DEPARTMENT OF HEALTH AND HUMAN SERVICES

Public Health Service
Centers for Disease Control
and Prevention (CDC)

Memorandum

Date: May 4, 2001

From: Roy M. Fleming, Sc.D., Director, Research Grants Program RMF
Office of Extramural Programs, NIOSH, D30

Subject: Final Report Submitted for Entry into NTIS for Grant 5 R01 OH003408-04.

To: William D. Bennett
Data Systems Team, Information Resources Branch, EID, NIOSH, P03/C18

The attached final report has been received from the principal investigator on the subject NIOSH grant. If this document is forwarded to the National Technical Information Service, please let us know when a document number is known so that we can inform anyone who inquires about this final report.

Any publications that are included with this report are highlighted on the list below.

Attachment
cc: Sherri Diana, EID, P03/C13

List of Publications None

Title: Wood Dust Intervention Study for Small Business
Investigator: David L. Parker, M.D.
Affiliation: Minnesota Department of Health
City & State: Minneapolis, MN
Telephone: (312) 676-5220
Award Number: 5 R01 OH003408-04
Start & End Date: 9/30/1995–9/29/2000
Total Project Cost: $800,672
Program Area: Intervention Effectiveness Research
Key Words:

Abstract:
Exposure to wood dust is associated with an increased risk of nasal carcinoma and other allergic, respiratory and dermatologic health conditions. This study developed and assessed the effectiveness of an intervention to reduce wood dust by 30% in small businesses that manufacture cabinets, fixtures or furniture. The study had three primary aims: (1) To measure mean wood dust exposures in small wood working businesses (3-20) employees and to assess the level of dust controls (engineering, administrative, and behavioral) as measured by a walk-through survey; (2) To determine if an efficient industrial hygiene intervention program can be implemented in small wood working shops; and (3) To assess the effectiveness of this industrial hygiene intervention by a standard public health strategy in a randomized controlled trial.

During the first year of the study, a pilot study was conducted to develop sampling and intervention methodology. Following this pilot study, 48 woodworking businesses (5-25 employees) were randomly assigned to intervention or comparison condition. The intervention consisted of written recommendations, technical assistance to enhance engineering and administrative methods and worker training, tailored to the needs of the business. Comparison businesses received written recommendations alone. Changes from baseline in dust concentration (via personal sampling of inhalable dust), availability, use and efficiency of dust control methods (via direct observation), and worker knowledge, attitudes and behavior (via questionnaire) were assessed in both groups one year later.

Baseline characteristics were similar for both groups. Workers in intervention businesses were more likely than those in comparison businesses to report at follow-up that they were informed about dust control (mean intervention effect= 0.25, 95% CI = 0.03, 0.46), to show an increase in stage of readiness to control dust (mean intervention effect = 0.43, 95% CI = 0.08-0.77) and to change work behavior consistent with reducing dust (mean intervention effect =0.12, 95% CI = -0.01, 0.25). However, the log mean dust concentration was only 0.11 mg/m3 lower among intervention businesses versus comparison businesses (95% CI = -0.34, 0.12), a difference of about 6%, and other environmental changes related to dust control were similarly minimal.

To properly design controls such as this, it is important to understand the activities which produce dust, the nature of exposures, and the knowledge, attitudes and beliefs held by

workers and owners toward wood dust and its health effects. To gather this information, the study team made use of a planning committee, worker/owner focus groups, and a pilot study in five woodworking shops. The planning committee consisted of representatives from small woodworking shops, a local industry association, state agencies, a local technical college, a large wood products manufacturer, and a local supplier. These individuals were instrumental in providing input on written materials, plans for technical and educational interventions, and ideas for gaining access to shops. This study is one of the few conducted in the occupational setting to date that employed a rigorous design with adequate sample size, was multidisciplinary, and utilized multiple methods of data collection. The failure of the intervention to reduce wood dust may be attributed more to the complex challenge of conducting intervention effectiveness research in the occupational setting, than to the intervention per se.

Publications

No publications to date.

Title: Minnesota Wood Dust Study: Final Report to NIOSH

D.L. Parker, Minnesota Department of Health, L.M. Brosseau, University of Minnesota, D. Lazovich, F.T. Milton, S.K. Dugan, University of Minnesota.

Funding for this research was provided entirely by a grant (5 R01 OH03408) from the National Institute for Occupational Safety and Health

Project Abstract

Objectives: Exposure to wood dust is associated with an increased risk of nasal carcinoma and other allergic, respiratory and dermatologic health conditions. This study developed and assessed the effectiveness of an intervention to reduce wood dust by 30% in small businesses that manufacture cabinets, fixtures or furniture. The study had three primary aims: 1) To measure mean wood dust exposures in small wood working businesses (3-20) employees and to assess the level of dust controls (engineering, administrative, and behavioral) as measured by a walk-through survey; (2) To determine if an efficient industrial hygiene intervention program can be implemented in small wood working shops; and (3) To assess the effectiveness of this industrial hygiene intervention by a standard public health strategy in a randomized controlled trial.

Methods: During the first year of the study a pilot study was conducted to develop sampling and intervention methodology. Following this pilot study, 48 woodworking businesses (5-25 employees) were randomly assigned to intervention or comparison condition. The intervention consisted of written recommendations, technical assistance to enhance engineering and administrative methods and worker training, tailored to the needs of the business; comparison businesses received written recommendations alone. Changes from baseline in dust concentration (via personal sampling of inhalable dust), availability, use and efficiency of dust control methods (via direct observation), and worker knowledge, attitudes and behavior (via questionnaire) were assessed in both groups one year later.

Results: Baseline characteristics were similar for both groups. Workers in intervention businesses were more likely than those in comparison businesses to report at follow-up that they were informed about dust control (mean intervention effect= 0.25, 95% CI = 0.03, 0.46), to show an increase in stage of readiness to control dust (mean intervention effect = 0.43, 95% CI = 0.08-0.77) and to change work behavior consistent with reducing dust (mean intervention effect = 0.12, 95%CI = -0.01, 0.25). However, the mean dust concentration was only 0.11 ln (mg/m3) lower among intervention businesses versus comparison businesses (95% CI = -0.34, 0.12), a difference of about 6%, and other environmental changes related to dust control were similarly minimal.

Conclusions: To properly design controls such as this, it is important to understand the activities which produce dust, the nature of exposures, and the knowledge, attitudes and beliefs held by workers and owners toward wood dust and its health effects. To gather this information, the study team made use of a planning committee, worker/owner focus groups, and a pilot study in five woodworking shops. The planning committee consisted of representatives from small woodworking shops, a local industry association, state agencies, a local technical college, a large wood products manufacturer, and a local supplier. These individuals were instrumental in providing input on written materials, plans for technical and educational interventions, and ideas for gaining access to shops.

This study is one of the few conducted in the occupational setting to date that employed a rigorous design with adequate sample size, was multidisciplinary, and utilized multiple methods of data collection. The failure of the intervention to reduce wood dust may be attributed more to the complex challenge of conducting intervention effectiveness research in the occupational setting, than to the intervention per se.

Part II: Study Methods, Results, and Discussion

Methods: We conducted the Minnesota Wood Dust Study in the 7-county metropolitan region which includes Minneapolis and St. Paul, Minnesota. We relied on the PRECEDE-PROCEED model of Green (Green and Kreuter, 1991) to guide us in understanding the woodworking industry and how best to intervene. Consequently, we formed a planning committee of individuals with connections to the woodworking industry, including business owners, government officials, technical college instructors, health and safety professionals, and trade association representatives. We also conducted a pilot study in 5 woodworking shops to gather the information we needed to design the trial. With this information, we designed a nested, cross-sectional group randomized trial where small businesses that manufacture wood products were the unit of randomization and independent samples of workers were selected to participate from each business at two time points (baseline and follow-up, one year later).

Using lists from the Minnesota Forest Products Directory (1995-97 edition) and the Yellow Pages we assembled a sampling frame from which we randomly selected businesses listed as engaged in the manufacture of wood products and invited them to participate in the study. A business was eligible to participate if it had between 5 and 25 employees, had been in business for at least 1 year, and was engaged in the manufacture of cabinets, furniture or fixtures. We recruited businesses sequentially over a period of one year. During that time, we contacted 189 businesses via an introductory letter, which was then followed by a phone call from the Principal Investigator (D.L.P) to assess eligibility and arrange an in-person meeting with the owner of the business.

Of the 189 businesses initially contacted, 122 (64.5%) were not eligible at the time of the screening call. Most of these businesses ($n = 63$) had fewer than 5 employees; an additional 25 businesses did not manufacture the types of wood products which met the eligibility criteria. At the initial meeting with the owner, the Principal Investigator described the study procedures and obtained informed consent for study participation. A total of 48 businesses (71.6% of those eligible) agreed to participate. Once we received the owner's consent, we arranged a meeting with the workers in the business to obtain their consent to participate in study activities. With the owner's permission for us to conduct the study in his business, nearly 100% of eligible workers were willing to participate in the research project.

We collected data at baseline, prior to randomization of the business to intervention or comparison condition, and followed the exact procedures again in each business one year later. Of the 48 businesses that participated in the study at baseline, only one business (assigned to the intervention), was not available at the one year follow-up. All data measurements were performed by industrial hygienists with masters level training. The specific types of data collected are described below.

As the first step in data collection, each consenting worker and the owner of each business was asked to complete a self-administered questionnaire on work practices related to control of wood dust. Individuals were asked to report on their interest in controlling wood dust, the importance they ascribed to dust control, whether they thought they were informed about methods of dust control and how confident they were in their ability to control dust. We developed a measure to stage individuals in their intentions and actions to control dust, similar to what has been used to assess stage of change for behaviors such as smoking and diet. We developed scales to assess workers' perceived effectiveness of dust control (6 items) and workers' work practices related to dust control (8 items). We also assessed factors which could encourage or discourage the use of dust control, such as management support (or lack thereof), or inconvenience of using dust control, as well as the general health and safety environment in the business (e.g., presence of a health and safety officer or committee, written procedures, etc). Finally, we collected information regarding length of experience as a woodworker, number of years employed by the business under study and other demographic characteristics.

Dust measurements

After the survey was completed, we randomly selected up to 5 consenting workers involved in production activities for personal sampling of inhalable dust levels, usually on 2 different days. We carried out sampling with inhalable dust samplers (IOM sampling, SKC, Inc., Eighty-Four PA), loaded with 5 um PVC filters and personal sampling pumps (SKC Aircheck, SKC, Inc, Eighty-Four PA), operated at 2 L/minute. At least three field blanks were used for every day of sampling at a location. Cassettes and filters were desiccated at least 24 hours before initial weighing using a Model 5200D or RC210P balance (Satorius Corporation, Bohemia NY). Cassettes loaded with filters were weighed once immediately after removal from the desiccator and then stored in transport clips in the laboratory desiccator prior to sampling. Loaded cassettes were taken from the desiccator the day of sampling and transported to a site in a case; IOM samplers were equipped with cassettes at the business in a clean location immediately before sampling. Blank filters were treated in a similar fashion.

We attached IOM samplers equipped with filters and cassettes to a pump and calibrated the pump to a flow of 2 L/minute using a rotameter. Samplers were then placed on the worker and start time was noted. To prevent overloading, flow was checked with the rotameter every two hours; if flow dropped more than 0.3 L/minute (15%) from the initial reading, the sampler was removed, a new filter/cassette was loaded into the IOM housing, the sample was recalibrated and replaced on the worker. A final flow was measured with the rotameter at the end of sampling and the cassette and filter were removed from the IOM housing and placed in the transport clip and case for transport to the laboratory, where it was stored in the desiccator for at least 24 hours until re-weighing. Eight hour time-weighted average concentrations of dust were calculated for each worker sampled; a dust concentration at the business level was obtained by taking the mean of the worker concentrations.

Task observation

At the time of personal dust sampling, we recorded at 15 minute intervals for each sampled worker the type of work task being performed, or tool being used, and whether or not some form of dust control was applicable to the task and available to the worker. If dust control measures were available, we recorded whether the worker made use of it while performing the observed task. For example, tasks performed using table saws create dust which can be controlled through use of a hood attached to a central ventilation system. So, if a worker was observed cutting wood with a table saw, we checked that there was a hood (i.e., dust control available) and that it was operating while the worker operated the tool (i.e., dust control used). Many tasks, such as reading a blueprint or transporting materials, did not result in the production of wood dust and in that case, we indicated that dust control was not applicable for that task.

We observed about 75 separate work tasks by the completion of the study. We grouped the tasks into seven categories, based on similarities of specific tasks in function and dust production, and summed the total time that the worker spent across task groups: 1) sanding with stationary tools, 2) sanding and cutting with hand-held power tools, 3) sawing, 4) shaping, routing, molding or milling, 5) cleaning in a manner that increased dust (e.g., blowing dust with a compressed air), 6) cleaning in a manner to decrease dust (e.g., vacuuming) and 7) miscellaneous tasks that did not produce dust. From these data, we calculated the percent of total time across workers within a business spent at tasks in each of the seven task groups and the percent of total time dust control methods were available and applied in that business.

Ventilation Assessment

Almost all businesses had a central dust collection (ventilation) system for which we computed a measure of the system's efficiency by taking the ratio of measured air flow to the recommended air flow. A pitot tube and slack tube were used to take measurements of the system that were at least 7.5 duct diameters downstream from major obstructions, bends or disturbances, in accordance with the American Conference of Governmental Industrial Hygienists (ACGIH) ventilation manual. After opening all blast gates, velocity pressure was measured in the main duct and velocity and flow were calculated for the system. The optimum flow was determined by adding the recommended flows (according to ACGIH ventilation manual) for all the tools attached to the system. A series of 16 questions about the design and condition of the system were used to assist in the development of recommendations for improving the operation of the system.

Randomization

For each business, we prepared a written report in which we summarized our baseline observations for dust concentration, tasks and the efficiency of the dust collection system and provided a set of general recommendations for reducing dust levels in the business. We then randomly assigned the business to the intervention or comparison condition. Businesses assigned to the comparison condition received the report of their results by mail. Businesses assigned to the intervention were subsequently scheduled for a meeting with an industrial hygienist to review the results of baseline data collection and to begin the intervention process.

Intervention Description

The intervention was designed to include engineering, administrative and behavioral components, depending upon the needs of the individual business. Emphasis was placed on improving the control of dust through more efficient dust collection systems and through changing work practices.

The goal of the dust collection system assessment was to provide more detailed technical information about the dust collection systems to intervention businesses than was possible at baseline. The additional measurements consisted of measuring branch duct flow and velocity for each individual tool attached to the central dust collector and comparing those measurements to the tool-specific recommended values from the ACGIH Ventilation Manual. For each tool, we assessed the hood design by visually inspecting the exhaust duct location for proximity to the site of dust production, comparing contours of hood design to those recommended by the ACGIH ventilation manual, and evaluating maintenance of the duct and hood.

Through a 1-hour worker training session, we aimed to provide information about dust control, build worker confidence about their own ability to control dust and to increase interaction among workers to encourage dust control. The training session was either held during working hours or over a lunch break. It was designed to be flexible, informal and participatory. At the training session, workers were informed about the health and safety effects of dust control. Workers were then engaged in a series of interactive exercises where they were asked to identify dust control activities (or the lack thereof) in the work place from photographs. A demonstration was performed with a handheld orbital sander and portable vacuum system to control dust. Workers were informed about dust concentrations at their worksite, and asked to identify what they considered to be major barriers to dust control and which of those they might be in a position to change. A checklist for monitoring dust control activities, other written materials, and T-shirts were provided.

The information gathered from the second dust collection system assessment and worker training was summarized and an additional set of recommendations for controlling wood dust were made to each intervention business. We also included fact sheets and case studies for dust control, as needed. With this information, we then met with the owner to help set priorities and motivate changes in the worksite. As an incentive, a small grant of $650 was offered toward the purchase of equipment or expertise that would facilitate implementation of the dust control recommendations.

As a final step in the intervention process, we invited all owners and two workers to visit a "model" shop where we held a short education session on dust collection systems and health and safety programs, followed by a tour of the model business' production activities. The purpose of this activity was to reinforce the recommendations, build relationships between individual business owners and give owners an opportunity to see how other businesses, similar to their own, were effective in controlling dust. Three tours were held throughout the intervention period.

Process evaluation

At follow-up, we created a checklist of the recommendations made (at baseline or as part of the intervention) for each business and queried the owner about which of the recommendations had been adopted. We then compared the proportion of total recommendations that were implemented between intervention and comparison businesses. Additionally, we tracked the total number of intervention businesses that were engaged in each component of the intervention (training, final recommendations meeting, the tour or received a grant), and the mean number of days from baseline that the activity was completed.

Analysis: Our primary outcome to determine intervention effectiveness was a comparison of the difference in dust concentration between baseline and follow-up for businesses assigned to the intervention compared to those assigned to the comparison condition. For these analyses, dust concentrations were log transformed to achieve a normal distribution. Secondary outcomes, i.e., that related to the work environment and were targeted by our intervention, included changes from baseline between intervention and comparison businesses in the percent time that dust control was available and used, and improvement in the ventilation system. To assess the effect of the worker training on dust control, we compared changes from baseline in worker knowledge, attitudes and practices obtained from the survey, for intervention versus comparison businesses. All outcome measures were aggregated across individuals within a business to provide a business-level measure of each outcome.

We employed statistical techniques appropriate for group randomized trials (Murray, 1998). Since dust concentrations (or other outcome measures) obtained by sampling workers from the same business are likely to be correlated with each other, it is necessary to take this correlation into account in the analysis, otherwise, invalid statistical inferences, such as underestimating standard errors, may occur. To properly account for this correlation, it is now standard to use mixed-effects multiple regression models, where in addition to the usual fixed effects, some random effects, such as the aforementioned business effect, are also included in the regression equation. The mixed-effects model can be easily fitted using SAS Proc Mixed.

In general, the distribution of business and worker characteristics and sampling methods was similar between the intervention and comparison businesses due to randomization (Table 1), therefore adjustment for covariates was not indicated. However, since small differences in the distribution of work tasks between intervention and comparison businesses could affect dust concentrations, we present the results for our primary outcome with and without adjustment for work tasks at baseline and follow-up.

Results: The log mean dust concentration (mg/m^3) at baseline was 1.77 among intervention businesses and 1.83 among comparison businesses (Table 2). One year later, the log mean dust concentrations had decreased by 0.22 ln(mg/m^3) in intervention businesses and by 0.11 ln(mg/m^3) in comparison businesses, resulting in a net reduction in dust concentration of -0.11 ln(mg/m^3) associated with intervention status; the effect was somewhat stronger (-0.15 ln(mg/m^3) after taking task distribution at baseline and follow-up into account. However, confidence limits around these estimates, crude or adjusted, were fairly wide and included the null value. Similar environmental changes at follow-up, that were greater for intervention than comparison businesses, were observed for the percent time that dust control was available, the percent time that dust control was used, if available, and ventilation system efficiency. While these changes were in a direction consistent with an intervention effect, the observed changes were small and could represent a chance finding.

One year after the intervention, workers in intervention businesses reported small declines from baseline in worker interest in dust control and its importance, whereas workers in comparison businesses reported increases in these characteristics, yielding a net difference against an intervention effect for these measures (Table 3). Changes between baseline and follow-up in worker confidence to control dust, the perceived effectiveness of dust control and barriers to controlling dust were similar between both groups of businesses. However, there was substantial improvement over time that was greater for workers in intervention than comparison businesses for whether they felt that they were informed about dust control (mean intervention effect= 0.25; 95% CI = 0.03-0.46) and their stage of readiness to control dust (mean intervention effect = 0.43; 95% CI = 0.08-0.77). Workers in intervention businesses were also more likely to report changes in their work behavior consistent with reducing dust compared to workers in comparison businesses (0.12); confidence limits almost excluded zero.

Except for one recommendation, to clean and maintain the dust collection system, intervention businesses reported the implementation of a greater proportion of recommendations than did comparison businesses (Table 4). Differences between conditions in the proportion of recommendations implemented ranged from 4.5% higher (install a dust collection system capable of exhausting dust from all stationary tools) to 32.7% higher (increase availability of dust controls for sanding tasks) among intervention businesses compared to comparison businesses. All intervention businesses participated in worker training and the final recommendations meeting and all these businesses applied for a small grant, however, only 50% of the intervention businesses attended the tour. It took approximately 99 days (range 36 – 218 days) from the baseline sampling to conduct the worker training, 136 days (range 69 – 238 days) to convene a final meeting with the owner to present the final analysis for reducing dust in their shop, 193 days (range 101-325 days) to attend the tour, and 292 days (range 138-644 days) to receive their small grant.

Discussion and conclusions: The effectiveness of an intervention consisting of technical assistance and worker training to reduce exposure to wood dust in small woodworking businesses was not demonstrated in this study. Although we observed changes in the work environment among businesses assigned to the intervention that were consistent with our goals, i.e., a decrease in dust concentration, an increase in the percent of time that dust control was available and used and an improvement in the efficiency of ventilation systems, these changes were modest at best. On the other hand, the intervention appeared to have some effect among workers employed by intervention businesses. These workers reported at the one-year follow-up that they were more informed about dust and its control and indicated a greater readiness to control dust compared with workers in comparison businesses. More importantly, workers from intervention businesses reported an increase in their work practices for dust reduction than workers from comparison businesses; this result almost reached statistical significance.

Our study had many strengths. It represents one of the few research efforts aimed at decreasing an occupational exposure that adhered to a rigorous study design—a large number of businesses was randomly assigned to intervention or comparison conditions and the analysis was performed at the level of the business (Murray, 1998). Thus, we have properly accounted for the similarity of workers within each business that could otherwise inflate the standard error associated with the intervention effect and overestimate the confidence we have in our results. Our research team was interdisciplinary and represented occupational medicine, industrial hygiene, epidemiology, wood products and biostatistics. We followed a robust model (PRECEDE-PROCEED) for intervention development and study implementation that increased the likelihood our efforts would be applicable and acceptable to the woodworking industry (Green& Kreuter, 1991). Our high response rate for study participation and loss of only one business at follow-up speaks to the success of our efforts in meeting the needs of the industry. Unlike most studies in occupational health and safety, our intervention was targeted at all levels of the hierarchy of controls--engineering, administrative and behavioral (Hopkins et al., 1986; Maples et al., 1992). Finally, we relied on several measures of effect, ranging from worker self-report of their knowledge, attitudes and work practices to industrial hygiene observation of work practices, and finally, to actual environmental changes in dust concentrations.

Given the strengths of our study, the fact that our intervention was unsuccessful in reducing wood dust to the levels planned at the outset, speaks to the enormous complexity of undertaking this type of research in the occupational setting. We can now point to several areas that may have limited the effectiveness of the intervention. First, our goal to reduce dust concentrations by 30% may have been unrealistic given the type of exposure and the way in which it can be controlled. However, to detect a smaller effect with greater precision would have required even more businesses than what we had, resulting in greater study costs. And we could run the risk of exhausting the pool of eligible businesses before reaching the desired sample size.

Another possibility is that one year was insufficient time to observe a change in dust concentrations in our study sample. Final recommendations to intervention businesses were, on average, not provided until about 4 1/2 months after the baseline dust sampling was performed and nearly an entire year passed before intervention businesses received their small grants. Although we attempted to motivate change in multiple ways, through technical recommendations, worker training, tours of other businesses and incentives, these activities were each carried out only once with each intervention business during the course of the year.

A more intensive effort, provided in an ongoing manner, and that is cognizant of the changing work environment (e.g., worker turnover) may be needed to effect greater reductions in dust levels. In addition, all businesses received information about dust concentrations and written recommendations to improve the control of dust. While it could be argued that this degree of intervention in comparison businesses compromised our ability to detect a greater change in intervention businesses, the small changes from baseline for either group argues against this line of reasoning. Finally, we may have failed to identify business characteristics or production aspects that had an impact on dust concentration that were not equally distributed between intervention and comparison conditions or changes to businesses over time (e.g., new workers, change in equipment), further compromising the potential for our intervention to be effective.

In addition to elements of the study design that had a bearing on the effectiveness of the intervention, our results are illustrative of some barriers that exist when reducing hazardous exposures in the work environment. We found that there was nearly universal use of dust control systems, however, only about half of tasks performed by workers had dust control available to them and this changed very little during the course of the year. Available central ventilation systems were typically poorly designed, with more tools attached than allowed by manufacturer specifications for optimal functioning. Several of our recommendations encompassed major and costly structural changes to these systems or the installation of downdraft tables or sanding booths; these were least likely to be adopted by either intervention or comparison businesses.

Although other recommendations appeared to be more acceptable, e.g., increasing the availability of dust control for sanding and cutting tasks or encouraging use of portable vacuums to control dust or otherwise clean up, overall compliance with most of these recommendations among intervention businesses was 50% or less. Since we saw little evidence that intervention businesses were willing to implement costly improvements for dust control, and such changes are normally beyond the control of the workers, the lack of change in workers confidence or barriers to dust control that we observed would appear to be an accurate reflection of the work environment.

While numerous group randomized trials have been conducted in the worksite to assess interventions to promote lifestyle changes such as smoking cessation, diet or screening among individuals there is a paucity of occupational health and safety research that utilizes a similar design to which we can compare our results. Interventions consisted of training to increase knowledge of health hazards and change work practices and typically avoided the more difficult challenge that we undertook to change the work environment.

Only two studies relied on measures in addition to worker self-report to assess the effectiveness of the intervention, including either direct observation of workplace hazards or incidence of injuries. As we found from our survey of workers, most of these studies also reported the intervention to be effective in increasing worker knowledge and changing some work practices, but since these results relied on workers' self-report, biased reporting cannot be discounted.

The study most similar to the Minnesota Wood Dust Study assigned small businesses to receive either an OSHA onsite consultation, consisting of an evaluation of the work environment for presence of hazards, or in combination with a formal training program of the facility supervisor. Based on the worksite evaluation, occupational hazards were reduced in both intervention and comparison businesses, and although the addition of training to an onsite evaluation was not effective, changes in the number of hazards were quite substantial in both groups. The type of hazards observed was not described. It is possible that the hazards in these small businesses were more easily addressed by business owners than wood dust, or that owners were more responsive to an OSHA evaluation, with its regulatory tone.

The National Institute for Occupational Safety and Health (NIOSH) recently published the National Occupational Research Agenda. Intervention effectiveness research was among the priorities identified through consensus building among NIOSH staff, researchers, stakeholders and health professions. In an article outlining the future of intervention research at NIOSH a number of considerations for carrying out such research were described, including the need for industry partnership and multidisciplinary approaches, an assessment of economic feasibility, taking organizational culture and worker attitudes into account, and "integration of behavioral interventions to influence workers' attitudes, knowledge and behavior."

The failure of the intervention to reduce wood dust may be attributed more to the complex challenge of conducting intervention effectiveness research in occupational settings, than to the intervention. We would emphasize that the owner's role is critical as gatekeeper for establishing priorities and supporting health and safety efforts. A better understanding of owners' motivations and intentions toward employee health and safety may lead to more powerful interventions in small business settings.

Part III Specific Aims:

Summary of specific aims and how there have been met follows. Scientific papers that have been written or at a reasonable stage of completion are attached as appendices.

(1) To measure mean wood dust exposures in small wood working businesses (3-20) employees and to assess the level of dust controls (engineering, administrative, and behavioral) as measured by a walk-through survey.

(2) To determine if an efficient industrial hygiene intervention program can be implemented in small wood working shops.

(3) to assess the effectiveness of this industrial hygiene intervention by a standard public health strategy in a randomized controlled trial.

(1) To measure mean wood dust exposures in small wood working businesses (3-20) employees and to assess the level of dust controls (engineering, administrative, and behavioral) as measured by a walk-through survey.

Inhalable Dust Exposures, Tasks and Use of Ventilation in Small Woodworking Shops: A Pilot Study. Brosseau L, Parker DL, Lazovich D, Dugan S, Milton T, Pan W. Accepted Am J Indust Med.

This objective was met in two parts. In the first, a pilot study was conducted to determine the best strategy for the evaluation of dust levels and dust control technology in small wood working shops. In the second, a random selection of 48 shops were evaluated as part of a

We used a convenience sample of 5 shops identified by recommendations from members of a planning committee consisting of representatives from the woodworking industry. The five shops had between 5 and 11 wood production employees and manufactured a variety of wood products, including store fixtures, component parts for doors and windows, and cabinets. All of the shops had some type of centralized dust collection system, but most had little or no control available for hand-sanding operations with portable, powered tools.

The sampling plan called for measuring personal inhalable dust levels for all consenting workers at least two times over the course of two weeks, sampling at least once on each day of the week (e.g. Monday, Wednesday and Friday in the first week and Tuesday and Thursday in the second week). At least one off day occurred between sampling days to allow for sample analysis and equipment preparation.

Sampling was carried out with inhalable dust samplers (IOM samplers, SKC, Inc., Eighty-Four PA) loaded with 5 μm-pore size 25 mm-diameter PVC filters and attached to personal sampling pumps (SKC Aircheck, SKC Inc, Eighty-Four PA) operated at 2 L/min. At least two field blanks were used for every day of sampling at a location. Cassettes containing filters were desiccated at least 24 hr before initial weighing using a Model R200D or RC210P balance (Sartorius Corporation, Bohemia NY). Cassettes loaded with filters were weighed once immediately after removal from the desiccator and then stored in transport clips in the laboratory desiccator prior to sampling. Loaded cassettes were taken from the desiccator the day of sampling and transported to a site in a case; IOM samplers were equipped with cassettes at the shop in a clean location immediately before sampling. Blanks were treated in a similar fashion as samples.

In this pilot study, we found that field blanks showed higher weights than samples during periods of high relative humidity. In such situations, the samples were either repeated or not included. We adjusted our sampling protocol during the main study to include three field blanks and careful quality control procedures. (Stainless steel samplers were not affordable.) Weight stability was an infrequent problem during the main study, probably because relative humidity is generally low in Minnesota throughout the year (except for several weeks in summer).

Task and Ventilation Use Observations

For each sampled worker, we noted the task being performed and the use of dust control every fifteen minutes throughout the entire sampling period. For each task observation, we noted whether dust control was used, not used, not available (but could be), or not applicable for that particular task (e.g. reading blueprints). Fifty-three tasks were grouped into seven categories for each sample (Table 1). Tasks were grouped by the expected degree and type of dust generated.

The percent time spent in each task group was then calculated for each sampled worker by dividing the total time spent in a task group by the total time spent performing all tasks. For each task group performed by a worker over the course of a full day of sampling, three measures of ventilation were calculated:

$$\text{\% Time Ventilation Available} = \frac{time_Y + time_N}{time_Y + time_N + time_0} * 100 \qquad (1)$$

$$\text{\% Time Ventilation Used if Available} = \frac{time_Y}{time_Y + time_N} * 100 \qquad (2)$$

$$\text{\% Time Ventilation Used} = \frac{time_Y}{time_Y + time_N + time_0} * 100 \qquad (3)$$

where:

$time_Y$ = total time ventilation was used while tasks in group were performed (min)

$time_N$ = total time ventilation was not used while tasks in group were performed (min)

$time_0$ = total time ventilation would have been appropriate but was not available while tasks in group were performed (min)

Observation Intervals

We conducted an evaluation of the "best" observation time interval in one shop, observing tasks for 8 employees at 5-minute intervals over the course of one day. Observations were grouped into the seven task groups at 5-, 10- and 15-minute intervals. The generalized estimating equation (GEE) approach was used to assess whether the three time intervals were significantly different in the information they would yield about percent time spent in the seven task groups.(14)

The generalized estimating equation was used to compare the time spent on each type of task based on different sampling time interval lengths, as follows. Suppose Z_{ij} is the difference between the time spent on task j for worker i for the intervals of 5 and 10 minutes (or similarly for the other combinations of three observation intervals). The regression model is:

$$Z_{ij} = b_0 + T_j + E_{ij} \qquad \text{for } j=1,...,7 \text{ and } i=1,...,5 \qquad (4)$$

where b_0 = average time difference

T_j = fixed effect for task j (i.e. $b_0 + T_j$ gives the average difference of time spent on task j based on the two sampling schemes)

E_{ij} = random error with mean 0.

In the GEE approach, we do not need to assume a specific distribution for E_{ij}. We should assume that the time spent on different tasks for the same worker may be correlated, but that measurements on different workers are independent of each other. Based on testing whether each T_j is significantly different from zero, we can draw conclusions on whether different sampling schemes lead to significantly different measurements of the time spent on each task.

Predicting Dust Levels

Mixed model multiple linear regression analyses are appropriate to this data set, where the random effects of shop, sampling date and worker must be included when investigating the fixed effects of variables such as time spent doing particular tasks and time spent using dust control (ventilation). We used the PROC MIXED procedure of SAS (Release 6.12, SAS Institute, Cary NC, 1997) for this analysis. In this case, the five shops are considered random variables (selected randomly from the population of small wood shops) and workers were randomly selected within a shop for repeated measures of dust exposures over time (days). Workers are considered to be "nested" within a particular shop. Date of sampling is also a random variable, nested within a particular shop.

Dust concentrations were log normally distributed; all modeling was carried out using the natural logarithm of dust concentration. We evaluated the effect of the ventilation measure 'percent time used " for the first four task groups (those for which ventilation control is appropriate) in conjunction with time spent in six task groups (including dusty cleaning and miscellaneous tasks but excluding task group 6—non-dusty cleaning—in which we observed no time spent). We then repeated this analysis using the ventilation measure "% time used if available." We did not evaluate the effect of our other ventilation measure "percent time ventilation was available," because this variable would, by definition, have a lower association with dust levels (availability does not imply that controls were used).

(2) To determine if an efficient industrial hygiene intervention program can be implemented in small wood working shops.

This objective was addressed in two scientific papers:

Designing Intervention Effectiveness Studies for Occupational Health and Safety: The Minnesota Wood Dust Study. Brosseau L, Parker DL, Lazovich D, Milton T, Dugan S. This manuscript has been submitted to the Am J Indust Med for review.

Sample Size Considerations for Studies of Intervention Efficacy in the Occupational Setting. Lazovich K, Murray D, Brosseau L, Parker DL, Milton T, Dugan S. This manuscript has been submitted to the Annals of Occupational Hygiene for review.

Wood dust exposure is associated with numerous health effects. A randomized controlled trial to evaluate the effectiveness of technical and behavioral interventions to reduce dust was conducted in 48 small woodworking shops in the Minneapolis-St Paul metropolitan area. To properly design such a study, it is important to understand the activities which produce dust, the nature of exposures, and the knowledge, attitudes and beliefs held by workers and owners toward wood dust and its health effects.

Guided by Green's PRECEDE-PROCEED model, we used a planning committee, focus groups and a pilot study to gain information on small woodworking shops, causes of and controls for high dust levels, and barriers and incentives surrounding availability and use of dust controls.. The planning committee consisted of representatives from small woodworking shops, a local industry association, state agencies, a local technical college, a large wood products manufacturer, and a local supplier. These individuals were instrumental in providing input on written materials, plans for technical and educational interventions, and ideas for gaining access to shops. Worker/owner focus groups yielded important information about health and safety; they also offered suggestions for an educational session on health effects and methods of dust control. The pilot study gave data about worker activities, typical exposures, types of dust controls, worker and owner acceptance of our plans. The design of intervention studies is challenging; implementing and assessing interventions in small businesses has additional difficulties. The use of a planning committee, worker/owner focus groups and a pilot study assured that the study and its implementation would be acceptable to small businesses. Lessons learned and recommendations for designing these types of studies will be presented.

The Minnesota Wood Dust Study was carried out in 48 small wood working shops, with the goal of reducing personal wood dust exposures by 30%. We evaluated each shop with the following measures: 1) personal samples of dust exposure; 2) 15-minute observations of tasks and the availability of dust controls, 3)flow measurements in the main duct of central ventilation systems; and 4) flow measurements and qualitative review of hood designn for each tool attached to thte central collector. We developed a protocol combining these measures, which was used to select and prioritize recommendations.

This protocol involved a series of decision making points including: 1) exposures greater than the Minnesota PEL for wood dust (10mg/m3); 2)tasks associated with high exposures 3) main duct flow <75% of optimal flow (calculated using ACGih recommendations for wood working tools); 4) dust control used <75% of the time, when available; 6) hood and branch flow adequacy; and 7) employee input about dusty tools or tasks.

By applying this protocol to all shops , we were able to provide consistency in the way interventions were determined and at the same time develop shop-specific, tailored messages for owners. For example, one shop might be asked to focus on increasing the use of controls for hand-held power sandingoperations and on improving hoods on saws, while another might be asked to increase ventilation system flow and to attach more tools to the collector.

(3) To assess the effectiveness of this industrial hygiene intervention by a standard public health strategy in a randomized controlled trial.

Lazovich D. Parker DL, Brosseau LM, Milton FT, Dugan SK, Pan W, Hock L. M.S.Effectiveness of a worksite intervention to reduce an occupational exposure: The Minnesota Wood Dust Study. Manuscript in submitted to Am J Industrial Med, December 2000.

Exposure to wood dust is associated with an increased risk of nasal carcinoma and other allergic, respiratory and dermatologic health conditions. This study assessed the effectiveness of an intervention to reduce wood dust by 30% in small businesses that manufacture cabinets, fixtures or furniture.

48 woodworking businesses (5-25 employees) were randomly assigned to intervention or comparison condition. The intervention consisted of written recommendations, technical assistance to enhance engineering and administrative methods and worker training, tailored to the needs of the business; comparison businesses received written recommendations alone. Changes from baseline in dust concentration (via personal sampling of inhalable dust), availability, use and efficiency of dust control methods (via direct observation), and worker knowledge, attitudes and behavior (via questionnaire) were assessed in both groups one year later.

Baseline characteristics were similar for both groups. Workers in intervention businesses were more likely than those in comparison businesses to report at follow-up that they were informed about dust control (mean intervention effect= 0.25, 95% CI = 0.03, 0.46), to show an increase in stage of readiness to control dust (mean intervention effect = 0.43, 95% CI = 0.08-0.77) and to change work behavior consistent with reducing dust (mean intervention effect = 0.12, 95%CI = -0.01, 0.25). However, the mean dust concentration was only 0.11 ln (mg/m3) lower among intervention businesses versus comparison businesses (95% CI = -0.34, 0.12), a difference of about 6%, and other environmental changes related to dust control were similarly minimal.

This study is one of the few conducted in the occupational setting to date that employed a rigorous design with adequate sample size, was multidisciplinary, and utilized multiple methods of data collection. The failure of the intervention to reduce wood dust may be attributed more to the complex challenge of conducting intervention effectiveness research in the occupational setting, than to the intervention per se.

Scientific papers that are or are near completion:

Brosseau L, Parker DL, Lazovich D, Milton T, Dugan S.Designing Intervention Effectiveness Studies for Occupational Health and Safety: The Minnesota Wood Dust Study. This manuscript has been submitted to the Am J Indust Med for review.

Brosseau L, Parker DL, Lazovich D, Dugan S, Milton T, Pan W. Inhalable Dust Exposures, Tasks and Use of Ventilation in Small Woodworking Shops: A Pilot Study. Accepted Am J Indust Med

Lazovich K, Murray D, Brosseau L, Parker DL, Milton T, Dugan S. Sample Size Considerations for Studies of Intervention Efficacy in the Occupational SettingThis manuscript has been submitted to the Annals of Occupational Hygiene for review.

Lazovich D. Parker DL, Brosseau LM, Milton FT, Dugan SK, Pan W, Hock L. M.S.Effectiveness of a worksite intervention to reduce an occupational exposure: The Minnesota Wood Dust Study. Manuscript submitted to Am J Industrial Med, December 2000.