

Noise as an explanatory factor in work-related fatality reports: A descriptive study

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INTRODUCTION

“The recognition of noise as a serious health hazard as opposed to a nuisance is a recent development and the health effects of hazardous noise exposure are now considered to be an increasingly important public health problem” (WHO 2001). Workplace noise exposure is a common reality in Quebec and worldwide. In 1990, approximately 30 million people in the USA were exposed to daily occupational noise levels greater than 85 dBA, compared to over nine million in 1981 (WHO 2001). In 1998, the Institut de la statistique du Québec (Quebec Statistical Institute) estimated that 12.8 % of Quebec workers were exposed, often or always, to occupational noises hindering conversations occurring a few feet away, even when shouted (ISQ 2001). Projected to the 2005 worker population, this would represent an estimated 476,000 workers.

Occupational noise exposure has been linked to numerous adverse health effects (Berglund 1999). The assumption of a causal or contributive impact of occupational noise on the occurrence of occupational accidents was addressed in some studies (Barreto et al. 1997; Dias & Cordeiro 2007; Melamed et al. 1992; Zwerling et al. 1997; Moll van Charante & Mulder 1990; Cordeiro 2005). Recent work by Girard et al. suggests a dose-response relationship between noise exposure, hearing impairment and accident risk (Girard et al. 2003a-c). Based primarily on two explanatory models (Figures 1 and 2) (Hétu 1994; Wilkins 1981) and empirical data, there is a biological plausibility for a causal relationship between noise exposure and accident risk (Hétu 1993; Wilkins 1981; Laroche et al. 1991). Ambient noise interference with communication appears as a chief plausible pathway (Robinson et al. 2000; Suter 1992; Hétu 1994; Ayres & Beyer 1994). Other plausible explanatory factors include habituation and reduced vigilance (Passchier-Vermeer & Passchier 2000; Smith 1992; Wilkins & Acton 1982). Nevertheless, the extent to which noise does act as a causal or contributive factor in fatal workplace accidents remains unclear and subject to debate.

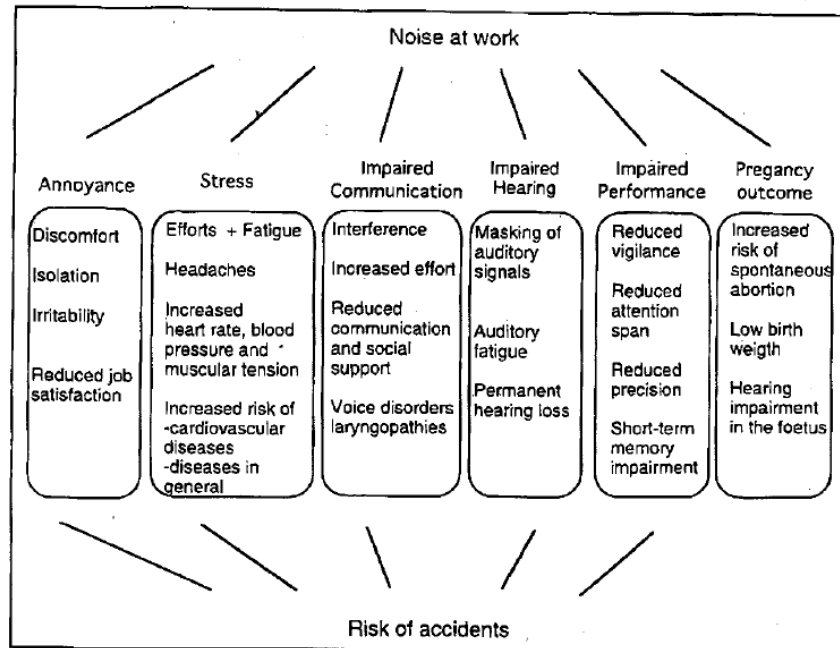


Figure 1: Outline of the various effects of occupational noise exposure (Hétu 1994)

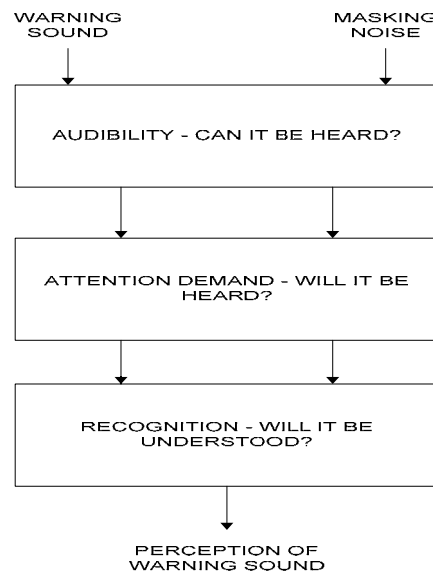


Figure 2 : Conceptual model of warning sound perception (Wilkins 1981)

Originating from a review of work-related fatality reports, this study aims at: 1- describing the characteristics and circumstances of fatal accidents occurring in noisy workplaces; 2- determining the number of instances where noise was identified as one of the potential causes and retained as such; 3- determining the number of instances where noise could have been identified as one of the potential causes; and, 4- examining the methods used in reports for analyzing the noise factor during accident investigations. Albeit not presented in this paper, a final objective was to determine the worth of fatality reports as a potential surveillance data source.

METHODS

Alike a multiple case studies design, this population-based descriptive study is based on a thorough analysis of the content found in the 788 fatal accident reports com-

pleted by various inspectors from the Commission de la santé et de la sécurité du travail du Québec (Quebec Workers Compensation Board (WCB)) during the 1990-2005 period. During their investigation into the causes of a fatal injury, two inspectors are assigned to each case. As a more standardized inquiry process was adopted in 2000, the reports were divided into two blocks: a main block covering accident reports issued between 2000 and 2005 (n=284), and a complementary block assessing those in the 1990-1999 period (n=504).

Briefly stated, assigned inspectors are responsible for gathering all interesting and relevant facts from various sources (witnesses, simulations, etc.), as well as classifying the information into essential and secondary items upon which they must identify potential causes to be further analyzed in reaching a plausible conclusion as to the causes of the fatal event. Within this study, appreciation of the noise factor was limited to the written information found in the publicly available reports regarding the essential contextual and technical elements used to assess the noise-accident relationship.

The underlying framework for analyzing each accident report is presented in Figure 3. Accidents were deemed to have occurred in a noisy environment whenever it was clearly indicated that at least one source of noise was operating within the victim's work area at the time of the accident, irrespective of the noise level. To be classified "Noise mentioned explicitly", a report had to contain at least one key word relating to the following categories: masking noise, warning signal or hearing loss. When mentioned explicitly, noise was classified as treated either "Directly" when analyzed as a potential cause *per se*, "Indirectly" when analyzed within another potential cause, or "In a general manner" when merely mentioned in the description of the fatal event. Lastly, reports, in which noise was identified as a cause of the fatal event by the inspectors, were classified "Noise retained as a cause".

When noise was mentioned explicitly, an in-depth content analysis was first carried out separately by at least two expert authors (audiologists or acoustic engineer) to examine the methods used by the inspectors in analyzing the noise factor. Thereafter, during a meeting to discuss individual reports, consensus was reached by all authors regarding the inspectors' choice of noise measurements and whether their analyses and conclusions were appropriate. The number of reports to be analyzed in-depth was determined by reaching saturation in the information of interest relative to the study's objectives. All reports not thoroughly analyzed were revised summarily by one of the authors to verify any new relevant information.

A comprehensive analysis of accident reports of the main block in which noise was not mentioned explicitly was also carried out to determine if noise could have been considered as a potential cause. To reach such a conclusion, the accident must have occurred in a noisy environment and involved a victim being "struck by a vehicle", since noise is more likely to interfere with communication in this context.

Whereas reports from the main block were scrutinized for information relative to all 4 objectives, those from the complementary block were analyzed only when noise was mentioned explicitly (objectives 2 and 4).

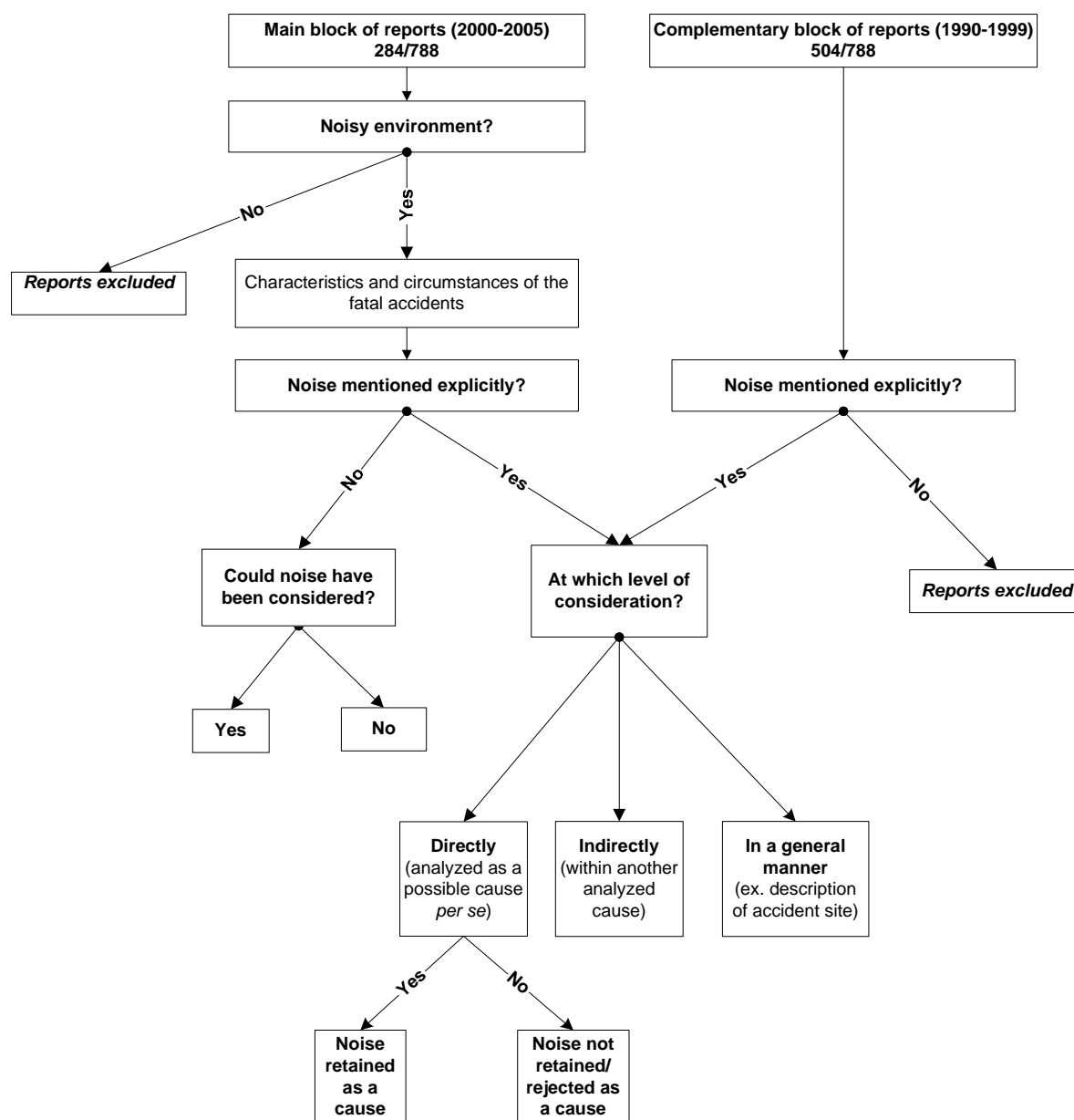


Figure 3: Framework for the analysis of noise in the Quebec WCB fatal accidents reports 1990-2005 (N=788)

RESULTS

From the 788 work-related accident reports covering the 1990-2005 period, noise was mentioned explicitly in 67 (8.5 %) reports (Figure 4). Among those, noise was treated “Directly” in 21 (2.7 %), “Indirectly” in 15 (1.9 %) and “In a general manner” in 31 (3.9 %). Moreover, inspectors concluded that noise was one of the causes in the fatal event in 18 (2.3 %) of 21 reports in which noise was analyzed directly.

From the 67 reports in which noise was mentioned explicitly, 50 were analyzed comprehensively, including 28 out of 32 from the main block and 22 out of 35 from the complementary block. The analysis revealed four noise assessment methods used by the inspectors: a) qualitative assessment (21 (42 %)), 19 of which also included quantitative measures; b) event simulations (13 (26 %)), 2 of which with expert consultants; c) quantitative measures only (6 (12 %)); and d) general description only (10 (20 %)). From the available information and despite poor data in some cases (i.e.

incomplete noise assessments, technical flaws), the authors concluded that the inspectors had reached adequate conclusions in 24 (48 %) cases. However, a more thorough investigation into the fatal event could have yielded a different conclusion relative to the noise factor in 3 cases (6 %). Finally, 23 (46 %) reports contained insufficient information for the authors to assess the validity of the inspectors' conclusions.

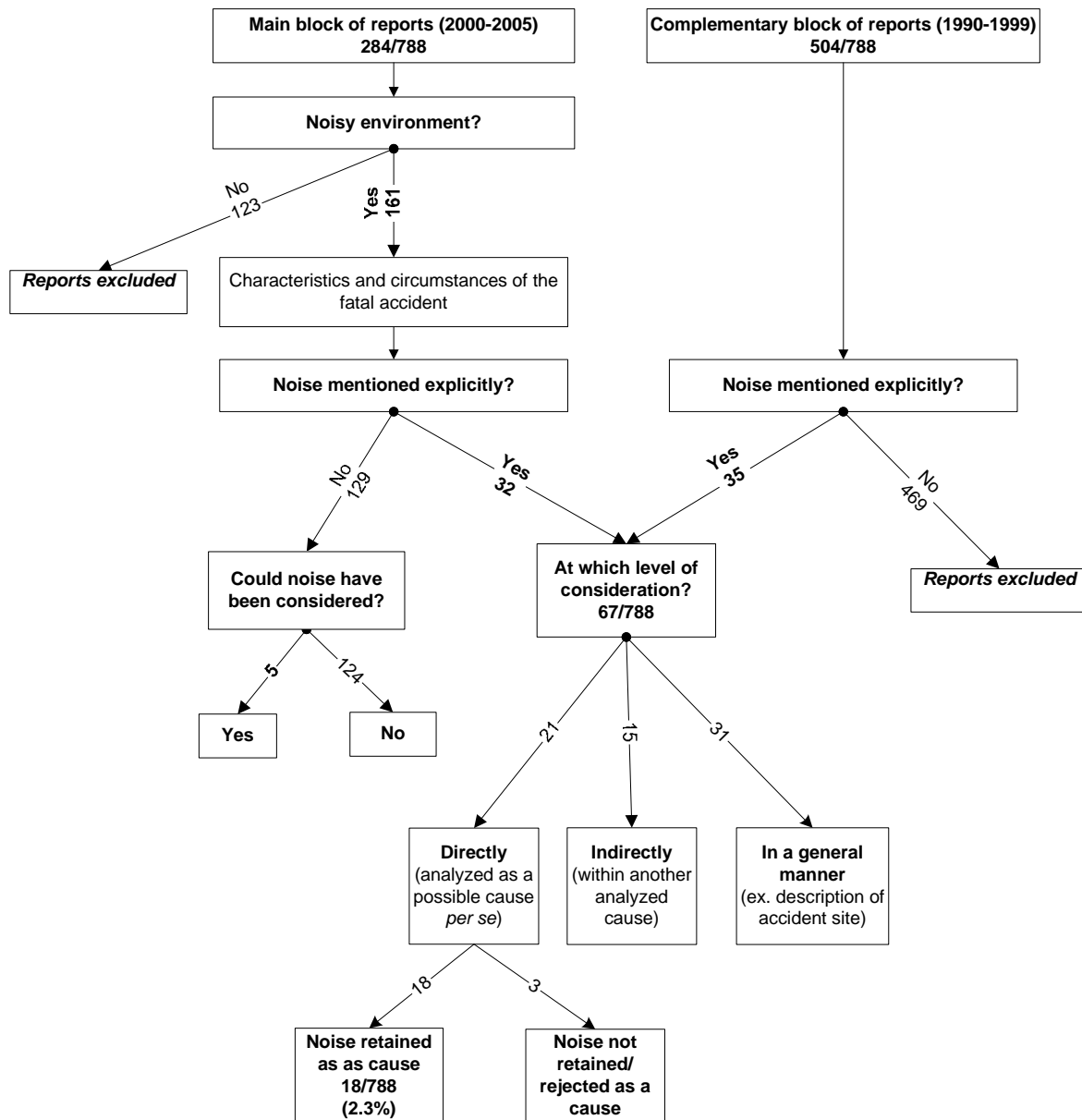


Figure 4: Noise as an explanatory factor in the Quebec WCB fatal accidents reports 1990-2005 (N=788)

During the 2000-2005 period, 161 fatal accidents took place in noisy work environments characterized by various noise sources (trucks, concrete saws, wood saws, conveyor belts, etc.). Although in most cases (122/161), the noise source was directly involved in the accidental event, noise *per se* was retained as a cause in 4.3 % (7/161). Construction (31/161) and forestry (28/161) workers accounted for 36.6 % of the victims. The mechanism of injury was “struck by a vehicle” in 47 (29.2 %) cases, hit/crushed by an object in 38 (23.6 %) cases or wedged/dragged in 34 (21.1 %) cases. The remaining 42 (26.1 %) victims fell or were injured by some other mechanism.

Over the same period (2000-2005), noise was not explicitly mentioned in 129 reports investigating fatal accidents in noisy work environments, including 29 (22.5 %) accidents involving a worker being “struck by a vehicle”. Following a comprehensive content analysis of these 29 reports, the authors concluded that noise could have been considered in 5 (3.9 %) reports because of sufficient circumstantial evidence of possible interference of ambient noise with communication or warning signals perception. However, the available written information did not make it possible to conclude if noise was actually a cause or not.

In all other reports involving a worker being struck by a vehicle (24/29), the authors agreed with the inspectors’ findings that noise did not need to be considered as other identified causes were sufficiently obvious to explain the event, irrespective of the noise levels.

DISCUSSION

Noise was explicitly stated as one of the cause in 2.3 % (18/788) of the fatal accidents reports. Although qualitative methods are more typically designed to explain phenomena than explore causal relationships, the goal of the inspectors’ inquiry is to gather all relevant information in order to reach conclusions with regards to the causes of a fatal event. The content analysis of 788 reports spanning a 16-year period strongly argues in favor of, although it cannot prove it, a causal relationship between noise and fatal accidents in the 18 cases identified by the inspectors. Given methodological limitations (i.e. access to written reports but not to inspectors’ notes, limited data in some reports, review of fatal accident reports only) and inspectors’ constraints during investigations, this Figure (2.3 %) most likely underestimates the proportion of workplace accidents explained at least partly by noise.

Interference with communication likely explains the causal relationship between noise and accidents. In all 18 cases in which inspectors identified noise as a cause (15 involving a worker being struck by a moving vehicle), communication was impaired. Indeed, the content analysis revealed that the warning device either failed or could not be heard over the ambient noise.

Interestingly, noise was identified as a cause in 11 cases during the 1990-1999 period, a time when inspectors were not, to the authors’ knowledge, specifically trained to carry out noise assessments and during which the causal relationship between noise and accidents was not yet well known or established. As inspectors gathered information from witnesses and other sources to understand the circumstances surrounding a fatal accident, the hypothesis of noise acting as one essential factor in cases where communication was at stakes likely emerged intuitively. So did interference with communication as a noise-related cause of accidents. This observation reinforces the authors’ interpretation of these results.

Noise is typically not identified as the sole cause in explaining fatal events. Indeed, multiple causes were identified in most accident reports. For the 21 cases in which noise was analyzed directly as a potential cause, shortcomings in work methods and work organization were also identified in all but 4 reports (data not shown). Lack of adequate training, poor visibility and faulty or absent safety measures were among the other identified modifiable causes, providing useful insight into the occurrence of fatal accidents within noisy work settings. Such factors could be considered potential confounders, along with other known factors such as age, in epidemiological studies investigating the relationship between noise and workplace accidents.

Other known adverse effects of noise may also contribute to fatal accidents, including reduced vigilance, precision and visual span (Héту 1994). Since inspectors only include essential elements in their analysis to conclude on potential causes, noise would not be identified as a cause in situations where these adverse effects come into play. This may partly explain why the impact of noise, measured in terms of relative risk or attributable fraction reported in some epidemiological studies (Moll van Charante & Mulder 1990; Girard et al. 2003a; Dias & Cordeiro 2007), is greater than the findings of the current study may suggest.

In the current study, only fatal accident reports were revised. However, some epidemiological studies report an association between noise and non fatal accidents (Moll van Charante & Mulder 1990; Girard et al. 2003a; Dias & Cordero 2007). Given a causal relationship between noise and accidents, noise would likely contribute to a significantly greater number of accidents than what these findings suggest if non fatal injuries were also included.

Author consensus was achieved relative to the inspectors' choice of noise measurements, analyses and conclusions. Such judgment was based solely on the information available in the written reports. Access to the full range of information gathered by the inspectors (including notes, simulations and interviews) might have yielded a different judgment.

Inferences were often necessary to determine if the fatal accident had occurred in a noisy environment since most reports did not contain noise measurement data. Noise may affect communication at various levels, as its effect consists of a complex interaction between different factors according to Héту's (1994) and Wilkins' (1981) models. Nevertheless, a conservative approach was used in this study to define a noisy environment in order to minimize overestimation.

A rather conservative approach was also used by the authors in deciding that noise could have been mentioned in cases when it was not explicitly stated by inspectors. This may partly explain the rather low percentage of such reports (3.9 %) in the 2000-2005 subset. However, the authors judged that noise was considered as a potential cause by the inspectors in the vast majority of events in which it should have been.

The findings of this study suggest that noise should be systematically considered as a potential cause in all investigations of work-related accidents where vehicular movement or communication between workers is at stake. As noise may also interfere with vigilance and other risk factors for accidents, it may be a much more important contributing factor to accidents than what was previously thought and what the findings of the current study seem to suggest. Given the omnipresence of noise and its plausible effects on worker safety, it should be a key component in the prevention of occupational accidents. In addition to reducing the risk for hearing loss, published results suggest that reducing workplace noise can yield beneficial effects on communication, worker comfort and, potentially, vigilance (Damongeot 1995; Cordeiro 2005; Smith 2003; Chabot & Gignac 2001; Suter 1987; Hoyos & Zimolong 1988; Moll van Charante & Mulder 1990; Wilkins 1982; Cohen 1976). Further studies, particularly those exploring contexts of impaired communication, such as warning sound perception, and interaction between noise and other risk factors for accidents, are needed to better understand the ways in which noise may cause or contribute to accidents, as well as to increase the effectiveness of accident prevention efforts.

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