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Operational safety practices as determinants of machinery-related injury on Saskatchewan farms

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ABSTRACT

Agricultural machinery is a major source of injury on farms. The importance of machinery safety practices as potential determinants of injury remains incompletely understood. We examined two such safety practices as risk factors for injury: (1) the presence of safety devices on machinery and (2) low levels of routine machinery maintenance. Our data source was the Saskatchewan Farm Injury Cohort baseline survey ($n = 2390$ farms). Factor analysis was used to create measures of the two operational safety practices. The farm was the unit for all analyses and associations were evaluated using multiple Poisson regression models. Limited presence of safety devices on machinery during farm operations was associated with higher risks for injury (RR 1.94; 95% CI 1.13–3.33; $p_{trend} = 0.02$). Lower routine maintenance scores were associated with significantly reduced risks for injury (RR 0.54; 95% CI 0.29–0.98; $p_{trend} = 0.05$). The first finding implies that injury prevention programs require continued focus on the use of safety devices on machinery. The second finding could indicate that maintenance itself is a risk factor or that more modern equipment that requires less maintenance places the operator at lower risk. These findings provide etiological data that confirms the practical importance of operational safety practices as components of injury control strategies on farms.

1. Introduction

Agriculture remains one of the most hazardous occupations in North America (Simpson, 1984; Brison and Pickett, 1991, 1992; Gerberich et al., 1998; Brison and Pickett, 2003). In 2003, almost double the percentage of Canadian farm workers sustained non-fatal, activity-limiting injuries relative to a 3.8% average for other occupations (Wilkins and Mackenzie, 2007). Activities related to farm machinery are responsible for about half of these agricultural injuries (Brison and Pickett, 2003; Purschwitz and Lessenger, 2006). On average, 177 hospitalizations per 100,000 people are reported annually due to agricultural machinery injuries in Canada (Brison et al., 2003). The annual economic burden of these injuries in terms of lost potential, disability, treatment and rehabilitation costs is substantial (Locker et al., 2003).

The etiology of machinery-related farm injuries remains incompletely understood. Existing theory suggests that the contextual nature of farm work environments plays an important role in the occurrence of injury (Pickett et al., 2008). Contextual factors that could lead to injury include operational safety practices associated with farm machinery use. For example, use of safety devices on machinery is a practice that can attenuate exposure of workers to physical safety risks (Murphy, 1992). These risks have been evaluated descriptively (Simpson, 1984; Kumar et al., 2000; Ingram et al., 2003), and analytically (Layde et al., 1995; Lee et al., 1996; Gerberich et al., 1998; Sprince et al., 2002; Carlson et al., 2005;

Abbreviations: RR, relative risk; CI, confidence interval; SFIC, Saskatchewan Farm Injury Cohort Study.

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Baker et al., 2008). Existing analytic studies have primarily evaluated demographic factors related to machinery use and only two have dealt specifically with safety device usage (Layde et al., 1995; Baker et al., 2008). The upkeep or state of machinery may play a role in the occurrence of injury. With the exception of one recent study, no etiological analyses evaluate the relationship of both maintenance and safety devices and risk for injury in the same multivariate model (Baker et al., 2008). Despite routine maintenance of agricultural machinery being advanced as a prevention strategy, there is a lack of etiological evidence that confirms its importance as a protective factor.

We had the opportunity to model potential relationships between these two sentinel safety practices and the occurrence of farm machinery injury using a cross-sectional analysis of data from an existing population-based survey. We initially hypothesized that: (1) reduced presence of safety devices on machines and (2) the amount of time committed to conduct routine maintenance would each be important operational determinants of machinery-related injury on farms.

2. Methods

2.1. Sample

Data were analyzed from an existing baseline survey conducted as part of the *Saskatchewan Farm Injury Cohort Study* (SFIC). The SFIC used a multi-staged cluster procedure, with 2390 farms sampled in clusters nested within 50 rural Saskatchewan municipalities. Sampling, recruitment and response rates are described in full elsewhere (Pickett et al., 2008). In brief, approximately one-half (4234 farms; 52%) of 8169 farms that were initially approached returned the baseline questionnaire; 923 farms were ineligible, 887 farms refused participation and 34 farms returned partially completed questionnaires. This left 2390 eligible farms (out of 7246; or 33%) for consideration in the current analysis (Hagel et al., 2008; Pickett et al., 2008).

2.2. Data collection and study design

Data collection was conducted for a one-year period of recall using a mailed questionnaire and standard survey methods (Dillman, 1978). To ensure face validity, the questionnaire was piloted on a sub-sample of 50 farm people who were not subsequently enrolled in the study (Day et al., 2008; Pickett et al., 2008). In the full baseline survey, a designated adult respondent on each participating farm completed the baseline questionnaire. Each respondent provided information that characterized farm residents, safety hazards, safety practices and the occurrence of injury on the farm. Ethics approvals were obtained from the University of Saskatchewan Research Ethics Board and the Queen's University Health Sciences Research Ethics Board.

We chose to conduct all analyses with farms as the unit of analysis consistent with the anticipated level of intervention. Measures consisted of: (1) indicators of safety behavior and practices measured at the farm level, as well as, (2) other individual level indicators aggregated to the farm level for analytical purposes.

2.3. Study variables

2.3.1. Outcome: machinery-related injury

Total counts of machinery-related injuries were calculated for each farm over a one-year period of recall (calendar year 2006). For the purposes of this study, farm machines were defined as any machine that: (1) involved moving mechanisms and parts; (2) was powered mechanically or physically; and (3) was applied to an agricultural production activity.

2.3.2. Exposures—operational safety practices

Summary scores were developed for each of the two sentinel exposures as measures of safety practices on the farm. These are described below.

2.3.2.1. Exposure 1—presence of safety devices on sentinel machines. The SFIC questionnaire contained a set of questions that were used to estimate the proportion of sentinel farm machine types that had safety devices in place. Responses were then compiled as a composite measure. Sentinel machines included: (1) farm tractors; (2) combines; and (3) augers. For each sentinel machine type, respondents were asked "How many of these [machines] have safety shields and guards in place (none/some/all of them). The three items were then reduced to a single factor score using common factor analysis. As the tractor item did not load on the created factor, it was removed from further consideration. The final safety score included measures of safety shields or guards on combines and augers (Cronbach's $\alpha = 0.84$; factor loading = 0.63).

2.3.2.2. Exposure 2—routine maintenance on sentinel machinery. Routine maintenance of sentinel farm machinery was reported using two separate questionnaire items for tractors and combines. Initial questions asked: "During 2006, how many hours per year did this person perform maintenance on [machine type]?" The separate items were then reduced to a single routine maintenance score using common factor analysis. Both items were retained in the created factor scale as they had a high degree of internal consistency and high factor loading values (Cronbach's $\alpha = 0.88$; factor loading = 0.71; Floyd and Windaman, 1995).

2.3.3. Potential mediator—machinery operational hours score

Durations of machinery operation were reported using two separate questions for tractors and combines. Initial questions asked: "During 2006, how many hours did the individual operate the [machine type]?" The two items were then reduced to a single score factor analytically, displaying a high internal consistency and factor loadings (Cronbach's $\alpha = 0.82$; factor loading = 0.57).

2.3.4. Potential confounders

Covariates were selected based on published evidence (Zhou and Roseman, 1994; Layde et al., 1995; Gerberich et al., 1998; Sprince et al., 2002; Carlson et al., 2005; Baker et al., 2008) and a contemporary definition of confounding (Rothman and Greenland, 1998). Some potential confounders were measured at the farm level directly (debt worry, cash-shortage worry; (Labrash et al., 2008), total acreage, total number of farm residents) while others were aggregate measures for individuals on the farm (an alcohol consumption index, a farm co-morbidity index, education level of the farm owner-operator).

2.4. Statistical analysis

All statistical analyses were performed at the farm level. Analyses were conducted using SAS version 9.1 (SAS Institute, Cary NC). First, the number of machinery-related injuries was profiled by machinery type, as well as by key individual and farm-level characteristics. Next, relationships between the injury outcome and exposures were examined. Key exposures and potential confounders were divided into categories for analytical purposes. The SAS GENMOD procedure with a Poisson distribution and log link function was used in regression analyses. The effects of the exposures on machinery-related injuries were initially examined