptual models and analyses from proximal determinants of injury risk.

Specific topics where more research is needed include studies collecting information on the benefits of work as well as the potential health hazards of work. To date, no study provides information on whether psychosocial and physical hazards cluster in the same jobs, or whether youth face difficult trade-offs in terms of benefits on working a job, but incurring the risk of work injury. In addition, understanding the relative contribution of risk appraisals (or misappraisals) to work injury, and the extent that workplace factors such as safety climate affect these appraisals (which would be hypothesized to influence behavior) would be a fruitful avenue for future research.

Expanding uses of administrative data sets containing information on youth work injury

A previous review [NRC 1998] recommended an expansion of monitoring and surveillance of youth's work patterns (e.g., work hours) and the hazards to which the youth are exposed, and this recommendation is essential in improving the ability of emergency department records and compensation claims to provide information on risk factors for work injury.

In the literature search for the original systematic review of young worker studies, 24 descriptive studies were found that provided breakdowns of work injury rates by demographic (e.g., gender) and industry/occupation [Breslin et al. 2006]. Descriptive studies of youth work injury refer to studies using claims, health records, or self-report that present work-injury rates in univariate or bivariate tables. The descriptive studies published in the early years of this literature were important in terms of documenting the increased work-injury rates young workers experienced compared to adults, and that the risk among youth were differentially distributed by, for example, gender and industry/occupation [NRC 1998].

However, these types of descriptive analyses by standard demographic and industry/occupation variables have limited value at this stage of the youth OHS literature. The limited returns are due to the confounding of demographic and industry/occupation that occurs with these simple breakdowns of rates. Nevertheless, such descriptive studies continue to be conducted and published (e.g., [Horwitz and McCall 2005]). Further, limiting any attempt to identify additional individual and work-related risk factors through compensation claims or health records is the limited type of information collected. For example, these data sources capture only basic job characteristics and demographic information, and variables such as immigrant status or education level, are typically not collected. Accordingly, it is recommended that studies that only descriptively summarize administrative data on young work injuries be avoided.

Despite these disadvantages of administrative data, there are certain types of risk factor issues for which these data sources may provide new information. An advantage of data sources such as claims or health records is that often there is a greater number of data points that can be analyzed compared to primary data collection with surveys. For example, geographic variation of work injuries by regions within a jurisdiction can be usefully explored with such administrative data [Brooks and Davis 1996]. Also, the greater number of observations allow for more refined analyses of a specific type of injury event. In addition, these data sources allow for the injury rates to be broken down further, and regression methods exist that allow for the estimation of risk, adjusting for other factors [Breslin and Smith 2006]. Accordingly, administrative data may be best used as a method for exploring geographic variation in youth injury risk and infrequent injury events or small young worker subgroups.

Use of longitudinal designs and improved measures

Currently, the majority of the risk factor studies on young worker injuries have a cross-sectional design. While providing essential preliminary evidence of association, the retrospective nature of such data does not address possible after effects of sustaining an injury that may obscure associations with a work injury or produce spurious ones. Accordingly, it is essential that future studies consider employing longitudinal designs that allow for the temporal patterning of risk factors and outcomes to be established, and for time-varying risk factors to be assessed more accurately (e.g., hours worked). This would include assessing multiple jobs that

youth hold over time, and their combined impact on likelihood of a work injury. In addition, this would allow an examination of how risk factors that vary over time affect work-injury risk, which acknowledges the dynamic nature of the injury process in a way that cross-sectional studies cannot capture.

Another key methodological issue is the measures used to assess risk factors and injury outcomes. The knowledge gap in hazard exposure within job categories and in potential mediators of injury risk noted above suggest that measures be developed that provide specific information on exposures that go beyond the job title. It can be difficult to efficiently cover the range of hazards that young workers may encounter given the variability of job tasks and workplaces they encounter (data cited in [NRC 1998]. However, such assessments would avoid the problem of misclassification and within job title variability, which can lead to reduced exposure-outcome links [Messing and Stellman 2006]. Relevant exposure measures include physical hazards, workplace safety climate, and organizational procedures.

For measures of job/workplace factors as well as psychosocial characteristics of the worker, it would be useful to provide evidence of the reliability and validity of these possible risk factors. A related issue specific to research questions on youth versus adult worker differences is that efforts must be made so that terms or variables used have similar meanings for all age groups [Messing and Stellman 2006]. For example, the same work arrangement (e.g., part-time, temporary work) may translate into different levels of job satisfaction, job security and possibly safety attitudes for youth than for adults.

Discussion: recommendations

Many young people in North America engage in paid employment [Usalcas 2005], and some benefits of youth employment have been documented [Mortimer 2003]. Nevertheless, descriptive epidemiological studies show that a substantial portion of youth sustain injuries that are preventable and have the potential to continue to affect their work life. Several substantive recommendations appear to follow from the preliminary evidence presented in the paper:

The consistency and strength of work setting and hazard exposure, both for explaining youth-adult work injury risk and for explaining injury risk just among youth, provide further empirical support for continuing to prioritize safety measures that either eliminate hazards youth encounter on their jobs, or for reducing youth's presence in those jobs/workplaces.

The same evidence that suggests that work-related factors account for much of the elevated risk of youth compared to adults also implies that developmental factors have a limited contribution to work injury risk. Within that limited contribution, indirect evidence raises the possibility that the social-emotional aspects of the adolescent/young adulthood life stage may be more relevant than cognitive functioning issues (e.g., risk misappraisal). This pattern suggests that interventions focusing on peer pressure and social norms (e.g., gender roles) and their relationship to workplace safety may be a useful supplement to traditional education that emphasizes safety knowledge and statistics aimed at changing risk appraisals.

To assist in providing evidence-based prevention of youth work injuries, sensitivity to age differences is necessary and includes more than comparing injury rates by age group, or an exclusive focus on youth-only samples. It requires a more detailed examination of the workplace reality for youth, and improving the quality of information on both potential risk factors and

outcomes. In addition, a better understanding of risk factors will require a multidisciplinary approach from the health, engineering, labor economics, and other social sciences to further delineate and explore the established and new factors underlying the burden of injury among young people, as well as the factors that select them into certain types of jobs and work arrangements.

Figure 1. Relevant methodological dimensions when assessing risk factors.

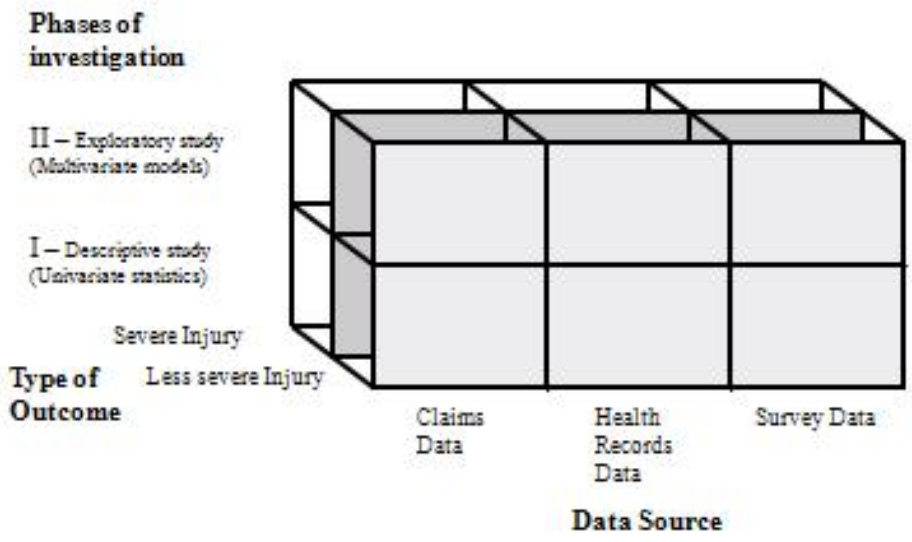

Table 1. Study background characteristics

Author (year)[ref]	Time period Jurisdiction	N Data source	Age (years)	Recruitment method Recruitment rate	Outcome definition
Evensen (2000)	1996 North Carolina, USA	117 who worked in the last 4 months (61% male) Source: phone survey	14–17	Respondents from a previous survey targeting a representative sample of teen workers were recontacted Recruitment rate: 207 of 238 eligible teens were interviewed	Ever been injured in current job by: a fall, burned, hit by vehicle, assaulted/ shot, cut, heavy lifting, falling object, shot? Sum of individual injury items (range 0 to 7).
Frone (1996)	1996 New York, USA	319 who currently worked for pay at least 5 h/week and a full-time student (40% male) Source: self- administered questionnaire	16–19	Recruitment through advertisements at three colleges and 37 high schools Recruitment rate: not reported	Average frequency (never to very often) of seven types of work injuries during the preceding 9 months: strains/ sprains, cuts or lacerations, burns, bruises/ contusions, fractured bone, dislocated joint, or other injuries.
Workers' Compensation Board of British Columbia (2001)	2000 British Columbia, Canada	All those employed within past 12 months, 33 males who had a compensation claim within past year, 36 males who had at least two traffic accident insurance claims, 76 males who had neither type of claim Source: self- administered questionnaire	18–22	Convenience sample from lists of claimants from the province's Workers' Compensation Board and the province's car insurance corporation The control group with neither type of claim was recruited by phone Recruitment rate: not reported	Number of injuries in current job from a list of 10 mechanisms of injury (e.g., cut by something sharp).
Driscoll (1997)	1993 Canberra, Australia	997 (83% males) Source: self-administered questionnaire	Mean age 20.2	All first- to third-year students at the Canberra Institute of Technology enrolled in a formal apprenticeship program were given the questionnaire Recruitment rate: not reported	Occurrence of injuries during the school year occurring in the school/ workplace where at least one of the following occurred: the loss of at least one shift, received hospital treatment, received sutures to a wound.

Table 1. Study background characteristics (cont'd)

Author (year)[ref]	Time period Jurisdiction	N Data source	Age (years)	Recruitment method Recruitment rate	Outcome definition
Barling (2002)	Time period not reported Large city in Canada	164 currently employed (51.3% male) Source: self-administered questionnaire	14–24	300 surveys were distributed to local high schools, colleges, and a downtown community center Recruitment rate: 85% of distributed surveys were returned	Average frequency (never to frequently) of experiencing seven types of work injuries during the past year: strains/sprains, cuts/lacerations, burns, bruises/ contusions, fractured bone, dislocated joint, serious muscle/ back pain, blisters.
Zierold (2004)	2001 Wisconsin, USA	3189 who worked during past summer (48% male) Source: self-administered questionnaire	10–14	Teachers in five school districts and one large urban school administered survey Recruitment rate: 5499 of the 10,366 students in the participating middle schools completed the survey (53%)	Occurrence of injury during summer job.
Breslin (2008)	2000-2001 Canada, excluding Northwest Territories	12,506 who worked during the last 12 months (51.8% male) Source: structured interviews	15–24	Secondary analysis of The Canadian Community Health Survey (CCHS), a large, population based sample survey of persons aged 12 and older, living in private dwellings in Canada Recruitment rate: 130,837 respondents of all ages from 125,159 households with a person response rate of 91.9%	Occurrence of injury at a job or business in the last 12 months serious enough to limit their normal activities and received medical attention from a health professional within 48 hours of the injury.
Breslin (2007)	1993-2003 Canada, excluding Northwest Territories and Yukon	17,041 who were employed (50.9% male) Source: structured interviews	16–24		Occurrence of a work disability absence for 1 week or longer due to a work-related illness or disability.

Table 1. Study background characteristics (cont'd)

Author (year)[ref]	Time period Jurisdiction	N Data source	Age (years)	Recruitment method Recruitment rate	Outcome definition
Breslin (2006)	2000-2001 Canada, excluding Northwest Territories	14,541 who worked during the last 12 months (51.6% male) Source: structured interviews	15–24	Secondary analysis of The Canadian Community Health Survey (CCHS), a large, population based sample survey of persons aged 12 and older, living in private dwellings in Canada Recruitment rate: 130,837 respondents from 125,159 households with a person response rate of 91.9%	Occurrence of injury at a job or business in the last 12 months serious enough to limit their normal activities and received medical attention from a health professional within 48 hours of the injury. Mechanisms of injury.
Westaby (2005)	Time period not reported, 10 US states	2542 who were employed (67% male) Source: self-administered questionnaire	12–21	Members of the National Future Farmers of America (FFA), a youth organization completed the survey in the context of FFA classroom activities Recruitment rate: Of 180 invited chapters of the FFA, 117 agreed to participate, a 65% group response rate.	The number of times injured at work in the past three months that required medical attention.
Weller (2003a)	May 1995 Texas (South), USA	1608 who reported working in the past 6 months (55% male) Source: self-administered questionnaire	10^{th}–12^{th} graders	Of the 23 high schools, larger schools had a randomly selected subset of classes surveyed. In schools with fewer than 200 students, all students were surveyed Recruitment rate: 3565 of 7221 eligible students	Ever injured while working
Weller (2003b)	May 1995 Texas (South), USA	3008 who reported working for pay Source: self-administered questionnaire	6^{th}–8^{th} graders	Of the 27 middle schools, larger schools had a randomly selected subset of classes surveyed. In schools with fewer than 200 students, all students were surveyed Recruitment rate: 7302 of 8757 eligible students	Ever injured while working and injury medically attended

Table 1. Study background characteristics (cont'd)

Author (year)[ref]	Time period Jurisdiction	N Data source	Age (years)	Recruitment method Recruitment rate	Outcome definition
Shipp (2005)	May 1995 Texas (South), USA	3265 who reported having ever worked for pay (50.5% male) Source: self-administered questionnaire	9^{th}–12^{th} graders	Of the 23 high schools, larger schools had a randomly selected subset of classes surveyed. In schools with fewer than 200 students, all students were surveyed Recruitment rate: not reported	Occurrence of injury while working for pay
Rauscher (2008)	1999 Massachusetts USA	1430 who reported having ever worked for pay (53.3% male) Source: self-administered questionnaire	14–18	Teachers administered the survey to students in grades 9 through 11 Recruitment rate: Of 2776 students, an overall response rate of 77% is estimated	Ever been injured while working by any of the following injuries: back injury, any other muscle injury, burn, cut, broken bone, electric shock, other.
Zierold (2006)	2003 Wisconsin, USA	3574 who reported working during the school year Source: self-administered questionnaire	14–18	Teachers in 5 school districts administered the survey to students Recruitment rate: Of 8085 students, 6810 completed the survey (84%)	Occurrence of injury. Occurrence of severe injury affecting normal activity for longer than 3 days.

Table 2. Summary of multivariate studies on young workers examining a broad range of injuries

	Outcome: time period of 12 months or less or linked to current job										Outcome: ever injured at work					
Factors	Evensen[1]	Frone[2]	WCB of BC[3]	Driscoll	Barling[4]	Zierold[5,*] (2004)	Breslin (2008)	Breslin[6] (2007)	Breslin (2006)	Westaby	Weller (TEX)	Weller (SMED)	Shipp[7]	Rauscher[8]	Zierold[9] (2006)	**Total**
Demographic Individual factors																
Gender	0	0				0	+	0	+		+	0				00000+++
Age		0				0	0	0	+		0	0				000000+
Race/visible minority						+			-		0	+			+	0+++-
Psychosocial traits		0	0							+						00+
Substance use		+											+			++
Not in school/ low education level							+	+	+							+++
Length of employment	0	+		+				0								00++
Socio-economic status									0		0	0		+		000+
Work- related factors																
Work setting/ Industry	0			+			+	+	+		+	+				0++++++
No. & types of hazards	+	+	0													0++
Duration of work hours	0	0	0			0	0	+	+		+	0				000000+++
Workload/ workplace	+	+	+		+[**]											++++
Shift	0		0			0	0									0000
Supervisor behaviors		0			+					+						0++
Co-worker behaviors		0														0
Population density						+		0	0							00+

(+) positive association with health outcome; (0) no association; (-) inverse association.

[1]Evensen also examined task validity (0)

[2]Frone also examined job boredom (+), role ambiguity (0), work/school conflict (0), job dissatisfaction (0), depression (0), somatic symptoms(+)

[3]WCB of BC also examined perceived risk in job (job safety) (0)

[4]Barling also examined perceived safety climate, safety related events, safety consciousness

[5]Zierold also examined no jobs (0), safety training (0), informed of legal rights (0), asked to do something dangerous (+), co-worker injured (+), near miss (+)

[6]Breslin (2007) also examined number of jobs (0), education level (-)

[7]Shipp adjusted for work hours, grade, sex, ethnicity

[8]Rauscher controlled for work history duration, hours worked per week, race

[9]Zierold also examined work permits (0)

*combined two studies; **indirectly thru safety climate/consciousness

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