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ABSTRACT

A study examined whether, holding work experience and sex constant, exposure to vocational education during secondary school was related to incidence of nonfatal work-related injuries. Data were from the 1987 and 1988 annual National Longitudinal Surveys of Labor Market Experience interviews of young adults who were between 14 and 21 years old on January 1, 1979. Point and interval estimates of the cumulative incidence of nonfatal work-related injuries were determined. Estimates of injury incidence were derived by assuming that the underlying distribution of work-related injuries was Poisson. The relative risks of work-related injury were estimated by secondary school curriculum participation pattern using linear Poisson regression procedures through a computing algorithm. Findings showed the cumulative incidence of work-related injuries reported was 9,049 injuries/100,000 work years of exposure to injury risk. Work-related injuries were more likely among males than females and less likely among young people in the upper two-thirds of the distribution of work experience. Participation in vocational education was not related to the relative risk of work-related injury. Three possible explanations were considered: (1) imprecision of measures of injury incidence and participation in vocational education; (2) employment in occupations not related to training; and (3) misspecification of the model of injury incidence. (41 references) (YLB)

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# *Epidemiology of Work Injuries Among Former Participants in Vocational Education*


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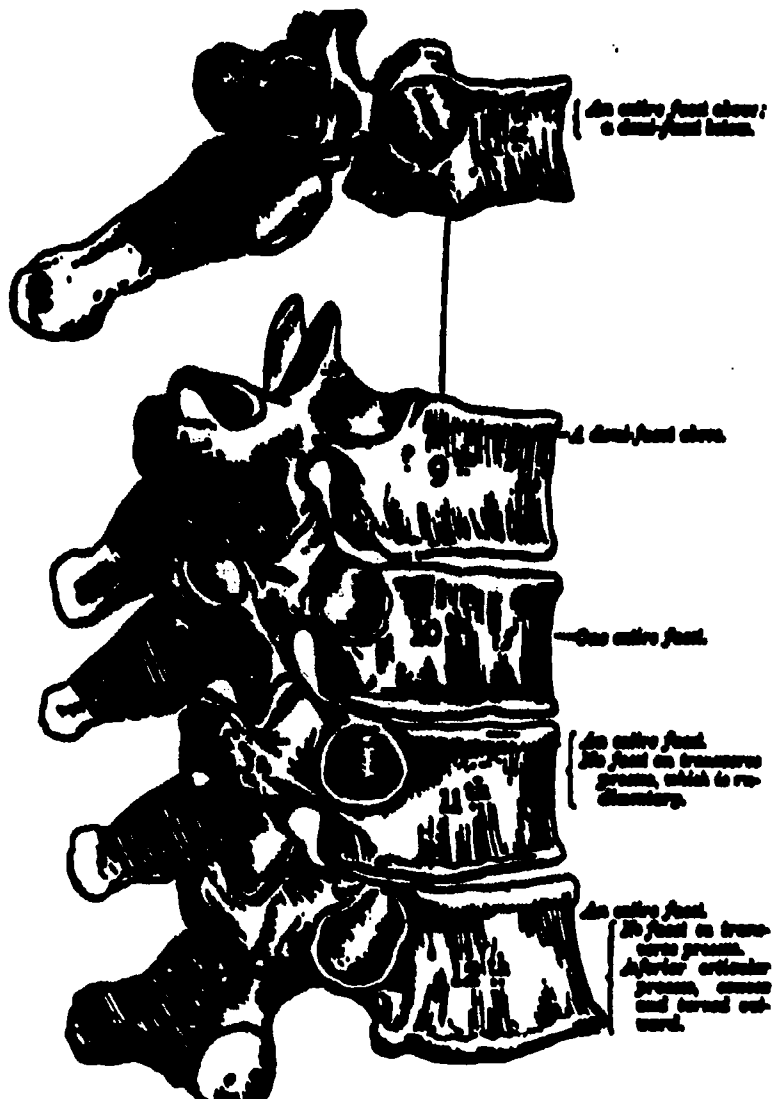

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# EPIDEMIOLOGY OF WORK INJURIES AMONG FORMER PARTICIPANTS IN VOCATIONAL EDUCATION

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A recent landmark report, *Injury in America*, describes injuries as the nation's "principal public health problem" (National Research Council & Institute of Medicine, 1985, p.v). Perhaps injuries are also the most overlooked public health problem. Because most deaths occur at older ages, the underlying disease processes of the elderly dominate mortality estimates (see, e.g., National Safety Council, 1988, pp. 8–9). As a result, heart disease, cancer, and cerebrovascular disease receive much public and professional attention than do injuries (Terris, 1983; Trunkey, 1983). However, injuries deprive Americans of more productive years of life than heart disease or cancer ("Premature Mortality," 1986, Table 1; "Years of Potential Life," 1982, Table V). Up to age 44, deaths due to injury outnumber deaths from any other cause (Baker, O'Neill, & Karpf, 1984, Figure 2–1, p. 8).

One of every four US residents is injured annually, and approximately 1% of US residents experiences an injury requiring hospitalization (Rice, MacKenzie, & Associates, 1989, Table 1). Injuries result in one of every four emergency room visits and are the leading cause of physician contacts (National Center for Health Statistics, 1983). Some injuries have profound, long–lasting consequences. Long–term care is required after injuries that lead to paraplegia, quadriplegia, and brain injuries, especially those leading to persistent vegetative states (Kraus, *et al.*, 1984; Kraus, Franti, Riggins, Richards, & Borhani, 1975). The total lifetime costs of injuries occurring in 1985 was $158 billion—almost three–fourths ($116 billion) for first–year costs and the remaining $41 billion for costs incurred in later years (Rice, MacKenzie, & Associates, 1989, Table 5).

Occupational injuries are a major source of injury morbidity, disability, and mortality. According to the National Safety Council (1988, p. 4), 10 of every 100,000 workers died due to work–related injuries during 1987. Disabling injuries numbered 1.8 million workers, including 70,000 permanent impairments. Work–related deaths and disabling injuries in 1987 cost $42.4 billion in lost wages, medical expenses, administration of medical treatment claims, and fire losses. During 1987, 35 million days were lost from work due to injuries, and over 100 million days will be lost due to these injuries in future work years. These loss estimates probably are conservative due to incentives for employers to underreport occupational injuries (Pollack & Keimig, 1987).

Even though injuries at work constitute a significant public health problem, information about nature, causes, and consequences of work–related injuries, especially those that are not fatal, is scarce, fragmented, restricted to a single type (e.g., head injury) or cause (e.g. falls) of injury, and often not population–based. Also, the rate of nonfatal injuries is highest among workers in their late teens and twenties (Akman, Brooks, & Gordon, 1972; Waller, 1985, pp. 427–428), but research on work–related injuries of young adults is scarce. As a result, information is lacking to support policies and practices for prevention and control of injury mortality, disability, and morbidity at work among specific target populations of young adults.

Robertson (1983) describes three general strategies for preventing and controlling injuries. First, imposition of laws and regulations designed to alter the behavior of individuals can reduce injuries. Laws restricting car speed or requiring the use of personal protective equipment such as seat belts or motorcycle helmets are examples of this strategy. Second, laws or regulations can reduce injuries by altering environments in which victims contact agents or vehicles that deliver injuring energy. Examples of this strategy include bans on the manufacture or use of dangerous consumer products or implementation of housing codes requiring smoke alarms and sprinkler systems. Third, methods to persuade or educate individuals to decrease risky behavior and to increase protective behavior can reduce injuries. Vocational education instruction is one method for persuading or educating young people to reduce work-related injury risks through instruction in the safe use of tools, materials, personal protective devices, industrial processes, and work procedures.

Most injury prevention and control activities in vocational education instruction in secondary schools aim to reduce teacher and school liability for damages caused by injuries occurring during instruction in schools or during cooperative work experiences (cf., Godbey, 1979; Padham, 1990; Rockefeller & Zikmund, 1990; Strong, 1975; Sullivan, 1990). In Pennsylvania, for instance, many vocational education teachers complete a safety education course as part of baccalaureate degree requirements, professional organizations provide extensive safety guidelines for teachers and administrators, legislation requires use of personal protective equipment such as eye protection, and approved vocational education program facilities must receive periodic safety inspections by property and liability insurance carriers or certified safety specialists (Pennsylvania Technology Education Association, 1988). Similar safety requirements exist in other states. As a consequence, education for safety at work is well-articulated with vocational education.

Although most injury prevention and control efforts in vocational education instruction are directed toward reducing school liability for injury losses, vocational education instruction provides many opportunities to increase awareness of hazards associated with tools, materials, and processes and to develop and practice safe work behavior. The research reported in this paper examines whether, holding work experience and sex constant, exposure to vocational education instruction during secondary school is related to the incidence of nonfatal work-related injuries occurring during 1987 and 1988 among young adults in the Youth Cohort of the National Longitudinal Surveys of Labor Market Experience (NLS-Y) (Center for Human Resources Research, 1990a).

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## Methods

### *Target Population and Sample*

Data are analyzed from annual NLS-Y interviews (Center for Human Resources Research, 1990b; Frankel, McWilliams, & Spencer, 1983). The target population for the NLS-Y is people living in the United States, or those on active military duty outside the United States, who were between the ages of 14 and 21 years old on January 1, 1979. People living permanently in institutions such as prisons and hospitals are excluded.

The NLS-Y sample is actually composed of three independent samples. A cross-sectional probability sample represents noninstitutional civilian youths in the United States. An oversample of noninstitutional civilian Hispanics, blacks, and economically disadvantaged non-Black, non-Hispanics supplements the cross-sectional sample. A military sample represents 17- to 21-year olds serving in the armed forces as of September 30, 1978. Face-to-face and telephone interviews began with 12,686 NLS-Y sample members in 1979, occurred annually after 1979, and are continuing.

By the 1988 NLS-Y interview, 10,465 young people, or 82.5% of the original NLS-Y sample drawn in 1979, remained in the sample. In 1984, 1,079 members of the military sample were dropped from the NLS-Y sample, accounting for 48.6% of sample attrition between 1979 and 1988. Other sources of sample attrition include the refusal of youths to remain in the sample (26.4% of total attrition), inability to locate sample members (11.2%), death (5.7%), and various miscellaneous sources (8.1%). Our analyses are restricted to NLS-Y sample members without missing values for any variable included in this study. As a result of attrition from the sample between the 1979 and 1988 NLS-Y interviews and deletion of sample members with missing data for any variable included in the analysis, information from 5,050 young people is analyzed in this research.

## *Variables*

### *Incidence of Work-Related Injuries*

According to Waller (1985, p. 8), a physical injury is damage to the human body that is produced in several ways. First, an injury can occur by exchanging energy beyond the body's resilience. Exchanges can involve energy from thermal, electrical, mechanical, chemical, kinetic, or ionizing radiation sources. Second, an injury can happen by blocking by external means normal body mechanisms for using energy sources (e.g., by immersion under water or by freezing). A scientific definition is not available that sharply distinguishes injuries from disease conditions. However, "injuries and events leading to them are generally more obvious and close together in time than are diseases and the events that precede them" (Baker, O'Neill, & Karpf, 1984, p. 2), although chronic energy exposure can lead to trauma (Waller, 1985, pp. 35–36). In general, the "result of acute exposure to large concentrations of energy is usually called injury, while the result of long-term, less concentrated exposures, such as to low-level ionizing radiation, is usually classified as disease" (Robertson, 1983, p.1).

Occurrences of nonfatal work-related injuries and illness are identified through responses to the 1988 NLS-Y interview question, "During the past 12 months, have you had any incident at any job...that resulted in an injury or illness to you?" (National Opinion Research Center [NORC] & Center for Human Resource Research [CHRR], 1988, p. 12–164). Then, occupational injuries are separated from illness by answers to the question "Did the incident result in an injury or an illness" (NORC & CHRR, 1988, p. 12–165).

The measure of the occurrence of work-related injuries obtained for this study is not the result of medical diagnosis. Rather, our measure relies on NLS-Y respondents' beliefs about, first, whether they experienced injuries and, second, about whether the injuries resulted from work activity. Therefore, our estimates of injury incidence based upon self-reports of injury are likely to differ from other estimates based upon, say, hospital records or physicians' diagnoses.

We estimate the cumulative incidence of nonfatal work-related injuries. The cumulative incidence of a health condition equals the number of new cases of the condition observed during a specified period of time divided by the number in the population at risk of acquiring the condition (Hennekens & Buring, 1987, p.57). We calculate the cumulative incidence of nonfatal work-related injuries by dividing the number of injuries reported by the number of work-years of exposure to the risk of injury at work. The result is multiplied by 100,000 so that the injury rate is expressed as the number of nonfatal work-related injuries per 100,000 work-years. Work-years of exposure are calculated by (a) counting the number of weeks each respondent was employed during the 12 months prior to the 1988 NLS-Y interview, (b) aggregating the weeks of exposure to injury risk at work over all respondents, and (c) annualizing exposure estimates by dividing aggregated weeks of exposure by 52.

### *Secondary School Curriculum Participation Pattern*

The design of this research incorporates a solution to a chronic methodological problem afflicting many previous evaluations of the effects of vocational education on its participants (see analysis of these problems by Passmore, Wang, & Olsen, 1989). In this study secondary school students' participation in vocational education is measured from high school transcripts rather than from self-reports that often have formed the basis of previous evaluations of vocational education (see, e.g., Grasso & Shea, 1970). Self-reports of participation in high school curriculums frequently are used to classify high school students into single curriculum tracks that they are believed to have followed throughout their secondary school studies. However, self-reports of curriculum status are subject to substantial errors of recall and response (Campbell, Orth, & Seitz, 1981). Moreover, a simple categorical measure of vocational education participation fails to reflect the well-documented, diverse curriculum experiences of high school students (Campbell *et al*, 1981).

Titles, Carnegie units of academic credit earned, and grades awarded for performance in high school courses are abstracted from NLS-Y sample members' high school transcripts. During the first NLS-Y interview respondents signed a release permitting the disclosure of their high school transcripts. By 1983, transcripts of 80.3% of sample members were abstracted. Carnegie units earned through completion of courses in the following six subject matter areas in vocational education are counted as vocational education credits: agriculture, distributive education, health occupations education, office occupations education, selected vocational home economics areas, and vocational, technical, and industrial education. We create two dummy variables to show variation in high school curriculum participation patterns by applying an algorithm originally developed by Campbell, Orth, and Seitz (1981).

Campbell *et al*. (1981) assert that not only does the accumulation of Carnegie Units reflect vocational education participation, but the timing and continuity of course-taking also is important. Campbell *et al*. employ the following five concepts to classify vocational education participation:

1. *Intensity* is the number of vocational education credits earned in a specialty area, defined as a vocational education subject matter area in which 60% of total vocational credits are earned.
2. *Diversity* refers to the number of vocational education subject matters areas from which students received a Carnegie unit.
3. *Continuity* refers to the number of years that students earned at least one-half vocational credit in a specialty area.
4. *Supportive diversity* is the number of vocational credits that supported students' specialty areas. Only students whose specialty area is either agricultural education or vocational, technical, and industrial education earn supportive diversity credits.
5. *Proximity* refers to the timing of credits earned in a specialty area. The most proximal credit is earned during th : 11th and 12th grades. Less proximal specialty credit is earned in the 12th grade only. Least proximal credit is earned in the 11th grade only.

Campbell *et al*. (1981) use these concepts to create the following seven patterns of high school curriculum participation:

1. *Concentrators* are former students who earn a substantial number of credits from a specialty area (high intensity), engage in a specialty over time (high continuity), and study in the specialty up to the point of graduation (high proximity).
2. *Limited concentrators* are similar to concentrators (high intensity and continuity) except they earn somewhat fewer credits, and have some breaks in time continuity as well as termination after the eleventh grade.
3. *Concentrators/Explorers* concentrate early on a specialty but frequently end concentration by the end of 10th grade (zero proximity); they also earn fewer credits in a specialty area.
4. *Explorers* do not develop a specialty. They earn credits widely across vocational education subject matter areas.
5. *Incidental/personal students* have a small number of vocational credits that are insufficient to be considered saleable skills.
6. *Academic students* do not fit in one of the five vocational patterns and earn at least *either* 4 credits of language, 3 credits of math, 2 credits of natural science, and 2 credits of social studies, *or* 4 credits of language, 2 credits of foreign language, 2 credits of math, and 2 credits of social studies in a four-year high school. In a three-year high school, academic students have at least 3 language credits, 2 math credits, 2 natural science credits, and 2 social studies credits.
7. *General curriculum students* do not belong to one of the five vocational education participation patterns and are not academic curriculum students.

Due to the relatively small number of work-related injuries in the population at risk, two dummy variables are created to summarize NLS-Y respondents' secondary school curriculum patterns: *HSC/C* (Campbell categories 1 through 3) and *HSC/E* (categories 4 and 5). The reference category for these two variables includes former students who followed the academic or general curriculum patterns (categories 6 and 7).

### *Work Experience*

Two dummy variables are created to specify the amount of work experience of NLS-Y respondents. First, the number of weeks of work experience between the first NLS-Y interview in 1979 and 52 weeks prior to the 1988 interview was calculated. Then, one dummy variable, *WORKH*, indicated whether the respondent's weeks of work experience is in the upper 1/3 of the distribution of weeks worked by all NLS-Y respondents. Another dummy variable, *WORKM*, indicated whether the respondent's weeks of work experience is in the middle 1/3 of the distribution of weeks worked. The reference category for these two dummy variables is formed by NLS-Y respondents in the lowest 1/3 of the work experience distribution. Because work experience is, by definition and in fact, highly correlated with the age of NLS-Y respondents, NLS-Y respondents' ages are not included in this study. Opportunities for work experience are greater among older than younger NLS-Y respondents during the period of the NLS-Y interviews. Therefore, age is confounded with work experience.

Work-related injury rates commonly are lower among more experienced workers (Sleight &

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Cook, 1974). Few studies, though, have separated the confounding of age and experience effectively. A study by Burov and Bisyayev (cited in Fried, Forbes, Giles, & Mumford, 1972) stratified age-injury profiles by years of work experience. Among new employees, both youngest and oldest workers experienced the highest rates of injuries. As Sleight and Cook (1974) concluded from an extensive review of literature, the nature of work performed also is an important contributing factor in injury occurrences by age and experience. For example, younger and less experienced workers are at risk when completing tasks requiring judgments and anticipation of unexpected conditions that are refined through experience.

### *Sex*

To capture the relationship between sex and work-related injury, a dummy variable, *MALE*, indicates whether an NLS-Y respondent is male rather than female. In general, the risk of injury is highest among males (Rice, MacKenzie, & Associates, 1989, p. 11). Overall rates of fatal and nonfatal occupational injuries follow this pattern (Waller, 1985, p. 431). However, the causal factors relating work-related injuries and sex are complex.

Waller (1985, pp. 431–432) cites studies documenting the clustering of injuries among women during premenstrual and early menstrual days and during pregnancy and post-delivery conditions, but these studies do not assess periodicity of injuries among males *and* females of comparable age and occupation. Women often have more extensive work loads at home in addition to their paid employment than do men, raising the potential for fatigue to contribute to injury. In fact, one study cited by Waller (1985, p. 432) found that women's injury rates in a fuse factory increased sharply compared to men's when work hours increased.

Sex differences in physique may play a role in occupational injury. Women *on the average* are smaller than men, particularly in limb lengths that determine horizontal and vertical reach (Ward, 1984). Although sex differences in muscular strength may be more a function of training than inherent strength, Canadian Air Force tests show that females are more likely than males to fail a sample of manual materials handling activities with high strength requirements (Celentano, Nottrodt, & Saunders, 1984; Snook & Ciriello, 1974). Employment of more women in nontraditional occupations may increase exposure to work tasks requiring strength.

Tools, machinery, and safety equipment often are designed to fit the ergonomic needs of male workers. Personal protective equipment and clothing are designed to fit the average-sized male ("Women's Protective Clothing," 1984). Hand tools often are too large and require too much grip strength for most women employed as telephone installers, construction workers, and telephone line crew members (Brooks, 1977). Equipment design leads to more hand and wrist injuries at work among women than men (Kaplan, 1981).

### *Analyses*

Point and interval estimates of the cumulative incidence of nonfatal work-related injuries are presented. Because work-related injuries are rare events in the population at risk, estimates of injury incidence are derived by assuming that the underlying distribution of work-related injuries is Poisson. The relative risks of work-related injury are estimated by secondary school curriculum participation pattern using linear Poisson regression procedures described by Kleinbaum, Kupper, and Muller (1988, pp. 497–512) through a computing algorithm developed and validated by Daly (1989). First, the relative risks of work-related injury are estimated with *HSC/C* and *HSC/E* in the regression equation. Then, *WORKH*, *WORKM*, and *MALE* are entered into a regression equation as simple main effects to allow estimation of the net relationship between secondary school curriculum participation pattern and work-related injury incidence. Although there is substantial interest in information about risks of injury by work experience and sex, our results focus on the relative risks of injury by curriculum pattern.

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## Findings

The cumulative incidence of work-related injuries reported by NLS-Y respondents is 9,049 injuries/$10^6$ work-years of exposure to injury risk. Table 1 contains estimates of the cumulative incidence and relative risks of work-related injury by secondary school curriculum participation pattern. Work-related injuries are more likely among males than females and less likely among young people in the upper two-thirds of the distribution of work experience (see footnote b in Table 1). Participation in vocational education is not related to the relative risk of work-related injury either simply by itself or when relative risks of injury by participation are adjusted by sex and work experience.

Table 1
*Cumulative Incidence and Relative Risk of Work-Related Injury During 1987–88 by Secondary School Curriculum Participation Pattern (n = 5,050)*

| | Cumulative Incidence | | | Relative Risk | |
|---|---|---|---|---|---|
| Pattern | Work Injuries | Work–Years Exposure | Injuries per $10^6$ Work–Years Exposed (upper 95% CI; lower 95% CI) | Unadjusted[a] (upper 95% CI; lower 95% CI) | Regression–Adjusted for Sex and Work Experience[b] (upper 95% CI; lower 95% CI) |
| *HSC/C* Concentrator | 157 | 1,640.4 | 9,570.8 (11,191.4; 8,184.9) | 1.09 (0.85; 1.40) | 1.16 (0.91; 1.50) |
| *HSC/E* Explorer | 149 | 1,703.6 | 8,746.0 (10,269.4; 7,448.6) | 1.00 (0.78; 1.29) | 1.04 (0.81; 1.35) |
| Academic/ General | 99 | 1,131.6 | 8,748.7 (10,653.5; 7,184.4) | 1.00 (reference category) | 1.00 (reference category) |

*Source:* Youth Cohort of the National Longitudinal Surveys of Labor Market Experience (Center for Human Resources Research, 1990b).

[a]Poisson regression equation (standard errors in parentheses): log (incidence) = -2.436 (0.101) + 0.090 (0.128) *HSC/C* + 0.001 (0.130) *HSC/E*.

[b]Poisson regression equation (standard errors in parentheses): log (incidence) = -2.625 (0.159) + 0.154 (0.129) *HSC/C* + 0.044 (0.130) *HSC/E* + 0.538 (0.104) *MALE* - 0.270 (.141) *WORKH* - 0.148 (0.132) *WORKM*.

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## Discussion

One possible conclusion from this study is that receiving more vocational education instruction rather than less does not help prevent work-related injuries. If this is true, then more effort should focus on the improvement of safety instruction in vocational education and on the analysis of hazardous work situations which could be remediated by worker safety education and training. A literature is emerging that describes methods for linking worker safety needs and training (see, e.g., Passmore, 1990; Passmore, Radomsky, Saperstein, & Bennett, 1988) However, several explanations are available to describe why work-related injuries are not lower for former participants in secondary vocational education examined in this study:

1. Imprecision of measures of injury incidence and participation in vocational education applied in this study might mask any relationship. Our measure of injury incidence is developed from self-reports of the occurrence of injuries at work. Our measure of participation in vocational education focuses on credits earned through vocational education courses, but not on how much instructional time is expended on safety instruction or on what safety theory and practices actually are learned in vocational education instruction. Also, we do not have any evidence to substantiate the reliability of either of these measures.

2. Participants in vocational education might not have become employed in occupations related to their training, and, therefore, they might not have received safety training during their vocational instruction that is specific to their ultimate employment. This explanation assumes that there is no general work injury and control approach that is used and is valid in vocational instruction and that occupationally-specific safety training is necessary. Haddon (1980) has suggested ten comprehensive strategies for injury prevention and control that focus on separating the hosts of injuries from the agents of energy that deliver injuries through a variety animate and inaminate vehicles. The central postulate of Haddon's suggestions is that work-related injuries are not random events (or "accidents"), but follow specific concentrations and patterns.

3. Misspecification of our model of injury incidence might lead to underestimation of the contribution of vocational education to the reduction of work-related injuries. Our current measure of the cumulative incidence of work-related injury is defined as the number of injury events/$10^6$ work-years of exposure to injury risk. The unit of analysis is the *person* in this formulation. The measure of exposure to injury risk is derived by calculating work-years of employment during the 12 months prior to the 1988 NLS interview. A major difficulty is that our current measure of risk to injury includes exposure over *all* occupations held within the previous 12 months, even though injuries occur while performing in occupations and industries that vary considerably in the ambient injury hazards they present. For instance, the exposure to injury risk borne by miners is treated in our formulation the same as the exposure of secretaries. Failure to hold industry- and occupation-specific exposure to injury hazards constant in our model might wash out any preventative effect actually yielded by vocational education instruction.

Work-related injuries exact well-identified and substantial costs. Additional research could illuminate the possibilities for prevention and control of work-related injuries through vocational education instruction. The current study takes an epidemiological approach to the examination of vocational education/work injury linkages. Epidemiology is the study of the distribution and determinants of morbidity and mortality from disease and other health conditions. Epidemiology can help identify problems in populations, but it typically does not provide the solutions to these problems. For example, epidemiological analysis uncovered the dose-response relationship between smoking and lung cancer. It did not identify the exact causative agent in cigarette smoke that led to cancer, not did it prescribe the cure for lung cancer. It did, however, highlight portions and practices of the population at risk so that subsequent research could pinpoint factors linking smoking to cancer. Perhaps other research approaches are needed. The NLS-Y data set is not designed specifically for the analysis of work-related injuries. A more focused study, perhaps using case-control approaches, might help identify more clearly the features of vocational instruction that are relayed to injuries at work. Or, analysis of injury cases involving former participants in vocational education might identify unsafe worker practices or behaviors that were, or should have been, identified in vocational instruction.

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