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The Snowman: A Model of Injuries and Near-Misses for the Prevention of Sharps Injuries

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Background *Sharps injuries (SI) and other blood/body fluid exposures (BBFE) present bloodborne pathogen risks for home healthcare (HHC) workers. While SI and BBFE are sufficiently frequent in HHC to be serious public health concerns, even moderately large surveys can still have insufficient power to identify risk factors. In this study, a new conceptual model for using near-misses for SI and BBFE was developed and its utility in statistical analyses of SI and BBFE risk factors was evaluated.*

Methods *A survey of HHC nurses (n = 787) and aides (n = 282) gathered data on the numbers of SI, BBFE, and near-misses in the past year. Questions focused on the circumstances leading up to the SI, BBFE, and near-misses. After evaluating the hypothesis that near-misses and events lie along the same causal pathway, we combined these outcomes to estimate their association with an important risk factor: employment status.*

Results *There were similar frequencies of risk factors for the events SI, BBFE, and their near-misses, suggesting that they may share common causal pathways. Combined data on events and near-misses confirmed our hypothesis that part-time and temporary HHC aides were at higher risk than full-timers.*

Conclusions *Analyses combining injuries and near-misses may be useful in risk factor investigations.* Am. J. Ind. Med. 53:1119–1127, 2010. *© 2010 Wiley-Liss, Inc.*

KEY WORDS: bloodborne pathogen; sharps injuries; blood/body fluid exposures; near-misses; home healthcare

INTRODUCTION

Bloodborne pathogen exposures in healthcare workers have been recognized as a serious occupational health hazard and a cause of potentially disabling or fatal infection [CDC, 1989; Saghafi et al., 1992; Shapiro, 1995; Bell, 1997; Gillen et al., 2002]. Healthcare workers are at risk of infection from bloodborne pathogens, primarily as a result of percutaneous injuries from needles and other sharp medical devices (''sharps'') and other blood and body fluids exposures (BBFE) to mucous membrane and skin. Home healthcare (HHC) workers provide a wide range of medical services in patients' homes. There are broadly two categories of HHC workers: nurses, who provide direct patient care including administering medications and treating wounds, and aides who have less education and do less direct patient care. HHC aides provide services like bathing, dressing, and assisting with feeding. HHC is one of the fastest growing sectors of the healthcare industry, and while it poses many of the same risks as found in hospitals, this aspect of the industry has not been well investigated [Haiduven and Ferrol, 2004; Markkanen et al., 2007]. To address this gap, we conducted a study of the risk of sharps injuries (SI) and other BBFE among HHC nurses and aides, called Project Safe Homecare and Risk

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Reduction for Providers (SHARRP). It included a qualitative phase to identify circumstances leading to SI and BBFE [Markkanen et al., 2007], followed by a questionnaire survey to quantify the frequency of SI and BBFE, their near-misses and contributing factors among a large population of HHC workers [Markkanen et al., 2008; Quinn et al., in press]. Near-misses were defined as instances when an adverse event almost occurs but does not.

While SI and other BBFE are sufficiently frequent in HHC to be serious public health concerns, results of the Project SHARRP survey showed their occurrence is relatively low in terms of having sufficient numbers for statistical analyses to identify a range of risk factors [Quinn et al., in press]. Statistical analyses to identify significant determinants or predictors of SI and BBFE are important for learning about possible public health interventions. It would be useful to be able to count near-misses along with the actual SI and BBFE events in order to increase the total number of outcomes used for statistical analyses, thus increasing the power to identify risk factors. Because the Project SHARRP survey included detailed questions on near-misses as well as the actual SI and BBFE events, we were able to evaluate the use of both types of outcomes. Objectives of the study presented here were to: (1) develop and evaluate a conceptual model for using near-miss and actual event data for the evaluation of SI and BBFE in HHC, and (2) apply the model to evaluate its utility in statistical analyses of SI and BBFE risk factors.

BACKGROUND

The use of near-miss data in safety programs has become widespread in several industries, particularly in the chemical, oil, nuclear, aerospace, and public transportation sectors [Jones et al., 1999; Barach and Small, 2000; Anon, 2007; Alamgir et al., 2009; UK Airprox Board, 2009], but is less commonly used in healthcare [Battles et al., 1998; Kohn et al., 1999; Barach and Small, 2000; Anon, 2006; Alamgir et al., 2009; CDC, 2009] although using near-miss data might be useful in primary prevention of SI and BBFE. The idea underlying the ''safety pyramid'' is that actual events, their near-misses, and the hazardous conditions that lead up to them, lie along the same causal pathway [Heinrich, 1931; Bird, 1966; Van der Schaaf, 1991; Bird and Germain, 1996; Wright and Van der Schaaf, 2004, 2005; Alamgir et al., 2009]. This is called the common cause hypothesis, and it underlies the safety pyramids of Heinrich [1931], Bird [1966], and Bird and Germain [1996] (Fig. 1). While the common cause hypothesis is plausible and has been used effectively for accident prevention, it has seldom been evaluated formally. The second important assumption of the safety pyramid is that more events are expected as we move down the pyramid to lower, less severe levels. This is called the constant ratio relationship [Wright and Van der Schaaf, 2004]. When these pyramids are presented, the main messages are usually that prevention should not wait until an actual event has occurred and that controls or interventions should not only be aimed at the most severe consequences but also target the lower levels [Van der Schaaf, 1991; Wright and Van der Schaaf, 2004, 2005].

The range of definitions of a near-miss is broad, including everything from potentially hazardous circumstances to minor injuries, depending on the study. We identified near-miss definitions from a variety of sources and identified five common methods used by researchers to distinguish an accident from a near-miss [Paparella, 2005; Shaw et al., 2005; Weissman et al., 2005; Wagner et al., 2006; Davies, 2008; Curtin University of Technology, 2009; University of Michigan Health System, 2009]. A near-miss has been variously defined as an accident that did not happen because of: ''good luck,'' ''chance,'' ''timely intervention,'' ''skillful management,'' or ''prompt evasive action.'' We developed a near-miss definition that we thought was more appropriate to the healthcare setting: ''a near-miss is a situation where a sharps injury almost occurred but did not.'' This is a broader definition than many found in the literature because ours does not include causal words like luck, chance, or timely intervention.

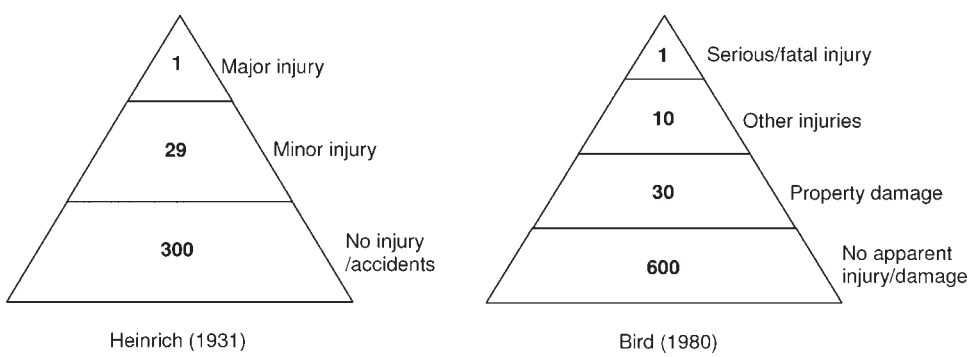

FIGURE 1. Examples of safety pyramids. The numbers represent hypothetical ratios of events, near-misses, and hazardous conditions.

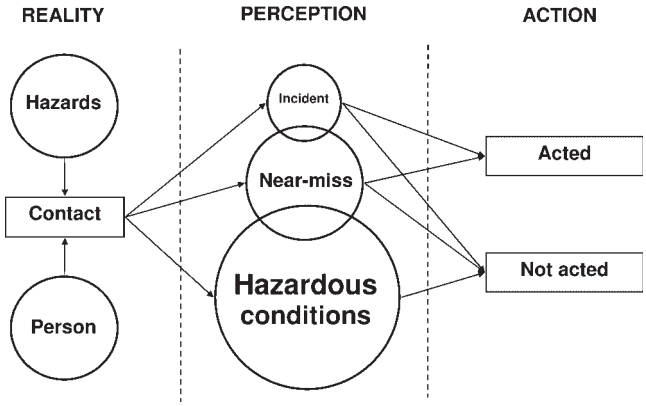

FIGURE 2. A conceptual model showing how perception of hazards leads to actions. Depending on how contact with a hazard is perceived, it may be judged to be an actual incident (event), a near-miss, or simply a hazardous condition.

Snowman: An Alternative to the Safety Pyramid

A limitation of the safety pyramid model for our work on SI is that it does not take into consideration the subjective experience of a worker and the role of his/her perception in determining whether an event is defined as an injury or a near-miss.

A simple causal model may be helpful in clarifying the roles of perception in injury and near-miss reporting (Fig. 2). There is a *reality* in which the person and the hazard come into contact. This reality may be *perceived* by the person in many ways, but we list three: an incident, a near-miss, or a hazardous condition. The distinctions between these three may not be clear and consistent from one individual to another; however, and this is indicated by the overlapping circles in Figure 2. Depending on this perception, the person may or may not take *action*; we are particularly concerned with the action of reporting the event to the employer so that appropriate prevention can be taken. Once the event occurs (*Reality*), it will be defined or classified by personal subjective criteria (*Perception*), which then determine whether the event is acted upon or not (*Action*).

In this process, bias may be introduced at the *Perception* stage if there is heterogeneity of the event defining criteria. Heterogeneity in an individual's criteria over time may occur if there is some shift in how that person perceives events (within-person heterogeneity). There may also be between-person heterogeneity if the same event is perceived differently by different persons. Variability in event defining criteria may lead to bias if it is not random with respect to characteristics useful for prevention activities. For example, if senior nurses are more likely than junior nurses to define a ''minor'' injury as a near-miss, then it may appear that they have a lower rate of injury, when in fact they do not. We call this problem ''perception bias.''

The three overlapping concepts in the middle panel of Figure 2—Incidents, near-misses, and hazardous conditions—are stacked in decreasing size to represent the likely pattern of their frequencies: injuries < near-misses < hazardous conditions. We call this representation the Snowman, and propose that it may be a more useful conceptual model than the safety pyramid when the data derive from human reports. The overlap areas between the circles (incident and near-miss, near-miss and hazardous conditions) represent the ''gray areas'' where people differ in their definitions of outcomes. Two examples from Project SHARRP include: (1) a nurse is injured by a needle that she is confident is clean and she determines it is a very low risk of infection. She may or may not define this as an injury; and (2) a nurse enters a room to see a used, unprotected hypodermic needle sitting on a chair, she might be sufficiently alarmed to define it as a near-miss, while others—perhaps those with more experience and less fear—might call this a hazardous condition, but not a near-miss.

It seems reasonable to assume that there will be less variability in reporting for more severe events—a deep wound with a used sharp for example—will be very unlikely to be confused with a near-miss, while a needle grazing the skin may be defined differently by different people. A used unprotected needle lying on a chair will probably not be mistaken for an injury, while a slight prick with a needle that is ''almost certainly'' unused might be called a near-miss by one person and an injury by another. Thus, we hypothesize that the perceived severity of events and near-misses will be important to understand when considering the potential for perception bias, and for estimating the size of the overlap—the ''gray area'' in the snowman's neck (Fig. 3). Each outcome, SI and SI near-misses, BBFE and BBFE near-misses, was represented by a circle (Fig. 3), with gradations in severity from high towards the top of the circle, medium severity in the middle, and low severity towards the bottom of the circle. The overlap between the event and near-miss circles then represents the difficulty of unambiguously distinguishing a low severity event from a high severity near-miss.

As the model in Figure 2 shows, perception bias can lead to reporting bias. Suppose that nurses are expected to report injuries, but not near-misses or hazardous conditions. If these injury self-reports are the only source of data, then perception bias as discussed above will determine whether or not an event is reported. In particular, it seems likely that more ''severe'' events will more likely be reported, but the definition of severity will be at least partly subjective.

METHODS

Study Population and Survey

The Project SHARRP survey was conducted among Massachusetts HHC clinicians from eight home care

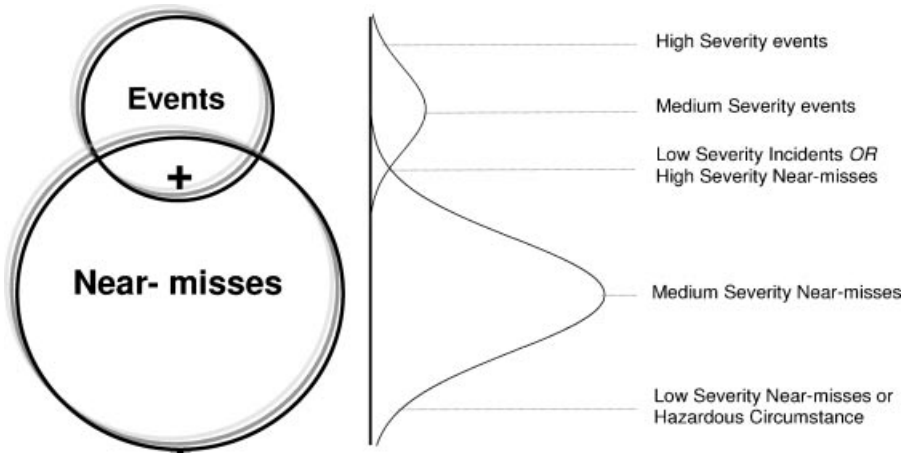

FIGURE 3. "Snowman," the conceptual model. There are gradations of severity within the categories "Events" and "Near-misses;" low severity events overlap high severity near-misses and may not be distinguishable.

agencies and two labor unions between October 2006 and May 2007. Detailed population recruitment and survey administration methods and the main survey findings are reported elsewhere [Markkanen et al., 2008; Quinn et al., in press]. A self-administered survey was developed, informed by results of focus groups conducted during the qualitative phase to characterize hazards and risks at work [Markkanen et al., 2007]. The questionnaire also included questions from the Massachusetts Department of Public Health ''Home Health Care Bloodborne Pathogen Exposure Incident Recording Form'' [MDPH, 2009] and the ''Survey of Healthcare Personnel on Occupational Exposure to Blood and Body Fluids'' [CDC, 2009]. The final survey was 18 pages long, and took ~20–30 min to complete.

Variables

Several questions were used to elicit information on SI and BBFE. Participants were asked: ''Have you ever been stuck or cut by a previously used sharp object, such as a needle or lancet, in home healthcare work?'' and ''Have blood or body fluids ever come in direct contact with your eyes, mouth, or broken skin during home healthcare work?'' Follow-up questions asked how many times in the past 12 months did you have a SI/BBFE/SI near-miss/BBFE near-miss, using the above definitions. Those who said that they had had at least one SI or BBFE were asked to supply detailed information on the circumstances leading up to the most recent event. Similar questions were also asked to gather data on near-misses for both SI and BBFE. As noted above, a near-miss was defined as a situation where an SI (or BBFE) almost occurred but did not.

The survey asked when the event occurred relative to particular steps in using the medical device: before use, during use, after use but before disposal, or during/after disposal of a sharp. A nine item checklist identified the medical procedures involved, and an additional 20 items concerned circumstances when the event occurred such as distractions from other persons in the home, clutter or unclean conditions, and lack of work space. These potential risk factors were identified by HHC nurses and aides during the Project SHARRP qualitative phase focus group discussions about the work and patient factors leading to a clinician experiencing a SI or other BBFE. They were then incorporated into the survey for administration to a larger population of HHC clinicians. Questions were either yes/no responses, multiple choice checklists, or agree/disagree Likert scales.

The analyses reported here were restricted to HHC nurses and aides; other occupations (physical and occupational therapists, nurse managers, telephone clinicians) were excluded due to small numbers. Three classes of employment status were provided in the survey: full-time, part-time, and per-diem (freelance hourly contractors).

Studying the Common Cause Hypothesis

The common cause hypothesis provides a rationale for combining near-misses with actual events. In past applications, such as with the safety pyramid, common cause has often been assumed but not formally tested. Our objective was to evaluate evidence for common cause between the SI and SI near-misses and BBFE and BBFE near-misses in our survey data. We hypothesized that if near-misses and actual events lie along the same causal pathway, then they should share common determinants. We used the survey data to calculate the frequencies with which SI, BBFE, and their near-misses were reported to have happened during different medical procedures (e.g., blood drawing, injecting medications, fingerstick/heelstick), steps in the use of sharp

medical devices (e.g., before, during after use), and other contributing circumstances (e.g., having to work in awkward postures, lack of workspace, and time pressures). Risk factors having fewer than five questionnaire responses were omitted from these analyses because these results would have been unreliable. The hypothesis testing was restricted to the questionnaire responses by nurses (N = 787) because the number of events and near-misses by aides was too small. Chi-square statistics were used to evaluate the similarities between the frequencies of SI, BBFE, and their near-misses.

Representing Events and Near-Misses With a Snowman

We used separate snowmen to represent each of the two outcomes—SI and BBFE, with the sizes of the circles determined by the ratios between events and near-misses, and the height of the snowman (*y*-axis) indicating the incidence rate. Rates were calculated per 100 fulltime equivalent (FTE) employees by expressing weekly hours worked as a fraction of 40 hr and assuming a 50-week-year.

RESULTS

Participants

Complete questionnaires were collected from 1,225 HHC clinicians employed in eight agencies or members of two unions (participants were contacted either through their agency or their union). The overall response rate was 69%. The analyses reported here focus on the 787 nurses and 282 aides from the total population. Additional results have been reported previously [Quinn et al., in press]. Both nurses and aides were predominantly female (>95%), and most were white (nurses: 96.2%, aides: 76.6%). Nurses and aides had similar average ages (48.1 and 46.8 years, respectively), and similar mean tenures in HHC (11.3 and 10.7 years, respectively). More than half of nurses were full-time employees (55.8%) while somewhat fewer aides worked full-time (44.3%) (Table I).

TABLE I. Sociodemographic Characteristics of the Study Population of Home Healthcare Nurses and Aides

	Nurse (n = 787)[a]		Aide (n = 282)[b]	
Variable	**Mean**	**SD**	**Mean**	**SD**
Age (years)	48.1	9.7	46.8	12.4
Working hours	33.9	10.7	29.6	11.4
Tenure in home healthcare	11.3	7	10.7	7.6
	Nurse (n = 787)[a]		Aide (n = 282)[b]	
Variable	n	%	n	%
Gender (female)	755	95.9	276	97.9
Race (white)	757	96.2	216	76.6
Employment status				
Full-time	439	55.8	125	44.3
Part-time	257	32.7	133	47.2
Per-diem	91	11.6	21	7.5

[a]Includes nursing for full range of home healthcare services such as cardio/pulmonary treatment, enterostomal therapy, hospice, IV therapy, medical/surgical care, etc.
[b]Aides including certified home health aides, certified nurse assistants, and personal care attendants.

Incidence and Ratio Relationships

The 787 nurses reported 36 SI and 226 SI near-misses in the last 12 months (Table II). The near-miss/event ratio was 6.3. Nurses reported almost twice as many BBFE as SI (n = 67), but a similar number of near-misses (n = 213), so the ratio (3.2) was about half of that for SI. Among 282 aides, there were only four reports of SI in the past 12 months, and 19 SI near-misses, resulting in a near-miss/event ratio of 4.8. Like the nurses, the aides reported more BBFE than SI—18 BBFE events and 57 near-misses in the last 12 months, yielding the same ratio as the nurses (3.2). Overall, these four comparisons of events to near-misses resulted in broadly similar ratios, between about three and six, with a suggestion that the ratio might be somewhat higher for SI than for BBFE.

Snowmen for Combining Events and Near-Misses

Figure 4 represents these findings using the snowman model. The circular shapes for events and near-misses in Figure 4 were assumed because we did not gather sufficient data with which to formally evaluate the severities of each reported injury or near-miss. The heights are scaled to represent the overall rates of events and near-misses per 100 full-time equivalent workers (areas of overlap are not to scale in this graphic). Comparison of the four snowmen

TABLE II. Actual Number of Events and Near-Misses in Home Healthcare Nurses and Aides in the Past 12 Months

Outcome	Nurses (n = 787) n	Aides (n = 282) n
SI	36	4
SINM	226	19
Ratio[a]	6.3	4.8
BBFE	67	18
BBFENM	213	57
Ratio[a]	3.2	3.2

SI, sharps injuries; SINM, SI near-miss; BBFE, blood and body fluid exposure; BBFENM, BBFE near-miss.
Multiple responses were counted independently.
[a]Ratio of near-misses to events.

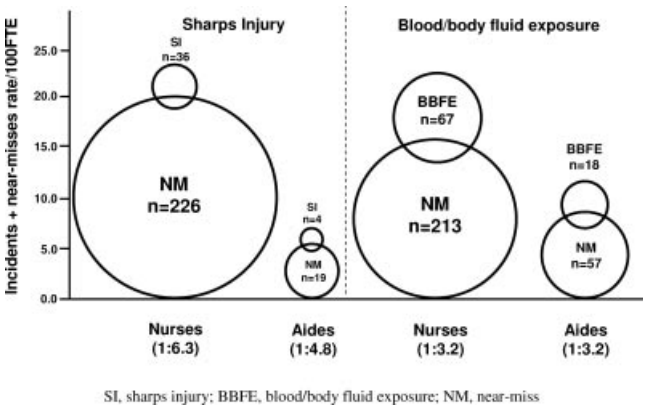

FIGURE 4. Family of snowmen representing events and near-misses reported by home healthcare nurses and aides. Heights represent incidence rates, ratios of diameters of heads to bodies reflect ratios of events to near-misses. Overlap areas are not to scale.

shows that nurses clearly had higher rates of both reported SI and reported BBFE than aides; the near-miss/event ratio was larger for reported SI than for reported BBFE; and among aides, the rates of reported BBFE were greater than of reported SI.

Common Cause Hypothesis for Events and Near-Misses

The proportions of events and near-misses attributed to a specific step in the use of a medical device, medical procedures, and other contributing circumstances were generally similar for both SI and BBFE (Table III). *P*-values testing null hypotheses of similar proportions of contributing risk factors between the events and their near-misses were generally large, meaning little support for rejecting the common cause hypothesis. Even when there were too few

TABLE III. Comparison of the Frequency of Circumstances Related to Events and Near-Misses Among Home Healthcare Nurses

	SI (n = 34)		SINM (n = 129)			BBFE (n = 42)		BBFENM (n = 122)		
Variables	**n**	**%**	**n**	**%**	***P*-value***	**n**	**%**	**n**	**%**	***P*-value***
Step in sharp medical device use							NA[c]		NA	
Before use	4	11.8	15	11.6	—					
During use	2	5.9	12	9.3	—					
After use and before disposal	21	61.8	61	47.3	0.13					
During or after disposal	6	17.7	41	31.8	0.11					
Medical procedures[b]							NA		NA	
Blood drawing	6	17.7	39	30.2	0.14					
Injecting medication	8	23.5	29	22.5	0.90					
Fingerstick/heelstick	11	32.4	31	24.1	0.32					
Using an IV line	3	8.8	14	10.9	—					
Putting sharps into a container	7	20.6	44	34.1	0.13					
Other contributing circumstances[b]										
Patient aggressive or mentally unstable patient	3	8.8	5	3.9	—	4	9.5	9	7.4	—
Patient needs physical support to stand or sit	1	2.9	3	2.3	—	9	21.4	29	23.8	0.76
Patient is uncooperative or will not stay still	3	8.8	13	10.1	—	12	28.6	14	11.5	0.01
Distractions from other persons in the home	7	20.6	28	21.7	0.89	4	9.5	22	18.0	—
Clutter or unclean conditions	7	20.6	26	20.2	0.96	6	14.3	28	23.0	0.23
Lack of work space	10	29.4	31	24.0	0.52	14	33.3	38	31.2	0.79
Poor lighting	4	11.8	15	11.6	—	8	19.1	23	18.9	0.98
Difficulty communicating with patient	5	14.7	5	3.9	0.02	3	7.1	15	12.3	—
Equipment difficult to reach	4	11.8	13	10.1	—	9	21.4	24	19.7	0.81
Long work days	5	14.7	14	10.9	0.53	5	11.9	15	12.3	0.95
Too many patient care assignments	7	20.6	15	11.6	0.17	6	14.3	15	12.3	0.74
Awkward postures	7	20.6	18	14.0	0.34	11	26.2	48	39.3	0.13
Time pressures	14	41.2	27	20.9	0.02	8	19.1	25	20.5	0.84

SI, sharps injuries; SINM, SI near-miss; BBFE, blood and body fluid exposure; BBFENM, BBFE near-miss.
Multiple responses were counted as single response.
*From Chi-square tests for differences of proportions. *P*-values not calculated when any cell <5. *P*-values >0.05 indicate no difference in the occurrence of a contributing circumstance between the actual event and its near-miss.
[c]NA: steps in sharp medical device use and medical procedures were relevant to sharps injuries, but not to BBFE.
[b]Procedures and circumstances with very few responses were omitted for clarity. Multiple responses were allowed and so percents do not sum to 100.

numbers to calculate *P*-values (when any cell was <5), the patterns were still quite similar. There was a suggestion that SI near-misses were somewhat more likely than actual SI to occur during or after disposal (32% vs. 18%, respectively), but overall the steps in the use of a medical device occurred in similar proportions between the SI and near-misses ($P = 0.13$). The three notable exceptions to the overall similarities in proportions of contributing circumstances between events and near-misses were: BBFE events were more than twice as likely as BBFE near-misses to be associated with uncooperative patients ($P = 0.01$); SI were more than three times as likely as SI near-misses to be associated with difficulty communicating with the patient ($P = 0.02$); and SI were more than twice as likely as SI near-misses to be associated with time pressures ($P = 0.02$). With these few exceptions there was substantial evidence showing that the events and near-misses had similar contributing circumstances. We conclude that this supports the common cause hypothesis—that in these data, events and near-misses generally lie along a common pathway.

TABLE IV. Using Near-Misses to Improve Risk Factor Evaluation: Association of Employment Status With Events and Near-Misses

Employment status	SI (n = 2)			SI + SINM (n = 17)		
	RR	95% CI		RR	95% CI	
Full-time	1			1		
Part-time	—	—	—	0.53	0.15	1.9
Per-diem	—	—	—	2.57	0.59	11.26
	BBFE (n = 13)			BBFE + BBFENM (n = 45)		
	RR	95% CI		RR	95% CI	
Full-time	1			1		
Part-time	1.13	0.37	3.50	1.42	0.69	2.89
Per-diem	1.61	0.22	11.72	3.32	1.16	9.49

SI, sharps injuries; SI + SINM, sharps injuries plus sharps injury near-misses; BFFE, blood and body fluid exposures; BBFE + BBFEN, BBFE plus BBFE near-misses; n, number of events; RR, rate ratio.
Multiple responses were counted as single response.
¯Could not be calculated due to small numbers.

Using Near-Miss Data to Increase Statistical Power to Study Risk Factors

Because we studied a smaller number of aides than nurses, and because the incidence of SI to aides was lower than to nurses, there were statistical power limitations when studying risk factors among aides alone. However, by combining events and near-misses to create a single outcome variable, we observed patterns of risk among aides that we could not detect with the few actual events only. One example is presented here. In an earlier article, we reported that SI and BBFE events were much more common among per-diem nurses than either full-time or part-time nurses [Quinn et al., in press]. We were interested to know whether the aides showed the same pattern, but it was not possible to examine this directly in aides because of small numbers—there were only two SI in the last year, and 13 BBFE events reported by aides (only one BBFE event reported by a per-diem aide). Combining the data on events and near-misses, we observed a pattern of increasing risk going from full-time to part-time to per-diem (Table IV). Thus, we conclude that employment status may be an important risk factor among aides as well as among nurses, although we could not observe this by using the event data alone.

DISCUSSION

The annual incidence of SI in this large survey of HHC clinicians was 3.3%. While this may be an underestimate because of the well-recognized problem of under-reporting of SI [Doebbeling et al., 2003; Osborne, 2003; Elder and Peterson, 2006], it is still likely the case that in a small to moderate-sized HHC agency with <100 employees, SI will happen only a few times per year. This should not be taken to mean that the problem of bloodborne pathogen exposure in HHC is not a serious one; but prevention activities may be difficult to target based on these relatively infrequent events. If one can study near-misses to target prevention activities, then a small agency may be able to learn from its mistakes (or ''almost mistakes''), and set priorities based on the evidence. We found near-misses to be three to six times more common than events in this survey. This would mean a substantial increase in statistical power, a point also made by Van der Schaaf and colleagues in the chemical and transportation industries [Van der Schaaf, 1991; Wright and Van der Schaaf, 2004].

Accepting the likelihood of a common causal pathway between risk factors and both near-misses and events is the key that allows one to combine events and near-misses. We found good evidence to support this for both SI and BBFE in HHC (Table II). Our findings also support the notion of a decreasing ratio between lower and higher levels on a safety hierarchy like the pyramid originally proposed by Heinrich [1931] and Bird [1966]. Alamgir et al. [2009] recently reported evidence for the common cause hypothesis when combining near-misses and minor, but not major injuries, using healthcare industry data for British Columbia.

We sought to apply the safety pyramid to our work on bloodborne pathogen exposure in HHC, but realized that the pyramid could be misleading in one important respect. In our study, as in many others, the only source of data on events and near-misses was a survey of the workers who experienced them. Thus, it was inevitable that individual subjectivity enters into the respondent's decisions about what was remembered, what was reported, and whether a particular

memory was recorded as an event or a near-miss (Fig. 2). These perception issues are potentially quite important; HHC workers are in close proximity to open wounds, sharps, and other hazards many times each day. If the definitions of events and near-misses shift over time or are different from one person to another, there may be serious bias introduced into the data. The safety pyramid gives the impression that there is a clear distinction between events and near-misses when this is not the case.

The Snowman model explicitly acknowledges the subjectivity of the reporting phenomenon and shows a ''gray area'' for events which may be reported as injuries/exposures, or as near-misses. The effect of perception on reporting should be greater for less severe events and more severe near-misses, but should diminish as the event or near-miss becomes less ambiguous. We did not gather data with which to formally evaluate the severity of the reported outcomes, and we recommend that future surveys of near-misses include questions to assess the perceived severity of events and near-misses so that the Snowman model could be more thoroughly evaluated.

In conclusion, we believe that collecting data on near-misses of bloodborne pathogen exposure events may be useful for targeting prevention activities in HHC. We recommend that future surveys of SI and other injuries collect near-miss data and evaluate common causality with the objective of combining near-miss and actual event data for more powerful statistical analyses. A new model, the Snowman, has advantages over the safety pyramid for conceptualizing the relationships between events and near-misses in safety research for events which are subjectively assessed.

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