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EVALUATING THE EFFECTIVENESS OF WARNINGS UNDER PREVAILING WORKING CONDITIONS

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ABSTRACT

Due to a lack of published test results from which to draw conclusions about the effectiveness of warnings under different working conditions, I conducted a field study as an aid in the formulation of expert opinion during the discovery phase of pending product-liability litigation. My intent was to measure the effectiveness of a label which warned of the risk of delayed lung disease. The design of the warning conformed to the existing requirements for the period of interest - the mid 1960s. To replicate the prevailing conditions in the plant at the time that exposure to the hazard occurred, appropriate engineering and administrative controls purposefully were omitted. The warnings failed to cause a significant reduction in the incidence of unsafe behavior.

INTRODUCTION

Human factors specialists are being called upon more frequently to provide expert consultation during product-liability litigation. The content and appearance of warnings, an issue in many cases, is an area in which human factors considerations have been applied extensively. In fact, it has been suggested that a human factors specialist should testify in every case involving the adequacy of warnings (Messina, 1984).

Certainly, warnings should be but one element of an integrated health and safety program for minimizing exposure to a hazard that cannot be effectively removed from the workplace through design changes. The other elements consist of engineering and administrative controls. Beginning with frequent monitoring, engineering controls serve to isolate the worker from the hazard and may include such methods as enclosure, guarding, exhaust ventilation, and proper job design. Administrative controls, on the other hand, include: (1) enforceable policies which limit the number of workers exposed and, as appropriate, require the wearing of personal protective equipment; (2) strict housekeeping practices; (3) periodic medical examinations; and (4) compulsory training and educational programs. Thus, the proper role of a warning is to reinforce what has been learned through compulsory education and carefully supervised training.

Despite many recent appeals that warnings be tested for effectiveness under representative working conditions (Christensen, 1983; Dorris and Purswell, 1977; Peters, 1984), such testing usually is limited to subjective evaluations of preference for or, perhaps, recall of competing warnings. Why should effectiveness testing under representative working conditions be an important consideration? Clearly, one reason is to minimize prospective liability, by documenting the comprehensiveness of the foreseeability analysis performed during the development of the warning. Second, if several formats and message contents seem applicable, then realistic effectiveness data can be factored into the design trade-offs. Third, due to a lack of published data from which to draw conclusions about the effectiveness of warnings under different working conditions, it may be necessary to conduct tests during the discovery phase of pending litigation, as an aid in the formulation of expert opinion.

BACKGROUND

Recently, I was asked to provide expert opinion in a case in which a failure to warn was alleged to be a contributing factor in the causation of occupational disease. The plaintiffs in the case had been exposed to asbestos fibers in the 1950s and 1960s at an asbestos insulation manufacturing plant. A review of the case exhibits and plant-related documents revealed that prescribed engineering and administrative controls were missing, and that warnings, had they been present on bags of raw asbestos entering the plant, would have been the principal method of controlling the hazard.

Besides their primary functions in minimizing exposure to a hazard, it seems evident that engineering and administrative controls also serve to heighten a worker's awareness of a hazard and the attendant risk. If these controls are indeed missing or deficient, might this not constitute a set of working conditions which could predispose an otherwise reasonable individual to devalue a warning that arguably was adequate in terms of basic design? And would this be especially true if the hazardous material had a delayed effect on the health of the individual? The functionally disabling, life-shortening nature of asbestos-related diseases now is well documented in the medical literature (Nicholson, Perkel, and Selikoff, 1982). However, case histories and epidemiological studies underscore the long latent period between initial exposure to asbestos fibers and the presence of definitive clinical symptomatology.

The question I attempted to answer empirically was what immediate impact would a well-designed warning have had, if "suddenly" presented under these prevailing conditions? In the design

of this study, I focussed on unskilled laborers among the plaintiffs who had unloaded and stacked porous bags of asbestos on an irregular basis for varying periods of time. Many had been provided to the plant by temporary employment agencies, and many had handled bags of asbestos for only a few days or weeks. No exhaust ventilation or respirators had been provided by the plant, proper dust control and housekeeping had been nonexistent, and no educational and training programs had been made available to describe the risks and to teach proper work practices and safeguards. Moreover, although perceived by the workers as annoying and bothersome, the asbestos material itself was not considered to be hazardous.

Clearly, I could not expose individuals in a field study to asbestos fibers; therefore, I substituted granular limestone - a nontoxic material classified as producing nuisance dust. However, the warning was modeled after an appropriate asbestos-related warning for the early to mid 1960s, i.e., not after the asbestos-related warnings which began to appear at that time nor, for that matter, after the current OSHA-mandated warning. Since the late 1930s, there had been general agreement that workers in asbestos insulation plants were at risk to develop asbestosis. However, consensus within the medical community concerning a causal relationship between exposure to asbestos and the development of lung cancer and mesothelioma was not achieved until the late 1960s, following publication in December 1965 of the Proceedings of the New York Academy of Sciences International Meeting on the Biological Effects of Asbestos.

In designing the format and content of a label which warned of a hypothetical limestone-dust hazard, I consulted the open literature and trade journals of the period, 1945 to 1971 revisions of the Manufacturing Chemists Association Manual L-1 (entitled "Warning Labels: A Guide to the Preparation of Warning Labels for Hazardous Chemicals"), and the 1976 ANSI Standard for precautionary labeling of hazardous industrial chemicals. Table 1 presents a listing of current guidelines for developing warning labels. These guidelines have been extracted from consensus standards, federal regulations, industry handbooks, government recommendations, textbooks, and journal articles. It is noteworthy that, of the guidelines prescribed today, only hazard-specific color coding and the use of attention-directing symbols and pictographs were not recommended by the 1960s.

Table 1. Current Guidelines for Warnings

I. Does the warning command attention?
  A. Is the warning conspicuous?
    1. Is the warning clearly visible?
    2. Have attention-directing symbols and pictographs been used?
    3. Has the appropriate signal word been used?
    4. Has appropriate color-coding been used?
    5. Is the size of the warning scaled to the dimensions of the product?
    6. Has a border been used to isolate the warning.

II. Does the text of the warning:
  A. Identify the hazard?
  B. Indicate the degree of risk and the consequences of exposure?
  C. List conditions under which the product is likely to be a hazard?
  D. List precautions and means of avoiding the hazard?
  E. Identify actions to be taken if exposure to the hazard occurs?
  F. Employ clearly understandable, familiar language?
  G. Provide a message that:
    1. Is accurate?
    2. Uses active voice?
    3. Is affirmative and avoids "fudge" words?
    4. Creates the appropriate concern for safety and perception of the risk by incorporating an urgency that is commensurate with the danger?
    5. Is concise?
  H. Take into account the persons to whom the warning is addressed?
  I. Conform to common standards, regulations, and practices?

III. Is the warning placed in reasonable proximity to the hazard?

IV. Is the text readable?
  A. Has a foreseeability analysis considered reading distance, illumination levels, and other factors?
  B. Have label life and degradation been considered?
  C. Have typographic features been considered?

EXPERIMENT

Workplace

A government warehouse was selected as the test site, since a wide variety of packaged materials is received from vendors, unloaded from trucks, stored, and eventually reloaded for shipment to other government installations. Moreover, it is not uncommon for individual containers or bags to be removed from or placed within truck trailers by hand, rather than be secured to pallets and transported by forklift.

Subjects

Seventeen men who were experienced in heavy loading and unloading were studied. Since it was important to eliminate the influence of administrative controls that were rigorously enforced by management, the men were not part of the work force assigned to this facility. Instead, they were employed by an agency routinely contacted by the warehouse when

experienced workers were needed for loading and unloading shipments after normal duty hours.

Procedure

Nine of the workers reported to the warehouse from 4 to 8 p.m., and they were assigned to 2 unloading crews of four and five persons, respectively. The other eight workers were told to report from 9 p.m. to 1 a.m., and they were assigned to 2 loading crews of four persons each.

The study was conducted on three consecutive days during the two time periods noted above. Again, unloading and loading tasks were performed at different times. Depending on the time period, the workers were told when first arriving that they would be unloading or loading shipments of limestone for the next three days. There was no discussion of a potential health hazard, nor was any safety-related training provided. The unloading crews were instructed to remove individual bags stacked in rows in the trailer and to place them on pallets positioned by the edge of the dock. The loading crews were instructed to lift individual bags from pallets also positioned by the edge of the dock and to stack them in rows in the trailer.

Individual bags of limestone weighed 22.7 kgs and were approximately 48 by 29 by 10 cm in dimension. During each time period, two trucks were either unloaded or loaded by separate crews at adjacent docks. The pallets were filled and emptied sequentially. Forklifts transported pallets to and from the docks. Each crew handled approximately 800 bags of limestone every day. Because the bags were perforated along the sides and at the top, and because there were no provisions for exhaust ventilation or portable dust collection, the dust was very visible and concentrated in the air within the trucks and surrounding the docks. The clothing and exposed areas of all workers were literally covered with this dust during the unloading and loading tasks.

On the first day, the workers acclimated to the task requirements. Bags of limestone without warning labels were unloaded and loaded in accordance with the procedures described above. The second day consisted of data collection in the control condition; again, no warning labels were present on the bags. The third day was devoted to data collection in the experimental condition; warning labels (as depicted in Figure 1) were present and clearly visible on every bag handled by the workers. A within-subjects design was chosen to examine the veracity of claims by certain plaintiffs in the case, that they would have heeded warnings on bags of asbestos even if such warnings appeared after they had begun working at the plant.

Recorded were: (a) the time required to fill and empty each pallet; (b) the number of workers requesting and wearing respirator masks; and (c) the number of workers reporting inadequate

CONTAINS LIMESTONE

WARNING! DUST IS CREATED WHEN LIMESTONE IS HANDLED. BREATHING LIMESTONE DUST CAUSES DELAYED LUNG DISEASE. SMOKING INCREASES THE RISK.

- Do Not Breathe Limestone Dust.
- Handle Limestone Only in Areas Where There Is Exhaust Ventilation.
- Always Wear an Approved Protective Mask When Handling Limestone.
- If Limestone Dust Has Been Inhaled, Contact Plant Management.

Figure 1. Format and Content of Warning.

exhaust ventilation or exposure to hazardous dust. All data were collected unobtrusively. It was decided that undue psychological stress could not be caused by having any of the workers believe that they were at risk for days or weeks. Therefore, all workers were fully debriefed after work on the same day that the warnings were introduced.

Results

At the beginning of the second work day (i.e., prior to the appearance of the warnings), 3 of the 17 workers requested and then wore respirator masks for the remainder of the study. Because many of the workers had prior work experience in other dusty environments and since they did communicate with each other during the unloading and loading tasks, it is not surprising that some workers, at least generally safety conscious, would seek protection after being exposed to the heavy dust on the first day. In fact, it supports the credibility of the test environment. However, a change from 0 to 3 in the number of workers wearing respirator masks is not statistically significant (Fisher exact probability test, $p > 0.10$). What is surprising is the finding that when the warning labels were introduced, only 3 of the 14 workers who were not wearing respirator masks at the time requested and wore them. This does not represent a statistically significant reduction in unsafe behavior (Fisher exact probability test, $p > 0.10$). If we adopt a legal criterion instead of a statistical criterion, an effective warning is one that "more probably than not" will reduce the occurrence of unsafe behavior in the workplace. Clearly, the instruction to wear respirator masks was not heeded by a majority of workers. Moreover, none of the 17 workers reported the hazard or complained about a lack of

exhaust ventilation.

If a worker does not explicitly follow the instructions in a warning, can it be assumed that he or she does not appreciate the risk. Perhaps real or perceived pressures from fellow workers or management can cause a worker to continue handling a substance without a respirator. Thus, it is possible that the warnings could have engendered the appropriate perception of risk even though unsafe behavior continued in the workplace. Since an abrupt change in the time required to complete a practiced task can be a sensitive measure of work-related stress, response time data were entered into a 2 X 2 X 20 repeated measures analysis of variance, representing task (unloading vs. loading), workday (control vs. experimental), and pallet number (1 through 20), respectively. Neither the main effect of workday nor any interaction involving this factor were significant; the time required to fill and empty pallets was not affected by the presence of warnings.

Although the work area was extremely dusty and they observed their co-workers wearing respirator masks, 11 workers still failed to comply with this precautionary measure after the warnings were introduced. All workers reported during the debriefing that they had seen the warnings. None stated that they had dismissed the warning as false or because it was insufficiently strong in wording. Rather, they believed that they could continue loading or unloading as they had the previous two days.

While the motivating factors which influence a person's decision to accept or reject risk are not well understood (Fischhoff, 1977), in times of high unemployment workers will take greater risks because they must remain on the job. Further, if exposure to the hazard is painless, albeit annoying, and the disease takes years to be manifest, then denial is a likely defense mechanism. In view of the special emphasis now being placed on warnings as a result of OSHA's new Hazard Communication Standard, hopefully even greater pressure can be exerted for effectiveness testing under a variety of representative working conditions.

CONCLUDING COMMENTS

Two additional points must be made. First, by the late 1960s, bags of asbestos handled in insulation manufacturing plants should have contained warnings specifically describing the risks of lung cancer and mesothelioma. Second, this paper should not be cited as proof that great care need not go into the design of warnings. Rather, in addition to training workers to interpret warnings, the findings of this study suggest that workers also should receive training to act in accordance with the warning.

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