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Janitors' mental workload, psychosocial factors, physical fitness, and injury: The SWEEP study

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ABSTRACT

Approximately 2.4 million janitors work in the United States. High physical workload may explain a lost-work days rate 2.7 times that of other occupations. Information is limited about non-physical workload factors for janitors and their relations to injuries. For this retrospective cross-sectional study, specially designed, pre-tested questionnaires were distributed to full-time janitor members of a union for two six-month sequential intervals. Questions addressed mental workload (modified NASA Task Load Index), job satisfaction (Andrews and Withey Job Satisfaction Scale), stress (Perceived Stress Scale-4 [PSS-4], and the Single Item Stress Scale [SISS]), physical fitness, and occupational injury experiences. Descriptive and multivariable analyses, with bias adjustment, were conducted. A decreased risk of injury was associated with increased job satisfaction (expressed as a risk ratio (RR): 0.91 [95% confidence interval (CI): 0.83, 0.97]) and increased physical fitness (0.89, [0.83, 0.96]). A highly suggestive increased risk of injury was associated with increased mental workload (1.07, [1.00, 1.15]).

1. Introduction

In 2016, there were 2,384,600 people employed as janitors (BLS, 2018) in the United States (U.S). Their work, involving reportedly high physical workloads, appeared to place them at risk for days away from work with a rate 2.7 times higher than all other occupations (BLS, 2016). However, little is known about non-physical workload factors and associations with injuries among janitors. Workload is a complex construct; there are many potential elements, including not only mental workload but, also, psychosocial factors, which may be related to work-related injuries (Christian et al., 2009). For example, mental workload has been shown to increase task errors and injury rates (Yurko et al., 2010; Elo et al., 2003; Frankenhaeuser, 1991), and Littman et al. (2006), reported that other psychosocial factors, including job satisfaction (Ramirez et al., 1996; Rentsch and Steel, 1992) and stress (Elo et al., 2003; Irie et al., 2001) were related to workload which, in turn, may be related to injury outcome. In addition, low physical fitness has been reported as related to injury (Knapik et al., 1993; Twitchett et al., 2010).

While the janitors' Service Employees Union International Local 26 (SEIU L26) noted a workload measure, not familiar to the janitors, based on average square feet cleaned per person per shift, it was not known how this relates to measurements of mental workload, psychosocial factors, physical fitness, and outcome of injury. Thus, to move to the next step, the objective of this study was to identify the relations between mental workload, job satisfaction, stress, physical fitness, and injury occurrence in janitors.

2. Materials and methods

2.1. Target population

Following approval by the University of Minnesota Institutional Review Board (Human Subjects Protection Case No. 1605P87861), the

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Safe Workload Ergonomic Exposure Project (SWEEP) Study, involving a closed prospective cohort study design, was initiated. The target population was the approximately 4,000 janitors who were members of SEIU L26. However, to optimize participation and retention over one year of data collection, the population was limited to the 1,200 individuals, identified by the union as full-time janitors. Ages ranged between 19 and 71 years, with the greatest proportion (60%) aged 31-50 years; by gender, 55% were female. Approximately 60 percent of this population was Hispanic, 20 percent Somali, and 20 percent other ethnicities. The SEIU L26 collaborated with the research team to facilitate participation of its members.

2.2. Data collection instruments

Data were collected through administration of specially designed and pre-tested questionnaires to collect occupational injury outcomes and exposure data for two sequential six-month recall periods in a one-year longitudinal study (May 2016–October, 2016, November 2016–April 2017). The questionnaires were distributed to the entire population of full-time SEIU L26 janitors by trained union stewards at the participating janitors' worksites. Survey items included demographic information, mental workload, psychosocial factors of job satisfaction and stress, physical fitness, and occupational injury outcomes.

2.3. Definitions and measures

2.3.1. Mental workload

One of the most cited measures of mental workload is the National Aeronautics and Space Administration (NASA) Task Load Index (TLX); workload represents the cost of accomplishing mission requirements for the human operator (Hart, 2006). The TLX is a scale that uses six dimensions of workload to provide diagnostic information about the nature and relative contribution of each dimension in influencing overall operator workload (Morgan, 2016). TLX subscales are Likert-type scales with 21 selection points. The dimensions assessed are mental demand, physical demand, temporal demand, performance, effort, and frustration. The ratings indicate how a person "appraises their interaction with the task environment" (Matthews et al., 1999) which is consistent with the operational definition for this study. Because the full weighted scale adds participant burden and is highly correlated to the unweighted scale ($r = 0.94$), a raw (unweighted) TLX scale was used in this study to measure mental workload (Gawron, 2000).

Mental workload has frequently been adversely associated with occupational injuries (Bagheri Hosseinabadi et al., 2019; Schwartz et al., 2020; Chen et al., 2015; Habibi et al., 2015; Hughes et al., 2007; Sprigg et al., 2007; Splitstoesser et al., 2012; and with degradation of performance (Yurko et al., 2010; Mehta et al., 2012; Cantin et al., 2009; Koca et al., 2015). Although mental workload has been adversely associated with injuries, the psychological mechanism by which this occurs is not clear. Chen et al. (2015), discuss possible ways that mental workload may affect the risk of injury, citing Endsley's (1995) three step model of how people perceive dangerous or risky situations; these three steps are detection of hazard signals, perception and comprehension of risk, and understanding of the consequences of actions taken (Endsley, 1995). Chen et al. (2015), also suggested a possible role of inattentional blindness, caused or exacerbated by mental workload. Inattentional blindness, reported from a study by Chabris and Simons (2011), identified approximately 50 percent of the participants who were focused on a mentally demanding task and failed to notice a man walk past them wearing a gorilla suit(Chen et al., 2016). Chen et al. (2015), suggested that the effect of mental workload distracts workers and makes them less likely to perceive risk factors, or to competently evaluate the likely consequences of actions, even when they are as seemingly obvious as a man in a gorilla suit. Similarly, workers may become so habituated to performing a repetitive task that the distraction of a high level of mental workload reduces their ability to perceive occurrence of something out of the ordinary from the routine task and, thus, and places them at increased risk. In this formulation, mental workload interferes with the worker's ability to detect cues that signal risk.

2.3.2. Psychosocial factors

Among psychosocial factors, job satisfaction and stress were measured in this study. They are identified in the following:

Job Satisfaction. Job satisfaction, operationally defined as "the global content a worker experiences about their employment," was measured by the Andrews and Withey Job Satisfaction Scale (Rentsch and Steel, 1992). The five items measure general feelings about a job, and add resolution on co-workers, the nature of the work, resources (equipment, information, supervision), and work quality (surroundings, hours, work load). This scale has been validated with the Job Descriptive Index (Kinicki et al., 2002) and the Minnesota Satisfaction Questionnaire (Gillet and Schwab, 1975), as well as with job performance, organizational commitment, and intent to turnover (Rentsch and Steel, 1992). Each individual's response to the Andrews and Withey scale (Rentsch and Steel, 1992) was used to measure job satisfaction in this study.

Job-related Stress. Two instruments were used to evaluate job-related stress. 1) Stress was measured by the Elo single-item stress scale (SISS), which has been used since 1970 to monitor perceived well-being for occupational health professionals (Elo et al., 2003). The item was worded as, "Stress means a situation in which a person feels tense, restless, nervous or anxious or is unable to sleep at night because his/her mind is troubled all the time. Do you feel this kind of stress these days?" Individual responses were measured on a 5-item Likert scale. The SISS has been validated in comparison to the Nordic Questionnaire for Psychological and Social Factors at Work (Wännström et al., 2009) and the emotional exhaustion scale of the Maslach Burnout Inventory (Schaufeli et al., 2001). Stress was also measured by the 4-item version of the Perceived Stress Scale (PSS-4); this version, known as the PSS-4, contains 4 of the 14 items of the original PSS-14 (Cohen, 1994). Both scales, the SISS and the PSS-4, approach "stress" in slightly different ways. Psychological stress can be considered a "particular relationship between the person and the environment, which is appraised by the individual as taxing or exceeding his(/her) resources, and endangering his (/her) well-being" (Folkman, 2013), the definition utilized by the PSS series (Cohen et al., 1983; Ramirez et al., 1996). However, the SISS defines stress as a form of situational anxiety. Yet, both of these definitions focus on the notion that resources for daily life situations are not sufficient. The operational definition of stress for this study was a simplified version of that of the PSS-4: *The extent to which people perceive that demands are greater than their ability to cope with those demands.* Individuals' responses to the SISS and PSS-4 scales were used in this study as the measures of stress.

2.3.3. Physical fitness

Physical fitness is defined as the ability to conduct "daily tasks with vigor and alertness, without undue fatigue and with ample energy to enjoy leisure-time pursuits and to meet unforeseen emergencies" (Caspersen et al., 1985). Consistent with that definition, fitness was measured in this study with a self-reported physical fitness item on the general survey for all janitors. This fitness question was adapted from the 2010 National Institute for Occupational Safety and Health (NIOSH) Long Haul Truck Driver Survey (Chen et al., 2015; Sieber et al., 2014), and the National Health Interview Survey (Schiller et al., 2018); the wording used was: "During either your work or free time, in the past 7 days, on how many days did you do moderate or vigorous physical activities like fast walking, pushing a lawn mower, or moving heavy boxes by hand for at least 30 minutes at a time?" (Sieber et al., 2014) The response to this question was used as the measure of physical fitness.

2.3.4. Work-related injury outcome

"Work-related" includes any activities, including travel, associated with the job or events that occur in the work environment. Work-related injuries are defined as any wounds or damage to the body associated with the job that occur in the working environment; they result from acute traumatic events that involve: restriction of normal activities for at least 4 hours; and/or the use of professional medical care; and/or loss of consciousness, loss of awareness, or amnesia for any length of time" (Erkal et al., 2008; Gerberich et al., 2001). Participants could identify up to four possible injury events for each of the respective six-month data collection periods.

2.4. Data analysis

For this study, the exposure variables of mental workload, the psychosocial factors of job satisfaction and stress, physical fitness, and the outcome of occupational injury were individually measured by survey. Data were independently entered by two researchers into a Redcap software database (Harris et al., 2009). This software enabled comparisons for consistency of entries; any conflicting responses were resolved by the research team.

Descriptive analyses of the frequencies and distributions of non-physically measured workload factors were conducted. Logbinomial regressions were used to examine relations between exposures and outcomes. This study had a non-rare binary outcome (injury) so risk ratios (determined by logbinomial regressions) were preferred to odds ratios determined by logistic regressions. Generalized Estimating Equations (GEE) were used to account for correlated data (i.e., repeated measures from the same janitor) for the multivariable regression analyses (Hanley et al., 2003). Potential confounders (age, smoking, and having a second job), were identified, based on the literature and research team expertise, using Directed Acyclic Graphs (DAGs) (Shrier and Platt, 2008; Textor et al., 2011; VanderWeele and Robins, 2007) (Fig. 1). Potential response bias was minimized by inversely weighting observed responses by probabilities of response (Horvitz and Thompson, 1952), estimated as a function of characteristics provided by the SEIU L26 (gender, age, and janitorial contracting company).

3. Results

3.1. Questionnaire response

There was an overall response rate of 32.5% among the initial 1,200 individuals who were to have received the questionnaires. This involved 390 janitors who responded to one of the two surveys; 137 (11.4%) janitors responded to both surveys, accounting for a total of 527 completed surveys (Fig. 2).

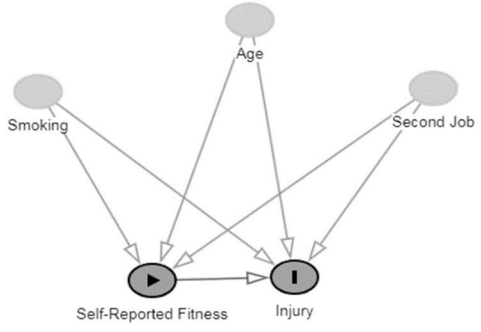

Fig. 1. Directed acyclic graph demonstrating the relation between the exposure of physical fitness and outcome of injury, with adjustment for age, smoking, and having a second job.

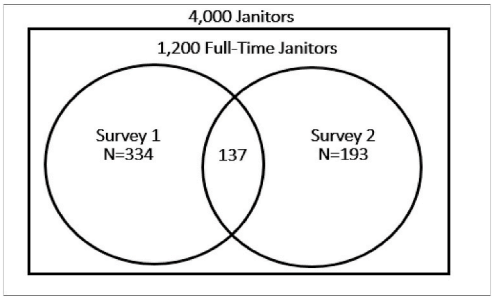

Fig. 2. Study size flow chart for the SWEEP study.

3.2. Mental workload results

To assess mental workload, the NASA TLX was utilized (Table 1). There were 444 responses to the TLX section of the survey (approximately 100 were from the same people over both survey periods). No partially answered scores were counted. TLX scores range from six to 30, with 30 denoting the highest mental workload. The TLX score used was the sum of the six domain items. The resulting mean score was 20.60 with a standard deviation of 4.08. Table 1 presents a description of the results.

3.3. Job satisfaction results

To assess job satisfaction, the Andrews and Withey Job Satisfaction Questionnaire was utilized. Job satisfaction scores are presented in Table 2. There were 386 responses to the job satisfaction scale; no partially answered scores were counted. The scores range from five to 25, with 25 indicating the highest job dissatisfaction. The resulting mean score was 12.85 with a standard deviation of 3.00.

3.4. Stress results

To assess stress, the Single Item Stress Scale (SISS) was utilized. There were 438 responses to the SISS out of a possible total of 527 (83%); of those 438 respondents, 31% reported that they were not at all or very little stressed, 36% reported that they were sometimes stressed, 23% were often stressed and 10% said they were very much stressed. SISS responses are identified in Table 3.

In addition, the Perceived Stress Scale-4 (PSS-4) was utilized. There were 310 responses to the PSS-4 (Table 4). No partially answered scores were counted. The PSS-4 ranged from four to 20, with 20 identifying the highest stress level. The mean for this population was 9.04 (median, 10.0), with a standard deviation of 2.51. A moderate correlation of 0.35 was found between the PSS-4 and the SISS.

3.5. Physical fitness results

For the physical fitness item (Table 5), there were 204 responses, with a majority of respondents (median) reporting that they exercised five days a week (mean = 3.61; standard deviation, 2.43).

3.6. Injury results

From the total 527 questionnaires completed, there were 78 reported injury events in the two six-month data collection periods for the respective questionnaire administrations. Repetitive motion (21%) and overexertion (19%) were the main sources of injuries.

In Table 6, the point estimates are reported as risk ratios. Of importance is a decreased risk of injury associated with both increased job satisfaction and increased physical fitness. Increased mental workload was associated with an increased risk of occupational injury. Stress, examined with either the PSS-4 or the SISS, was not found to be

Table 1
Mental workload distribution of janitors as assessed by NASA task load index (TLX): The SWEEP study.

	Survey Questions											
	How mentally demanding has it been working as a janitor?		How physically demanding has it been working as a janitor?		How rushed have you been working as a janitor?		How successful were you in completing what you were asked to do?		How hard did you have to work to do your job?		How frustrated have you been with your work as a janitor?	
Demand Level	N	%	N	%	N	%	N	%	N	%	N	%
Very Low Demand	26	5.9	10	2.3	8	1.8	3	0.7	25	5.63	41	9.2
Low Demand	59	13.3	43	9.7	41	9.2	31	7.0	45	10.1	83	18.7
Medium Demand	185	41.7	148	33.3	156	35.1	140	31.5	145	32.7	168	37.8
High Demand	125	28.2	172	38.7	165	37.2	199	44.8	165	37.2	103	23.2
Very High Demand	49	11.0	71	16.0	74	16.7	71	16.0	64	14.4	49	11.0

Table 2
Job satisfaction distribution of janitors as assessed by the Andrews and Withey questionnaire: The Sweep study.

	Survey Questions									
Response	How did you feel about your job?		How did you feel about the people you worked with - your coworkers?		How did you feel about the work you did on your job -the work itself?		How did you feel about where you worked- the physical surroundings, the hours, the amount of work you were asked to do?		How did you feel about the resources (equipment, tools, information, supervision etc.) you had available for doing your job?	
	N	%	N	%	N	%	N	%	N	%
Terrible/Unhappy	14	3.6	29	7.5	27	7.0	15	3.9	18	4.7
Mostly Dissatisfied	135	35.0	214	55.4	188	48.7	165	42.8	178	46.1
Mixed Feelings	196	50.8	110	28.5	139	36.0	161	41.7	131	33.9
Mostly Satisfied	28	7.3	24	6.2	25	6.5	39	10.1	47	12.2
Pleased/Delighted	13	3.4	9	2.3	7	1.8	6	1.6	12	3.1

Table 3
Stress distribution of janitors as assessed by the Single Item Stress Scale: The SWEEP study.

Survey Question		
Stress means a situation in which a person feels tense, restless, nervous or anxious or is unable to sleep at night because his/her mind is troubled all the time. Do you feel this kind of stress these days?		
Response	N	%
Not at all	69	15.8
Very Little	66	15.1
Sometimes	158	36.1
Often	101	23.1
Very Much	44	10.0
Total	438	100

Table 4
Stress distribution of janitors as assessed by the Perceived Stress Scale-4: The SWEEP study.

	Survey Questions							
Response Level	In the past month how often have you felt that you were unable to control the important things in your life?		In the past month how often have you felt confident about your ability to handle your personal problems?		In the past month, how often have you felt that things were going your way?		In the past month, how often have you felt difficulties were piling up so high that you could not overcome them?	
	N	%	N	%	N	%	N	%
Never	61	19.7	55	17.7	38	12.3	52	16.8
Almost Never	60	19.4	107	34.5	95	30.7	92	29.7
Sometimes	129	41.6	103	33.2	141	45.5	125	40.3
Fairly Often	41	13.2	20	6.5	21	6.8	33	10.7
Very Often	19	6.1	25	8.1	15	4.8	8	2.6

Table 5
Survey-based distribution of physical fitness: The SWEEP study.

Survey Question		
During either your work or free time, in the past seven days, on how many days did you do moderate or vigorous physical activities like fast walking, pushing a lawn mower, or moving heavy boxes by hand for at least 30 minutes?		
Days Exercised	N	%
0	37	7.0
1	21	4.0
2	17	3.2
3	13	2.5
4	5	1.0
5	70	13.3
6	14	2.7
7	27	5.1
Missing	323	61.3

associated with injury occurrence.

4. Discussion

Slappendel et al. (1993), and Yurko et al. (2010), reported that increased mental workload can increase task errors and injury rates. The findings from the current study, indicating a positive association between mental workload and injury, is consistent with this literature.

Rentsch and Steel (1992) indicated that the scale used for the SWEEP study to examine job satisfaction, the Andrews and Withey Job Satisfaction Questionnaire, was significantly correlated with job performance, organizational commitment, and turnover intentions. Data reported by van Saane et al. (2003), upheld the reliability and validity of this scale. The current study identified that low job satisfaction, or dissatisfaction, as measured by the Andrews and Withey Job Satisfaction Questionnaire, was associated with an increased risk of occupational injury occurrence.

As noted, previously, the current study used the 4-item version of the PSS, which is a derivative of the 14-item PSS. There is also a 10-item form of the PSS. Using psychometric tests such as Cronbach's alpha,

Table 6
Logbinomial regressions of workload exposures to injury outcomes in janitors: The SWEEP study.

Measures	Unadjusted				Adjusted			
	RR	95% CI		p-Value	RR	95% CI		p-Value
Mental Workload[a]*	**1.07**	**1.01**	**1.14**	**0.0205**	**1.07**	**1.00**	**1.15**	**0.0425**
Job Satisfaction[b]*	**0.89**	**0.84**	**0.95**	**<0.0001**	**0.91**	**0.83**	**0.97**	**0.0245**
PSS-4[c]*	1.01	0.90	1.14	0.8737	1.01	0.88	1.17	0.8423
SISS[c]	1.04	0.96	1.13	0.3070	1.06	0.92	1.22	0.3969
Physical Fitness[d]*	**0.88**	**0.83**	**0.93**	**<0.0001**	**0.89**	**0.83**	**0.96**	**0.0027**

Adjusted mental workload and PSS-4 did not converge with Logbinomial regression; Poisson regression was used.
RR = Risk Ratios CI=Confidence Intervals.
[a] Adjusted by gender, age, and physical fitness.
[b] Adjusted for mental workload and stress.
[c] Adjusted for age, gender, physical fitness, mental workload.
[d] Adjusted for age, smoking status, and second job status.

Pearson's Spearman's Correlation, or interclass correlation coefficient (ICC), examinations of test-retest reliability of the PSS series found that the PSS-14 and the PSS-10 were both superior to the PSS-4 (Lee, 2012). However, the ease of application of the PSS-4 allows greater application of this stress scale (Lee, 2012; Lesage et al., 2012; Warttig et al., 2013) which was important for this study population. Regardless, both the PSS-4 and the SISS were not important, based on multivariable analyses pertinent to injury.

Analyzed in relation to injury outcome, physical fitness demonstrated a protective effect. As noted, previously, Knapik et al. (1993) and Twitchett et al. (2010), documented similar relations of fitness to workload and injury. Heir and Eide (2007) also noted that military conscripts who were less physically active experienced a higher rate of injuries. In contrast, Gabbett and Domrow (2007) and Hootman et al. (2001), each reported that the risk of injury may be increased with higher duration of physical activity and higher fitness levels. McGill et al. (2012), determined that fitness and injuries were not related in college athletes. Lee et al. (2001), reported that injury risk is more likely related to types of fitness activities than overall fitness levels, indicating potentially more complex relations.

4.1. Advantages and limitations

Potential biases of this study include reliance on self-reported questionnaire data (Van De Mortel, 2008). The response rate of 32.5% was also lower than anticipated, given the extensive effort in study development and pre-testing and the fact that the SEIU L26 had approached the research team to establish a collaborative effort because of their concerns relevant to their working conditions. However, this potential response bias was reduced by inversely weighting observed responses by probabilities of response, estimated as a function of janitor characteristics provided by SEIU L26 (Horvitz and Thompson, 1952).

Another concern is that, even though janitors participated in this study, there may have been barriers relevant to reporting of injury incidents. Azaroff et al. (2002), documented barriers limiting the collection of accurate injury data: fear of reporting to supervisors; fear of lost [payable] time; deficient recognition of work-related injuries and illnesses; the complicated reporting for Workers' Compensation, and others. Pompeii et al. (2016), reported that workers may be unclear about when and where to report incidents and, instead, rely on their own personal threshold of when to report, based on situational events. Underreporting may also be related to unwillingness to reveal incidence which can also be related to fear of reprisal for reporting injuries (Braun et al., 1994; Lipscomb et al., 2013).

Questionnaire facilitation by union stewards may possibly have introduced information bias in the responses. However, the stewards were provided with comprehensive training on the content and required distribution and collection of the questionnaires to ideally mitigate this potential bias.

This study involved cross-sectional data collection which can introduce temporal bias (Szklo and Nieto, 2014). While the cross-sectional design provided efficiency in the data collection, it does not allow inferences of etiologic associations (Gordis, 2013).

Recall bias, among participants, can lead to differential misclassification of the relevant variables (Hassan, 2005). Raphael (1987) observed that recall bias is especially problematic for cross-sectional studies which include retrospective components. Zwerling et al. (1995), reported that researchers must "choose between a shorter recall period to minimize recall bias and a longer period to maximize the precision of rate estimates." Braun et al. (1994), reported that the "sensitivity and specificity of self-reported injury was highest within six months of the examination date." As such, the SWEEP's study period of one year was divided into two six-month periods to minimize this potential recall bias (Connelly et al., 2000; Coughlin, 1990; Gabbe et al., 2003; Yoshihama and Gillespie, 2002). Teschke et al. (2000), reported that open-ended versus specific exposure questions were more frequently subjected to recall bias; however, the SWEEP study did not rely on open-ended items.

There were many advantages associated with this project. The SWEEP Study involved participant-driven research, in that the subjects were enthusiastic about the project and requested assistance to study the potential effect of their workload on injury. Being able to consult on appropriate study design with active janitors allowed the research team to design a study that was responsive to the needs of the target population. This effort was also among the first studies to address the important population of janitors that has not typically been open or accessible to such research team efforts.

5. Conclusions

Results from this study identified decreased risks of injury for both increased job satisfaction and increased physical fitness. Increased mental workload was associated with an increased risk of occupational injury. These findings serve as a basis for further research and opportunities for development of relevant intervention efforts.

Extension of this research to populations such as hotel housekeepers and construction workers could provide important findings where there are similar but not identical exposures that also place these workers at high risk of injury. It will also be important to involve large participating populations, using study designs that will optimize reporting and identification of risks associated with injury outcomes.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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