

Impact of a Worker Notification Program: Assessment of Attitudinal and Behavioral Outcomes

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Background *Hundreds of worker notification programs are conducted each year to communicate occupational risks to workers. However, few attempts have been made to evaluate their effectiveness and few have described how communication theories are applied in developing notification messages. We developed and assessed the effectiveness of a worker notification program at a beryllium machining plant.*

Methods *We compared self-protective attitudinal and behavioral responses among workers in two plants: (1) an intervention plant that received beryllium risk notification and (2) a matched control plant that did not receive notification.*

Results *Workers receiving notification reported significantly stronger perceptions of threat and efficacy, more positive attitudes toward safety practices, and engaged in more protective behaviors than the workers at the control plant.*

Conclusions *This study demonstrates the utility of applying communication theories in the development of notification messages and the results suggest that mass presentations may be just as effective, if not more so, than one-on-one notifications. Am. J. Ind. Med. 37:205–213, 2000. Published 2000 Wiley-Liss, Inc.†*

KEY WORDS: *worker notification; beryllium; communication theory; program evaluation; attitudes; health behavior*

INTRODUCTION

Although hundreds of worker notification programs are conducted each year across the nation [Baker et al., 1991], little is known about their effectiveness. Informing workers about potential health hazards is a communication process and can benefit from the vast body of research or theories found in the communication literature. For example, Slovic et al. [1980] states that, “To be effective, any information program must be buttressed by extensive empirical research focused on understanding public attitudes and developing effective ways of presenting information about risk.” Prior studies have shown that theoretically-based persuasive messages result in greater levels of health-protective behaviors, are more efficient, and often cheaper to develop [Maibach and Parrott, 1995]. While guidelines to designing risk mes-

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sages have been recommended [Cohen et al., 1985; Slovic, 1986], few studies have described how to apply them in developing notification messages.

Most research on worker notification programs has been descriptive, typically assessing whether workers understood and liked the message, and measuring the psychological impact [Boal et al., 1995; Hornsby et al., 1985; Lash et al., 1993; Mazzuckelli and Schulte, 1993; Rosenman et al., 1993; Schulte et al., 1985; Stanbury et al., 1993]. Although the ultimate goal is to improve primary and secondary prevention by educating workers, these studies have not assessed whether such risk messages changed worker attitudes and behaviors. This report describes the development and evaluation of a worker notification program that used communication theories in the design of its messages. We compared self-protective attitudinal and behavioral responses among workers in two beryllium plants: (1) an intervention plant that received beryllium risk notification, and (2) a control plant that did not receive beryllium risk notification.

BACKGROUND

Cases of chronic beryllium disease (berylliosis) attributed to beryllium dust brought home on work clothes and to air pollution were documented in the 1940s, 1950s, and 1960s [Eisenbud and Lisson, 1983; Lieben and Metzner, 1959]. A recent report of chronic beryllium disease affecting the spouse of a beryllium production worker suggests that household cases still occur [Newman and Kreiss, 1992]. However, little is known about how family members come in contact with beryllium.

In September 1996, the National Institute for Occupational Safety and Health (NIOSH) and the National Jewish Medical and Research Center (National Jewish), conducted a study to determine if workers at a precision machining plant were carrying residual beryllium out of the plant and into their personal environment [Sanderson et al., 1999]. Sixty-one workers participated in a week-long study in which their hands and the interior of their personal vehicles were tested for beryllium contamination. We observed that the workers carried beryllium dust from the worksite on their skin and clothing into their vehicles, producing levels of contamination ranging from non-detectable to thousands of mg/ft², with wide variation among individuals. Although the data from this study could not predict current or future risk of chronic beryllium disease, we believe that until more was known, the amount of residual beryllium contamination leaving the plant should be reduced to as low as possible. Specific recommendations for workers to reduce contamination included washing their hands, showering and changing out of their work clothes before leaving the plant, and vacuuming and cleaning the interiors of their vehicles.

In February 1997, an initial meeting was held between NIOSH, National Jewish, and the plant representatives to discuss the results of the contamination study and how to disseminate its findings to the workers. The decision on how best to deliver the notification messages was made in collaboration with the plant representatives, who requested a two-part notification program: (1) a series of five plant-wide live presentations about the study's aggregate results to all workers, and, (2) one-on-one notifications for those workers who participated in the beryllium contamination study.

MATERIALS AND METHODS

Message Development

Theoretical basis

Communication theories provide explanations to the complex processes of human behaviors. A multitude of theories exists in the literature and knowing which theory to apply for a given health problem can be confusing. Hence, Witte [1995] developed the Persuasive Health Message (PHM) Framework which takes three prominent persuasion theories—Theory of Reasoned Action, the Elaboration Likelihood Model, and Protection Motivation Theory—combines them, and outlines procedures for developing effective health messages. The framework has been used successfully to develop campaign messages to prevent tractor-related injuries and deaths among agricultural workers [Witte et al., 1993] and was used to guide the development of notification messages for our study. Much research on the PHM and a complementary model, the Extended Parallel Process Model (EPPM), has repeatedly shown across diverse populations and health topics, that high threat messages (which make one feel susceptible to a serious threat) accompanied by high efficacy messages (which make one feel able to perform an effective recommended response) produce consistent and stable attitude and behavior change [Witte et al., 1993, 1996; Witte, 1994]. However, the research has also shown that high threat messages without accompanying efficacy messages can backfire, causing people to reject messages and behave in maladaptive ways [Witte, 1992, 1994]. Therefore, the PHM suggests that effective messages should promote high threat messages only when accompanied by high efficacy messages.

In brief, the PHM framework outlines two separate factors, the constant and the transient factors, that must be addressed when designing an effective persuasive health message. The "constant" factors refer to three structural elements of a message that must always be addressed: threat, efficacy, and cues. That is, each health education message should address the health threat of focus, the

efficacy of recommended responses to prevent the health threat, and subtle cues such as source credibility, organization of message, presentation of a message, and channel through which the message is given. The threat portion of the message attempts to make the audience feel susceptible to a severe threat. The efficacy portion of the message convinces the audience that they are able to perform the recommended response (i.e., self-efficacy), and that the recommended response effectively averts the threat (i.e., response efficacy).

The “transient” factors of a message are those elements that change with different given populations and health issues, such as beliefs, cultural background, recommended responses, and message goals. The transient information is plugged into the constant or structural components to develop the actual message content. For example, in this case the message goal (transient information) was the prevention of chronic beryllium disease from overexposure to beryllium (the health threat). The recommended responses were defined as (a) “washing my hands,” (b) “changing my work clothes,” and (c) “vacuuming my car.” It is important to note that self-efficacy and response efficacy always refer to these recommended responses (e.g., self-efficacy and response efficacy toward washing hands). More specific transient information, such as the workers’ beliefs and source and message preferences were solicited through a focus group interview at the plant.

Focus group findings

Most focus group participants believed that overexposure to beryllium dust was a serious health threat. They were concerned about the negative consequences to their own health, as well as the potential adverse health effects on their families by bringing beryllium dust home from their work. Most knew at least one person who had been adversely affected by beryllium exposure, and they believed themselves to be extremely susceptible to getting chronic beryllium disease and expressed a great deal of fear about the threat.

The workers discussed the dangers of beryllium with their families and coworkers. While most workers knew about the safety guidelines established by the plant to reduce beryllium exposure, most felt they could learn more about how to protect themselves (e.g., “the more we know, the better off we are”). With respect to the preventive measures already in place, they believed that they could easily carry them out (self-efficacy). The workers gave no information about how effective they thought the different ways to protect themselves from beryllium contamination (response efficacy) were. However, the overall discussion suggested that workers were skeptical that they were effectively preventing exposure to beryllium. This caused them to be extremely concerned about their health.

National Jewish and NIOSH were the most preferred sources for beryllium safety and health information. While the videotape was mentioned by most as the preferred channel, pamphlet, sticker, and poster or a combination of these channels were also suggested by the workers.

Notification materials

Figure 1 depicts how we adapted the PHM and the EPPM for our study based on the formative focus group results. In creating the notification messages, careful attention was paid to the theoretical variables of interest. Specifically, the messages addressed each of the theoretical variables: (a) the severity of beryllium exposure, (b) one’s susceptibility to beryllium exposure, (c) one’s self-efficacy toward the recommended responses, and (d) the response efficacy toward the recommended responses. The recommended responses emphasized were washing hands, changing clothes, and vacuuming one’s car. In addition to the communication theories, literature on notification helped guide the development of the notification materials [Acquavella and Collins, 1993; Averill et al., 1993; Rudolph, 1993; Schulte and Singal, 1989; Schulte et al., 1993].

Given the formative focus group results indicating high threat perceptions and moderate to no efficacy perceptions regarding the recommended responses, special efforts were made to strengthen response efficacy and self-efficacy perceptions while maintaining threat perceptions (since workers already had high levels of threat). We attempted to increase response efficacy perception by emphasizing that the recommended preventive measures would reduce beryllium exposure substantially (e.g., “these very simple behaviors substantially reduce exposure to beryllium”). Further, clear, concise, and simple instructions on how to perform the preventive measures were written to increase the workers’ perceived ability to perform the recommended responses (self-efficacy). By emphasizing that the recommended responses were effective in minimizing exposure to beryllium dust, and by outlining the simple and easy steps workers could engage in to prevent harm to themselves, we hypothesized that the messages would promote high efficacy perceptions to accompany the strong threat perceptions, thus motivating high levels of protective action.

Although the focus group indicated that the workers’ most preferred channel for receiving information was a videotape, time constraints dictated the decision to produce what was most feasible in three months—a combination of information bulletins, stickers, and posters. We developed two types of information bulletins. One was distributed during plant-wide presentations, and the other was distributed during one-on-one notifications with the study participants. The first bulletin, *Beryllium Contamination Study—Results and Information*, described the purpose of

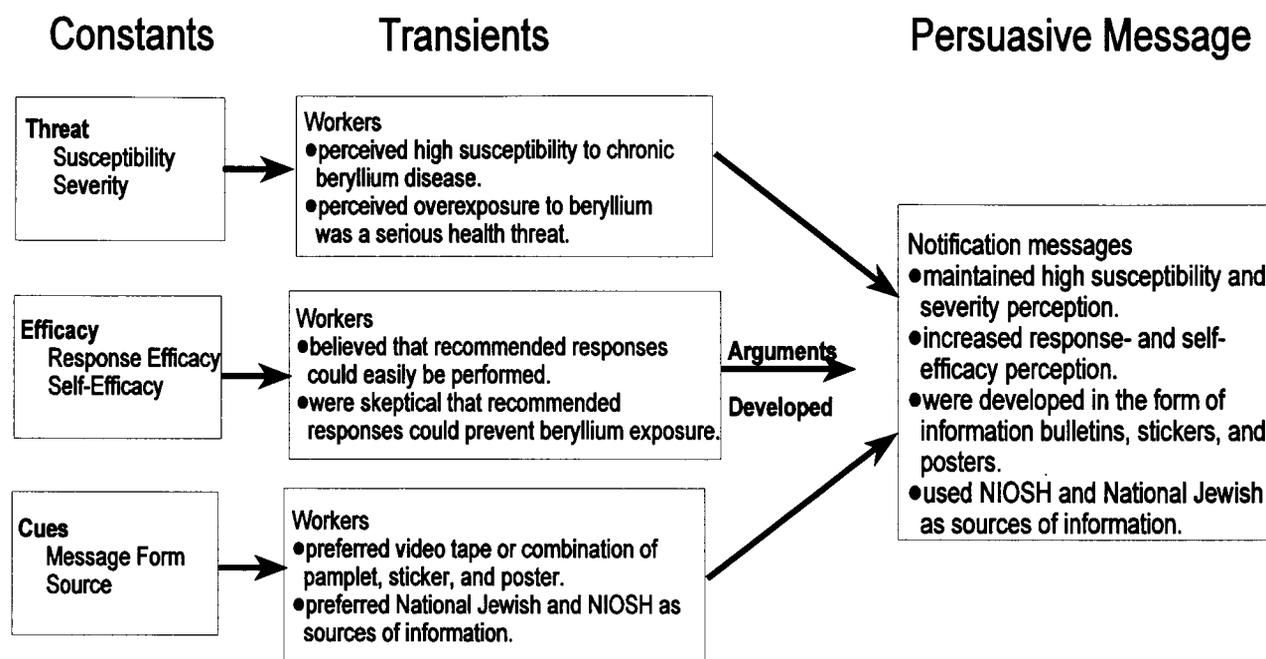


FIGURE 1. Persuasive Health Message Framework for developing beryllium risk notification message.

the exposure study, the aggregate results and their implications to the workers, and the follow-up recommendations. The second bulletin, *Beryllium Contamination Study—Your Personal Results and Information*, described the purpose of the study, individual results and their implications to the worker, and the follow-up recommendations. The second bulletin was also accompanied by a cover letter thanking the worker for participating in the study and a NIOSH phone number to call should the worker have any questions about the results.

Stickers and posters were developed to remind the workers to protect themselves. Both the stickers and posters had the “Be Careful” slogan, “Be” representing the conventional chemical symbol for beryllium. The posters also highlighted the different prevention measures that workers could take to reduce beryllium contamination. Accompanying the notification materials was the *Med Facts*, originally developed by National Jewish and modified for our study. It explained the health effects of beryllium and symptoms and treatment of chronic beryllium disease. Each of these messages focused on increasing the perceptions of response efficacy and self-efficacy, as well as maintaining strong perceptions of susceptibility and severity to the threat.

Study Participants

A total of 90 workers—60 from the intervention plant and 30 from the control plant—were randomly selected to participate in the evaluation. Of the 60 workers who were

employees at the intervention plant, 30 were randomly selected from those who had participated in the 1996 beryllium contamination study [Sanderson et al., 1999] and the other 30 were selected from those who had not participated in the original study.

The control plant consisted of workers at another precision machining plant located in the same geographic region. Similar to the intervention plant workers, the control plant workers faced beryllium exposure and had participated in the beryllium medical surveillance program conducted by their plant. At both plants, there were known cases of chronic beryllium disease and most workers knew at least one person who had chronic beryllium disease.

Study Design

A quasi-experiment was conducted using a post-test only design with non-equivalent groups [Cook and Campbell, 1979]. A self-administered survey was conducted at two points in time—immediately after the notification (Time 1) and one month following the notification (Time 2)—in the intervention and control plants. In addition to the survey, pretest and post-test observations were made at the intervention plant to assess behavioral change.

Intervention

Over a two-day period in May 1997, five plant-wide presentations and 56 one-on-one notifications were conducted at the intervention plant. Each plant-wide presenta-

tion consisted of presentations conducted by personnel from NIOSH, who provided the results and follow-up recommendations from the beryllium contamination study, and by National Jewish, who provided health effects information on beryllium. A question and answer period followed each presentation together with the distribution of the *Beryllium Contamination Study—Results and Information* bulletins, stickers, and the National Jewish *Med Facts* to each worker in attendance. Posters were given to the human resource personnel to be placed in each department. During the presentations, two posters were displayed at the front of the break room where the presentations were conducted. Each worker who participated in the beryllium contamination study met one-on-one with the NIOSH investigators for ten minutes to obtain their individual results and a *Beryllium Contamination Study—Your Personal Results and Information* bulletin. Each of these messages had been developed as part of the program (described previously) and each of the live presentations were consistent with the theoretical model of promoting response efficacy and self-efficacy, and maintaining perceptions of threat regarding beryllium exposure.

While the control plant did not receive any notification materials during the evaluation, an extensive beryllium educational program was implemented in the control plant the following year.

Questionnaire

Survey questions covered demographics, theoretical variables, communication and media variables, and outcome variables in assessing the impact of the notification program. Except where noted, all variables were measured on a 7-point Likert scale [Likert, 1932] with “1” representing “strongly agree” and “7” representing “strongly disagree.”

Demographics

In addition to marital status, number of children, gender, education, race, and income, workers were asked whether or not they knew anyone with chronic beryllium disease.

Theoretical variables

The Risk Behavior Diagnosis Scale, a standardized instrument with well-established validity and reliability [Witte et al., 1996], was used to measure response efficacy, self-efficacy, susceptibility, and severity. Response efficacy and self-efficacy were measured with six items each. Self-efficacy was assessed with questions such as, “I am able to change work clothes after handling beryllium products”—from “strongly agree” to “strongly disagree”, and response efficacy was determined by questions like, “Washing hands

after handling beryllium is effective in preventing harm from beryllium”—from “strongly agree” to “strongly disagree”. Susceptibility was measured with three items and severity was measured with six items. Perceived susceptibility to harm from beryllium exposure was assessed with questions such as, “I am susceptible to harm from beryllium exposure”—from “strongly agree” to “strongly disagree”, and perceived severity was measured with items like, “Beryllium exposure leads to serious health problems”—from “strongly agree” to “strongly disagree”.

Communication and media variables

Each worker at the intervention plant rated the clarity, accuracy, ease of understanding, informativeness, and objectivity of the notification message. The workers rated the degree (strongly agree to strongly disagree) to which the various media of communication (e.g., plant-wide presentation, one-on-one notification, information bulletin, etc.) influenced them to follow the recommended safety practices.

Outcome variables

Attitudes toward and intentions to follow recommended safety practices were assessed using questions adopted from Ajzen and Fishbein [1980]. Nine items measured attitudes, which asked workers to respond on a scale of 1 (bad/undesirable) to 7 (good/desirable) to questions such as, “Vacuuming my car frequently after handling products would be”. Intentions to follow recommended safety practices were measured with nine items such as, “I intend to wash my hands before going home after handling beryllium products during the next month”—from “strongly agree” to “strongly disagree”. Behavioral changes were assessed at the one-month follow-up with three questions per recommended safety practice (e.g., Since the May beryllium presentations/Since completing the first survey, I vacuum my car more often—strongly agree/strongly disagree) for a total of nine questions. Change in hand-washing behavior was also measured at the intervention plant by direct observation. The amount of hand-soap used per day by the workers was weighed one week before and one week after the notification. Washing hands with a specific type of hand-soap was recommended in the notification materials to reduce the amount of beryllium taken out of the workplace. Thus, this measure indicated the degree to which actual behavioral changes were made in response to the notification messages.

Data Analysis

The Pearson chi-square test was used to compare categorical variables, and the Student’s *t*-test was used to

compare means of continuous variables. A level of $P < .05$ was considered statistically significant.

RESULTS

Demographic Characteristics

Of the 60 workers randomly selected from the intervention plant, 56 completed the Time 1 survey and 54 completed the Time 2 survey. Of the 30 workers randomly selected from the control plant, 28 completed the Time 1 survey and 24 completed the Time 2 survey. As Table I shows, there were no significant differences between workers in the intervention and control plants with respect to the number of children, knowledge of someone with chronic beryllium disease, educational level, and income. Although both groups were predominately male, white, and married, the proportion for each feature was greater in the intervention group ($P < .05$). Additionally, while workers in both groups were in their 40s, the control plant workers were, on average, older than the intervention plant workers ($P < .05$).

Theoretical Variables

Table II shows that the notification messages appeared to promote the perceptions desired (high threat/high efficacy) among the intervention plant workers compared to the control plant workers. Specifically, workers receiving the notification messages reported stronger response efficacy and self-efficacy perceptions toward recommended responses than workers at the control plant. Similarly, workers receiving the notification messages reported stronger susceptibility perceptions to harm from beryllium than did workers from the control plant. Both groups of workers had high levels of perceived severity of harm toward beryllium exposure, thus, there was no significant difference in perceived severity between workers at the two plants.

TABLE II. Theoretical Variables of Beryllium Machining Workers in Intervention and Control Plants in Southern United States at Time 1^a

Variable	Intervention mean (SD)	Control mean (SD)	P
Response efficacy	3.19 (1.37)	4.76 (1.33)	<.0001
Self-efficacy	2.14 (0.93)	2.95 (1.26)	<.0001
Susceptibility	3.03 (1.94)	4.08 (1.40)	<.008
Severity	2.31 (1.26)	2.45 (1.54)	NS

^aScores range from 1 (strongly agree) to 7 (strongly disagree). NS, difference statistically not significant ($P > .05$).

Communication and Media Variables

As Table III shows, workers at the intervention plant rated the notification messages as clear (mean = 1.53, SD = 1.15), accurate (mean = 1.50, SD = 0.92), easily understood (mean = 1.70, SD = 1.24), informative (mean = 1.47, SD = 0.95), and objective (mean = 1.89, SD = 1.71). Among the various communication media, workers at the intervention plant rated the plant-wide presentations as most influential, followed by the information bulletin/fact sheet and one-on-one notification (Table IV). Family and friends were rated as least influential in motivating them to protect themselves compared to discussions with the plant safety coordinator and with the plant administrator. Significant differences in ratings were found among all communication media except for the following: between information bulletin/fact sheet and one-on-one notification, and between one-on-one notification and safety coordinator (Table IV).

Outcome Variables

Survey results

As shown in Table V, workers at the intervention plant showed more positive attitudes towards beryllium safety

TABLE I. Demographics of Beryllium Machining Workers in Intervention and Control Plants in Southern United States

	Intervention plant (n = 57)	Control plant (n = 28)	P
Marital status (% married)	89.5	69.2	<.05
Number of children	2.18	1.89	NS
Known someone who has chronic beryllium disease (%)	82.5	84.6	NS
Gender (% male)	87.7	69.2	<.05
High school graduates with some college or trade school (%)	44.6	53.8	NS
Race (% white)	98.2	80.8	<.05
Income over \$45,000 (%)	54.0	54.2	NS
Mean age	40.07	48.13	<.05

NS, difference statistically not significant ($P > .05$).

TABLE III. Beryllium Machining Workers' Opinions of the Notification Messages at the Intervention Plant in Southern United States

Range: 1 (strongly agree) to 7 (strongly disagree)	Mean (SD)
The notification program information was clear	1.53 (1.15)
The notification program accurately described beryllium disease and protection techniques	1.50 (0.92)
I understood the information given during the notification	1.70 (1.24)
I learned a lot about beryllium disease and protection techniques from the notification program	1.47 (0.95)
The notification program objectively described beryllium disease and protection techniques	1.89 (1.71)

TABLE IV. Comparison of Communication Media on Protective Behaviors Among Beryllium Machining Workers at the Intervention Plant in Southern United States

Question: Please indicate the degree to which the following sources may have influenced you to protect yourself against beryllium exposure? ("1" high score / "7" low score)

Communication medium	Mean (SD)
Plant-wide presentation	1.35 (0.67) ^a
Information bulletin/fact sheet*	1.75 (1.04) ^b
One-on-one notification	1.95 (1.61) ^{bc}
Safety coordinator	2.30 (1.42) ^c
Administrator	2.86 (1.49) ^d
Mass media materials (poster/sticker)	4.09 (1.75) ^e
Family/friends	4.70 (1.52) ^f

^{a-f} Variables with different superscripts are significantly different from each other, $P < .05$.
 * Included the two forms of information bulletin developed by NIOSH and the fact-sheet developed by National Jewish.

TABLE V. Differences Between Beryllium Machining Worker Attitudes, Intentions, and Behaviors in the Intervention and Control Plants in Southern United States*

Variable	Intervention mean (SD)	Control mean (SD)	P
Attitudes			
Time 1 Attitudes	1.59 (0.86)	2.12 (0.97)	<.01
Time 2 Attitudes	1.46 (0.90)	1.81 (0.78)	<.07
Intentions			
Time 1 Intentions	2.61 (1.17)	3.26 (1.09)	<.01
Time 2 Intentions	2.68 (1.26)	2.85 (0.99)	NS
Behaviors (Time 2)			
Washing hands	2.40 (1.96)	3.91 (2.32)	<.01
Changing clothes	4.07 (2.49)	4.10 (2.09)	NS
Vacuuming cars	4.27 (2.33)	5.32 (1.72)	<.05

*Scores for attitude range from 1 (good/desirable/favorable) to 7 (bad/undesirable/unfavorable). Scores for all other measures range from 1 (strongly agree) to 7 (strongly disagree). NS, difference statistically not significant ($P > .05$).

measures and stronger intentions to engage in safety behaviors at Time 1 when compared to workers from the control plant. At Time 2, the intervention plant workers still had stronger attitudes and intentions than did the control plant workers, but there was some regression toward the mean primarily due to the control plant workers' becoming more positive.

In terms of behaviors, significant differences in washing hands and vacuuming cars were found between workers at the intervention and control plants. At the one-month follow-up, workers at the intervention plant reported significantly higher levels of hand washing and car vacuuming than did workers at the control plant. On the other hand, the results on clothes changing indicated no significant differences between the two plants. However, during the study the control plant management mandated clothes changing while clothes changing remained voluntary at the intervention plant. Thus, given the lack of significant difference in clothes changing between the plants, this finding indicates that the intervention plant workers were now changing their clothes at the same rate as the control plant workers who were mandated to change their clothes.

Observational results

The amount of hand-soap used at the intervention plant pre-notification as compared to post-notification increased significantly. Specifically, the week prior to the notification, 62.5 oz of soap was used. The week following the notification, 154.75 oz was used. The Student Newman Kuehl t-test indicated a significant increase in the amount of soap used pre vs. post notification ($F = 17.56$, $df = 2$, $P < .001$).

DISCUSSION

The findings of this study provide evidence that workers who participated in the notification program changed positively in their self-protective attitudes and behaviors with regard to beryllium exposure. The intervention plant workers reported significantly stronger perceptions of susceptibility toward beryllium exposure, and significantly stronger response efficacy and self-efficacy perceptions

toward the recommended responses when compared to the control plant. Similarly, the workers who received the notification reported more positive attitudes toward beryllium safety measures and engaged in more protective behaviors than those workers at the control plant. Specifically, higher levels of self-reported hand-washing and car-vacuinating at the intervention plant as compared to the control plant offered evidence that the notification program was effective in promoting protective health behaviors. The significant increase in the amount of hand-soap used after the notification in the intervention plant helps validate the higher levels of hand-washing reported by the intervention plant workers.

The Time 2 survey showed that attitudes and intentions toward beryllium safety measures remained strong at the intervention plant, even though there was a one-month gap between Time 1 and Time 2. While these findings indicate minimal decay effects, it is not known whether our one-time intervention will have a long-term effect on worker attitudes and behaviors. It is interesting to note that attitudes and intentions at the control plant grew more positive in the month between Time 1 and Time 2 surveys. Factors that may have contributed to this movement are pretesting effects, regression toward the mean, and the implementation of mandatory clothes changing in the control plant during the month between Time 1 and Time 2 surveys.

One interesting finding concerned the lack of significant differences between the control and intervention plants on changing clothes. The similarity of clothes changing scores between the plants suggests that the intervention plant workers voluntarily changed their clothes at the same rate as did workers who were required to change clothes through a mandated policy in the control plant. This finding suggests that the notification program can yield voluntary protective behaviors at levels similar to mandated policy levels. However, further follow-up is needed before any firm conclusions can be drawn on this issue.

A second objective of our study focused on the relative influence of different communication media. Although the focus group results had indicated that the workers often discussed the dangers of beryllium with their families and coworkers, family and friends were rated as least influential in motivating them to protect themselves. On the other hand, plant-wide presentation had a significantly stronger influence on worker self-protective behaviors than did any other method, including one-on-one personal notifications and mass media materials. This finding is significant given the time and expense needed to engage in one-on-one notifications. If self-protective behaviors can be promoted best through live presentations to large groups, as these results indicate, then much time, effort, and money can be saved. However, further research is needed on this issue, as these results are based on workers' self-reported appraisals of what influenced their safety behaviors most, and not on

actual observation. Nonetheless, these results are intriguing in that they run counter to popular wisdom that one-on-one interpersonal interaction is best.

Previous worker notification studies [Meyerowitz et al., 1989; Needleman, 1993; Schulte et al., 1985] have suggested that relevant social networks (e.g., spouse, friends, coworkers) strongly influence behavioral responses. However, no studies to date have compared the relative influence of different communication media on workers' behaviors. Our data suggest that plant-wide presentations, information bulletins, and one-on-one notifications influenced safety behavior to a greater degree than did the safety coordinator, administrator, and family and friends. Thus, these findings suggest that the workers found expert sources (i.e., NIOSH and National Jewish) to be more credible and believable than familiar sources. This finding is consistent with the focus group findings where workers expressed a preference for obtaining beryllium safety and health information from expert sources.

One limitation of this study was our inability to conduct a truly controlled experiment in which individuals could be randomly assigned to groups exposed to different hazards, and then be notified or not about their risks. Obviously, ethical concerns prevent a study of this nature. Nonetheless, a comparison of demographics showed an adequate match between the control and intervention plant group participants. The clothes changing policy at the control plant, however, prevented true comparisons on that particular variable. Another limitation of this study was the reliance on self-report data. Every effort was made to generate valid and reliable items by adopting items from Fishbein and Ajzen's Theory of Reasoned Action [Ajzen and Fishbein, 1980] and the Risk Behavior Diagnosis Scale [Witte et al., 1996]. Further, the observation of daily soap usage at the intervention plant corresponded strongly to self-reported hand-washing, helping to validate the latter measure. Future research should include additional objective behavioral measures from both the control and intervention plants to validate self-reported data.

While this study demonstrated immediate and short-term effectiveness of a notification program, we cannot use these data to draw conclusions about which aspects of the intervention contributed to the effectiveness or about its long-term effects. For example, we cannot determine if the theory-driven messages alone were responsible for the positive outcomes or whether the high level of worker and management involvement contributed to its effectiveness. Likewise, it remains unclear whether a single, communication intervention results in permanent changes in attitudes, intentions, and behaviors, or if repetition of persuasive risk communication will be needed to maintain self-protective outcomes. To maximize the efficiency of future notification programs, further research is needed to identify specific determinants that contribute to effective worker notification.

CONCLUSION

We conclude that the worker notification program promoted adherence to recommended safety measures. Further, contrary to popular wisdom, the results of this study suggest that mass presentations before a live audience may be just as effective, if not more so, than one-on-one notifications. Finally, this study also suggests that perhaps outside experts from government and other institutions may be seen as more credible disseminators of health and safety information than are members of close social networks such as family/friends and coworkers. In sum, the positive outcomes seen in this study demonstrate the utility of using communication theories in the development of worker notification messages.

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REFERENCES

- Acquavella J, Collins JJ. 1993. Perspective on the content of worker notifications. *Am J Ind Med* 23:77–83.
- Ajzen I, Fishbein M. 1980. *Understanding attitudes and predicting social behavior*. Englewood Cliffs, NJ: Prentice Hall, 278 p.
- Averill E, Henry CJ, Rubenstein H, Sattler B, Tiry S. 1993. Content of worker notification. *Am J Ind Med* 23:77–83.
- Baker EL, Schulte PA, French JG. 1991. Worker-notification activities at the National Institute for Occupational Safety and Health, past and present. *Ann NY Acad Sci* 572:144–150.
- Boal WL, Friedland J, Schulte PA. 1995. Workers' response to risk notification. *Am J Ind Med* 27:471–483.
- Cohen A, Colligan MJ, Berger P. 1985. Psychology in health risk messages for workers. *J Occup Med* 27(8):543–551.
- Cook TD, Campbell DT. 1979. *Quasi-experimentation: design and analysis issues for field settings*. Chicago, IL: Rand McNally, 405 p.
- Eisenbud M, Lisson J. 1983. Epidemiological aspects of beryllium-induced nonmalignant lung disease: a 30-year update. *J Occup Med* 25:196–202.
- Hornsby JL, Sappington JT, Mongan P, Gullen WH, Bono SF, Altekruze E. 1985. Risk for bladder cancer, psychological impact of notification. *JAMA* 253:1899–1902.
- Lash AA, Kumekawa ES, Becker CE. 1993. Evaluating the clarity of research reports written for research subjects. *Am J Ind Med* 23:211–219.
- Lieben J, Metzner F. 1959. Epidemiological findings associated with beryllium extraction. *Am Ind Hyg Assoc J* 20:494–499.
- Likert R. 1932. A technique for the measurement of attitudes. *Arch Psychol* 140:1–55.
- Maibach E, Parrott RL, editors. 1995. *Designing health messages. Approaches from communication theory and public health practice*. Thousand Oaks, CA: Sage Publications, 304 p.
- Mazzuckelli LF, Schulte PA. 1993. Notification of workers about an excess of malignant melanoma. A case study. *Am J Ind Med* 23:85–91.
- Meyerowitz BE, Sullivan CD, Premeau CL. 1989. Reactions of asbestos-exposed workers to notification and screening. *Am J Ind Med* 15:463–475.
- Needleman C. 1993. Social aspects of high-risk notification among chromium-exposed workers. *Am J Ind Med* 23:113–123.
- Newman L, Kreiss K. 1992. Nonoccupational beryllium disease masquerading as sarcoidosis. Identification by blood lymphocyte proliferative response to beryllium. *Am Rev Respir Dis* 145:1212–1214.
- Rosenman KD, Stanbury M, Lemon A, Solice-Sample G, Kalush A. 1993. High-risk notification of chromate and bichromate production workers. *Am J Ind Med* 23:125–134.
- Rudolph L. 1993. Issues in notification: reflections of a public health worker. *Am J Ind Med* 23:53–59.
- Sanderson WT, Henneberger PK, Martyny J, Ellis K, Mroz MM, Newman LS. 1999. Beryllium contamination inside vehicles of machine shop workers. *Appl Occup Environ Hyg* 14:223–230.
- Schulte PA, Boal WL, Friedland JM, Walker JT, Connally LB, Mazzuckelli LF, Fine LJ. 1993. Methodologic issues in risk communications to workers. *Am J Ind Med* 23:3–9.
- Schulte PA, Ringen K, Altekruze EB, Gullen WH, Davidson K, Anderson SS, Patton MG. 1985. Notification of a cohort of workers at risk of bladder cancer. *J Occup Med* 27:19–28.
- Schulte PA, Singal M. 1989. Interpretation and communication of the results of medical field investigations. *J Occup Med* 31(7):589–594.
- Slovic P, Fischhoff B, Lichtenstein S. 1980. Informing people about risk. In: Morris L, Mazis M, Barofsky I, editors. *Product labeling and health risks: Banbury Report 6*. Cold Spring Harbor, NY: The Banbury Center, p 165–180.
- Slovic P. 1986. Informing and educating the public about risk. *Risk Anal* 6(4):403–415.
- Stanbury M, Solice-Sample G, Pescatore J. 1993. Asbestos disease risk communication conducted by the New Jersey Department of Health. *Am J Ind Med* 23:97–104.
- Witte K. 1992. Putting the fear back into fear appeals: the Extended Parallel Process Model. *Commun Monogr* 59:329–349.
- Witte K, Peterson TR, Vallabhan S, Stephenson MT, Plugge CD, Givens VK, Todd JD, Beckett MG, Hyde MK, Jarrett R. 1993. Preventing tractor related injuries and deaths in rural populations. Using a persuasive health message framework (PHM) in formative evaluation research. *Int Q Commun Health Educ* 13(3):219–251.
- Witte K. 1994. Fear control and danger control. A test of the Extended Parallel Process Model (EPPM). *Commun Monogr* 61:113–134.
- Witte K. 1995. Fishing for success. Using the persuasive health message framework to generate effective campaign messages. In: Maibach E, Parrott RL, editors. *Designing health messages*. Thousand Oaks, CA: Sage Publications, p 145–166.
- Witte K, Cameron K, McKeon J, Berkowitz J. 1996. Predicting risk behaviors: development and validation of a diagnostic scale. *J Health Commun* 1:317–341.