

HUMAN BEHAVIOUR IN FIRE

4th International Symposium

July 2009
Cambridge, UK



London, UK

Proceedings of the 4th International Symposium on Human Behaviour in Fire 2009

held at the Robinson College, Cambridge, UK
13-15 July 2009

A conference organised by:
Interscience Communications Ltd
West Yard House, Guildford Grove,
LONDON SE10 8JT, England

Human Behaviour in Fire 2009

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ISBN 978-0-9556548-3-1

p680, 134 tables and 276 illustrations

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THE WORLD TRADE CENTER EVACUATION STUDY: FACTORS ASSOCIATED WITH EVACUATION TIME AND INJURY

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INTRODUCTION

The World Trade Center Evacuation Study (WTCES) was designed to identify the individual, organizational and structural (environmental) factors that were significantly associated with three major study outcomes associated with evacuation: length of time to initiate evacuation, length of time to fully evacuate either World Trade Center (WTC) Tower 1 or Tower 2, and risk of injury. By identifying and better understanding these factors, the study aimed to inform improvements in high-rise building design, codes, standards, and evacuation procedures in order to reduce or minimize the risk of harm in the event of other extreme high-rise emergencies. The study was unique in several major ways, including the incorporation of a participatory action research (PAR) framework to guide the study design and implementation. The WTces was also novel in that it was conducted from a public health perspective, thereby utilizing epidemiologic methods to collect and analyze data. The WTces study team, led by public health preparedness experts, benefited from the input of a large, interdisciplinary Advisory Board, comprised of disaster and fire safety specialists, high rise building engineers, public health experts, and ethicists. Because of the study's public health perspective, it was designed to identify population-based recommendations for risk reduction rather than more individual-based strategies. Therefore, the recommendations tend to target organizational-level risk factors, although the importance of individual risk factors and risk management strategies are also considered.

The five-phase study, which unfolded over a period of slightly less than 4 years, utilized a mixed-methods approach, incorporating both qualitative and quantitative methodologies, all guided by the participatory action research framework.¹ From the earliest inception of the project, and in keeping with published guidelines on the ethical conduct of disaster research, study participants (i.e., WTC evacuees) and other key stakeholders were involved in formulating the study questionnaire, data collection procedures, and feedback and dissemination plan. At the conclusion of the data analysis phase, two PAR teams were formed. These were comprised of WTC disaster evacuees and study investigators, with outside expert advice from consultants with a wide range of expertise, including fire safety, disaster mental health, emergency planning, occupational safety and high-rise building management. Over an extended period, lasting several months, the team members worked closely to identify strategies that would address the most significant risk factors that impacted the three major study outcomes. The overarching goal of this process was to improve emergency preparedness processes and procedures for high-rise buildings. The final recommendations developed by the PAR teams were presented at two conferences, one designed for the lay community, including WTC survivors, families and friends of the WTC decedents, and members of the general public, and another for the scientific community, including fire safety, emergency preparedness, and disaster researchers and practitioners. In both of these conferences, representatives from the Fire Department, City of New York presented the new landmark fire codes for high rise buildings in New York City.² Study investigators were honored to be a part of this landmark legislation by being invited to participate in the development of guidance and implementation plan documents for the New York City Emergency

Action Plan Directors (§9-08). This involvement brought the WTCEs full circle into the application of findings into practice to reduce risk.

This paper provides an overview of the study methods and study findings, and presents the data-driven recommendations of the PAR teams.

STUDY METHODS

Participatory Action Research

This approach to research involves the active engagement of study participants in the research process. Increasingly applied to a range of research activities, it is seen as enhancing not only the ethical conduct of research but also the research itself. The WTCEs investigators decided to apply this framework, which is based on the recently published guidance of renowned disaster researchers, including Dr. Alan Fleischman, who served as the Chairman of the WTCEs Advisory Board. Under his leadership and the published guidance, every aspect in each phase of this lengthy study applied, where feasible, the tenets of PAR.³ These include conducting research that has the following attributes:⁴

- 1) is *participatory*, i.e., study participants are involved in all phases;
- 2) is *collaborative*, i.e., researchers, consultants, and study participants all contribute their expertise and, to the extent possible, share decision making and control of the research process;
- 3) fosters *co-learning*, i.e., skills and knowledge are exchanged in a reciprocal manner between all parties, with special emphasis given to the expertise study participants have regarding their personal experiences, their organization, or their community;
- 4) involves *system development*, i.e., the system or group utilizes the competencies of each party in order to engage in the multi-stage research process;
- 5) is *empowering*, i.e., all partners gain influence and control through their participation;
- 6) *balances knowledge generation and intervention development*, i.e., strikes a balance between generating knowledge and developing interventions or policies for the mutual benefit of all parties.

Because PAR involves an empowering process that emphasizes collaboration, knowledge generation, and co-learning among participants and researchers,⁵ it is especially effective at identifying systems-level, organizational change.⁶ Since the utility and effectiveness of the PAR framework has been most promising in the field of occupational safety and health, this approach is known to be useful for identifying and implementing risk management strategies, similar to what is needed in disaster preparedness.^{4,6-9} Also, since PAR methodology has been demonstrated to be particularly effective in worksite health promotion, due to its inherent ability to create a climate of trust between researcher, labor, and management participants, it is ideally suited to help support individual behavior change within the context of organizational change. Recommendations promulgated by PAR teams are more likely to be acceptable to all stakeholders when stakeholder representatives are involved in the process.

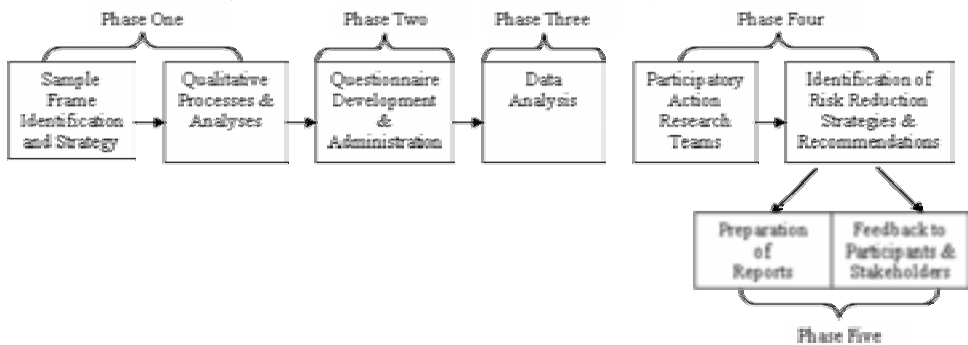
Although rarely if ever used before, at least to this extent, the research team felt that the PAR process was especially suitable for this workplace disaster research and especially for the identification of risk reduction interventions for several reasons.¹⁰ First, the involvement of WTC disaster survivors as members of the PAR teams added to the value of the data, which was collected from survivors in the form of first person accounts and survey data. As survivors, evacuees were in a unique position to review the data and to make meaningful contributions to the research team's understanding of the findings. In other words, they could and did help to *interpret* the data from their perspective. The opportunity to learn from their first hand experiences was invaluable. Second, by having professional researchers, members of the study population, and expert consultants participate and collaborate in a co-learning process, PAR teams are likely to generate recommendations that are innovative, relevant,

and practical. These are relevant in the context of high rise risk reduction. Third, participation in the PAR process itself may be both psychologically beneficial and empowering for disaster survivors.¹¹⁻¹³ PAR participation was found to be helpful in this study, and additionally was helpful to the study team since many, if not all, of the team members also experienced signs and symptoms of secondary exposure to traumatic event. Participation in the process of research can be uplifting for disaster survivors, as their valuable contributions to scientific knowledge may be potentially life-saving for others. For all these reasons, disaster research conducted within the framework of PAR, wherever feasible, is highly recommended based on our experience, as we found it to be both an ethical and valuable approach for identifying risk-reduction strategies.¹

Study Design

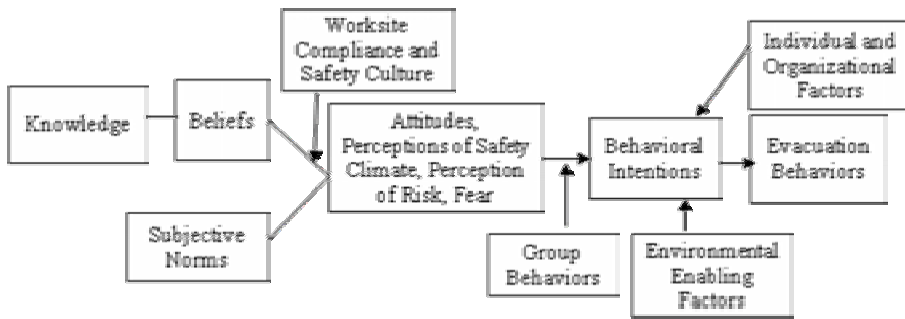
The WTCEs was guided by a multi-year, five phase study design (see Figure 1) to identify factors that affected the length of time to initiate and complete evacuation from the WTC Towers 1 and 2 on September 11, 2001, controlling for a number of variables such as use of elevators, as well as risk factors for sustaining an injury during the evacuation process. Data were collected using both quantitative and qualitative procedures, including key informant interviews, in-depth interviews, focus groups, and the administration of a 95-item questionnaire, which could be completed either online or by mail.

Figure 1. World Trade Center Evacuation Study overview¹⁴



In close collaboration with the Advisory Board, a conceptual framework (Figure 2), which was guided by a theoretical model modified from DeJoy’s Behavioral Diagnostic Model,¹⁵ (which itself is an adaptation of Green’s PRECEDE model),¹⁶ along with concomitant study constructs (Table 1), was formed to guide the development of data collection tools. Prior to data collection, several measures were taken to ensure that all study procedures were in full compliance with published recommendations for research involving disaster victims and survivors.³ These recommendations are: (1) to assess decisional capacity of potential participants, (2) to assess vulnerability of research subjects, (3) to carefully weigh and balance risks and benefits of research participation, and (4) ensure informed consent. For example, to assess vulnerability, a *Pre-Screen test* was developed to help identify participants with post-traumatic stress disorder symptoms so that they might be deferred from participation and referred into treatment if requested. To determine the impact of participation on participants’ well being, *Post-Screen tests*, at multiple time periods, were conducted as well. One of the primary risks to participation, in addition to the adverse impact this might have on the mental health and well being of participants, was the potential loss of confidentiality. For this reason, we requested and obtained a Certificate of Confidentiality from the National Institutes of Health. Altogether, the study involved 10 separate consent forms and disclosure statements, a testament to the study’s strict adherence to university and national guidelines on the ethical conduct of research. Following the implementation of the ethical protocols, the first steps towards data collection began, as described below.

Figure 2. Model used to guide the key and sub-hypotheses of the study



PHASE ONE: QUALITATIVE PROCESSES

Participant recruitment began several months into the study period, which was 18 months after the WTC attack. To enroll study participants into the qualitative study processes, a multi-media campaign was launched to encourage survivors to self-select into one of two qualitative procedures (i.e., in-depth interviews or focus groups). Using a prepared semi-structured script, which addressed the study constructs, experienced and trained doctoral level psychologists and social scientists conducted 30 semi-structured interviews and five focus groups. Each interview and focus group was two to two and one-half hours in length, and each session was tape-recorded and later transcribed for analysis, resulting in approximately 3,000 pages of transcribed data.

The data were analyzed using an eclectic approach that utilized manifest and latent thematic coding as well as deductive and inductive data analysis procedures. Point comparisons were made between the investigators' coding; inter-rater reliability was assessed and found to be extremely high ($kappa = 0.92$). Each transcript was re-read in order to perform manifest analysis, in which key words and phrases were collated. Major themes were then identified and coded into three major categories: individual, organizational or environmental factors. Latent thematic analysis of each factor was then conducted, and each factor was characterized as either a facilitator or barrier to evacuation.

Utilizing a deductive analysis process, each identified factor was then mapped to the original theoretical model. (Predefined constructs of the initial model are listed in Table 1). Afterwards, an inductive analysis approach was taken to identify additional factors and themes that were not included in the original model. The final goal of this analysis was to examine evacuation behaviors and the social and structural processes that helped to form these behaviors.

The result of these analyses led to the identification of a number of barriers and facilitators at the individual, organizational and structural (environmental) levels.¹⁷ At the individual level for instance, facilitators to initiation of the evacuation process included prior experience in evacuation in the aftermath of the 1993 WTC bombing, exposure to numerous sensory cues, and knowing the steps to take to begin evacuation. Barriers at the individual level included delaying behaviors, concern regarding physical capability to effect a full evacuation using the fire stairs, and hesitation for fear of adverse impact that evacuation would have on their employment. Lack of knowledge was also seen as a deterrent to rapid initiation. At the organizational level, facilitators included direction by authority figures or hearing directions given by persons with authoritative voices. The organizational barriers included lack of authority figures, and ambivalent or contradictory messages. At the structural level, facilitators included a wide range of building cues, such as smelling smoke or lights flickering. The barriers to initiation included communication failures.

Human Behaviour in Fire Symposium 2009

Table 1. Model constructs and predefined characteristics

Construct	Characteristics	Major Factor Category
Attitudes, perceptions of safety climate, perception of risk, fear	The individual's perceived risk to self, as well as his/her perception of his/her employer's commitment to safe work practices	Individual
Behavioral intentions	The behavioral intentions regarding evacuation	Individual
Beliefs	Belief in one's own ability to determine the need for evacuating and belief in one's capability to do so	Individual
Environmental enabling factors	The physical environment facilitators which helped evacuee during the evacuation	Environmental
Evacuation behaviors	Specific actions taken by the individual evacuee regarding evacuation	Individual
Group behaviors	Collective behavior of a group of individuals	Individual and organizational
Individual and organizational factors	Specific characteristics of the individual or organization that might affect evacuation	Individual and organizational
Knowledge	The individual's awareness and understanding of evacuation protocols and procedures, as well as possible means of egress from the building	Individual
Subjective norms	Basic understanding of what was considered to be appropriate for the situation within the context of the social work environment. Influence of co-workers and supervisors	Organizational
Worksite compliance and safety culture	Safety practices and procedures of employers, and the managers, and fire safety personnel of the WTC buildings	Organizational
Sensory Cues*	Emergent cues in the environment (e.g., smoke, fire, noise, alarms, etc.) that serve to make the individual aware of an event	Individual
Instinct*	Instinctive sense ("gut feeling") of danger	Individual

*dotted lines denote factors added to the original model based on qualitative findings

In terms of the full evacuation process, a number of individual facilitators were identified, including both prior training and experience in evacuation, high level of knowledge of the building itself, wearing comfortable footwear, and following the crowd down and out of the building. The barriers to continued evacuation included poor physical condition, including obesity and other health problems, and inappropriate footwear. At the organizational level, management leadership and direction facilitated movement, as did the encouragement of the first responders when evacuees encountered them on the stairs and in the lobby. Adaptive and pro-social behavior of evacuees on the stairs was a facilitating factor. Barriers included lack of direction once evacuees reached the street level. Structural facilitators included continued building-related sensory cues, as well the relatively sound condition of the fire stairs. Structural barriers included periodic crowing on the stairs, debris and deteriorating conditions on the stairs, and locked or blocked doors preventing egress onto certain floors when evacuees' passage was slowed or blocked by slow moving persons. At the lobby level, some evacuees reported that others were shoving to get out onto the street.

Human Behaviour in Fire Symposium 2009

Many of these conditions were time dependent, i.e., early evacuees did not encounter deteriorating stairwell conditions, whereas this was frequently noted by later evacuees. Injuries were mainly related to the initial impact, with survivors closest to the impact zone most likely to be injured. Injured persons were naturally slower both to initiate evacuation and to progress through the process.

These findings were instrumental in designing the study questionnaire, which was implemented in Phase Two described below.

PHASE TWO: QUESTIONNAIRE DEVELOPMENT

The questionnaire was developed with input from the Advisory Board over a period of several months. As noted, it was based on a modification of a theoretical model which was particularly suitable to addressing both worker-centered constructs as well as organizational safety attributes, sometimes referred to as organizational “safety culture.”¹⁸ The adapted model also took into account the impact of organizational determinants (enabling factors) that employees actually apply in the adoption of safety behaviors (e.g., emergency lighting that allows employees to exit when the power fails, width of egress doors, number of stairwells, etc.). Thus, this new model emphasized the inter-connectedness between the individual and the work environment. The model also illustrates the importance of risk beliefs and attitudes in precaution adoption in the workplace. Major constructs included items related to: the job, such as the work setting (corporate versus small private business), location (floor), size, structure, as well as job/task variables (e.g., work load, work pace, demand/control issues etc.). Other organizational variables, such as safety culture, and enabling factors, such as whether the local worksite had an on-site safety officer, fire marshal, or other safety professional, and the presence of emergency safety manuals, emergency response training, evacuation drills, emergency call system, chain of command, etc., were also considered.^{19,20} Psychosocial variables, such as influence of subjective norms (measured by items related to co-worker and supervisor attitudes), that might affect emergency-response practices were also considered. Employee perceptions, including risk assessments, risk and efficacies of protective actions, safety climate perceptions, as well as attitudes and beliefs, were also important constructs to measure. Employees were asked about evacuation intentions and behaviors, the dependent measure. Finally, individual factors, such as sociodemographics, health status, disabilities, job tenure, prior experiences, etc., were also considered.²¹

The final study draft underwent survey validation processes, including content, criterion and construct validity procedures. The final draft questionnaire also underwent extensive cognitive testing and pilot-testing, including pilot tests of the internet version of the questionnaire. The final study questionnaire (both versions) was 10 pages in length and consisted of 95 items. Response categories predominantly included multiple choice items, although three questions were open-ended. Copies of the study questionnaire and code book are available from the study principal investigator (Dr. Robyn Gershon).

Recruitment for the self-administered WTCS questionnaire was based on two sources: (1) a large, random sample of WTC employees and contractors selected from the security badge list obtained with the cooperation of Port Authority of New York and New Jersey and from Silverstein Properties (the landlord for the WTC) and, (2) the NYC Department of Health and Mental Hygiene (NYC DOHMH) Registry.

From these sources, information on former occupants of the buildings was obtained. This included contact information, including, the name of the occupant, his or her firms’ name, tower and floor location, and badge type (i.e., Port Authority employee, leaseholder employee, contractor, service employee, etc.). Current contact information for each leaseholder was then updated by the research team where possible. Approximately 60% of the list was able to be fully updated. Approximately 25% of the leaseholders went out of business, and approximately 15% returned to their country of origin, and no longer have U.S.-based branches. Both of these groups of persons had to be removed from the database. Names of all persons who died in the September 11, 2001 WTC terrorist attack

were also removed from the database. After this cleaning of the database, the research team selected a random sample of 20,000 names using a computer program to generate the sample; each name was then assigned a random encoded number. The WTCES investigators then attempted to contact as many of this group of WTC evacuees as possible. Recruitment letters were mailed to the current address of the person's WTC employer, with a note on the envelope requesting that the envelope be forwarded to new work addresses, if known. The recruitment letter included a postcard for potential participants to complete and return to the study office. The postcard provided two options to participate: (1) Instructions to access the survey online using a pre-assigned password, or (2) the option to receive the questionnaire by mail with a pre-paid return envelope provided. Nearly 800 questionnaires were returned after this phase of recruitment. Concurrently, the research team also mailed recruitment letters to the entire sample frame of NYC Department of Health and Mental Hygiene registry participants who indicated that they had evacuated the WTC and who agreed to be contacted by other researchers. From an initial single mailing of approximately 3500 questionnaire packets, over 1000 were returned. A total of 1767 questionnaires were completed online or in the paper version. Of these, 1441 had actually evacuated the towers on September 11, 2001 and thus constituted the final sample.

PHASE THREE: DATA ANALYSIS

Data from the questionnaire pilot testing was examined to determine the quality of data obtained for each item. This included checking for floor and ceiling effects, bimodality, consistency of response (cross-validation), response set, etc. Exploratory factor analyses were conducted after the questionnaire was piloted. Factors were retained based on their eigen values and the factor loadings obtained using orthogonal varimax rotation. This enabled us to refine the scales and shorten the final questionnaire.

Once the full dataset was finalized, and after checks for internal reliability and validity of responses and other data editing procedures were completed using a variety of statistical software packages, we performed an array of descriptive statistics (e.g., frequencies, histograms, and measures of central tendency and dispersion), and graphical techniques to characterize the distribution of variables, starting at the most refined level of measurements. This strategy provided familiarity with the data and allowed us to determine if the data met assumptions required by the intended statistical testing procedures.

Once individual variables were validated, confirmatory factor analysis was applied to all scales. Subsequent analysis used the scales derived from these analyses. Analyses then proceeded as follows:

We determined the scale statistics for each of the constructs measured: (1) evacuation-related behavioral intentions and actual behaviors; (2) individual characteristics (e.g., beliefs, knowledge, attitudes, perceptions) as well as sociodemographic and health status factors; (3) organizational factors (e.g., worksite readiness for evacuation, including training and drills, communication systems and processes, organizational culture, group behavior, etc.); (4) structural elements associated with evacuation (e.g., physical structures, egress paths, stairways, etc.). Next, we determined confidence intervals as well as point estimates that were utilized to estimate population values on all variables. We also determined the prevalence of emergency preparedness by determining the degree of worksite compliance with various compliance elements.

We determined the effect of all three major categories of factors (individual, organizational, structural) on evacuation intentions and behaviors. Procedures appropriate to this goal included a variety of bivariate statistics such as chi-squared and odds ratio statistics, analysis of variance, etc. Descriptive statistics for subsamples of interest, such as type of workplace, size of work population, and worker-related variables, such as gender, language, age, and health status (physical challenges, etc.,) were also performed. Contingency tables with appropriate statistical tests were constructed to test for differences in key variables between organizational subsamples.

Human Behaviour in Fire Symposium 2009

We then determined the independent and joint relationship of these factors with evacuation outcomes. Variables that were statistically significant in the bivariate models were incorporated into multivariate models where feasible. Given the multitude of significant variables at each level, we did not perform final regression models. Interactions between the predictor variables (evacuation timeliness) and potential modifying variables (e.g., safety climate, influence of subjective norms) were tested for each dependent variable (i.e., intentions and behaviors). We tested a number of multivariate regression models using statistical techniques depending upon the nature of the outcome to be analyzed.

PHASE FOUR: RESULTS

Characteristics of the Sample

Sample demographics were similar to characteristics of the New York City Department of Health and Mental Hygiene registrants from the WTC Towers 1 and 2 and also similar to 1993 evacuees²². The sample is described in Table 2 below.

Table 2: Demographics (n=1444)

Gender	58% male
Age, mean yrs	44 yrs
Age, range	22-80 yrs
Tenure, mean	6 yrs
Tenure, range	0-37 yrs
Marital status	70% married/partner
Children	48%
Race	80% Caucasian
Education	66% college or higher
Employment	84% private company
Union membership	7%

Outcome Variables

On average, evacuees delayed their initiation for six minutes. Roughly the length of time to fully evacuate varied significantly by tower, as shown in Table 3 below.

Table 3. Key Time Periods

	WTC 1 range:	WTC 2 range:
First became aware:	8:46-9:20	8:46-9:02
Made decision to leave:	8:46-9:30	8:46-9:30
Began to leave	8:46-9:30	8:46-9:30
Reached street level	8:46-10:28	8:46-9:58
Length of Time to Initiation:	WTC 1 and 2 combined Mean: 6 Minutes Range: 1-44 minutes	
Length of Time to Descend:	WTC 1 Mean: 42 minutes Range: 1-96 minutes	WTC 2 Mean: 27 minutes Range: 0-70 minutes

Injuries

Injuries were prevalent during among evacuees; 37% experienced one or more injury. The most commonly reported were: surface trauma (12%), inhalation trauma (11%), orthopedic injury (7%), eye injury (4%), and general trauma (4%). These injuries were consistent with the NYC DOHMH registry data.²³

Factors associated with initiation of evacuation

The primary factors leading to delays was difficulty locating fire exits, followed by a lack of leadership. Poor signage and a public announcement (Tower 2) that advised occupants to remain in place were also significantly associated with delays.

Factors associated with length of time to full building evacuation

The key factors that extended the length of time to fully evacuate the buildings included any physical disabilities or impairment, including injuries sustained during the attack, and delaying activities, such as stopping to make phone calls or to rest. Structural conditions, such as any environmental condition, and damaged or crowded stairwells, also led to significant delays. Organizational preparedness was significantly associated with both initiation and progression delays, generally through lack of familiarity with buildings, knowledge gaps related to exit locations (including fire stairs), lack of participation in drills, and fear of employment consequences.

PHASE FIVE: DEVELOPMENT OF RECOMMENDATIONS AND DISSEMINATION

Participatory Action Research (PAR) Teams

PAR teams were formed in order to identify data-driven opportunities for improvements. We organized teams of evacuees recruited from the WTC 1 and 2, and then combined both teams to work together to develop recommendations for improvement. We included key informants, as well as experts in the field of evacuation, fire safety and structural design, emergency, etc., as consultants to the teams. Periodically, the teams were joined by our study trauma psychiatrist. The teams' activities were organized using the Joiner methodology²⁴. Results of the teams' deliberations were disseminated in several ways. First, by a publication of team findings¹, second, by two well-attended conferences, one for the scientific community and the other for the lay community. The recommendations are summarized in Table 4 and 5 below. Additional information about the study, as well as links to WTCEs publications can be found at the WTCEs website: <http://www.mailman.hs.columbia.edu/CPHP/wtc/>.

Human Behaviour in Fire Symposium 2009

Table 4: Risk Factors that Delayed Initiation of Evacuation

Risk Factor	Recommendations for Improvement by Category (I=individual level, O=organizational level, S=structural level)
1. Seeking out others to form a group for mutual support and information-sharing during evacuation	<ul style="list-style-type: none"> • Participate in group activities both within company and on the floor where office is located (I) • Have multiple sources of communication available (e.g., battery operated radio) (I) • Provide wireless cellular telephones for the safety team members (O) • Link company computers to television stations, emergency broadcast announcements (e.g., NYC Office of Emergency Management) (O) • Limit non-emergency public address (PA) announcements to only those that are necessary (O) • Link all communication sources to 1 main broadcast site (S)
2. Personal concerns about own health and ability to evacuate	<ul style="list-style-type: none"> • Individuals should conduct self-assessment of their capability and time needed to fully evacuate (I) • Individuals should inform the building's safety personnel of any special evacuation needs (I) • Preplan for persons with disabilities (O) • Perform evacuation drills for persons with special evacuation needs, including situations in which elevator does not function (O)
3. Individual behaviors that delayed initiation of evacuation (e.g., gathering items, making phone calls, work related tasks, waiting for directions or permission to leave, changing shoes)	<ul style="list-style-type: none"> • Maintain an emergency "go bag" at desk (I) • Delay calls until completely exited (I) • Take ownership of personal safety actions (i.e., act independently) (I) • Wear sensible footwear that will facilitate rapid evacuation (I)
4. Uncertainty about which evacuation route to take including: exit locations, staircase endpoints, roof access, locked re-entry points, when to use elevators	<ul style="list-style-type: none"> • Compliance with training and drills (I) • Facilitate a workplace climate for emergency preparedness (O) • Enforce training and education of all employees for evacuation (O) • Enforce mandatory drills that involve entry into the staircase and various routes for terminal egress (O) • Color code the exit doors so that their location (e.g., N, S, E, W) is clear to help orient employees (S) • Post signage that indicates where staircases terminate (S)

Table 5. Risk Factors that Increased Length of Time of Evacuation

Risk Factors	Recommendations for Improvement by Category (I=individual level, O=organizational level, S=structural level)
1. Lack of knowledge and poor emergency preparedness of workers	<ul style="list-style-type: none"> • Active participation in training and drills (I) • Promote an organizational emergency preparedness safety culture/climate from top down (O) • Conduct specialized safety training for senior management (O) • Foster employer ownership of safety training and climate, accountability enforced by building owner (O)
2. Footwear that inhibited rapid exit down stairs and through lobby debris field	<ul style="list-style-type: none"> • Encourage wearing sturdy, closed toe, flat soled footwear in the workplace (O)
3. Staircase characteristics (e.g., width, design, access)	<ul style="list-style-type: none"> • Widen staircases where feasible (S) • Consider drainage for water on stairs (S) • Assign widest staircases for evacuation and accommodation of persons using wheelchairs (S) • Assure that doors to floors off of stair wells unlock during emergency (S)
4. Complex building design caused confusion	<ul style="list-style-type: none"> • Design high-rise buildings that are intuitive and easy to navigate (S)
5. Suboptimal workplace emergency safety climate	<ul style="list-style-type: none"> • Ensure an organizational safety culture including emergency preparedness from top down (O)
6. Inadequate communication system infrastructure	<ul style="list-style-type: none"> • Ensure a working emergency generator and PA system (S)
7. Procedures for evacuation of persons with health conditions or disabilities	<ul style="list-style-type: none"> • Practice use of evacuation chairs by co-workers or response team (O) • Preparedness planning for persons with disabilities (O) • Assign buddies for evacuation of persons with disabilities (O) • Pass new regulations to protect persons with disabilities (O) • Assure confidentiality of information about persons with disabilities (O) • Perform special evacuation training/drills for persons with disabilities (O) • Keep extra wheelchairs at lobby level for persons with disabilities (O)

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Human Behaviour in Fire Symposium 2009

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