EXPLORING THE LINK BETWEEN HOUSEKEEPING AND OCCUPATIONAL INJURIES

by:

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PREFACE

In the quest to improve safety in the workplace, there is often a push to resolve problems before a solid understanding of injury etiology can be established. When attempting to reduce injury rates, companies may put into place various and elaborate schemes, hoping that something will work out. Although this practice does sometimes succeed, the complexity and profusion of safety interventions further confuse the understanding of which approaches actually improve safety. Without this knowledge, poor investment choices are made, and the success of injury prevention is diminished. Lacking confidence in the effectiveness of injury reduction programs, companies are reluctant to support prevention efforts and everyone loses.

In this presentation, I have taken a step back from the confusion of complex interventions and elaborate models to look at one small part of the problem.

The main literature review for this dissertation was prepared in the format of a critical review article. A reduced version of this article is presently undergoing a second review for publication to the journal, Safety Science. The presentation fits well into the structure of this dissertation, broadly covering the current state of occupational injury epidemiology, and focusing on studies that address the main subject area treated by this dissertation — the association between the state of housekeeping and occupational safety. As it contains material which is under review for publication, the following text is reproduced from the "Guidelines for Thesis Preparation" as per requirements:

> Candidates have the option of including, as part of the thesis, the text of one or more papers submitted or to be submitted for publication, or the clearly-duplicated text of one or more published papers. These texts must be bound as an integral part of the thesis.
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> If this option is chosen, **connecting texts that provide logical bridges between the different papers are mandatory**. The

thesis must be written in such a way that it is more than a mere collection of manuscripts; in other words, results of a series of papers must be integrated.

The thesis must still conform to all other requirements of the "Guidelines for Thesis Preparation". **The thesis must include:** A table of Contents, and abstract in English and French, an introduction which clearly states the rationale and objectives of the study, a review of the literature, a final conclusion and summary, and a thorough bibliography or reference list.

Additional material must be provided where appropriate (e.g. in appendices) and in sufficient detail to allow a clear and precise judgment to be made of the importance and originality of the research reported in the thesis.

In the case of manuscripts co-authored by the candidate and others, **the candidate is required to make an explicit statement in the thesis as to who contributed to such work**

and to what extent. Supervisors must attest to the accuracy of such statements at the doctoral oral defense. Because the task of the examiners is made more difficult in these cases, it is in the candidate's interest to make perfectly clear the responsibilities of all the authors of the co-authored papers.

ACKNOWLEDGMENT

When I think of my progress in occupational safety my first thoughts go to Jorma Saari. It was Jorma, in our first meeting in the spring of 1990, who demonstrated a contagious passion for occupational safety and a conviction that progress was possible in this field. To him I owe a great debt for steering me in the direction of injury etiology through the study of housekeeping.

Without the workers in the companies I studied, as well as generous company management, who allowed me to wander throughout their workplaces, this study would not have been possible. I am also grateful for the assistance of the health and safety experts at the sector-based health and safety association (ASFETM), for drawing up a list of eligible companies and making the initial contacts with the companies so I could carry out the study. The experts at ASFETM also helped in the development of the checklist, were instrumental in getting it ready for the study and served as observers for inter-observer reliability testing.

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I would also like to thank my advisor, Claire Infante-Rivard, for encouraging me to undertake this uphill battle for the attainment of a PhD, for her willingness to act as my advisor throughout my PhD, and for encouraging me to venture into the unknown by furthering my studies in Chapel Hill. It was her belief in my capabilities that gave me the courage to tackle this beast they call the PhD. Dr. Infante-Rivard is also co-author on the article which is presently under review in the journal "Safety Science". As co-author, she helped with the development of the arguments, made considerable editorial comments and especially guided the section on methodological issues.

While in Chapel Hill, I was fortunate to meet and exchange with many brilliant people, who have given me more material to help crystallize my ideas, and finish writing my PhD. Among these people I count, Carol Runyan, Director of the Injury Prevention Research Center, David Savitz, Chair of the Department of Epidemiology, and Jonathan Kotch, professor in the department of Maternal and Child Health.

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Finally, I dedicate this dissertation to Kim Benham, Claire, Abrahm, Emma and India. Rather than waiting patiently in the wings, they have been challenging me to reach higher, showing me the consequences of my actions and the power of the will to change.

Vincent Dufort

Chapel Hill, 1997

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I was taught that the way of progress is neither swift nor easy.

-- Marie Curie

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ABSTRACT

Background: Housekeeping is an important aspect of safety in the workplace. There have been only a limited number of studies assessing the impact on injury of housekeeping. In addition, measuring the state of housekeeping has posed continuous problems in these studies due to the lack of standardized and objective instrumentation. Objectives: The objectives of the first part of this thesis involved the development and evaluation of an instrument for measuring the state of housekeeping in industry. The second part examined the association between housekeeping and safety. Methods: This study began with the development of a checklist for evaluating housekeeping and proceeded to a fifteen-month prospective cohort study of fifty-seven companies in the transportation equipment and machinery manufacturing sector in Quebec, Canada, each employing between twenty and sixty workers. Companies were followed over 16 months to evaluate housekeeping levels. At the end of the study, information on compensable injuries that occurred during the study period was obtained. Results: Inter-observer reliability of the instrument was reasonably high (ICC 0.88, 95% CI 0.81-0.94) though test-retest reliability was less stable (ICC 0.73, 95% CI 0.68-0.78). In the second part of this study, housekeeping was found to be significantly associated with both injury rates (IRR 1.35, 95% CI 1.08-1.70) and rate of days lost (IRR 1.48, 95% CI 1.39-1.57), and trends were seen across categorical housekeeping levels. The association between cleanliness and safety was not as strong, nor was a trend found. Conclusions: The housekeeping checklist demonstrated high inter-observer reliability. The less stable test-retest reliability is partly due to changes in housekeeping between visits. Obstructions *(lack of clutter, clear access to workstations, equipment and exits)* and cleanliness components of housekeeping were more difficult to measure and observers disagreed more when evaluating these components of housekeeping. While some of the associations between housekeeping and safety did remain after controlling for confounding, this was not true for all components of housekeeping.

RÉSUMÉ

Introduction: L'entretien des lieux de travail joue un rôle important dans la sécurité au travail. Peu d'études ont évalué l'impact de l'entretien par rapport à la sécurité. Le manque de mesures standardisées et objectives pour évaluer l'entretien des lieux continue de poser des problèmes. Objectifs: Le premier volet de cette thèse inclut le dévelopement et l'évaluation d'un instrument qui avait pour but la quantification du niveau d'entretien des lieux de travail. Le deuxième volet de cette thèse a étudié le lien entre l'entretien des lieux de travail et les accidents survenus au travail. Matériel et méthodes: Cette étude prospective de quinze mois, a suivi cinquante-sept entreprises employant entre vingt et soixante travailleurs dans le secteur de la fabrication d'équipement de transport et de machines au Québec. Résultats: La fiabilité entre les observateurs de cet instrument était raisonablement élevée (ICC 0.88, 95% CI 0.81-0.94), mais la fiabilité mesurée lors de la répétition du test était moins stable (ICC 0.73, 95% CI 0.68-0.78). En ce qui trait au deuxième volet de l'étude, il démontre que l'entretien des lieux de travail était significativement lié au taux d'accidents (IRR 1.35, 95% CI 1.08-1.70) ainsi qu'au taux de jours perdus lors d'accidents (IRR 1.48, 95% CI 1.39-1.57). Le risque était plus élevé parmi les entreprises qui démontraient plus de difficulté avec l'entretien des lieux. Conclusions: La fiabilité entre observateurs de cet instrument était élevée, mais la fiabilité dans la répartition du retest était moins stable. Cette instabilité lors de la répétition du test était due en partie aux délais entre répétitions du test. Les obstructions et la propreté étaient plus problématiques à mesurer, et les observateurs étaient plus souvent en désaccord lors de cette evaluation.

INTRODUCTION

Injury has been identified as a substantial public health problem in North America [Baker, 1989; CDC, 1990; Christoffel, 1993; Rice et al., 1989; Rivara and Grossman, 1996]. Occupational injury is a major contributor to this [Belville et al., 1993; Brooks et al., 1993; Christoffel, 1993]. Understanding injury etiology is an essential component in the pursuit of answering the problem. Theoretical models that describe plausible pathways to injury causation serve as one way to promote this understanding. Many models have been proposed to explain occupational injury genesis [Baker, 1989], however, the assumptions that are at the foundation of these models remain essentially untested. This is one of the challenges facing occupational injury epidemiology today.

One model that reflects current thinking in injury genesis presents injury as the endpoint in a sequence of events. The events leading up to an injury are initiated by a change, or "deviation", in the usual interactions between the worker and the environment or system [Laflamme, 1990]. It is postulated that the deviations are influenced by situational and organizational factors. Situational factors are characteristics of the individual, equipment and task related to an event, i.e.: the micro-environment. Organizational factors can be defined as the characterization of the human and technical aspects of the work environment, i.e., the macro-environment. Make-up of the workforce, operating procedures, machines and protection from the macro-environment. These are broad factors that describe the collective workplace rather than the local / individual environment directly involved in the injury process.

The complex temporal and spatial factors influencing the worker-environment interactions function as a system. In this system, each part plays a role in the modification of disturbances. Essentially, this model proposes that the many aspects of the work environment can have an effect on the chain of events following a deviation. When looking at any one factor in injury genesis, it is important to keep in mind the possible influences of other factors. Both the micro-and at the macro-environmental influences must be considered. In other words, injuries are multi-causal; distinct components of causality cannot be looked at without controlling for the other factors.

According to safety experts, the state of housekeeping is one aspect of the work environment influencing injury rates [Bird and Germain, 1990; McDonald, 1989; WHO, 1982]. This has, to some extent, been shown through **injury taxonomy** (the dissection and classification of injury events using injury reports and investigations) [McDonald, 1989]. Although obstacles or safety hazards are detected through injury taxonomy, it is not easy to verify the contribution of subtler factors, such as organization or aesthetics. Because of the inadequacy of injury taxonomy in identifying subtler antecedents, the possible connection between the aesthetic side of housekeeping and injury has still not been ruled out [Saari, 1987].

Injury causation model assumptions indicate that the contribution of the state of housekeeping to injuries is influenced by other micro- and macro-environmental factors. Studies of the contribution of housekeeping to safety should therefore consider the context of the work environment both for the micro- and the macro-environment.

OBJECTIVES

This study had two main objectives. The first was to develop and evaluate a simple checklist for the measurement of housekeeping in a defined group of companies. The development followed a model of checklist building used in housekeeping intervention studies in Finland [ILCI, 1991]. The evaluation consisted mainly of test-retest and inter-observer reliability testing of the final checklist. The second objective of this research was to study the association between the level of housekeeping in the workplace and occupational injury rates, while controlling for other factors that may influence outcome.

DEFINITION OF HOUSEKEEPING

Researchers have been divided in their focus on housekeeping. Some have preferred to remain within boundaries which are clearly defined through hazard control (e.g., tripping hazards, cluttered hallways), while others have included cleanliness in their definitions in a productive and hazard-free work environment [Bird and Germain, 1990].

In the present study, housekeeping was defined as the **state** of the workplace with regards to; 1) *organization* - orderly and structured placement and storage of tools, equipment and materials, 2) *obstructions* - lack of clutter, clear access to workstations, equipment, and exits, and 3) *cleanliness*.

LITERATURE REVIEW

Measuring housekeeping in industry

In the domain of safety research, there exist many safety audit systems which include an evaluation of housekeeping [Bird and Germain, 1990; Diekemper and Spartz, 1970; Jones, 1973; McDonald, 1989; Reber and Wallin, 1983; Rees, 1967]. Although these evaluations have different components and scoring systems, they tend to be similar in many respects. Safety audit plans are often developed by individual researchers or safety consultants in order to respond to immediate and local company needs. Unfortunately, the audit plans developed to date were either company specific, or they often did not include housekeeping as a major component to the evaluation. In addition, many focused on behaviors rather than on workplace conditions.

Rees [1967], working at reducing accident frequency in a modern chemical factory, developed a technique for counting safety defects. It was suggested by Rees that the measurement could be conducted on a weekly basis to count unsafe conditions and unsafe acts, and to feed back this information to the working group. The observation checklists developed by Rees was designed to be used by a "trained observer" in order to increase the reliability of the measurement. Rees drew up the basic structure of the checklist which was then to be adapted to the specific enterprise being evaluated. Comparison between groups or between companies was not an intended goal of this measurement approach. Housekeeping was only a minor component of the checklist, and only injury hazards such as blocked passageways and tripping hazards were considered.

Diekemper and Spartz [1970] used an exhaustive evaluation of five categories of "activity standards" covering organization and administration to industrial hazard control. A total of 29 activities were assessed using a rating of Poor, Fair, Good and Excellent. These activity ratings were given a weighted score and the total rating was calculated from this. Although housekeeping was included in the assessment, it was evaluated using a single question and it was not defined.

Jones [1973] described the implementation of a specially tailored safety audit program in his company that focused on "violations." The audit included unsafe acts as well as unsafe conditions. Inspiration for checklist items came from initial surveys of the workplace identifying actual violations. Some specific items, such as oil and water spills, were included in the audit. Other less well defined items, for example, "general housekeeping poor or inadequate" and "disorderly break areas" were also included on the list. In addition to being designed for a specific workplace, few of the items on the audit form actually addressed housekeeping.

Focusing on unsafe behaviors, Reber and Wallin [1983] developed a checklist that included limited attention to housekeeping. Survey items were identified through reviews of accident reports, safety practices advocated by OSHA (Occupational Safety and Health Administration), and other sources. Although comparisons were made between departments, the final checklist used only 37 safety rules to cover all aspects of safe behavior, of which housekeeping played a minor role. Additionally, by focusing on behaviors rather than conditions researchers had to witness the commission of an act, rather than evaluate a more stable condition of the workplace.

Bird and Germain [1990] described the necessary components of planned inspections. Although they included housekeeping, the procedure went well beyond establishing a measure of the level of housekeeping. The inspection developed by Bird and Germain was undoubtedly useful in identifying hazards in the workplace, however, it was not suited to comparisons between workplaces. While housekeeping, as defined by Bird and Germain, covered both cleanliness and organization, the actual procedure for rating housekeeping in the workplace was not defined. Once the condition was defined, i.e., "tools must be properly stored," the observer was expected to rate the condition, yet item rating tolerances were not explicit (very poor, poor, fair, good, excellent). Inter-observer reliability would depend on training observers or on better definition of item tolerances.

In a series of intervention studies aimed at reducing injuries through improved housekeeping, Saari and Näsänen [Näsänen and Saari, 1987; Saari, 1987; Saari and Näsänen, 1989] developed department-specific checklists for providing feedback to workers. Concentrating on housekeeping evaluations, the researchers used a simplified scoring system and relied on clear definitions for item tolerances. Because of the specificity of the checklist and survey procedure to one workplace, it is not possible to use these directly to compare housekeeping between workplaces. However, it is possible to use these checklists to direct the development of a checklist and survey procedure that would be useful in cross-workplace comparisons.

Association between housekeeping and safety

Summary

In order to illustrate some basic principles of epidemiology and to suggest how they can be applied to occupational safety studies, articles published between 1967 and 1997 concerned with the association of housekeeping and order to safety in the workplace were reviewed. Population studies were identified through electronic databases and manual searches. Five of the studies were descriptive or exploratory, and found several factors, including housekeeping, associated with company safety. Four studies were quasi-experimental, and showed improvements in safety following changes in various behaviors and conditions, including housekeeping. Design weaknesses were found, significantly compromising the validity of these findings. These included the lack of external comparisons, history and selection bias, and failure to control for confounding. Control for other variables was only done partially through the design, and no attempt to use

multivariate statistical models was made. The comments presented in this review should be seen as a base for guiding future studies in occupational safety.

Occupational health and epidemiology

Lack of good housekeeping in the workplace is considered a risk factor for occupational injuries [Bird and Germain, 1990; Laflamme, 1990]. Despite the intuitive basis for a relation between order and injuries, few studies have been carried out to investigate this association and evidence of a causal relationship is limited. There have been few published studies assessing the relation between housekeeping and occupational safety. Additionally, the housekeeping safety studies show major methodological weaknesses which limit their usefulness.

Epidemiological methods have been developed to study health problems at the population level [Rothman, 1986]. Epidemiology has also made substantial contributions to our understanding of occupational diseases [Checkoway et al., 1989]. Appropriate use of these methods to evaluate the causal association between housekeeping or other potential injury risk factors and occupational injuries could considerably enhance the understanding of injury risk factors.

The objective of the present chapter is to review occupational housekeeping safety studies while illustrating some basic principles of epidemiology. Where specific methodological problems to safety studies arise, suggestions are made to address them.

A short discussion on commonly encountered study methodologies is presented in order to address some possible approaches for occupational safety studies. Specific difficulties related to population-based safety studies are also addressed. Although this brief treatment could not begin to cover all study methodologies in detail, an effort is made to cover at least the basic approaches useful in addressing the question of injury etiology. Within this framework of basic approaches lie most of the variations in study methodologies. This discussion is followed by a critical appraisal of published occupational safety studies of the last 30 years dealing with housekeeping and safety.

Methodological issues

Study designs

Before considering approaches to be used in conducting studies, one must have a clear question in mind. The nature of the question will help determine how the investigator will conduct the study. Once the study hypothesis is clearly defined, choosing the appropriate design to test it is the next step in obtaining a credible answer. The following section will discuss some of the frequently used designs in population-based studies.

Experimental studies

When properly conducted, experimental studies are the strongest to test a hypothesis [Rothman, 1986]. In the experimental study, the observer defines and controls the intervention under study, and subjects (or groups) are assigned the intervention on a random basis. For example, an investigator may be interested in knowing which of two types of gloves is better at preventing hand injuries. Using an experimental approach, the investigator would randomly select, among all study participants, those that would use the new gloves. If sample size is large enough, other risk factors should be evenly distributed between study groups as a result of the random assignation of subjects into groups and comparisons of injury rates should be free from bias due to an imbalance of these other factors. The only aspect which distinguishes one group from another in the true experimental study is the intervention.

Quasi-experimental design

Because random allocation which is critical for experimental studies is not always possible, other approaches are used. In the quasi-experimental design, though study subjects are not randomly assigned to the experimental and control groups, the investigator may control the intervention. Using the previous example of work gloves workers may demand to have the freedom to choose their gloves, or certain companies may opt for the new gloves though others will remain with the old style. The important distinction from the true experimental approach is that study participants who are given the standard gloves may be different from those who use the newer gloves in ways that may distort the outcome of the study. The investigator is left with the burden of demonstrating that any differences between the groups using different gloves are not associated with injury rates, which is usually done by accounting for these differences in the analysis. Unfortunately, some variables affecting outcome may not be known and would not have been measured, leading to spurious conclusions.

Observational studies

Investigator manipulation of the conditions of the study is not always possible. In these situations, observational studies may be used. Among the observational study designs, **analytical studies** are generally thought to be stronger than **descriptive** or **hypothesis generating** ones [Rothman, 1986].

Analytical studies

Two common types of analytical studies are the cohort, and case-control studies. Both follow a defined study population for a period of time during which the outcome of interest develops. In the cohort study, the study sample is defined on the basis of exposures. For example, an investigator may want to study the relative risks of incidents between two different methods for handling sharp instruments in the operating room. Using the cohort design, the investigator would observe the outcomes of numerous operations, comparing incidence rates under the two instrument handling methods. The case-control study, on the other hand, defines the study sample on the basis of outcomes. Operations where incidents occurred (*cases*), and a sample of surgeries where incidents did not occur (*controls*) are identified [Checkoway et al., 1989]. Comparisons are made between exposure status of case operations and exposure status among control operations.

Particular attention to study design and choice of appropriate risk estimators can lead to similar conclusions for both case-control and cohort studies [Greenland and Thomas, 1982; Greenland et al., 1985]. One important distinction, though, is that case-control studies are limited to one or few outcomes by design, though cohort studies allow the investigator to study various outcomes. Case-control studies, however, have the advantage of being less expensive than cohort studies if the outcome of interest is rare.

Descriptive studies

Unlike the previously described study methodologies, descriptive studies are designed mainly to generate specific hypotheses about situations for which little is already known. One form of the descriptive study is the cross-sectional study, where the outcome is the number of cases present in the population at one point in time (prevalence). The causal relationship in cross-sectional studies is not easily established. For instance, an investigator may discover that the prevalence of carpal tunnel syndrome (CTS) is highest in the quality control department of a certain industry. However, without knowing work histories, the researcher would be unable to demonstrate that the CTS resulted from the work in the quality control department. It is possible that the workers developed CTS in other areas of the plant, and migrated to the less physically demanding quality control department. It is also possible that the measured prevalence is an underestimate of the true prevalence if affected workers have stopped working for the company altogether. Results from cross-sectional studies usually have to be confirmed by studies with better designs.

Other methodological issues

Internal validity

A study is said to have internal validity when the outcome is due to the factors under investigation [Rothman, 1986]. For example, in the glove study, the internal validity is assured when the different injury rates observed are not attributable to other factors associated with incidents such as worker experience or tasks being performed. Although several factors can compromise internal validity, the following discussion will be limited to a few of the more general biases; confounding, selection bias, information bias, and history bias.

Confounding

A confounder is a predictor for the outcome of interest which is associated with the exposure variable under study. Confounders are defined a priori based on previous studies as well as functionally based on their influence on the measure of effect (e.g., relative risk, odds ratio) [Kleinbaum, Kupper and Morgenstern, 1982]. In the glove study, the association between glove type and injury could be distorted by the workers' experience. If one type of glove was used more often by inexperienced workers, confounding by experience would lead to a distortion of the apparent safety of the different gloves. To remedy this, the estimation of measure of effect must be adjusted for the confounding factors through study design or statistical techniques in the analysis (controlling for confounding). However, it is sometimes difficult to identify and measure all possible confounders, and confounding remains a potential problem, particularly in studies where randomization has not been used.

Selection bias

A second threat to internal validity, selection bias, appears when the selection of a group under investigation fails to produce a sample which is representative of the target population. This bias compromises the ability to generalize the results of the study to the targeted population [Rothman, 1986]. For example, if cases entering a study are more likely to be exposed than all potential cases whereas study controls are representative of all potential controls with respect to exposure, the risk estimate for the studied exposure would be overstated. As with confounding, selection bias may not be obvious, and there remains the risk of compromising validity because of this. Selection bias is best dealt with in the design of the study, ensuring that the study group is representative of the target population.

Information bias

Errors in the measurement of the variables of interest are what comprise information bias [Rothman, 1986]. This bias could lead to either an inflation or an underestimation of the measure of effect. For example, the previously mentioned study of safety classes may rely on self-reported injuries for the outcome of interest. If workers who follow the training were more likely to report injuries than those who did not follow training, and there was a reduction of injuries due to the classes, the injury rate measured in the group receiving classes could be overestimated or similar in comparison with that of the other group. To address information bias, attention needs to be paid to the accurate evaluation of variables under study.

History bias

Conditions which change during the course of an experimental study also have the potential of distorting the measure of effect if they are associated with outcome. This bias is referred to as history bias [Campbell and Stanley, 1966]. For example, an investigator may be studying sprain reduction following the introduction of a newly designed pneumatic wrench. Part-way into the study if the company decided to increase the speed of the assembly line, the investigator is left with a change that may also have an effect on sprains and will have difficulty separating the two conditions. Any changes susceptible to effect outcome should be identified by the investigator and caution should be used in interpreting results where these changes are known to have occurred. As with other biases, identification of history bias may not always be evident.

Sample size and unit of analysis

Conceptually, all studies aim to answer questions within the context of a larger population [Rothman, 1986]. Adequate sample size is needed to control for the effect of random measurement errors which can lead to study imprecision and low study power to demonstrate effects. Traditional sample size calculations are based on a random sampling of individuals within the entire population. In occupational studies, workers are often selected in groups such as companies or departments rather than individually. Similarities among individuals within the same group reduces the power of the study [Donner and Klar, 1994, Koepsell et al., 1991]. Sample size must be increased to compensate for the non-independence of the units of analysis [Donner et al., 1981; Donner, 1982; Donner and Hauck, 1989].

Within-group design

Preliminary investigations are often comprised of within-group studies in one or few companies. These approaches are used because it is often difficult to solicit the participation of many companies, especially when the nature of the study is exploratory. Although these approaches offer some contribution to the understanding of injury etiology at an early stage, the lack of power in small within-group designs restricts their ability to provide conclusive results. It is therefore imperative to eventually go beyond the small within-group investigations and look at ways of reproducing results in other settings.

Although the preceding section on methodological issues does not pretend to address all of the questions pertaining to the study design in the area of occupational injuries, it can at least be seen as a foundation against which many existing studies can be compared. In the following section, these issues will be used to guide the presentation and discussion of studies published over the past thirty years dealing with the association between occupational injuries and housekeeping.

Review of studies

Selection of studies

Sources used to identify studies included electronic databases; MEDLINE, CCINFO, CIS-ILO and Science Citation Index, as well as a manual search in the reference section of the articles thus identified. The first objective was to find occupational 'safety', 'injury' or 'accident' etiology or improvement studies which either look at housekeeping as a risk factor for injuries or looked at housekeeping improvement as a means for improving occupational safety. Housekeeping was also defined variously as 'organization', 'order', and 'environment' in the automated searches for relevant articles.

A total of nine studies published between 1967 and 1997 were found (Table I). Because of the small numbers of studies that were initially found, those that failed to address safety were not excluded, nor were studies which comprised multiple interventions aimed at behavior modification if they addressed housekeeping behavior.

Quasi-experiments

A quasi-experiment by Rees [1967] attempted to demonstrate how feedback of safety defect scores can reduce injury rates. Poor housekeeping was considered one of the safety defects. The injury rate was reduced by about 50% of pre-study levels in the study company. Although the results of this study were promising, the lack of an appropriate comparison group does not eliminate chance as a possible explanation for the results. Many unexplored factors could have been responsible for the observed reduction in injuries. Additionally, this study does not allow for identification of housekeeping as a distinct contributor to safety.

In another study, an intervention was carried out to examine the effects of feedback of safety practices and conditions on safety [Fellner and Sulzer-Azaroff, 1984]. Safety practices and conditions assessed included storage of materials and equipment. A multiple-baseline approach (staggered introduction of the intervention) was used to control for history biases. Although injury rates were lower during the intervention, this represented only three months of observations. Substantial fluctuations in injury rates experienced in the three years prior to the study puts into question the actual impact of the intervention on injury rates. No mention is made, either, of injury rate fluctuations in other departments of the same company. As with Reese's study [Reese, 1967], though the improvements in safety may be due to the intervention, it is not possible to establish the contribution that housekeeping has to this change.

In another study, an intervention aimed at improving housekeeping was implemented in two production halls of a shipyard [Saari and Näsänen, 1989]. The number of injuries went from 37, 33 and 29, respectively, in the three years before the intervention to 9, 5 and 9 injuries, respectively, in the three years following the intervention. Injury rates in the whole shipyard also decreased by about 25% over the same time period. The main weakness of this study comes from the absence of a comparison group and the impossibility to impute changes in accident rates to the intervention.

A modified housekeeping improvement intervention as the one reported by Saari and Näsänen [1989] was carried out in a further twenty-two departments of the same shipyard [Saarela, 1989]. In this approach, small groups were formed to carry out the intervention and the goal was to see if small group activities could improve housekeeping and safety. Secondary to this study, it was reported that injuries related to housekeeping showed a 20% decrease when compared to the previous year. Although corroborating results of the previous shipyard study, some of the same weaknesses were apparent. The higher success of the first study indicates a selection bias for that earlier study. Those departments that believe in the positive effects of the system may participate first and reinforce the notion that the intervention is successful. Again, the extent to which the results within a single company can be translated to potential successes in other companies is questionable.

Descriptive studies

Eleven worksites were used to study the association between the quality of the work environment and occupational safety [Mattila et al., 1994]. Quality of the work environment included, but was not restricted to, housekeeping items. There was a significant correlation between the eighteen-item work environment index and the injury rate. As well, housekeeping was found to be strongly correlated with injuries in univariate analysis. One main criticism of this study lies in the definition and evaluation of housekeeping which was vague and included items not clearly related to housekeeping (housekeeping and illumination in the walkways). Small sample size also precluded multivariate analysis, which would be necessary to address confounding.

A descriptive study of twelve departments of a farm machinery manufacturing company looked at the relationship between unsafe behavior and injuries [Reber and Wallin, 1983]. Unsafe behaviors included, but were not restricted to, housekeeping issues (wiping up spills). Significant correlations were found between safety behavior and total injury rates and lost-time injury rate. Although some of the observations addressed housekeeping behavior, no attempt was made to evaluate the various behaviors separately and it is not possible to determine the possible contribution of housekeeping alone to the injury rates.

Eleven pairs of companies, with one "low injury" and one "high injury" company in each pair, agreed to participate in a study looking into injury determinants [Simonds and Shafai-Sahrai, 1977]. Each company was visited once to evaluate conditions such as lighting, tool placement, visibility and noise levels. In pair-wise comparisons, the companies with lower injury frequency had a better index of general physical conditions. In the univariate analyses, other factors, such as better recordkeeping, and use of injury cost analysis also differentiated the two groups. However, possible confounding was not addressed. As well, there was no indication that the observer was blind to the status of the companies before the visits, which could have lead to an information bias, contributing to the positive results of the study.

As a follow-up to a questionnaire survey of safety program practices, seven pairs of plants were selected for site visit surveys to determine practices which reduce injuries [Smith et al., 1978]. Each pair was comprised of a one low injury rate and one high injury rate company. Two low injury rate companies and one high injury rate company had better housekeeping and cleanliness than their match. There were no differences in housekeeping and cleanliness scores within the four remaining pairs. No statistical analyses were reported. Again, factors were not treated in a multivariate model, and there is no indication that information bias did not have an effect on the results of the study.

In another study, six pairs of plants were visited to determine which safety activities had been effective in reducing injury rates [Chew, 1988]. Again, each pair contained one high injury rate and one low injury rate company. The authors reported a significant association between good housekeeping and lower injury rates. Univariate analysis also pointed to other factors associated with effective occupational safety activities.

In the descriptive studies review here, small sample size and unclear sample selection continue to compromise the strength of the findings. Being hypothesis-generating, their contributions to the field is important, but specific findings need to be corroborated by further studies.

Discussion

The contribution of this group of studies towards the understanding of the association between housekeeping and safety has to be appreciated regardless of each study's weaknesses. On the other hand, some caution must be exercised because there is no way of knowing if this sample of studies, i.e., the published ones, is representative of the population studies, both positive and negative, which looked at housekeeping and safety.

It must also be kept in mind that only one study had initially planned to specifically explore the association between safety and housekeeping [Saari and Näsänen, 1989], the other studies being either hypothesis-generating, having a limited focus on housekeeping or focusing on outcomes other than safety. Regardless of stated objectives, these studies were selected in part because of their claim of an association between housekeeping and safety. Their failure to adequately address this question through the study design is a main criticism of this presentation. The design weaknesses also limit the studies' potential to realistically attain their various stated objectives.

Although the quasi-experimental model can be one of the strongest study designs to demonstrate associations, studies reviewed here failed to show that the improvement in safety was a result of the intervention. The researchers must also make some effort to engage a sufficient number of study subjects in order to demonstrate the ability to replicate the experiment.

Sample size is also an issue for the descriptive studies. Although it is difficult to engage the participation of many companies, failure to obtain an adequate sample hinders the ability to look at the data using anything but a simple univariate approach. Although the studies did find positive associations despite small study sizes, controlling for potential confounders was not done, reducing confidence in the results obtained.

The validity of the information obtained in the descriptive studies is also questionable. For assessing housekeeping, usually only one visit to the workplace was made, and no mention was made of the ability of the measurement tool to evaluate housekeeping. Additionally, the status of the companies, in terms of injury rates, was already known before the observers evaluated housekeeping. Given that the assessment of housekeeping appeared to be quite subjective, and that the observer may have known beforehand the status of the companies, it is quite possible that the results could have been biased towards an association between safety and housekeeping.

Finally, the reviewed studies must, in all fairness, be looked at in the context of when they were conducted; mainly from the 1970's through the 1990's. The knowledge of study design in the field of occupational disease (or injury) etiology has grown over this time period. The comments presented in this review article should be seen as a base for guiding future studies in occupational safety, and not merely as a criticism of the reviewed studies. Regardless of their weaknesses, these studies present a valuable first look into the association between housekeeping and safety. It is not sufficient to stop there, however. The success of good epidemiological designs for occupational disease etiology can serve as an example of how the application of sound investigative techniques can lead to useful and valid results, and how attention to detail can help reduce doubts about potential study biases. Improvements in study techniques should ensure progress in the field of occupational safety. Rather than focusing on experimental or quasi-experimental studies, which are often restricted because of the difficulty of applying them in large numbers of companies, researchers should perhaps try to focus more on descriptive studies which, although methodologically weaker than true experimental studies, also tend to be much easier to carry out successfully in the work environment.

OCCUPATIONAL HEALTH AND SAFETY IN QUEBEC

Substantial modifications were made to Quebec's health and safety legislation in the 1970s. Some features of the new labor law facilitate research endeavors. These features will be presented in the following section.

Sector associations

Quebec's labor law permits the establishment of non-partisan sector-based health and safety associations. The associations provide information, counseling services and training to employers and workers and can facilitate research activities. These health and safety associations play a large role in preventing injuries and thus reducing claims. They can also identify research questions relevant to their member companies and help in the pursuit of these questions.

The decision to create a sector-based organization is an option granted to employee and employer representatives together. Once both parties decide they want an association they petition the **Health and Safety Commission** {Commission de la Santé et de la Sécurité du Travail (**CSST**) — *workers' compensation board*} for the financial support and right to do so. It is possible that not all companies in a given sector will want an association to service their sector but under the law, all companies have the right to the association's services. The financing of the associations is assured mainly through annual dues paid to the Health and Safety Commission by companies represented by the associations.

Several incentives exist to encourage interactions between companies and associations. Companies wishing to use the services of their association are charged only minimal fees. Because companies are already paying for the services of the associations through the dues, they are inclined to make use of association expertise. The continued survival of health and safety associations also hinges on continued service to sector companies. To increase utilization of services, health and safety associations try to be as visible and valuable to their member companies as possible. Association consultants are often assigned to a subset of companies, consulting with company representatives and training workers. Associations also employ experts, such as engineers and industrial hygienists to further serve the needs of their companies. Because of their many interactions with member companies, associations are also valuable intermediaries for conducting occupationally–oriented research.

"Universal" coverage

Quebec's health and safety legislation covers virtually all workers. A few occupations, such as domestic workers, professional athletes, self-employed workers and company officers are not automatically covered by the compensation, although they can opt into the plan. Employees working for federal corporations are covered under federal labor laws, however there are some provisions for optional coverage under the provincial legislation. This essentially universal coverage can be of interest to researchers if they are concerned with compensated cases.

Uniform reporting and injury definition

If an injury is recognized as work-related and necessitates a leave of absence, compensation begins the day following the injury. It is usually in the interest of both workers and companies to report injuries that require an absence from work because compensation for lost wages is ensured through the worker compensation insurance. The circumstances surrounding injuries are reported to the Commission on standard forms when requesting compensation. The presence of uniform reporting gives comparable sources of information for work-related injury studies.

Statistical services

The data that are gathered using compensation forms are entered in databases by the Commission's statistical services. Data managers and statisticians at the Commission compile data and produce statistical reports. Researchers may also request information from this centralized database, making it a valuable resource for studying occupational injuries.

HOUSEKEEPING AND SAFETY IN INDUSTRY

Measuring housekeeping

The state of housekeeping in industry is thought to reflect, to some extent, levels of safety [Bird and Germain, 1990; Saari and Näsänen, 1989]. One could reasonably expect, then, that monitoring the levels of housekeeping could serve to keep companies informed of evolving safety conditions. Although some methods for evaluating the state of housekeeping have been used in the past, little attention has been paid to the validity or reliability of these measurements.

Some researchers have produced measures that assessed worker behaviors and workplace conditions [Fellner and Sulzer-Azaroff, 1984; Reber and Wallin, 1983; Rees, 1967], but did not examine housekeeping as a separate construct. Aside from being unable to distinguish between behavior and the work environment, only one of the above studies

[Rees, 1967] contained a comprehensive set of questions actually pertaining to housekeeping.

Housekeeping *behavior* has also been studied as a component of safety behavior [Reber and Wallin, 1983], yet the state of housekeeping as a workplace condition was not always considered. A study by Mattila and coworkers [1994] separated housekeeping from worker behaviors, but less than half of the items on the eighteen item checklist evaluated housekeeping conditions. Other studies separated housekeeping from behavior or company organizational structure but used summary questions (i.e., rating housekeeping on a scale of one to five) [Chew, 1988; Simonds, 1977; Smith, 1978].

More recently, in a series of quasi-experimental studies examining the use of feedback for injury reduction, housekeeping evaluations have been used to provide a marker for changes in the work environment [ILCI, 1991; Saarela, 1989; Saari and Näsänen, 1989]. Detailed checklists and observation procedures were designed to evaluate the level of housekeeping in a well defined work area. The results of the evaluations were used to provide feedback to the workers on their progress in improving the work environment. However, these measures were workplace-specific and could not even be used to evaluate the level of housekeeping in other departments within the same industry. The evaluations were also restricted to a few goals that the intervention team had identified as being easily changeable.

As far as what housekeeping means to researchers, different properties of the work environment have been classified under the heading of housekeeping. In most studies, housekeeping encompassed aesthetic and organizational aspects as well as safety hazards and compliance with safety regulations. Other studies also included subjective evaluations of lighting and noise levels. Most studies, however, failed to define housekeeping in any way.

In one textbook written for safety professionals, housekeeping includes:

> *"Cluttered and poorly arranged areas. Untidy and dangerous piling of materials. Items that are excess,*

obsolete or no longer needed. Blocked aisles. Material stuffed in corners, on overcrowded shelves, in overflowing bins and containers. Tools and equipment left in work areas instead of being returned to tool rooms, racks, cribs or chests. Broken containers and damaged material. Materials gathering dirt and rust from disuse. Excessive quantities of items. Waste scrap and excess materials that congest work areas. Spills, leaks and hazardous materials creating safety and health hazards." [Bird and Germain 1990].

The evaluation of the state of housekeeping needs to be improved. Given its complexity and the variety of workplaces, proper evaluation of housekeeping requires a checklist that does a thorough job of measuring its many aspects rather than resorting to a general subjective evaluation. The model used for workplace-specific evaluations [Bird and Germain, 1990; Näsänen and Saari, 1987; Saari and Näsänen, 1989] serves as a starting point for building an exposure assessment tool that should greatly improve its evaluation, but it needs to be modified to be applicable in more than one workplace.

Housekeeping and safety

In 1989, approximately one in ten workers in Quebec was compensated for time off work due to workplace injuries [CSST, 1990a]. In the machinery and transportation equipment manufacturing sector, one in five workers was injured on the job [CSST, 1990b]. Rates paid by industry to cover the direct costs of injuries, amounted to close to 1.5 billion dollars in Quebec, and these direct costs represented only part of the total cost of injuries to industry. In 1989, over 67 million dollars were spent by the CSST for prevention programs [CSST, 1990a].

Workplace health and safety legislation in Quebec and elsewhere has been evolving towards the general goal of eliminating risks to the health and safety of workers. The concern of preventing workplace injuries is also shared by industry and workers. However, a better understanding of injury risk factors is vital to tackling this complex problem.

Despite the advances that are made in occupational epidemiology, some questions, such as the association between housekeeping and occupational safety, have been inadequately studied. Although a few articles have studied its role as a factor in occupational injuries [Chew, 1988; Mattila, Rantanen and Hyttinen, 1994; Reber and Wallin, 1983; Rees, 1967; Saarela, 1989; Saari and Näsänen, 1989; Simonds and Shafai-Sahrai, 1977; Smith et al., 1978; Sulzer-Azaroff and Fellner, 1984], methodologies were often inappropriate. Furthermore, studies evaluating the association between housekeeping and safety usually relied on simple observations and untested risk-factor measures.

Objectives

The objectives of the first part of this study are to develop an instrument for measuring housekeeping that is detailed and applicable across companies and to evaluate its test-retest and inter-observer reliability.

The second part of this study uses the newly developed instrument to investigate the association between housekeeping and safety using a prospective study design.

Methods

Definition of housekeeping

As stated earlier, in the present study, housekeeping was defined as the state of the workplace with regards to; 1) *organization* - orderly and structured placement and storage of tools, equipment and materials, 2) *obstructions* - lack of clutter, clear access to workstations, equipment, and exits, and 3) *cleanliness*.

Checklist development

Previous examples of single workplace checklists [Bird and Germain, 1990; Saari, 1987; Saari and Näsänen, 1989] were used to guide the development of a preliminary version. Sector-based and external experts were then consulted to further formulate checklist items, and to ensure that survey items were relevant to the targeted industrial sector and company size. Each item on the checklist was studied, and definitions were elaborated when necessary to ensure that the checklist items were clear and easy to evaluate. The following principles were used:

1) Checklist items had to be observable in various types of companies.

2) Questions requiring technical expertise, expert opinions, or lengthy observation were excluded.

3) Observations were restricted to workplace conditions; not the measurement of worker behavior.

4) Measurements requiring specific tools, (such as those for evaluating temperature, lighting or noise levels) were excluded.

5) The observation of the workplace had to be carried out in a way that minimized interference with the work.

6) The final checklist had to minimize observation time, allowing for its incorporation into a walk-through survey of the workplace.

7) Questions had to be well defined to limit subjective evaluations.

Weekly meetings were held with safety experts to discuss modifications and to verify that the questions were clear and that they met the criteria listed above. Once the questionnaire was ready, pilot testing was carried out in four companies with the help of sector-based experts. Comments and suggestions gathered during the piloting were integrated into the checklist.

Final checklist and evaluation

The checklist consisted of 73 distinct questions (Appendix C for the English translation) and encompassed three attributes of housekeeping: organization of tools and materials, obstructions, and cleanliness. Because some questions were repeated in more than one area within the workplace, they developed into 218 observed items per visit.

In addition to the checklist questions, a protocol for conducting the observation visit was elaborated. The main focus of the evaluation was an assessment of the housekeeping levels in the *production area* of each workplace. Given the size of the typical workplace, and the presence of departments in many of the companies, it was decided to divide the *production area* for easier observation. This would also provide a summary of housekeeping for companies where these levels varied between departments. The *divisions* corresponded to departments whenever possible. If a workplace did not have distinct departments, the *divisions* were made within the *production area*. Using these criteria, four observation *sections* were identified in the *production area* of each workplace. Although production areas provided an estimation of general housekeeping, a sampling of individual workstations (e.g., work benches, paint booths, machines) was carried out to address more detailed characteristics of housekeeping. This was done by systematically sampling four *personal work areas*. The work area that was physically located closest to the center of each observation section was selected. Finally, two *storage areas* (consisting of 1 chemical and 1 material storage area) were also included in the housekeeping assessment visits.

Calculating housekeeping levels

If an observed item was endorsed (e.g., slings stored), this resulted in a positive score of one for that item. Incorrect items scored zero, and items that were not applicable (e.g., no slings present) did not contribute to the score. From the completed checklists, a housekeeping score for each visit was calculated as the percentage of positive scores among all scored items. Individual visit scores were used to establish checklist reliability. Mean scores for all visits were also computed for each company and used in the evaluation of the association between housekeeping and safety. High scores correspond to better housekeeping.

Study population

This study was conducted among registered companies in the transportation equipment and machinery manufacturing sector, in the

Montreal, Sherbrooke, Granby and Quebec city regions in Quebec, Canada between January 1, 1992 and April 1, 1993. Companies in the chosen regions, listed as employing between twenty and sixty workers, were eligible for the study. The regions were chosen for their relative concentration of eligible companies in order to minimize study costs. The restrictions of size and industrial sector were imposed to increase the probability of homogeneity among the companies being observed, thereby facilitating the identification of common survey items for the checklist. This sector was also chosen because it was represented by a non-partisan health and safety association.

Selection of the participating companies

Health and safety consultants from the sector-based bi-partisan health and safety association representing the manufacturers of transportation equipment and machinery were asked to make initial contacts with companies, inviting them to participate in the study. In all, eighty-two eligible companies were contacted, and sixty-six consented to participate. Among the latter, four companies were rejected because they had less than five workers. A further five companies were eliminated, it was not possible to obtain injury information from them because they closed before the end of the study. Finally, data from fifty-seven companies were used in the analyses.

Observation visits to assess housekeeping

Companies agreeing to participate were contacted by the main observer to set a date for the first visit. Subsequent visits were usually arranged on site. Companies were visited an average of four times during the study period. Each company was visited on at least two different occasions and one main observer was used for the study. Alternate observers were used for inter-observer reliability testing. A company representative usually led the observer on an initial visit of the workplace before observations were carried out. For subsequent visits, the observer was often allowed to proceed through the observation alone. The evaluation of housekeeping was performed during walk-through surveys of the companies using the checklist designed for this study (Appendix C). Companies did not have access to the checklists, nor were the companies told which specific items were being observed.

Checklist validity

The process used for checklist construction, involving both internal and external experts, ensured that definitions were addressed and were relevant for the targeted sector (*content validity*). As well, the measurement protocol, which included repeat visits and visits at different times of the week, month, and across seasons, ensured capture of fluctuations in housekeeping levels over time (*construct validity*). However, because "gold standards" for measuring housekeeping do not exist, it was not possible to estimate concurrent validity. As well, given that the association between housekeeping and some outcome such as injury was not clearly understood, it was not possible to evaluate the predictive validity of the measure.

Checklist reliability

Companies were visited by one observer on more than one occasion to evaluate test-retest reliability. Repeat visits were spaced at least one week apart to reduce the possibility that the observer would remember the previous scoring. For test-retest reliability, seventy-seven pairs of closely-spaced visits (no more than three weeks between visits) and 253 pairs of widely-spaced visits (over three weeks between visits) were compared.

To evaluate inter-observer reliability, the main observer was accompanied by one of four alternate observers. Company management was asked ahead of time for permission to allow two observers during a visit. In addition to assessing total housekeeping, separate scores for obstructions, organization, and cleanliness were also computed.

Study design to assess safety

This study was designed to evaluate the association between current housekeeping levels and current injury levels. Visits were made to companies throughout the study period to assess average housekeeping levels. Injuries, and days lost due to injuries during the same time period, were also obtained. For the most part, the information on injuries came directly from the companies' compensation request forms. In a few cases, the companies were unable to provide this information but gave permission for release of the same information from the compensation board, which processes the claims. From both sources, information about injuries for which claims were filed could be obtained.

The condition of housekeeping in industry should impact immediately on injury rates. Because of this, this study looks at the state of housekeeping for the same period of time for which injury information was pursued.

Study outcomes

The two outcomes of interest in the cohort study were injuries (injuries per million person-hours worked) and days lost due to injuries (number of days lost per million person-hours worked). At the end of the study, information was abstracted from copies of compensation claims submitted to the Quebec Workplace Health and Safety Commission (CSST) for injuries occurring during the study period (January 1, 1992 - May 1, 1993). Seven companies were unable to provide copies of compensation claims, but authorized the release of the information directly from the statistics branch of the Commission. The nature of the injury, date of the event, number of lost days, external cause of the injury, location of the event, job title, employment status, age and experience of the worker were also abstracted.

Confounders

Information on confounders was collected at the end of the study, however, responses pertained to the period covered by the study.

Presence of a Health and Safety Committee, whose functioning and composition are regulated by Quebec's Workplace Health and Safety Act, was determined at the end of the study for each of the study companies.

Workweek duration (hours) and number of workshifts were also determined at the end of the study.

Two further potential confounders, product size and workplace setup were determined by the main observer during the final visit. Product size was considered as a potential risk factor because certain injuries, such as overexertion, were more likely with big or heavy workpieces than with smaller workpieces.

The presence of an assembly line or variable production layout, as opposed to fixed production workstations, was also included as a potential confounder. Workers who were constantly having to adapt to new workplace layouts, as production changed and workstations were modified, were expected to present a higher risk for injuries than those for whom the layout of the workplace remained unchanged.

Finally, worker age and worker experience were provided by company representatives at the final visit, and were also included as potential confounders.

Other variables of interest

Given that yearly injury rates fluctuate greatly in smaller companies, the relation of this year's injuries to past experience was estimated by company representatives (usually health and safety officers) as fewer, more than, or the same as usual.

Analysis

Test-retest and inter-observer reliability for the housekeeping instrument

The goal of testing inter-observer or test-retest reliability is to ensure that the measurement instrument gives comparable results with different observers and over time. When using binary scales, and even with multi-level categorical scales, Kappa scores can be derived to assess reliability. Kappa estimates the degree of agreement between the two sets of scores. Unfortunately, Kappa is not suited to evaluating reliability of continuous scales, and other methods must be used. Many researchers use the Pearson product moment correlation, *r*, or linear regression to assess agreement between continuous measures. However, correlational or regression techniques do not give valid measures of agreement because a high correlation is also possible when agreement is low (e.g., one rater consistently rating higher than another one will give high correlation scores, but agreement between raters is not high). It is also possible to obtain low correlation coefficients when the agreement between tests is high [Altman and Bland, 1983].

The first step for determining repeatability of continuous measurements is to verify that the variance between measures does not change with the magnitude of the measurements [Altman and Bland, 1983]. The homogeneity of measurement variances is an assumption in the modeling of reliability testing for continuous measurement scales. Residual risk plots of score differences between visit pairs against mean visit pair scores were produced to verify these basic assumptions.

Once it was clear that between subject variances were independent of housekeeping scores, reliability was assessed using one-way random effects analysis of variance (ANOVA) for Intra-class correlation (ICC) [Altman and Bland, 1983; Cho, 1981; Fisher, 1959; Muller and Buttner, 1994; Shrout and Fleiss, 1979]. Intra-class correlation is the appropriate measure for assessing reliability of continuous measures. Using the one-way ANOVA, reliability is obtained from the residual standard deviation of measurements. Unlike the Pearson product moment correlation or regression, ICC measures the degree of agreement. ICC scores range from perfect agreement (score of 1.00) to no agreement beyond what would be expected by chance (score of 0.00).

Association between housekeeping and safety

After data cleaning and initial descriptive analysis, Poisson regression was conducted using the PROC GENMOD module of SAS. Poisson regression allows for better modeling of person-time incidence rates than simple regression, and fits distributions of discrete outcomes such as injuries. Companies were categorized into three groups according to mean company housekeeping scores during the year of the study. The categorizations were made to divide the companies into three approximately equally sized groups. Incidence rate ratios were computed using the highest housekeeping score category as the comparison group.

Unadjusted incidence rate ratios were calculated first. Adjusted incidence rate ratios were calculated by adding potential confounders to the model. All potential confounders were kept in the model, regardless of their influence on the incidence rate ratio for the main effect - housekeeping.

Results

Initial workplace observations did not exceed forty-five minutes. Subsequent observations lasted less than thirty minutes on average.

Total housekeeping scores ranged from a low of 33.5% to a high of 94.6%. Mean scores for houskeeping components were relatively equivalent, with cleanliness scoring lowest and organization scoring highest (Table II).

Company characteristics across categorical housekeeping scores were similar for workweek duration and number of workers (Table III). However, a greater proportion of companies with high housekeeping scores claimed to have fewer injuries in the study year compared to previous years, had only one workshift, and had assembly line production. These companies were also less likely to have health and safety committees and small production pieces (Table III).

Worker characteristics did not vary much between companies when grouped by housekeeping scores (Table IV).

Reliability of housekeeping checklist

Residual-like plots of differences between observations against mean of observations show graphically that test-retest (Figure 1) and inter-observer (Figure 2) variations did not seem to be dependent on score. This was consistent for all components of housekeeping. However, the alternate observers did tend to score slightly lower than the main observer (Figure 2).

The results of the test-retest reliability are shown in table V. Intra-class correlations for the entire checklist showed that, overall, results from closely-spaced visits were more alike than those from widely-spaced visits. When checklist items were grouped into categories representing cleanliness, organization, or obstructions, correlations between scores for closely-spaced visits (no more than 3 weeks apart) were consistently greater than for widely-spaced visits (at least three weeks apart).

Intra-class correlation (ICC) for inter-observer reliability tests comparing concurrent visits were higher than test-retest reliability scores (Table V). With an intraclass correlation of 0.88 (95% CI 0.81-0.94), inter-observer reliability of total housekeeping was highest. Scores for cleanliness were the least reproducible between observers.

Association between housekeeping and safety

As explained above, mean housekeeping scores were categorized into three levels. These levels were set to get approximately equal numbers of companies in each group. Incidence rate ratios were computed using the highest housekeeping score category as the referent group. High scores corresponded to better housekeeping and lower risk. Crude incidence rate ratios for both injuries (Table VI) and days lost (Table VII) showed more injuries or days lost for poorer housekeeping scores. The increased risk of injuries was present as well among companies with low scores when considering the different aspects housekeeping;

cleanliness, obstructions, and organization. A trend in rate ratios was also seen, with higher risk of injuries in companies with poorer housekeeping scores. This trend was also apparent for obstructions and organization, but not for cleanliness.

Adjusting for potential confounders

When the incidence rate ratios were adjusted for potential confounders, they continued to be elevated and statistically significant in companies with poorer housekeeping scores in most cases. The trend across categories, however, was less evident. As with unadjusted scores, the trend was not seen for cleanliness scores. In addition, the injury incidence rate trend for obstructions was no longer present (Table VI).

DISCUSSION

Development of housekeeping checklist

In the first part of this study a comprehensive new checklist for measuring housekeeping across different companies was developed and tested. Although between-company evaluations of housekeeping are not new, previous measures have relied on casual estimations of housekeeping, or detailed but workplace-specific evaluations. This is the first time that a method has been developed for conducting a systematic between-company housekeeping evaluation that includes clearly defined measurement standards. The instrument is expected to reduce variability and bias in determining the level of housekeeping because specific items define scoring parameters. Although minimal inter-observer testing was performed, this type of checklist promises to have strong inter-observer reliability because of its clearly defined checklist items and measurement protocol. Though the alternate observers did have an opportunity to review the questions before the workplace visits, no trial observations were performed. In spite of this low level of training, inter-observer agreement was high.

In the inter-observer reliability testing, housekeeping and organization showed better agreement than cleanliness and obstruction. This was expected because organization dealt with the presence of systems that tend to be consistent throughout the workplace, making generalizations easier. Cleanliness and obstructions vary more within the workplace. Assessments that required a summary of the conditions in the workplace, such as total volume of trash or size of spills, were more difficult to make.

Test-retest reliability was lower than inter-observer reliability. This is partly due to changes in housekeeping between visits. Test-retest observation pairs were conducted at least one week apart, whereas inter-observer reliability observations were conducted simultaneously. For closely-spaced visits, where housekeeping levels should be more similar, agreement between visits was higher. It is reasonable to expect that the test-retest reliability would be even better had there been no changes in actual housekeeping levels in the workplace. The inability to adequately assess test-retest reliability of the checklist is one limitation of this study. It was not possible to separate actual changes from agreement problems. Although same-day test-retest reliability evaluations would come closest to avoiding problems resulting from actual changes in housekeeping levels, observers would remember how the previous visit was scored. In spite of the expected differences between revisits of at least one week apart, the test-retest reliability scores were reasonably high. Unfortunately, there are no easy solutions to evaluating test-retest reliability of a housekeeping measure in actual workplace settings.

For test-retest reliability, cleanliness and organization seemed to be less reliable than total housekeeping or obstructions. It is more difficult to speculate on the causes of this lower reliability given that the ICC scores are made up of actual changes in housekeeping as well as some component of reliability. As housekeeping levels in the workplace can easily change between observations, these attributes are, perhaps, dimensions of housekeeping that tend to fluctuate more over time.

Other detailed checklists have been constructed to evaluate the state of housekeeping in single company interventions [Mattila et al., 1994; Näsänen and Saari, 1987; Saarela, 1989; Saari and Näsänen, 1989]. Unfortunately, the specificity of these checklists to a single company, or department, precludes their application in between-company studies. Scores cannot be compared between companies because the survey items and protocols are not shared. The present checklist has been designed and shown to fit a variety of companies. Fifty-seven companies were involved in this study. Although they were all in the same industrial sector, there were differences between them that challenged the establishment of a common housekeeping evaluation checklist. Some companies employed high-precision engineering with low-tolerances for producing aircraft components, while others were labor-intensive, large machinery production companies. The specificity of the checklist had to be compromised for it to be applicable in the situations presented by these various companies. However, it was still felt that this checklist did address the main housekeeping concerns of all companies involved. When in doubt, items that were not observable in all companies remained in the checklist.

Given the diversity of companies, even within one industrial sector, it is questionable whether a checklist for housekeeping could be devised such that it adequately assessed housekeeping in all types of companies while being reproducible over time and between observers. One stumbling block to a universal measurement is the fact that industries and their standards vary greatly across economic sectors. Housekeeping in food production, for example, focuses on different issues than in foundries. Layout of the workplace and machinery also differ from sector to sector, raising another barrier to common measurement items. Although the development of a common instrument applicable to all workplaces may be difficult, the approach used here can be taken to build checklists specific to other industrial sectors. Checklist items should reflect specific housekeeping concerns typical plant layout, machinery, and industry standards for the chosen companies.

This checklist avoided questions requiring technical expertise or measurement instruments. Items that could not be easily measured were not eligible. This was done, in part, to shorten the observation time and thus make this type of evaluation easily adaptable to many companies. Some researchers have suggested that lighting, for example, should fall under the definition of housekeeping [Simonds and Shafai-Sahrai, 1977]. The need for specialized training and instrumentation for lighting evaluations precluded its use in this type of housekeeping evaluation. Compliance to safety standards has also been suggested as a possible item for housekeeping checklists [Bird and Germain, 1990]. Safety standard compliance is not easily evaluated, given the complexity of the standards and diversity of equipment in the various workplaces. The focus of the checklist has to be on easily measurable items that can be observed in the various companies by observers with minimal training. The drawback of such an instrument, though, is that it would be unsuitable for evaluating industry-specific and potentially critical safety concerns. Although housekeeping may reflect the level of safety in companies, measuring housekeeping could never replace more in-depth safety audits that thoroughly evaluate the condition of the work environment and machinery, and identify specific concerns of the workplace being evaluated.

As far as extending this type of evaluation to smaller or larger companies within a particular industrial sector, this should be easily possible. In larger companies, it may be sensible to divide the company into more observation areas, and it may also be helpful to measure housekeeping levels for departments as well as on a company-wide basis. This would help identify departments where housekeeping improvements are be more pressing.

Association between housekeeping and safety

The aim of the second part of this study was to investigate the association between housekeeping and safety. Unlike previous studies, this study controlled for many potential confounders. This was done both by selection of companies from a narrowly defined industrial sector as well as by taking potential confounders into consideration in the analysis. Though this present study was restricted to one industrial sector, it represents an important first step in studying this problem.

This study was restricted to compensable injuries that were reported to the workers compensation authorities. Differential reporting may be a concern between companies, although concentrating on one industrial sector should reduce between-company differences in reporting rates. Under-reporting is more problematic when there is an incentive or a discouragement for reporting injuries. In the present case, there is no reason to suspect differential distribution of under- or over-reporting between companies with different levels of housekeeping. Additionally, one could argue that not all injuries were detected by these means since the employee only becomes eligible for compensation after one day away from work following injury. The information does not cover injuries requiring only first aid or injuries that do not lead to a full day of disability. This is a dilemma which is not easily solved since no other reliable source of this information presently exists. However, injuries that involve at least one full day of missed work should be well represented by this source of information.

Housekeeping was significantly associated with injury rates and rates of days lost due to injuries in the univariate models, however, once confounders were considered this association was weaker, and even disappeared for some components of housekeeping. These findings underscore a main weakness of previous studies of injury etiology using univariate models: Although it is possible to find associations between a variable of interest and a certain outcome, it is imperative that possible confounders also be considered.

The estimation of confounders may also have been subject to some errors. For instance, some variables such as mean workweek duration and numbers of workers fluctuate over time. Many of the study companies employed more workers for certain periods and/or increased workweek hours temporarily to meet customer demands. In slower times, temporary workers were laid off. Production piece size and the presence of assembly line production were also liable to change over the course of the study. For example, one manufacturer produced snowplow blades during the winter and fork lift trucks the remainder of the year. Other companies had various products and production setups, so these variables were not clearly dichotomous. Lack of precision in the evaluation of any of the study variables probably led to weaker than actual associations seen in the models.

Some early studies in Scandinavian countries have shown that injury rates may fall substantially after the implementation of participatory housekeeping improvement programs [Saari and Näsänen, 1989; Saari, 1997]. Researchers have questioned whether this reduction was a result of improvements in housekeeping levels, or perhaps a result of new dynamics established in companies with the introduction of these participatory interventions. These early studies, although promising, were preliminary and efforts to explore this further have been unsuccessful because of difficulties of performing large scale intervention studies in industry. Attempts to implement these same interventions on a larger scale in North American companies have met with considerable resistance [Saari, 1997]. It is hoped that the evidence from this study, which supports the association between housekeeping and injury, will encourage companies to try these interventions and allow researchers to explore the effect of improving housekeeping on safety in industry.

After controlling for confounders, this study showed that companies with poorest houskeeping levels had about 35% higher injury rates (IRR 1.35) and just under 50% higher rate of days lost due to injuries (IRR 1.48) than reference companies. Although housekeeping was never expected to account for all injuries, the evidence is strong that poor housekeeping does contribute to a substantial percentage of injuries in the companies studied. In addition, higher incidence rate ratios for days lost due to injuries seem to indicate that the injuries experienced in companies with poorer housekeeping are not only more frequent but also more severe than injuries experienced in comparison companies.

Trends in incidence rate ratios were also seen for housekeeping and organization, but the same trend was not seen for cleanliness. Although cleanliness, organization, obstructions, and housekeeping are closely correlated, the failure of cleanliness components alone to significantly predict safety, or to demonstrate the same trends as the other components of housekeeping, indicate that these other components more clearly identify actual hazards.

Surprisingly, the trend in incidence rate ratios for obstructions and injury rate was also absent, though it was seen for rate of days lost due to injuries. The presence of this trend in the unadjusted rates indicated that confounding was present for obstructions. One factor, in particular, workplace setup, correlates highly with obstructions. Companies that changed production setup also had more difficulty in establishing clear passages between equipment, workstations, exits, and emergency equipment. Attention to workplace setup, for example; avoiding built-in obstructions, is especially important if the production setup changes frequently.

Because of fluctuations over time in levels of housekeeping, as shown in this study, the cursory evaluations of housekeeping that have been used in the past, and up to a point in this study, cannot be expected to give an accurate picture of mean levels of housekeeping over time. A single visit to a company will only yield housekeeping levels for that day.

Averaging the results of repeated visits will provide better estimates of mean levels. However, the need to visit the workplace frequently must be balanced with the desire to disrupt the workplace as little as possible. Keeping the visits short and low-key facilitated repeat visits to the companies at regular intervals. However, it was also noticed that more frequent visits would have been a problem for some companies.

This study looks at the state of housekeeping for the same period of time for which injury information was pursued. The issue of causality is less easily addressed, however, fluctuations in housekeeping were not great throughout the study period and it can be argued that mean yearly levels were a good approximation of pre-injury levels. In the end, this may be a question which could be best answered using an experimental approach.

Some lessons learned from this study concern the interactions with companies during observations. Although companies were generally open to the observations, there were some barriers that had to be negotiated to successfully conduct this study. Any measures that require observations in the workplace must aim to minimize disruptions in production. Restricting numbers of observers and minimizing observation time helped ensure that the observations were unobtrusive. Companies were sensitive to the effect of disruptions on lost production, and were reluctant to approve of observations they felt would distract their workers. In this study, the duration of all visits were well within acceptable limits for the companies. After a few visits, workers generally recognized the observer and went about their chores without interrupting their work. It was felt that the success in enrolling and keeping companies throughout the year of the study was greatly due to the relative unobtrusiveness of the observations. There is also no doubt that without the help of the sector-based health and safety association, this study would have been much more difficult to conduct.

This study is not without its limitations. The small sample size limited its power. Even with these constraints, it was still possible to demonstrate how previously relied upon univariate testing failed to control adequately for confounding.

FINAL CONCLUSION AND SUMMARY

In conclusion, the first part of this study has shown that a reliable and detailed evaluation of housekeeping is possible at least within a well defined industrial sector, though there may be practical problems in trying to construct a checklist that could easily measure all workplaces. In the second part of this study, this sector-specific checklist was used to demonstrate that housekeeping is associated with safety. Companies in North America should look towards improvements in housekeeping as a strategy for reducing injuries.

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Table I: Description of 9 Studies Linking Occupational Injuries to Housekeeping

	Rees '67	Simonds '77	Smith '78	Reber '83	Fellner '86	Chew '88	Saarela '89	Saari '89	Mattila '94
Study design	quasi-experiment	observation of differences in pair-matched companies	observation of differences in pair-matched companies	observation of link between safety and behavior score and injury	quasi-experiment	observation of differences in pair matched companies	quasi-experiment	quasi-experiment	observation of the link between work-environment and safety
Objective or question posed	not mentioned	isolating injury determinants	discover practices which reduce accidents	demonstrate the relationship between safety and behavior	can feedback lead to safe practices and conditions, and decrease injuries	which safety activities have been effective in reducing injury rates	can feedback improve housekeeping and safety	can small group activities improve housekeeping and safety	is there a connection between work environment and safety
Control group	none, compared pre to post accident rates	matched by size, state, and industry	matched by size, industry, and location	none	none - compared pre to post- injury rates	matched by industry	none - compared pre to post- injury rates	none - compared pre to post- injury rates	compared different sites of construction company
Assessment of outcome	company records	bureau of safety	reported OSHA injury rates	company injury rates	company records	not mentioned	company records	company records	company insurance reports
Independent variables (intervention)	(feedback on housekeeping, hand tools, protective clothing / equipment, unsafe acts / situations, etc.)	management involvement, record-keeping, cost analysis, roomy and clean environment, etc.	management structure, human relations, plant physical, housekeeping and cleanliness, etc.	behaviors; tool & equipment use, material handling, general safety, housekeeping, etc.	(feedback; behaviors and conditions i.e.; hoses, skids, obstructions)	management, safety training / rules, record-keeping, housekeeping, etc.	(feedback; housekeeping conditions)	(feedback, housekeeping conditions)	housekeeping, illumination, protective equipment, etc
N of subjects in the analysis / base population	one company / ?	eleven pairs of companies / ?	seven pairs of companies / ?	12 departments 12	seventeen rooms in one mill / ?	thirty-six pairs of companies / ?	two departments of one company / ? 22	all departments of one company (? 22) / ? 22	11 sites of one construction company
Outcome variables	minor / lost-time / disabling accidents, and classified injury	accident rate (bivariate high - low within each pair).	accident rate (bivariate high - low among all companies.)	departmental injury rates	practices and conditions / injuries	injury incidence rates	accident rates	accident rates	incidents causing at least one lost shift (insured)
Exposure assessment / (validation)	walk-through survey conducted by trained observers / (not reported)	interview with management and walk-through / (not reported)	interview with management and walk-through / (not reported)_	observations of safe / unsafe behaviors / (% agreement, construct validity)	weekly walk through observations / (% agreement, construct validity)	interview and walk-through / (not reported)	walk-through with checklist / (% agreement)	walk-through with checklist / (not reported)	walk-through with checklist / (% agreement, once for each observer)
Statistical analysis	none -"reductions (in accidents) to about a half of previous experience"	sign test and wilcoxin matched pairs signed rank test	none - % of low accident rate plants scoring higher than their high accident rate partners	rank difference correlation (spearman rho)	correlated t test	wilcoxin matched pairs signed-ranks test	*F* test and t test	none for accident rates	simple correlation

Table II: Housekeeping Scores for 59 Manufacturers of Transportation Equipment and Machinery in Quebec from a cohort study of Occupational Injuries, 1992-93

	Mean (Median)	S.D.*
Total	74.1 (74.7)	9.5
Obstructions	70.3 (71.1)	10.0
Organization	74.2 (75.5)	10.4
Cleanliness	67.2 (67.8)	12.4

*** S.D. -- Standard Deviation**

Table III: Company Characteristics by Housekeeping Levels: Quebec Transportation Equipment and Machinery Manufacturers Injury Study, 1992-93

	Categorical Housekeeping Scores		
	≤70 (N=17)	70.1-80 (N=21)	>80 (N=21)
Mean workweek duration (hours)	41.4	40.4	40.5
Mean number of workers	29.0	34.7	31.8
Estimated relation of this year's injuries to past years			
Fewer than usual	24%	35%	43%
More than usual	29%	15%	5%
Only one workshift	41%	40%	52%
Health and Safety Committee	82%	85%	71%
Small production pieces	94%	76%	62%
Assembly line production	24%	24%	33%

Table IV: Worker Characteristics by Housekeeping Levels: Quebec Transportation Equipment and Machinery Manufacturers Injury Study, 1992-93

	Total Housekeeping Scores		
	≤70 (N=17)	70.1-80 (N=21)	>80 (N=21)
Mean age of injured workers (years)	37.3	35.5	36.6
Mean age of all workers (years)	37.7	35.4	36.0
Mean experience of injured workers (years)	7.6	6.1	8.3
Mean experience of all workers (years)	9.7	7.8	10.2
Injuries per million* hours worked	209	196	118
Mean days lost per injury	14.7	15.6	12.5
Injury days lost per million* hours worked	2576	2614	1717

*** Million hours ≈ 500 worker-years**

Table V: Test-Retest and Inter-Rater Reliability of a New Housekeeping Checklist Designed for Manufacturers of Transportation Equipment and Machinery in Quebec, 1992-93 -- Intraclass Correlation Coefficients

	Intraclass correlation coefficient	(95% CI)*
Test-retest reliability		
Close visits*		
Total	0.73	(0.68 - 0.78)
Organization	0.62	(0.55 - 0.69)
Cleanliness	0.65	(0.59 - 0.72)
Obstruction	0.75	(0.69 - 0.79)
***Distant visits*†**		
Total	0.55	(0.51 - 0.60)
Organization	0.41	(0.36 - 0.46)
Cleanliness	0.50	(0.46 - 0.55)
Obstruction	0.61	(0.57 - 0.65)
Inter-observer reliability		
Total	0.88	(0.81 - 0.94)
Organization	0.86	(0.79 - 0.93)
Cleanliness	0.71	(0.56 - 0.83)
Obstruction	0.74	(0.61 - 0.85)

*** 95% C.I. -- 95% Confidence Interval of Intraclass Correlation Coefficient**
**** Revisit within three weeks**
† Visits over three weeks apart

Table VI: Injury Incidence by Housekeeping Levels: Quebec Transportation Equipment and Machinery Manufacturers Injury Study, 1992-93.

Housekeeping Score	Observed Injuries	Exposure Hours[†]	Crude		Adjusted*	
			IRR	95% CI	IRR	95% CI
Total housekeeping						
≤70 (N=17)	227	1193	1.84	1.52-2.22	1.35	1.08-1.70
70.1-80 (N=21)	325	1820	1.67	1.40-1.99	1.28	1.06-1.56
>80 (N=21)	198	1741	- -	Referent	- -	Referent
Obstructions						
≤70 (N=14)	187	1031	1.67	1.36-2.05	1.01	0.79-1.29
70.1-80 (N=25)	382	2225	1.49	1.25-1.78	1.23	1.02-1.49
>80 (N=20)	181	1498	- -	Referent	- -	Referent
Organization						
≤70 (N=17)	243	1189	1.93	1.60-2.32	1.44	1.16-1.80
70.1-80 (N=22)	308	1856	1.51	1.27-1.81	1.16	0.96-1.42
>80 (N=20)	199	1709	- -	Referent	- -	Referent
Cleanliness						
≤65 (N=25)	326	2187	1.62	1.31-2.02	1.14	0.90-1.45
65.1-75 (N=20)	314	1490	2.06	1.67-2.57	1.60	1.27-2.03
>75 (N=14)	110	1077	- -	Referent	- -	Referent

[†] Thousands

* Adjusted for Health & Safety Committee, shiftwork, workweek hours, worker age, worker experience, injury experience, workplace setup, workpiece size

Table VII: Incidence of Injury Days Lost by Housekeeping Levels: Quebec Transportation Equipment and Machinery Manufacturers Injury Study, 1992-93.

Housekeeping Score	Observed days lost	Exposure Hours[†]	Crude IRR	Crude 95% CI	Adjusted* IRR	Adjusted* 95% CI
Total housekeeping						
≤70 (N=17)	3140	1193	1.75	1.67-1.84	1.48	1.39-1.57
70.1-80 (N=21)	4136	1820	1.47	1.40-1.54	1.19	1.13-1.25
>80 (N=21)	2866	1741	--	Referent	--	Referent
Obstructions						
≤70 (N=14)	2806	1031	1.72	1.63-1.81	1.34	1.20-1.43
70.1-80 (N=25)	4690	2225	1.25	1.20-1.31	1.06	1.00-1.11
>80 (N=20)	2646	1498	--	Referent	--	Referent
Organization						
≤70 (N=17)	3302	1189	1.73	1.65-1.82	1.56	1.47-1.65
70.1-80 (N=22)	3835	1856	1.25	1.19-1.31	0.99	0.94-1.04
>80 (N=20)	3005	1709	--	Referent	--	Referent
Cleanliness						
≤65 (N=25)	4765	2187	1.71	1.62-1.81	1.40	1.31-1.49
65.1-75 (N=20)	3859	1490	1.84	1.73-1.99	1.54	1.45-1.65
>75 (N=14)	1518	1077	--	Referent	--	Referent

[†] Thousands

* Adjusted for Health & Safety Committee, shiftwork, workweek hours, worker age, worker experience, injury experience, workplace setup, workpiece size

Figure 1: Difference against means for housekeeping score - test-retest reliability - close visits

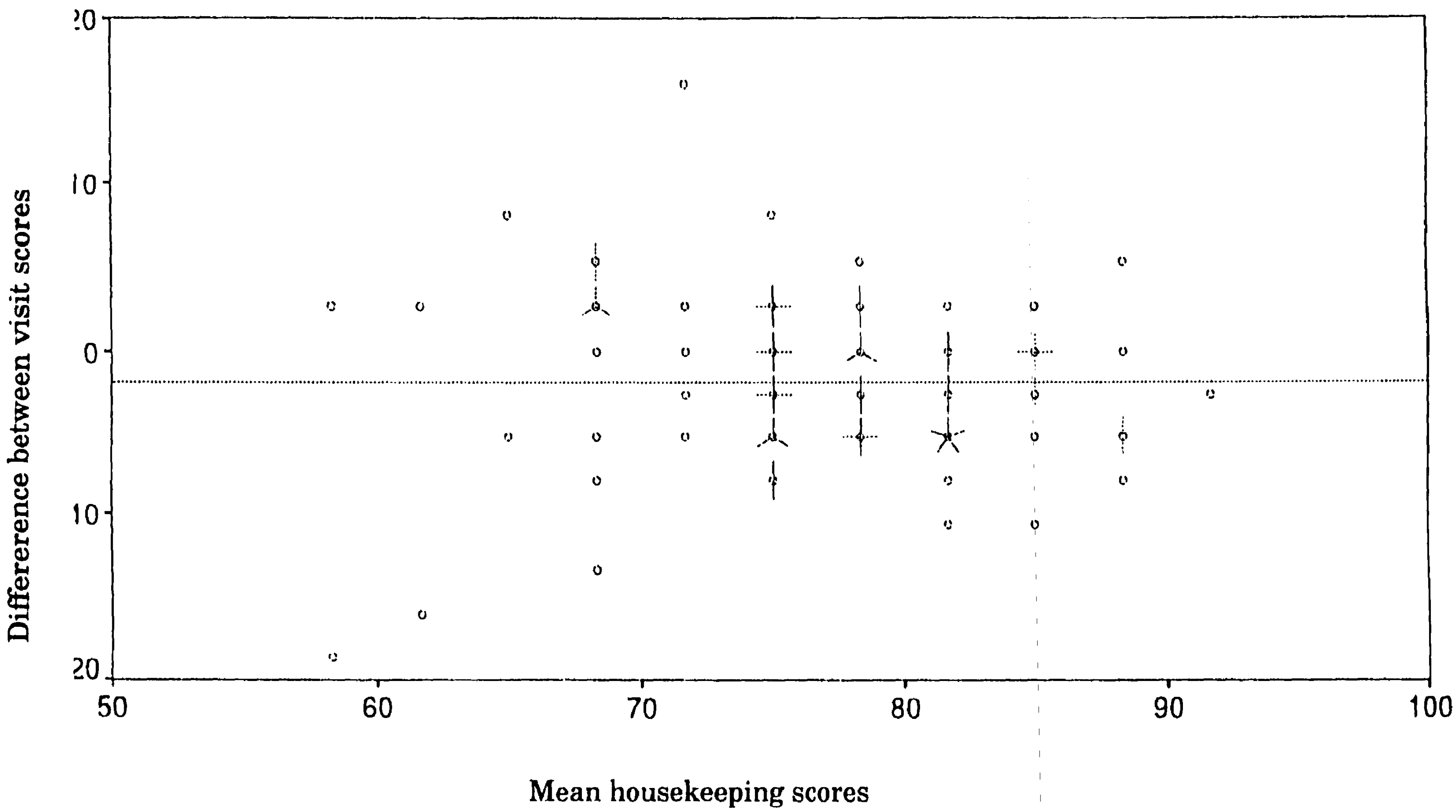
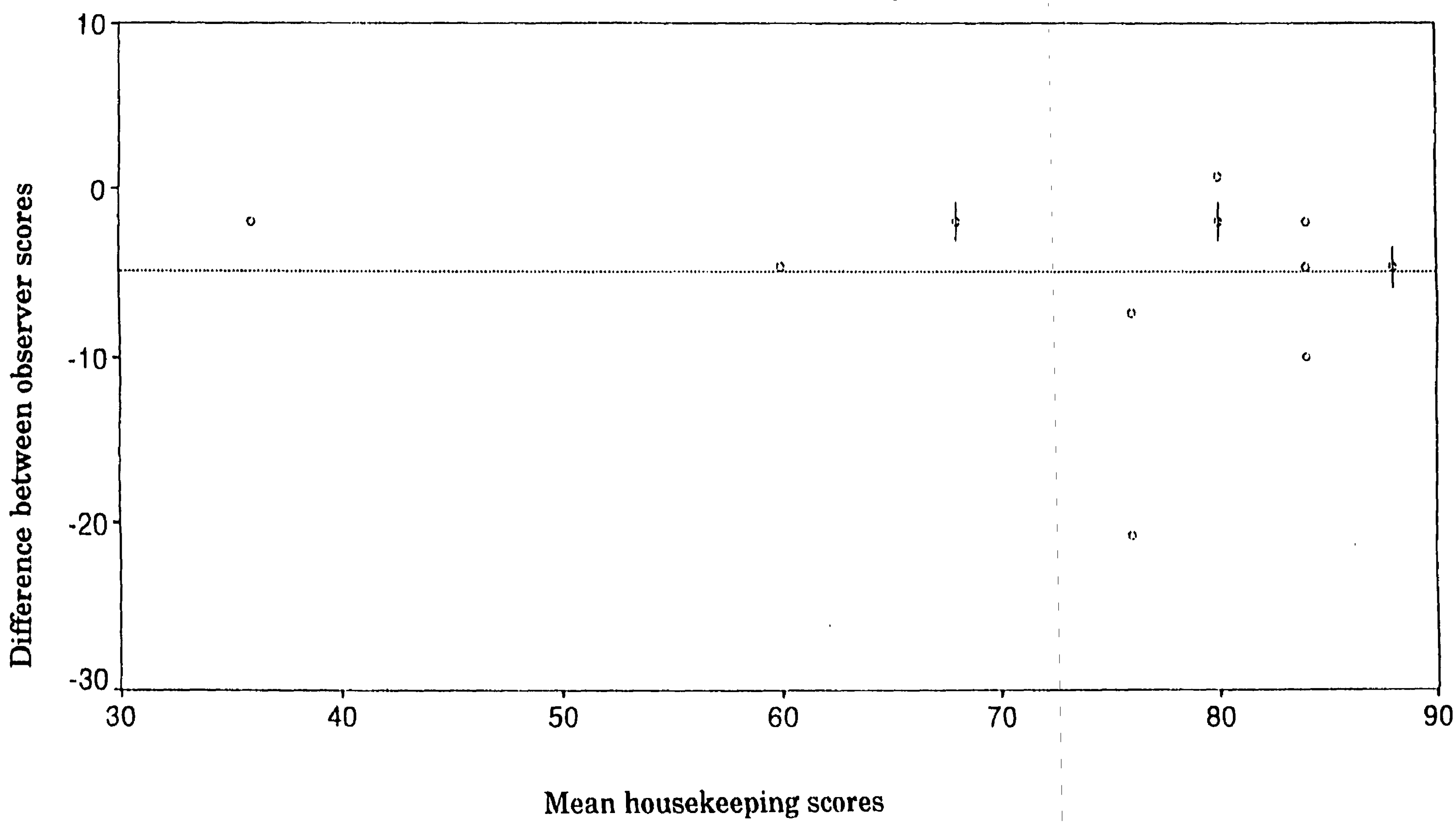


Figure 2: Difference against means for housekeeping score - inter-observer reliability



Appendix A: STATEMENT OF ORIGINALITY

STATEMENT OF ORIGINALITY

The two main parts of this thesis constitute original scholarship and an advancement of knowledge in occupational injury epidemiology. The first part of this study comprised the production and preliminary testing of an effective new checklist for measuring housekeeping across different companies. While between-company evaluations of housekeeping are not new, previous measures have relied on casual estimations of housekeeping or detailed but workplace specific evaluations. This is the first time that a method has been developed for conducting a systematic between-company housekeeping evaluation that includes clearly defined measurement standards.

The aim of the second part of this study was to investigate the association between housekeeping and safety. While other studies have attempted to look at this association, this is the first study that extensively controlled for potential confounders. This was done both by selection of companies from a narrowly defined industrial sector as well as by taking into consideration potential confounders in the analysis.

Appendix B: Final housekeeping checklist - French version

Le lieu de travail est divisé en quatre zones d'observation égales. La partie «A» de la grille d'observation est remplie quatre fois (une fois par zone)

A. Zone d'observation ( ) du lieu de travail *(chaque établissement est divisé en quatre zones d'observation)*

	oui	non	n/a
ALLÉES PRINCIPALES ET SECONDAIRES DANS LA ZONE D'OBSERVATION			
1. «Allées secondaires» existantes	1234	1234	1234
2. Entreposage situé à l'extérieur des allées	1234	1234	1234
3. «Volume total de tout rebut inférieur à une tasse de café»	1234	1234	1234
4. «Surface de chaque flaque inférieure à une carte de crédit»	1234	1234	1234
5. Allées libres de tout câble et boyau	1234	1234	1234
6. Allées libres de tout matériel/équipement/outil.	1234	1234	1234
7. Accès à plus que ¾ des panneaux electriques, des extincteurs et des boyaux d'incendie «dégagé»	1234	1234	1234
8. «Sorties» dégagées	___	___	1234
9. Escaliers dégagés	___	___	1234
PLANCHER DANS LA ZONE D'OBSERVATION			
10. Volume total de tout rebut inférieur à une tasse de café	1234	1234	1234
11. Surface de chaque flaque inférieure à une carte de crédit	1234	1234	1234
12. Poubelles présentes	1234	1234	1234
13. Poubelles moins que ¾ pleines	___	___	1234
14. Volume total des rebuts autour des poubelles (1 mètre) inférieur à une tasse de café	___	___	1234
MATÉRIEL EN-DEHORS DES ALLÉES, DANS LA ZONE D'OBSERVATION			
15. «Lieu de rangement» fourni pour matériel	1234	1234	1234
16. «Système d'identification» existant	1234	1234	1234
17. Matériel et produits «rangés par catégorie»	1234	1234	1234
18. «Au moins ¾ du matériel rangé»	1234	1234	1234
19. Au moins ¾ des produits chimiques rangés	1234	1234	1234
20. Récipients pour égouttements en place (Au besoin - sous les robinets de distribution d'huile ou de solvant)	1234	1234	1234

	oui	non	n/a
21. Récipients pour égouttements en place (Au besoin - sous les robinets de distribution d'huile ou de solvant)	1234	1234	1234
22. Moins que 10% de l'entrepôt utilisé pour matériel, outils ou équipement périmé (ex., équipement brisé et désuet, pneus usées, produits chimiques non identifiables, peinture inemployable, etc)	1234	1234	1234

ÉQUIPEMENT, MACHINES ET OUTILS, DANS L'ENTREPÔT

	oui	non	n/a
23. Bain oculaire et/ou douche disponibles et libres d'accès (ex., produit corrosif présent)	1234	1234	1234
24. Matériel pour contenir et récupérer déversements existant	1234	1234	1234
25. Matériel pour contenir et récupérer déversements libre d'accès	1234	1234	1234
26. Équipement d'entretien des lieux existant	1234	1234	1234
27. Équipement d'entretien des lieux libre d'accès	1234	1234	1234
28. Au moins ¾ de l'équipement d'entretien des lieux rangé	1234	1234	1234
29. Lieu de rangement pour équipement et outils existant	1234	1234	1234
30. Machines, outils et équipement «rangé par catégorie»	1234	1234	1234
31. Système d'identification existant	1234	1234	1234
32. Toutes les bonbonnes de gaz rangées et attachées	1234	1234	1234
33. Au moins ½ des outils et équipement rangés	1234	1234	1234
34. Élingues rangées	1234	1234	1234
35. Au moins ½ des boyaux et câbles rangés	1234	1234	1234
36. Outils/équipement exempts de dépôt graisseux plus grands qu'une carte de crédit	1234	1234	1234
37. Au moins ½ de chaque surface de travail dégagée	1234	1234	1234

ÉQUIPEMENT, MACHINES ET OUTILS DANS LA ZONE D'OBSERVATION

	oui	non	n/a
21. Lieu de rangement pour équipement et outils existant	1234	1234	1234
22. Système d'identification existant	1234	1234	1234
23. Équipement, machines et outils rangés par catégorie	1234	1234	1234
24. Élingues rangées	1234	1234	1234
25. Au moins ¾ de l'«équipement d'entretien des lieux» rangé	1234	1234	1234
26. Au moins ¾ des outils et de l'équipement rangés	1234	1234	1234
27. Équipement/outils exempts de dépôts graisseux plus grands qu'une carte de crédit	1234	1234	1234

POSTE DE TRAVAIL AU CENTRE DE LA ZONE D'OBSERVATION

	oui	non	n/a
28. Lieu de rangement pour équipement, outils existant	1234	1234	1234
29. Système d'identification existant	1234	1234	1234
30. Équipement, machines et outils rangés par catégorie	1234	1234	1234
31. Au moins ½ des boyaux et câbles rangés	1234	1234	1234
32. Au moins ½ des outils rangés	1234	1234	1234
33. Équipement/outils exempts de dépôts graisseux plus grands qu'une carte de crédit	1234	1234	1234
34. Au moins ½ de chaque surface de travail dégagée	1234	1234	1234
35. Volume total de tout rebut inférieur à une tasse de café	1234	1234	1234
36. Surface de chaque flaque inférieure à une carte de crédit	1234	1234	1234

La partie «B» de la grille d'observation est utilisé pour les entropôts matériel et chimique. Si les deux sont situées au même endroit, une seul partie «B» est utilisé. Si les deux entrepots sont séparés, une copie de la partie «B» est remplie pour chaque entrepôt.

B. <u>Entrepôt matériel ou chimique</u>

	oui	non	n/a
ALLÉES DE L'ENTREPÔT			
1. Entreposage situé à l'extérieur des allées seulement	1234	1234	1234
2. Volume total de tout rebut inférieur à une tasse de café	1234	1234	1234
3. Surface de chaque flaque inférieure à une carte de crédit	1234	1234	1234
4. Allées libres de tout matériel/équipement/outil	1234	1234	1234
5. Accès à plus que ¾ des panneaux electriques, des extincteurs et des boyaux d'incendie dégagé	1234	1234	1234
6. Sorties dégagées	___	___	1234
7. Escaliers dégagés	___	___	1234
PLANCHER DANS L'ENTREPÔT			
8. Volume total de tout rebut inférieur à une tasse de café	1234	1234	1234
9. Surface de chaque flaque inférieure à une carte de crédit	1234	1234	1234
10. Poubelles présentes	1234	1234	1234
11. Poubelles moins que ¾ pleines	___	___	1234
12. Volume total des rebuts autour des poubelles (1 mètre) inférieur à une tasse de café	___	___	1234
MATÉRIEL DANS L'ENTREPÔT			
13. Système d'identification existant	1234	1234	1234
14. Matériel et produits rangés par catégorie	1234	1234	1234
15. Au moins ¾ du matériel rangé	1234	1234	1234
16. Au moins ½ du matériel rangé	1234	1234	1234
17. Au moins ¼ du matériel rangé	1234	1234	1234
18. «Au moins ¾ du matériel identifié»	1234	1234	1234
19. Au moins ½ du matériel identifié	1234	1234	1234
20. Au moins ¼ du matériel identifié	1234	1234	1234

Appendix C: Final housekeeping checklist - English translation

Final checklist items - english translation: main workplace area

Main and *secondary aisles*[a]

1. Secondary aisles present.
2. All storage outside of aisles.
3. Total volume of all rubbish less than a coffee cup.
4. Total area of any spill less than the size of a credit card.
5. Aisles *free*[b] from all cables and hoses.
6. Aisles free from all material/equipment/tools.
7. Access to more than 3/4 of all electircal panels, fire extinguishers and fire hoses free.
8. Exits free.
9. Stairways free.

Floor in the observation areas

10. Total volume of all rubbish less than a coffee cup.
11. Total area of any spill less than the size of a cridit card.
12. Garbage containers present.
13. Garbage containers less than 3/4 full.
14. Total volume of rubbish around garbage containers (one meter radius) less than a coffee cup.

Material in the observation areas

15. *Storage area*[c] provided for material
16. *Identification system*[d] present.
17. Materials and products *stored by category*[e].
18. *At least* 3/4 *of the material stored.*[f]
19. At least 3/4 of the chemical products stored.
20. Drip trays or containers in place (when needed - under barrel and pipeline spigots).

Equipment, machinery and tools in the observation areas

21. Storage area for equipment and tools present.
22. Identification system present.
23. Equipment, machinery and tools stored by category.
24. Slings stored.
25. At least 3/4 of the *housekeeping equipment*[g] stored.
26. At least 3/4 of the tools and equipment stored.
27. Equipment/tools free from grease deposits larger than a credit card.

Work station in the centre of each observation area

28. Storage area for equipment and tools present.
29. Identification system present.
30. Equipment, machinery and tools stored by category.
31. At least 1/2 of the hoses and cables stored.
32. At least 1/2 of the tools stored.
33. Equipment/tools free from grease deposits larger than a credit card.
34. At least 1/2 of each work surface free.
35. Total volume of all rubbish less than a coffee cup.
36. Total area of any spill less than the size of a credit card.

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[*] ***definitions;***

[a] ***secondary aisles*** - aisles leading from the main aisle to the workstations or to storage areas

[b] ***free*** - no obstructions, either partial or complete, and not used for storage.

[c] ***storage area*** - shelves, boxes, drawers, cupboards, hooks, hangers, suspension systems, etc.

[d] ***identification system*** - labels, drawings, markings, index, inventory system, etc.

[e] ***stored by category*** - paints together, wood tools together, etc.

[f] ***at least. . .of the material stored*** - Stored in the storage area, using some type of a storage system.

[g] ***housekeeping equipment*** - brooms, mops, shovels, rags, solvents, absorbants, soaps, etc.

Final checklist items - english translation: storage area

Aisles in the storage area

1. All storage outside of aisles.
2. Total volume of all rubbish less than a coffee cup.
3. Total area of any spill less than the size of a credit card.
4. Aisles free from all material/equipment/tools.
5. Access to more than 3/4 of all electircal panels, fire extinguishers and fire hoses free.
6. Exits free.
7. Stairways free.

Floor in the storage area

8. Total volume of all rubbish less than a coffee cup.
9. Total area of any spill less than the size of a cridit card.
10. Garbage containers present.
11. Garbage containers less than 3/4 full.
12. Total volume of rubbish around garbage containers (one meter radius) less than a coffee cup.

Material in the stroage area

13. Identification system present.
14. Materials and products stored by category.
15. At least 3/4 of the material stored.
16. At least 1/2 of the material stored.
17. At least 1/4 of the material stored.
18. *At least* 3/4 *of the material identified*[*].
19. At least 1/2 of the material identified.
20. At least 1/4 of the material identified.
21. Drip trays or containers in place (when needed - under barrel and pipeline spigots).
22. Less than 10% of the storage area used for spent material, tools, and equipment (ex., broken or worn equipment, old tires, non-identified chemical products, old paint cans, etc.)

Equipment, machinery and tools in the storage area

23. Eye wash station and/or shower availiable and access free (ex., when corrosive products present.).
24. Spill containment material or system present.
25. Spill containment materials within easy reach.
26. Housekeeping equipment present.
27. Housekeeping equipment within easy reach.

28. At least 3/4 of the housekeeping equipment stored.
29. Storage area present for equipment and tools.
30. Machinery, equipment and tools stored by category.
31. Identification system present.
32. All compressed gas cylenders stored and tied.
33. At least 1/2 of the tools and equipment stored.
34. Slings stored.
35. At least 1/2 of the hoses and cables stored.
36. Equipment/tools free from grease deposits larger than a credit card.
37. At least 1/2 of each work surface free.

• Definitions;

[a] ***at least. . .of the material identified*** - scientific name, common name, part number, etc.

Appendix D: Prototype letter of introduction of study to companies

Le 26 août 1992

<Addressed to company representative>

OBJET: Étude du lien entre l'entretien des lieux de travail et les accidents

La présente fait suite à votre discussion avec M. XXXX XXXXX, conseiller en prévention de l'ASFETM concernant ma visite pour le projet de recherche pour lequel votre établissement a été sélectionné.

Comme vous le savez probablement, je suis étudiant au doctorat, à l'École de santé au travail de l'Université McGill, sur un projet de recherche financé par l'IRSST (Institut de recherche en santé et en sécurité du travail).

Cette recherche, faite en étroite collaboration avec l'ASFETM est maintenant rendue à l'étape des visites aux établissements sélectionnés. C'est ici que votre précieuse collaboration est requise, comme celle de 60 autres établissements. Mon intervention consiste en de simples observations des lieux de travail, à partir d'une grille d'observation. Il est bien entendu que les informations recueillies demeureront confidentielles et qu'elles ne seront utilisées que pour cette étude. La durée de chacune de mes visites ne dépassera pas une heure et ne demande aucune participation des employés.

Suite à l'étude, qui durera un an, j'effectuerai un recensement des accidents survenus au cours de l'année dans tous les établissements visités. Toutes les informations seront dépersonnalisées et les noms des entreprises ne seront pas dévoilées.

Si vous désirez recevoir un résumé des résultats finaux, il me fera plaisir de vous le faire parvenir.

Je vous remercie de votre collaboration et vous prie d'agréer l'expression de mes sentiments les meilleurs.

Vincent Dufort, M.Sc.A.
Département de Santé au Travail
Université McGill
1130 avenue des Pins, ouest
Montréal, (Québec) H3A 1A3

Appendix E: Prototype letter sent to companies for information on injuries occurring during the year of the study.

mercredi le 27 octobre 1993

<Addressed to company representative>

La présente fait suite à notre conversation concernant la fin du projet de recherche dans lequel votre établissement participe déjà depuis l'année dernière. Tel que mentionné au téléphone, j'aurai besoin de quelques informations supplémentaires pour terminer l'étude.
J'aurai besoin de l'information suivante concernant les accidents du travail survenu chez vous durant la période du **premier janvier 1992 au premier avril 1993**:

Pour chaque accident, autant que possible;

1) la date de l'événement
2) la nature de la lésion ainsi que le siège de la lésion (description).
3) la durée d'absence suite à l'accident
4) le lieu de l'événement
5) le métier du travailleur impliqué
6) le statut du travailleur (temps plein, temps partiel, mi-temps) impliqué
7) le nombre de mois et d'années d'ancienneté du travailleur impliqué
8) l'age du travailleur impliqué ou l'année de naissance

Je tiens à vous remercier de votre collaboration lors de cette étude et vous prie d'agréer l'expression de mes sentiments les meilleurs.

Vincent Dufort M.Sc.A.
Département de Santé au Travail
Université McGill
1130 avenue des Pins, ouest
Montréal, (Québec)
H3A 1A3

Appendix F: Prototype letter asking for signature to allow release of information from the Quebec Health and Safety Commission (CSST)

mercredi le 27 octobre 1993

<addressed to company representative>

La présente fait suite à notre conversation concernant la fin du projet de recherche dans lequel votre établissement participe déjà depuis l'année dernière. Tel que mentionné au téléphone, j'aurai besoin de quelques informations supplémentaires pour terminer l'étude. Je suis préparé à prendre les démarche au sein de la CSST, mais j'aurai besoin de votre approbation. Je vous envoie en deuxième page la lettre, et vous prie de **signer et me retourner**, pour me donner la permission de demander cette information de la CSST.

Je tiens à vous remercier de votre collaboration lors de cette étude et vous prie d'agréer l'expression de mes sentiments les meilleurs.

Vincent Dufort M.Sc.A.
Département de Santé au Travail
Université McGill
1130 avenue des Pins, ouest
Montréal, (Québec)
H3A 1A3

Appendix G: Prototype letter signed by companies, for release of information from the Quebec Health and Safety Commission (CSST)

Service de financement

La présente est pour vous aviser que nous donnons l'approbation à **Vincent Dufort** du **Département de Santé au Travail de l'Université McGill**, de recueillir chez vous l'information suivante concernant les accidents du travail survenu chez nous durant la période du premier janvier 1992 au premier mai 1993:

Pour chaque accident;

1) la date de l'événement
2) la nature de la lésion ainsi que le siège de la lésion (description).
3) le nombre de journées indemnisées
4) le lieu de l'événement
5) le métier du travailleur impliqué
6) le statut du travailleur (temps plein, temps partiel, mi-temps) impliqué
7) le nombre de mois et d'années d'ancienneté du travailleur impliqué
8) l'age du travailleur impliqué ou l'année de naissance

XXXXXXXXXXXXX
<company representative>

Appendix H: Prototype letter to Quebec Health and Safety Commission (CSST) statistics department asking for injury data detailing information required and companies

Montréal, le 26 janvier 1994

CSST - Service de la statistique

SUJET: Demande de renseignement

La présente fait suite notre conversation téléphonique concernant des données d'accidents survenus dans quelques entreprises de la région de Montréal et Québec, secteur fabrication d'équipement de transport et de machines. Tel que mentionné, j'aurais besoin de quelques informations pour terminer mon étude au Département de Santé au Travail de l'Université McGill. Je vous envoie les lettres, **dûment signées**, me donnant la permission de recevoir cette information de la CSST.

Comme je l'ai écrit aux responsables de ces entreprises, je tiens à receuillir les renseignements suivants concernant les accidents du travail survenus dans ces entreprises au cours de la période **du 1er janvier 1992 au 1er mai 1993**. Pour chaque accident, (section de l'ADR);

1) la date de l'événement (section 1).
2) la nature et le siège de la lésion (vous pouvez utiliser les **codes numeriques**).
3) date du retour au travail (section 4).
4) le lieu de l'événement (**poste de travail ou ailleurs**; section 4)
5) le métier ou profession du travailleur impliqué (section 6).
6) le statut du travailleur impliqué (**temps plein, temps partiel**; section 6).
7) Ancienneté du travailleur impliqué (**années, mois**; section 6).
8) l'age du travailleur impliqué (**seulement l'année de naissance**; section 1).

Les entreprises concernées sont:

XXXXXXXXXXXXXXXXX

Je tiens à vous remercier de votre collaboration lors de cette étude et vous prie d'agréer l'expression de mes sentiments les meilleurs.

Vincent Dufort M.Sc.A.
Département de Santé au Travail
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Montréal, (Québec) H3A 1A3