Hand-Arm Vibration Assessment Using Exposure Prediction Models: A Systematic Review

April Liu¹, Catherine Trask¹

¹Canadian Centre for Health and Safety in Agriculture, University of Saskatchewan, Saskatoon, Saskatchewan, CANADA

Introduction

Hand-arm vibration (HAV) is an occupational hazard which frequently occurs in workers who use hand-held vibration tools. Direct measurement of hand-arm vibration exposure in the workplace is the gold standard for obtaining accurate occupational HAV exposure; the task is difficult and time-consuming due to the high cost of measuring equipment, interruption of work, and long travel to worksites. An alternative method is exposure prediction modeling, which involves developing statistical models to represent the relationship between HAV exposure and occupational characteristics which influence HAV exposure. The method has been used for multiple hazardous exposures such as asbestos (Dement JM, 1983), fungal exposure (Macher JM, 1992) and whole body vibration exposure (Chen et al., 2004; Village et al., 2012). However, it is unknown to what extent has this method been used to find the predictors of HAV exposure. The purpose of this systematic literature review is to determine to what extent has exposure prediction modeling been used for HAV in published scientific literature and the nature of studies.

Method

A search algorithm was developed using three categories of search terms (“Occupational Diseases”, “Hand-Arm Vibration”, and “Modelling Methodology”), which was applied to 5 online bibliographic databases: Medline, CINAHL, Web of Science, Scopus, and EMBASE. The original articles found were screened for relevance through applying 5 binary questions to the title, abstract, and full-text levels of each article. The binary questions were used to find the articles of interest, which were adult (above 18 years of age) human studies, published in English, involved in statistical modeling with tri-axial accelerometer measured vibration as dependent and can be applied to the occupational setting.

Results

Of the 361 original articles found, 7 were deemed to fit the inclusion criteria. For modeling methods: 3 articles used analysis of variance (ANOVA), 2 studies used mixed effects model, 1 used generalized linear model, and one used multiple logistic model. 2 Studies were experimental, 3 were quasi-experimental, and 2 were observational. The significant predictors found can fit in 3 categories: tool characteristics (eg. tool brand, tool age, tool weight, etc.), task characteristics (eg. material worked on, time to complete task), and worker characteristics (eg. participant). The significant predictors were mostly tool and task characteristics with only participant and participant-tools interaction as significant worker characteristics. Only 3 studies reported the percentage of variance explained by significant predictors, with tool characteristics explaining from 18 – 50% of variance and worker characteristic (participant-tools interaction) explaining 12% of variance.

Discussion
Although only 7 published articles in the scientific literature used exposure prediction modeling for HAV exposure, patterns did arise within these articles. Tool characteristics appeared as potential predictors more frequently in 7 articles overall than participant characteristics. The significant vibration differences observed between tool types can be attributed to larger variation in vibration measurements obtained from tool types such as hammer, saws, or drill and from same type of tools. The authors suggested that tool designs should be studied along with tool type in future HAV exposure modeling studies. The study with participant-tools interaction as significant predictors explained that variation in grip and push force and differences in tool design could lead to difference in HAV exposure.

Knowing the different types of studies and model building techniques performed by the published studies is important in designing future studies, where different model building techniques (such as bootstrap, etc.) can be used. The tool and task characteristics dominating the significant predictors found in existing studies while participant characteristics’ significance were few could be due to participant characteristics were not studied as extensively, giving an incentive to study it more in the future. The significant predictors found can also serve as a guide for installing safety precaution to prevent future HAV exposure.

**Keywords:** Systematic review, Hand-arm vibration, Exposure prediction modeling, Industrial hygiene, Determinants of exposure

**References:**


