

Effects of education on risk perception: a study of Hurricane Katrina cleanup
workers

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Executive Summary

A large population of cleanup workers involved in the Hurricane Katrina cleanup effort received health and safety trainings not approved by the Occupational Safety and Health Administration (OSHA). However, little is known about the utility of these trainings. This study evaluated the effectiveness of non-OSHA approved and OSHA approved trainings provided to volunteer (receiving non-OSHA approved training) and professional (receiving OSHA approved training) cleanup workers in New Orleans. Training effectiveness was measured by changes in workers' risk perception and anticipated use of personal protective equipment (PPE) after undergoing training. This study surveyed a total of 276 workers both before and after receiving training.

All workers experienced a significant increase in overall risk perception and anticipated PPE use after training. Compared to professionals, volunteers had lower baseline perceptions of risk and anticipated PPE use and experienced a significantly greater increase in anticipated PPE use after training. Multivariate analyses were conducted to identify worker characteristics influencing training effectiveness (with training effectiveness as the dependent variable). Results indicated that the effect of training on risk perception and anticipated PPE use was greater for workers with higher baseline perceptions and without ongoing health conditions. The effect of training on anticipated PPE use was also greater for volunteers, workers from the Katrina-affected region, and workers aged 35-50. These results show that trainings are valuable interventions for volunteer worker populations, and that baseline perceptions, along with worker health, type, proximity to the disaster, and age, are important characteristics to consider when designing effective trainings.

1.0 Introduction

1.1 Post-disaster worker protection: health and safety trainings

The protection of worker health and safety during post-disaster cleanup operations is a major challenge. Both natural and human-made hazards can produce significant health and safety risks. The major obstacles in protecting against these risks include the large proportion of population exposed, the extended period of exposure, and the range and severity of possible exposures per individual. Also, many workers participating in cleanup have limited training in disaster response, exacerbating the health and safety risks posed by hazards.

Health and safety trainings are interventions aimed at reducing or eliminating the magnitude of an individual's exposure to workplace hazards. This individual-level approach equips the workers with the resources necessary to protect against exposures through education on proper use of personal protective equipment (PPE), and in some cases, free access to PPE. Environmental interventions, which manage system-wide exposures in the workplace by altering working conditions, are another approach to protecting worker health and safety. However, environmental interventions require direct manipulation of workplace exposures and are therefore less feasible in post-disaster environments where exposures are often unknown, under limited control, and constantly changing (Berrios-Torres et al., 2003; Feldman et al., 2004). Thus, individual-level interventions like training are more productive risk-reduction tools after disasters.

The utility of individual health and safety trainings may be limited by several factors. First, training interventions are predicated on the assumption that education can substantially alter workers' risk perception and behavior. Secondly, in post-disaster

situations, the definition of worker blurs and often broadens to include volunteers who have virtually no training or past experience in disaster response. Workers trained in post-disaster response might include police officers, firefighters, and emergency medical service (EMS) technicians, while non-trained workers might identify as trade professionals (such as carpenters, ironworkers, utilities, and maintenance), truck drivers, residents, or volunteers (Berrios-Torres et al., 2003; Herbert et al., 2006).

This variability in worker backgrounds poses a challenge in ensuring comprehensive and effective trainings for all post disaster workers. Constant fluxes and turnover in the worker population, due in part to short-term volunteer positions, lead to continuous changes in worker experience levels, thereby complicating efforts to protect all “at risk” populations. At present, only a small number of workers with disaster-related occupational backgrounds receive trainings that have been reviewed and approved by the Occupational Safety and Health Administration (OSHA), in accordance with OSHA guidelines (29 CFR 1910.120) (OSHA, 2004a).¹ The remaining workers sometimes receive shorter, non-standardized, and unregulated trainings from organizations and community groups involved in post-disaster cleanup. However, these lesser-trained workers are largely unstudied in the health and safety literature.

The exclusion of individuals with backgrounds non-specific to emergency relief from OSHA-certified worker trainings and surveillance studies complicates efforts to ensure equal health and safety protection for all workers. This also creates a knowledge gap in the evaluation of how trainings impact worker populations without emergency relief backgrounds. Thus, this study attempts to fill the gap by jointly evaluating the

¹ The Occupational Safety and Health Administration (OSHA) is a government agency dedicated to issuing and enforcing workplace health and safety standards.

effect of OSHA-certified and non-certified trainings on worker risk perception and by identifying workers characteristics that might contribute to this effect.

The need for training evaluations is clear: as global temperatures rise, disasters are predicted to be more frequent and severe (WHO, 2005). These climatic changes will necessitate adaptations in disaster response, including an increased involvement of less traditionally trained workers in post-disaster operations. This poses new challenges for the design and enforcement of worker protection policy. Indeed, the provision of intensive, OSHA-certified trainings for all cleanup workers may be economically unfeasible and impractical. Yet, an improved knowledge of the utility of non-certified trainings, relative to government-certified trainings, may allow for identification of new mechanisms for educating and safely integrating non-government certified workers into post-disaster response plans.

1.2 Research objectives

In order to effectively protect all worker types, we must first understand how knowledge of risks translates into safe behavior. A clear disconnect still persists between worker knowledge about hazards and their ability and willingness to take action to protect themselves (Roscoe and Kruger, 1990; Rotheram-Borus and Koopman, 1991; Prezant et al., 2002; Feldman et al., 2004). Simply put, although workers may know what protective measures they should take in hazardous environments, this knowledge does not always result in them adopting such measures. Thus, in order to be effective, trainings must be able to narrow the gap between knowledge and action so that risks are minimized.

This study measures worker risk perception in Hurricane Katrina cleanup workers to determine workers' attitudes towards risks and inclination to reduce risks, both before and after receiving training in New Orleans, Louisiana. Risk perception is assessed for workers undergoing both OSHA and non-OSHA certified trainings in order to examine differences in training outcome across different worker populations. The main research objectives are to: a.) understand the effect of educational interventions on cleanup workers' perceptions of risks and proper PPE use, b.) determine whether this effect differs across worker type, and c.) identify factors that might limit this effect, including barriers to PPE use and worker characteristics.

First, I begin by describing the scope of the physical damage, populations affected, and the environmental health risks caused or exacerbated by Hurricane Katrina. I outline the health and safety concerns specific to the cleanup efforts and identify the challenges in protecting workers from environmental exposures. I present the methodology and results of risk perception surveys and measures of worker exposure. A discussion of these study results focuses on the ways in which the findings can inform and strengthen post-disaster worker protection programs. I address the challenges and uncertainties involved in this endeavor and attempt to provide recommendations for future worker protection strategies that might build upon my findings and extend their real-world applications.

1.3 Case study: Hurricane Katrina

1.3.1 Background

Hurricane Katrina made landfall along the Gulf Coast near New Orleans, Louisiana on Monday, August 29, 2005. The Category 3 hurricane (on the Saffir-Simpson scale) generated enough wind and rain to produce levee breaches along the four major flood protection units that comprise the New Orleans flood-protection system (Seed et al., 2005). Roughly 80% of the city was filled with floodwaters deeper than three meters in some locations (Presley et al., 2006). The hurricane impacted a space of over 90,000 square miles, flooded roughly 120,000 homes, and caused the displacement of around 1 million people (CDC, 2005a; Solomon et al., 2006). The Federal Emergency Management Agency (FEMA) reported that about 650,000 people, over one-third of the 1.7 million Gulf Coast residents, were affected by floodwaters. The majority of the affected population resided in the city of New Orleans (over 350,000), Jefferson Parish (175,000), and St. Bernard Parish (53,000), as well as 54,000 in a 3-county area along the coast of Mississippi (Logan, 2005).

An early assessment of the total damaged caused by Hurricane Katrina showed a disproportionate impact on African American and poor populations. According to one study, 46% of the total damaged area was habited by African Americans and 21% of damaged households had incomes below the poverty line (Logan, 2005). In the city of New Orleans, 75% of the population impacted by the damage was African American and 29% of households impacted had incomes below the poverty line.

Katrina also contributed to a significant shift in racial composition and population size in Orleans Parish. A comparison of recent demographic estimates with U.S. Census

data for 2000 shows that the percentage of the population identifying as white increased from 28% to 43% after Katrina, while the percentage of the population identifying as black dropped from 67% to 47% (LDHH, 2006). The total population of Orleans Parish dropped by 61% after Katrina, from 484,674 to 191,139.

The remaining residents of New Orleans have been left with a monumental task of cleaning up the debris left behind by Hurricane Katrina. This task involves a wide variety of environmental health risks, many of which the residents are not economically, physically, and psychologically equipped to handle (LDHH, 2006). To further complicate worker protection efforts, contractors and subcontractors chose not to follow health and safety plans designed to protect cleanup workers (NIEHS, 2006). This disregard for safety protocols might have gone unreported by workers because many were undocumented or afraid of losing their jobs (Fletcher et al., 2006). Also, many immigrant and low-wage workers were not fully aware of their rights to workplace safety and compensation for injuries (NELP, 2005). Thus, individual cleanup workers often faced workplace obstacles that deterred them from taking action to protect their health and safety.

1.3.2 Environmental health concerns

Floodwater and sediment samples taken in the months following Hurricane Katrina suggest a high likelihood of unsafe exposure to various contaminants. High levels of arsenic, lead, aldrin (insecticide), and semivolatile organic compounds (including polycyclic aromatic hydrocarbons (PAH's)) were identified in sediment (EPA, 2005; Presley et al., 2006). Elevated levels of coliform bacteria, as well as lead, arsenic

and chromium were also detected in floodwater (Pardue et al, 2005; Presley et al., 2006). Furthermore, a study on indoor and outdoor mold exposure by Solomon et al. (2006) reveals that the mean outdoor mold concentration in flooded sections of New Orleans was roughly twice (66,167 spores/m³ vs. 33.179 spores/m³) the concentration in non-flooded sections. Maximum measured mold concentrations were found inside homes, demonstrating that the risks of exposure were high in both indoor and outdoor working environments.

Due to their high prevalence in the environment, the main contaminants of concern included arsenic, lead, and PAH's. Worker exposure to these contaminants can occur through a variety of media and can pose mild to serious human health risks. Major health concerns included: cancer (arsenic and PAH's), nervous system and brain damage (arsenic and lead), reproductive damage (lead and PAH's), as well as other serious illnesses (Hodgson, 2004; ATSDR, 2006). Mold also posed serious respiratory health concerns, especially for persons with allergies or other respiratory illnesses.

1.3.3 Insufficient training and worker illness

While worker surveillance studies from recent disasters agree that post-disaster relief and cleanup workers lack sufficient training, they do not offer a consensus on exactly what material trainings should cover and how the trainings should be conducted (Prezant et al., 2002; Scanlon, 2002; Berrios-Torres, 2003; Feldman et al., 2004; Johnson et al., 2005; CDC, 2006a). In the case of Hurricane Katrina, the immediate and long-term cleanup efforts required the assistance of workers with or without health and safety training (CDC, 2006a). Workers less likely to have received training were often working

in the same hazardous environments as the trained workers. This disparity in worker training for equally hazardous duties posed serious exposure risks that may have contributed to undesired health outcomes.

After Hurricane Katrina, several hospital surveillance studies documented that clean up workers were experiencing respiratory illnesses (CDC, 2006b; CDC, 2006c). A survey of cleanup workers performing mold remediation found that non-trained workers (residents) were more likely to not use appropriate respiratory protection, in part due to a lack of availability (CDC, 2006a). These findings suggest a possible relationship between the improper use or lack of respiratory equipment and reported illnesses in cleanup workers. Thus, a lack of information and experience, as well as barriers to PPE use, may be factors influencing workers' risk perception and cleanup behavior.

1.3.4 Guidelines for training and PPE use

Employee populations in New Orleans, Louisiana received OSHA certified trainings from government programs such as the Worker Education Training Program (WETP) and by private businesses. Training curricula covered hazardous waste operations and emergency response (HAZWOPER), as well as mold remediation. Volunteer workers received non-OSHA certified trainings from individual organizations involved in cleanup. Unlike OSHA certified trainings, these non-certified trainings did not follow accepted guidelines or standards. Thus, training curricula differed between and within OSHA and non-OSHA certified trainings, suggesting possible differences in effect of trainings on worker risk perceptions and anticipated PPE use.

OSHA standards for PPE use apply to general cleanup situations and not specifically to disaster response (Professional Safety, 2006). However, after Katrina, government agencies issued recommendations for PPE use specific to certain cleanup situations. The Center for Disease Control (CDC) recommended the use of respirators, gloves and dermal protection, and safety goggles for the healthy person doing moderate cleaning or more aggressive work that involved stirring up dust or mold (CDC, 2005b). For all response and recovery operations (encompassed in the HAZWOPER standard), OSHA also recommended the use of a hat and boots, but not the use of dermal protection, unless required by the specific hazard (OSHA, 2007b).

Recommendations across government agencies differed slightly and did not address all cleanup activities, leading to unclear interpretations of “correct” types and level of PPE use. However, government agencies clearly communicated the importance of taking precautionary measures during cleanup.

2.0 Materials and methods

This study surveyed Hurricane Katrina cleanup workers in New Orleans, Louisiana between May 2006 and July 2006. Workers received health and safety training in New Orleans and intended to participate in cleanup, remediation, and rebuilding activities following training. A convenience sample of workers was recruited from six organizations providing training. These organizations consisted of: private business (Environmental Management and Training), unions (the United Steelworkers Union), and community organizations (Common Ground Collective, ACORN, Hands On New Orleans, and the RHINO Project). The workers were grouped into two categories

(volunteer and professional) based on the intensity of the organization's training curriculum (defined as the length of training and the number of cleanup environments discussed): OSHA-certified (professional) or non-OSHA certified (volunteer) (Table 1). The study was approved by the Brown University Institutional Review Board, and informed consent was obtained from study participants prior to administration of the surveys.

2.1 Survey methods

Structured surveys with questions on risk perception, cleanup activities, and use of personal protective equipment were distributed to workers before and after receiving health and safety trainings. All surveys were conducted in New Orleans, Louisiana, between 29 May 2006 and 17 July 2006 (Appendices A and B provide the surveys given before and after training). The survey administered prior to the onset of training collected demographic information and the disaster-related experiences of each respondent. It also gathered information on perceptions of risk associated with specific cleanup activities, the anticipated use of PPE during future cleanup, and perceived barriers to PPE use. The second survey was administered at the completion of the training and prior to the onset of cleanup activities. It repeated questions on risk perception and anticipated PPE use after training. The first survey required 15-40 minutes to complete while the second survey required only 5-15 minutes.

The curricula at volunteer trainings were designed by their organization to cover risks and risk-reducing behavior (such as proper use of PPE) specific to the cleanup of flooded homes. Training group sizes ranged dramatically (between 3 and 100+ workers

and 1-2 trainers), and trainings lasted approximately 30 minutes. Professional trainings addressed risks and precautions required in a variety of specialized hazardous cleanup tasks. Group sizes were smaller (2 to 22 workers and 2 trainers), and trainings were significantly longer (24-40 hours). Each organization granted permission for surveys to be administered at trainings and a representative of each organization was present during the administration of all surveys.

This study evaluated the effectiveness of health and safety trainings using risk perception and PPE use as indicators of effect. Risk perception was measured as a score (1= no risk to 4= high risk), based on eight potential adverse outcomes (Table 2). Anticipated PPE use was measured as a score 1-5 representing the amount of equipment each participant expected to use in five cleanup scenarios (Table 3). Perceived barriers to PPE use was measured as a score 1-4 by the number of barriers workers selected, and only workers who selected one or more barriers were counted (Table 4).

The three main research questions driving this study included:

- 1.) Does training affect risk perception, and does this effect vary by worker type?
- 2.) Does training affect anticipated PPE use, and does this effect vary by worker type?
- 3.) What factors, including barriers to PPE use and worker characteristics, limit training effectiveness (measured by changes in risk perception and anticipated PPE use during cleanup) (Table 5)?

Each of the questions was explored in detail in the surveys and is addressed in the analysis.

2.2 Analytical methods

Chi square contingency tests were conducted to identify differences in population characteristics between volunteer and professional worker types. ANOVA was used to detect significant differences in risk perception and anticipated PPE use measures between and within training and worker categories, both before and after training. Limitations to training effectiveness were also explored using ANOVA and chi square contingency tables.

Multivariate linear regression models were constructed to identify population characteristics best explaining baseline measures of risk perception and anticipated PPE use for various cleanup activities, as well as perceived barriers to PPE use. Regression models were also created to detect population characteristics influencing the effect of training on risk perception and expected PPE use (Venables and Ripley, 2002). A total of 12 measures of population characteristics were selected for the models based on univariate analyses examining differences between volunteers and professionals (Table 6). All models were assessed for collinearity (Fox, 2006) and all statistics were conducted using the statistics packages JMP and R (JMP, 2003; R Development Core Team, 2006).

3.0 Results

3.1 Population characteristics

A total of 300 workers were contacted for the study, with 276 agreeing to enroll. The sample yielded a total of 241 volunteers and 35 professionals. Population characteristics were compared across volunteers and professionals to identify differences that might influence risk perception of workers in each category (Table 7). Distributions

of characteristics were significantly different between volunteers and professionals for all characteristics except marital/relationship status and ongoing health condition.

Females and males were evenly represented in the volunteer category, while males comprised 77% of the professional category. Volunteers were overwhelmingly younger than professionals. The racial composition also differed, with 86% of volunteers identifying as Caucasian and 80% of professionals identifying as African American. The majority of volunteers and professionals had attained some level of post-secondary education. Roughly half of both worker types were currently employed, with a greater student volunteer population and a larger unemployed professional population.

Almost half of volunteers and two-thirds of professionals were married or in a relationship, while a one-third of volunteers and two-thirds of professionals had children. Nearly all volunteers lived in locations not directly affected by Hurricane Katrina, while almost all professionals lived in locations affected by the storm. Most volunteers were not in New Orleans when Hurricane Katrina hit, although many professionals were in the city at that time. Over half of professionals had experienced a hurricane other than Katrina, while less than half of volunteers had done so. Similarly, over half of professionals but only a few volunteers had already participated in some form of cleanup. Both groups perceived themselves as healthy, with 25% or less reporting an ongoing health condition that existed before the hurricane.

3.2 Changes in risk perception

Overall, workers' risk perception for individual health concerns increased after training. However, the magnitude of change differed by health concern and worker type.

For individual health concerns, comparisons of risk perception scores before and after training showed that volunteers' perception increased significantly for all health concerns except access to health care (Figure 1), while professionals' risk perception did not significantly change for any health concerns (Figure 2). When all health concerns were examined together, both volunteers' and professionals' risk perception increased significantly after training, and both experienced the same magnitude of change (Figure 3). However, professionals' cumulative perception of risk was higher than volunteers both before and after training.

When short-term and long-term health concerns were examined as risk categories, training had a significant positive effect on short-term risk perception (Figure 4) and long-term risk perception (Figure 5) for all workers combined and for volunteers alone. Volunteers and professionals experienced the same magnitude of risk perception change for short-term health concerns (Figure 6), while volunteers experienced a slightly, although not significantly, greater change for long term health concerns (Figure 7). Overall, professionals were more concerned about potential short and long-term illnesses than were volunteers. Volunteers remained more concerned with short-term illnesses over long term illnesses both before and after training, while professionals expressed similar concern for both illness types. However, volunteers experienced a significant increase in concern over both short and long-term illnesses after training, while professionals did not.

3.3 Changes in anticipated PPE use

After training, all workers anticipated wearing more PPE for all cleanup activities (Figure 8). However, volunteers experienced a significantly greater change in overall anticipated PPE use than did professionals (Figure 9). Volunteers expected they would wear more PPE for all situations (Figure 10), while professionals anticipated using more PPE for all activities except the removal of damaged material from the home (Figure 11). For individual activities, comparisons of anticipated PPE use scores before and after training indicated that training had a significantly positive effect on workers' expectation of using PPE for all cleanup activities except demolition work and the removal of damaged material from the home. Training had a significant positive effect on volunteers' expected PPE use for all activities, but only on professionals' expected PPE use for the repair or removal of roofing.

This shows that training had a different effect on volunteer and professional perceptions of proper PPE use for individual activities. However, when analyzed across all cleanup activities, training significantly increased the number of PPE selected by both volunteers and professionals. Thus, training was effective in increasing expected PPE use overall, but had limited utility in increasing volunteer and professionals' anticipated PPE use for individual cleanup activities.

3.4 Limitations to training effectiveness: barriers to PPE use

On average, volunteers perceived more barriers to PPE use than did professionals. Out of four possible barriers, a greater proportion of volunteers selected two barriers, while a larger proportion of professionals selected one barrier (Figure 12). However,

ANOVA showed that worker type had no effect on the number of barriers identified (DF= 1, F= 0.8952, Prob > F= 0.3450). Thus, volunteers and professionals did not hold significantly different views on the magnitude of barriers to PPE use.

When analyzed by barrier type, greater proportions of volunteers (than professionals) perceived no access to PPE as a barrier, while greater proportions of professionals perceived PPE discomfort, affordability, and no need for PPE as barriers (Figure 13). Pearson's chi square showed significant differences between volunteers' and professionals' perceptions of two barriers including: PPE discomfort and the lack of need to wear PPE (Table 8). This indicates that discomfort and a perceived lack of need for PPE were significantly greater barriers for professionals than volunteers. Thus limitations to training effectiveness, as measured by the number of barriers to PPE use, did not differ by worker type. However, when measured by the type of barriers to PPE use, training limitations did differ significantly by worker type.

3.5 Effect of worker characteristics on training utility

Multivariate regression models were constructed to identify worker characteristics associated with baseline scores for risk perception and anticipated PPE use as follows:

Baseline score = Worker characteristics

$$\text{Baseline score} = \alpha + \beta_1 (x_1) + \beta_2 (x_2) + \dots \beta_n (x_n) + \varepsilon$$

Worker characteristics influencing the effectiveness of training, as measured by risk perception score and anticipated PPE use score, were assessed using two different models:

Model 1: Change score = (score after training- baseline score) = Worker characteristics

$$\text{Change score} = \alpha + \beta_1 (x_1) + \beta_2 (x_2) + \dots \beta_n (x_n) + \varepsilon$$

Model 2: Score after training = Baseline score + Worker characteristics

$$\text{Score after training} = \alpha + \beta_1 (x_1) + \beta_2 (x_2) + \dots \beta_n (x_n) + \varepsilon$$

The first model measured factors influencing the absolute difference in risk perception and anticipated PPE use scores before and after training. The second model measured the effect of baseline scores and other factors on risk perception and anticipated PPE use scores after training. In Model 2, baseline perceptions were included as predictor variables in order to control for risk perception before training.

3.5.1 Worker characteristics associated with baseline risk perception and anticipated PPE use

The age and race of cleanup workers were the strongest predictors for worker risk perception before training, while the presence of an ongoing health condition had the greatest effect on anticipated use of PPE before training (Table 9). Younger adult workers (18-24) had significantly lower perceptions of risk than older workers, while African Americans perceived a significantly greater risk than Caucasians and Hispanics. Workers with ongoing health conditions had higher baseline perceptions of PPE use. Thus, of the predictor variables tested, age, race, and existing health conditions had the greatest effect on baseline worker perceptions of health and safety.

Although less significant, personal experience of a hurricane other than Katrina influenced baseline risk perception, while worker type, previous participation in cleanup, and region of residence affected perception of PPE use. Both models explained a small

portion of the variance ($R^2=0.106, 0.082$), indicating that baseline perceptions were also likely affected by worker characteristics not measured in this study.

3.5.2. Worker characteristics associated with training effectiveness

Model 1: Change in risk perception and anticipated PPE use scores

The presence of an ongoing health problem (existing before the storm) in workers had a significant negative effect on the change in risk perception score after training (Table 10). Similarly, the presence of a health problem and residence in non-Katrina affected regions had significantly negative effects on changes in anticipated PPE use after training. Being a volunteer produced a significant positive effect on change in expected PPE use. These results show that an ongoing health condition may restrict the magnitude of perception change in workers. The adjusted R^2 for these models were low, suggesting that certain key risk factors for predicting changes in risk perception and anticipated PPE use were not accounted for ($R^2= 0.024$, Model A, 0.069 , Model B).

Model 2: Risk perception and anticipated PPE use scores after training

Findings confirmed that baseline perceptions had a significant effect on perceptions of risk and expected PPE use after training (Table 11). An ongoing health condition remained a significant predictor for risk perception after training (Model A), illustrating that workers with health conditions existing before Katrina had lower post-training risk perception scores than workers without health conditions. Worker type, age, and race were important predictors for post-training perceptions of proper PPE use. After controlling for pre-training PPE scores, volunteers anticipated wearing more PPE than professionals after training. Middle-aged workers (35-50) had higher expected PPE use

scores than both younger and older workers. Hispanics were most positively associated with post-training expected PPE use scores, while Caucasians were most negatively associated with post-training expected PPE use scores (although scores between races were not significantly different). The adjusted R^2 for both models increased significantly from the difference score models (Model 1), indicating that baseline risk perception and anticipated PPE use scores are important predictors of scores after training ($R^2 = 0.412$, Model A, 0.300, Model B).

Both multivariate modeling approaches demonstrated that ongoing health conditions have a robust negative association with risk perception scores (as affected by training). Similarly, worker type (volunteer/professional) is a primary factor influencing the effect of training on anticipated PPE use. Since worker type is an indicator of the training curriculum, changes in anticipated PPE use are shaped by the intensity of the training curriculum workers undergo. Thus, training effectiveness is influenced by long-term worker health and the intensity of the training curriculum. Finally, the best explanatory models incorporated baseline perceptions, indicating that workers' responses to training are largely dependent on their perceptions before training.

4.0 Discussion

4.1 Training effectiveness and worker type

This study indicates that training is effective in increasing overall risk perception and anticipated PPE use in all cleanup workers. Training increased concerns for short and long-term illnesses and resulted in a heightened awareness of long-term health issues after training. Expected PPE use for specialized tasks (mold removal, sweeping, roof

repair) increased significantly, although general gutting tasks (demolition, removal of belongings) did not.

Study findings also suggest that training effectiveness differed across worker types (due to differences in training curriculum). While significant changes in overall risk perception were observed for both worker types, only volunteers experienced significant changes on the level of individual health concerns. Similarly, expected PPE use changed overall for both worker types, but volunteers selected significantly more PPE for all cleanup activities, while professionals chose significantly more PPE only for roof repair. These differences, although influenced by sample size, may also indicate disparities in effectiveness of varying training curricula.

The utility of training is widely supported in private and government-affiliated research, reports, and literature reviews. A comprehensive literature review for OSHA (Sattler et al., 1997) concluded that training was associated with an increased awareness of health and safety concerns in workers. A report by Cohen and Colligan (1998) attributed a decline in injury rates after training to increased awareness, providing further evidence for the observable positive effects of training on workplace health and safety. Due to time constraints, this study did not assess the impact of training on injury or illness rates among cleanup workers, although heightened risk perceptions after training may suggest a protective effect on worker illness and injury.

Existing literature, although confident in training effectiveness, does not clearly delineate the conditions required to maximize the effects of training (Cohen and Colligan, 1998). However, studies have identified key factors affecting training utility including: group size, length/frequency, educational approach, and trainer qualifications. These

factors, which were not controlled for in this study, differ across training type, and may contribute to observed differences in perception changes between volunteer and professional workers.

Finally, this study evaluated training effectiveness by significant positive changes in perception scores rather than by workers' capacity to attain correct perception scores. A comparison of anticipated PPE use scores with a benchmark score would have been useful. However, government recommendations for proper PPE use were not consistent and did not specify appropriate PPE use for all cleanup scenarios addressed in this study. Also, this study examined workers' use of more commonly worn PPE rather than all recommended forms of PPE. Thus, a reliable benchmark for proper number and type of PPE could not be established.

4.2 Training as a predictor for behavior

Although PPE use was not assessed directly in this study, it was evaluated indirectly by measuring anticipated PPE use and perceived barriers to PPE use. Professionals demonstrated greater overall inclination to wear PPE both before and after training and identified fewer barriers to PPE use (# barriers/person). These results suggest that professionals are more inclined toward protective behavior than volunteers.

Proportionally, professionals saw discomfort, affordability, and no need for PPE as greater barriers to PPE use, while volunteers were more concerned with lacking access to proper PPE. Because volunteers were reliant on cleanup organizations for resources, the number and type of perceived barriers may have been shaped by their lack of individual control over available PPE. Professionals were mostly from the affected

region and may have been more concerned with issues, such as discomfort and affordability of PPE, that were more salient to the local community. Thus, these results could represent a level of control and familiarity with cleanup risks instead of an inclination toward safe cleanup behavior.

4.3 Predictors for risk perception and anticipated PPE use

This study identified population characteristics associated with risk perception and anticipated PPE use after training. Poor worker health, defined by the presence of a self-reported ongoing health problem, was a robust predictor of training's effect on risk perception and inclination to wear PPE. Contrary to expectations, prior health concerns were negatively associated with risk and anticipated PPE use scores change score and scores after training. However, workers with prior health conditions had higher risk perceptions scores before training began, thereby limiting the magnitude of change due to training. These results suggest that training is less effective for persons with health problems, since they may already have a heightened awareness of health and safety issues.

Worker type (i.e.- volunteer or professional) was also important in predicting the effect of training on anticipated PPE use, as well as baseline perceptions of PPE. While volunteers experienced greater changes in expected PPE use, they also had lower baseline perceptions of proper PPE than professionals. Thus, training was more effective in encouraging PPE use in volunteers. However, professionals' overall higher perception of risks and anticipated PPE use (both before and after training), as well as lower barrier score, suggest that professionals may tend towards safer behavior than volunteers.

Baseline scores were driven by a mix of experiential and demographic factors. Not surprisingly, previous hurricane experiences increased baseline risk perception, while previous involvement in cleanup increased expected PPE use. Thus, past personal exposure to a risk increased baseline perceptions of that risk and the inclination to minimize the risk. A positive relationship between previous behavioral experience and risk perception has been supported in past research (Cohn et al., 1995), although other research suggests a negative relationship (Gerrard et al., 1996; Halpern-Felsher et al., 2001).

Age and race affected baseline risk perception, as well as perceptions of PPE use after training. In both measures, African Americans exhibited higher perceptions than Caucasians, although differences were only significant for baseline perceptions. These results are likely affected by disparities between professional (mostly middle-age and African American) and volunteer (mostly young adult and white) populations, with significantly higher risk perception and anticipated PPE use in professionals. Past research on risk perception showed weak to strong increases in perception with age (Lazo et al., 2000; Rafaely et al., 2006; Slimak and Dietz, 2006), and higher perceptions of hazards in minority populations (women and blacks) than in majority populations (white males) (Savage, 1993; Flynn et al., 1994).

4.4 Study strengths and limitations

This study provides important contributions to the field of worker protection for several reasons. First, to the author's knowledge, no study has yet examined risk perception and anticipated PPE use together in one analysis. Also, the effect of training

on risk perception and expected PPE use is modeled in two separate ways, allowing for a more informed interpretation of results. Most importantly, this study offers new information on a poorly understood population of volunteer workers and suggests the value of training all workers in post-disaster operations.

Limitations to this study include: the use of a convenience sample, the lack of a control (i.e.- untrained) population, small sample size for professional workers, inability to directly measure worker PPE use and incidence of illness/injury after training, non-uniform training curricula, and a lack of knowledge on workers' previous training experiences. Differences in training curricula within professional and volunteer groups complicate interpretation of results, as observed disparities in perceptions between groups could be exacerbated by one or several especially intense or non-intense training curricula. Finally, workers were not asked about their previous training experiences. Thus, the effect of previous trainings on baseline perceptions cannot be assessed. However, this limitation is likely applicable only to professional worker populations.

Some studies also cast doubt on whether risk perception is a reliable predictor of safe behavior. Rundmo (1997) reports that risk perception is correlated with, but not predictive of, behavior. Other research suggests that risk perception affects behavior under specific circumstances or not at all (Rimal and Real, 2003; Wong et al., 2005). Thus, risk perception may hold limited utility in forecasting worker behavior and should be interpreted with caution.

Finally, a recent study found that people who are open to receiving risk information are more likely to retain it than those who dread and avoid learning about risks (Turner et al., 2006). This suggests that a population bias could have existed

because many trainees were attending training and participating in cleanup out of their own free will and therefore may have been more receptive to risk information. Thus, observed changes in perceptions of risk and expected PPE use, as well as baseline perceptions, may have been inflated.

These limitations indicate that study results may be not generalizable beyond post-disaster scenarios where worker populations (volunteer and professional) receive non-uniform trainings and possess distinctly different worker characteristics (i.e.- differences in age, race, living in the disaster-affected region) that influence risk perception and anticipated PPE use. Also, the results of this study pertain only to separate professional and volunteer trainings and cannot be extrapolated to collaborative training efforts where abbreviated professional trainings are provided to volunteer workers. Finally, the magnitude of devastation following Hurricane Katrina was exacerbated by physical and social vulnerabilities in New Orleans that may not be present in many or most disaster scenarios. Thus, a widespread demand for cleanup workers and a need to train volunteer workers may not apply to less vulnerable communities affected by disasters.

5.0 Conclusion and recommendations

The results of this study agree with the literature suggesting that workers undergoing trainings experience a significant increase in risk perception. However, training intensity may be less important than baseline risk perceptions in determining workers' risk perceptions after training. Even short, non-government approved trainings can produce a significant change in risk perception. Thus, trainings may be a more useful

intervention for volunteers, who had a lower baseline risk perception and therefore greater room for change.

The robustness of an ongoing health condition as a predictor for training effectiveness suggests that other indicators of worker vulnerability should be studied in order to better understand a possible link between vulnerability, higher baseline perceptions, and a smaller effect of training on perceptions. Social and economic stressors, such as race/class tensions and disparities in access to resources, are often present in affected populations after a disaster and may be important determinants of worker responsiveness to trainings.

Studies have shown that training workers as educators increases workplace trust and training effectiveness (Koh, 1995). Volunteer trainers, comprised of on-the-ground cleanup workers, may therefore be successful in enforcing compliance with health and safety goals established in trainings. However, whether uncertified volunteer trainers know and follow proper guidelines for PPE use remains an unstudied factor. Future research should examine whether volunteer trainers advise proper PPE use during trainings, follow their own advice, and whether trainee behavior reflects that of the trainer.

Furthermore, the volunteer worker population participating in Hurricane Katrina cleanup efforts was demographically different from the professional population. Although this variability may not hold for future disasters, research should consider how key demographic differences such as age affect training utility for different worker types. EPA Brownfields worker training programs, which train residents in environmental cleanup practices, should be evaluated and compared to OSHA trainings in order to

elucidate the effect of worker characteristics on training utility in worker populations with existing or non-existing backgrounds in emergency response (EPA, 2006).

Anecdotal evidence collected in this study also suggests that diverse use of media and institutional information sources affects worker perceptions of risk and proper PPE use, and may be important predictors of training effectiveness. Future research should explore how workers' varying use of information sources affects baseline risk perceptions.

In order to better elucidate the effect of training on worker health and safety, future studies should employ consistent training curricula when possible and follow workers through time to document behavior and possible health outcomes including injury and illness. However, consistent interventions and worker follow-up studies are very difficult to maintain in the wake of a disaster. Cleanup needs limit the time and resources dedicated to worker training, and changing worker populations restrict tracking capacity. Thus trainings given in advance of disasters, when time is less constrained, will continue to provide valuable opportunities for understand training utility as an educational tool, but not as a determinant of worker behavior and health.

From a policy perspective, government-approved trainings are not practical nor are they necessary for all worker types. As demonstrated in this study, community groups provide effective health and safety trainings to volunteers. As a result, they will be important players in policy efforts to broaden training availability to volunteer worker populations. However, community organizations would benefit from dialogue and exchange of ideas with government agencies experienced in designing, implementing, and evaluating trainings. Volunteer trainings can be further improved by adopting

elements of standardized, OSHA approved training curricula that have been shown to be effective in practice. Thus, government organizations involved in worker protection, such as OSHA, CDC, and the National Institute of Environmental Health Sciences (NIEHS), should assist community organizations in incorporating successful elements of OSHA approved trainings into their own training curricula and in developing a framework for periodic evaluations of their trainings.

Much work remains in ensuring adequate protection of cleanup workers after disasters. The changing climate and human disturbance to our environment will continue to provide unique opportunities to evaluate and improve worker protection strategies in post-disaster cleanup situations. Training is a highly adaptable intervention that positively affects perceptions of diverse worker populations. This study shows that even cursory trainings are useful for volunteers, although volunteers may benefit more from trainings of greater intensity. Thus, health and safety trainings should remain a critical educational tool and should be expanded and adapted to meet the needs of the ever-changing and mobile worker population.

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