The utility of task-based noise exposure assessments in epidemiology: lessons learned from compliance sampling in machining and stamping plants

Woskie, S.R.[*1] Prince, M.[1] Waters, M. [1] Zhou, X.[1]

(*) University of Massachusetts Lowell, Lowell, MA, USA (Susan_Woskie@uml.edu)
(1) National Institute of Occupational Safety and Health, Cincinnati, OH, USA (Mprince@cdc.gov, Mwaters@cdc.gov, XZhou@cdc.gov)

Introduction

As part of a study to evaluate the effectiveness of hearing conservation programs, NIOSH received access to noise exposure surveys conducted every two years during the 1990's at two large U.S. automobile manufacturing facilities. The facilities used a task-based data collection method that involved developing detailed sound exposure profiles for each unique department/job combination in the plants. These exposure databases provide a unique opportunity to examine the nature of daily and task noise exposures in parts machining and stamping operations. Because of the task based nature of the data, it also provides an opportunity to investigate the utility of bootstrap sampling methods for efficient estimation of noise exposures for epidemiologic studies and exposure control.

Methods

Sound exposure profiling, or task-based sampling (TBS) for exposure assessment, has been used in the large automotive parts manufacturing plants covered by this study because of the efficiency introduced by the method and the ability to customize hearing loss prevention evaluations for a large number of workers (1). The approach is similar to that described for chemical exposures where task level times time is summed across all tasks and divided by the total work time to estimate the daily TWA. However, in the case of noise, the calculation differs somewhat due to the logarithmic dB scale of noise measurement.

The first step in a TBS evaluation is to determine the tasks that comprise the representative work assignment. The list of tasks is developed based on an understanding of the job under study through observation, and interviews with supervisors and workers. The supervisor provides information about what the job entails and the amount of time spent on each activity. Once the tasks are defined, sound level measurements are made in the hearing zone of the worker as each of the activities is performed. Typically this involves measurement over several repeated occurrences of each activity. The compilation of these activities is defined as a profile. These profiles typically include the daily average sound level (TWA in dBA), the minimum and maximum sound level during the day, as well as the peak sound level, if an unweighted peak exposure of over 120 decibels is recorded.

Each profile created from a survey was exported to a SAS database. Daily time weighted average and task noise levels, as well as the task time estimates were examined for normality and descriptive statistics developed for the whole dataset and by time periods by job, task, noise source and control method used. Of particular interest was whether job complexity (number of tasks within a job) had an impact on exposure variability.

Results

The database for the machining plant contains 2659 daily time weighted average estimates over the period of 1990 to 1999. Examination of the daily TWA's by job and by department show most subsets to be approximately normally distributed. Within the machining plant, jobs vary in task complexity, containing from 1 to 9 activities with a mean/median of 4 activities (SD = 1). The mean/median number of activities decreased from 4 in 1990 to 3 in 1999. There was no significant difference in the number of activities associated with production and non-production jobs. However, as the complexity of the jobs increased in non-production, the standard deviation of the 8 hour TWA noise level decreased, while for production jobs the standard deviation of the 8 hour TWA increased with increasing complexity.

The database for the machining plant contains 8874 task-based samples. These samples consist of 2016 unique activities. Only 52% of the activities listed a specific noise source. Of those, the most common noise source (26%) was "part impact" (noise caused by the impact of a part against a work surface), followed by "machine mechanical" (9%) (noise resulting from internal machine components).

Within this data set, job level exposure assessments were done 1 to 216 times. Twenty-five percent (25%) of the jobs had 14 or more assessments. Since each job assessment has a median of 3 to 4 activities, this is a substantial sampling effort. We are currently using a bootstrap resampling approach to evaluate the optimal number of assessments of individual task levels and task times needed to reliably estimate a job exposure level.

Discussion

Little has been published describing the nature of noise exposures. Of particular interest is how variable noise exposures are within jobs, tasks and noise sources. Such information is key to the development of sampling strategies for noise exposure assessment. The task-based approach to noise sampling described here is also relevant for chemical exposure assessment. For example, the time in specific tasks was shown to be a significant predictor of daily dust and endotoxin exposure level of farmers, helping to explain significant portions of the variability in worker exposures (2). Task-based sampling in the construction environment is particularly useful because the tasks, environmental conditions and exposure sources are all highly variable (3). Thus, a full shift sample will not provide useful information about how to protect workers from transient high exposures. However, a task-specific sampling strategy can identify which tasks contribute most to the overall exposure level (4).

Task based sampling approaches have not been widely used in occupational epidemiology. However, when task exposure levels are highly variable and the fraction of time a task is performed is highly variable as well, then a task-based exposure assessment may even provide more precise estimates of the mean exposure (5). Bootstrap sampling has been used to estimate the optimal sample size for evaluating lumbar posture at work (6) but has not yet been applied to optimizing task-based daily exposure estimation. In this study, we use the bootstrap technique to estimate the most efficient sampling strategy for task-based sampling using our noise exposure assessment database.

References

(1) Hager L Sound Exposure Profiling: A Noise Monitoring Alternative. *American Industrial Hygiene Association Journal* 1998;59:414-418.

(2) Preller, L., D. et al : Determinants of dust and endotoxin exposure of pig farmers: development of a control strategy using empirical modeling. *Annals Occupational Hygiene* 1995;39(5):545-557.

(3) Susi, P et al: A task-based exposure assessment model. *Applied Occupational Environmental Hygiene* 1995;10(4):395-399.

(4) Andersson, I-M. et al: Detailed work analysis of control of exposure to airborne contaminants in the workplace. *Applied Occupupatonal Environmental Hygiene* 1995; 10(6):537-544.

(5) Nicas, M et al: A task-based statistical model of a worker's exposure distribution: Part I— Description of the model. *American. Journal Industrial Hygiene Association Journal* 1993;54(5): 221-220.

(6) Burdorf, A. et al : Design of strategies to assess lumbar posture during work. *International Journal of Industrial Ergonomics* 1996;18:239-249.

NR 2001:10

x2001 – Exposure Assessment in Epidemiology and Practice

Mats Hagberg, Bengt Knave, Linnéa Lillienberg and Håkan Westberg (Eds)

ARBETE OCH HÄLSA | VETENSKAPLIG SKRIFTSERIE

ISBN 91-7045-607-0 ISSN 0346-7821 http://www.niwl.se/ah/

Dept of Occupational Medicine

ICOH Industrial Hygiene

National Institute for Working Life

ARBETE OCH HÄLSA

Editor-in-chief: Staffan Marklund
Co-editors: Mikael Bergenheim, Anders Kjellberg,
Birgitta Meding, Gunnar Rosén and Ewa Wigaeus Tornqvist

© National Institute for Working Life & authors 2001

National Institute for Working Life
S-112 79 Stockholm
Sweden

ISBN 91–7045–607–0
ISSN 0346–7821
http://www.niwl.se/ah/
Printed at CM Gruppen, Bromma

Preface

This book contains the extended abstracts to the X2001 Conference on Exposure Assessment in Epidemiology and Practice in Göteborg, Sweden, June 10-13, 2001. The excellent work performed by the contributing scientists has made this book a first-class, up-to-date, state of the art review on what is known about exposure assessment today.

The outstanding scientific quality of the extended abstracts was secured through the work of five international programme committees. The chairmen for the committees were: Chemical, Patricia Stewart; Ergonomic, Alex Burdorf; Physical, Ulf Bergqvist; Psychosocial, Annika Härenstam and Biological, Jean-Francois Caillard.

Financial support to the conference and thereby to the publishing of this book was made possible by contributions from The National Institute for Working Life, Stockholm, Sweden; The Swedish Council for Working Life and Social Research, Stockholm and Volvo. Without the excellent skills of the organizing committee - Ulrika Agby (administration and layout), Ann-Sofie Liljenskog Hill (administration) and Christina Lindström Svensson (administration) - the production of this book would not have been possible.

We want to express our gratitude to the contributing authors, session chairmen and to the participants who presented papers and contributed in the discussions, for making X2001 an outstanding meeting.

Göteborg in June 2001

Mats Hagberg
Department of Occupational Medicin
Göteborg University, Göteborg

Bengt Knave
The National Institute for Working Life
Stockholm

Linnéa Lillienberg
Occupational and Environmental Medicine
Sahlgrenska University Hospital, Göteborg

Håkan Westberg
Occupational and Environmental Medicine
Örebro Regional Hospital, Örebro