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Paper:

How did People Respond and Evacuate in WTC Twin Towers in 2001?

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When the twin towers of the World Trade Center were attacked on September 11, 2001, thousands of people were able to evacuate the complex before the buildings collapsed. This paper describes the evacuation of the two towers, based on an analysis of first-person accounts that began to appear in the media immediately after the incident. In all, accounts from 435 survivors who were present in the towers at the time of the attack were reviewed. Using a questionnaire adapted from a study of an earlier evacuation of the towers in 1993, the accounts were 'interviewed.' Results of the analysis provided information on the location of occupants, their initial awareness of events, the conditions and obstacles they encountered during their evacuation and the time taken to evacuate. The evacuation is compared to events in 1993. Other studies of the evacuation in 2001 are described briefly.

Keywords: human behavior, egress, emergency decision making

1. Introduction

An estimated 17,000 people were able to evacuate the twin 110-story towers of the World Trade Center in New York City that were attacked on September 11, 2001 [1]. The event began at 8:46 a.m., when a hijacked Boeing 767 from Boston bound for Los Angeles struck the north tower (WTC1) between the 94th and 98th floors, effectively eliminating stairwell access for everyone above the 93rd floor. At 9:03 a.m., a second Boeing 767 bound for Los Angeles from Boston struck the south tower (WTC2) between the 78th and 84th floors, at a slight angle that left one stairwell available for a short period of time [2]. Many occupants of WTC2 began their evacuation when they heard or witnessed the attack on WTC1. As a result, an estimated 75% of the occupants of the upper floors of that tower began their evacuation in that 16-minute period and were able to reach floors below the impact point before the tower was struck [1].

At 9:59 a.m., 56 minutes after it was struck, WTC2 collapsed. Approximately 29 minutes later, WTC1 collapsed. The death toll released by the City of New York in October 2003 was 2,752, including building occupants and first responders.

Each tower, at full capacity, could host approximately 25,500 people, including visitors [1], but given the timing of the attack there were far fewer people in the building. Despite the almost 3,000 fatalities that day, it was, to a great extent, an extremely successful evacuation of the two towers [3].

The findings discussed in this paper are based primarily on an analysis of first-person accounts that appeared in the media after the incident [4]. Other, larger, studies of the evacuation were undertaken over the next few years following the incident and will be described briefly here. These studies shared a disadvantage in that they started at least a year after the incident, when memories for certain details may have faded and access to witnesses may have been reduced.

The evacuation of the World Trade Center on September 11, 2001, will also be compared with the evacuation that occurred after a fatal bombing incident in 1993 that resulted in the evacuation of both towers.

2. Purpose of this Evacuation Study

There were two principal objectives to be achieved by studying the World Trade Center incident. First, even though there was a horrifically high loss of life in the attacks, many things were done right that kept the loss from being much higher, and it was important to capture and recognize those lessons, considering, particularly, the improvements that were made to the emergency plans and provisions for the towers after the 1993 bombing. A study of the evacuation on September 11 could demonstrate their life-saving effectiveness. Also, as in any post-fire human behavior study, there is great value in documenting the evacuation process, the timing of people's actions, the information available to the occupants and how they used that information.

Second, although the unique circumstances of the incident might call into question the wisdom of certain strategies and messages – like defend-in-place strategies, reliance on voice communication announcements and phased evacuations – it was important to develop enough information to allow this experience to be incorporated into fire safety program and message recommendations while not over-reacting and creating a situation where society constantly guards against a repeat of this

incident with strategies and behaviors that could worsen losses in other, more common types of incidents. It was necessary to consider the potential impact of the building collapses on future fire safety training and education for high-rise building occupants, especially in terms of any long-term negative effect on safety messages concerning various evacuation strategies and use of voice communication systems.

In 1993, after the terrorist bombing that resulted in the evacuation of the towers, a study was done based on written questionnaires sent to members of the fire safety team. Given the destruction of the towers on September 11, and the losses to the fire department and the Port Authority of New York and New Jersey whose cooperation in that study had been essential, it seemed that a similar study would be impossible in the near future, if ever. In the days following the tragedy, the National Fire Protection Association, in collaboration with the National Research Council of Canada, undertook to collect survivors' stories to document the event, in case no more structured project could begin in a timely manner.

3. First-Person Account Methodology

First-person accounts were found in newspapers and books, on radio and television programs, in e-mail exchanges and on a variety of websites. During the first three months, more than 280 accounts were assembled. In the end, over a period of 18 months, a total of 745 first-person accounts were collected, some of which had been published up to 14 months after the event. Although media accounts do not provide the scientific rigor of a proper study, they do present important insights into the events of the day. The large number of accounts that were found, the level of detail in some of these accounts, as well as their time of publication, which for many was much closer to the event than any human behavior and evacuation research could be conducted, supported the decision to conduct an analysis of the first-person accounts.

The objectives of the analysis of the first-person accounts were to gain insight into the variability of human behavior and response time displayed during the evacuation, with the findings to be used as a guide for future research. Data gathered would help to create a better understanding of individual experiences of occupants in specific locations by documenting, to the extent possible, the information available to the person, and the conditions on their floor and along their evacuation route.

To analyze the content of the first-person accounts, a questionnaire tool was developed and used to 'interview' each account. The questionnaire had 33 questions such as: "On what floor was the person?," "What was the first cue of the event?," "Was the person injured?," "What were the conditions in the stairs?." Not every account provided answers for all 33 questions, since some accounts lacked certain details, but this is similar to a respondent who does not answer some questions in a survey.

All the accounts were reviewed independently by two researchers who summarized the responses into a matrix. When completed, the matrix summaries were compared, and any discrepancies were discussed and resolved. Once the 745 first-person accounts were summarized, multiple accounts from the same person were merged into one, as some survivors provided multiple accounts through different sources. This process provided accounts for 465 individual survivors.

Based on the responses to each question, a coding scheme was developed and each individual's account was coded. Before any analysis began, the database was further limited to the 435 civilians who were in either WTC1 or WTC2 at the World Trade Center on that day when the attacks occurred.

The statistical analyses conducted for this study were essentially confined to descriptive statistics to organize and summarize the information. Inferential statistical tests were not conducted since the data obtained was not a representative sample of the population. Results presented in this paper cannot be generalized to all occupants in the tower during the event. The terms 'the occupants' and 'the survivors' as used here refer only to the accounts that were included in the study.

4. Findings from the NFPA/NRCC First-Person Accounts Study

4.1. Demographics of Sample Population

The sample contained accounts from 435 survivors, ranging in age from 20 to 89 years old (mean = 39.5, SD = 11.8). The total sample contained accounts from 314 men and 118 women; with three accounts not mentioning gender. The substantially higher number of men in the sample may be because there were more men working in the two towers than women or because men might be more likely to talk to the media than women.

Among the subjects in this study, 27 mentioned that they had some sort of disability. Three were wheelchair users, three had hearing impairments and two were visually impaired. Another 19 mentioned physical challenges such as a heart condition, asthma or obesity.

Of the 435 survivors, 251 were located in WTC1 (58% of the sample) and 184 were in WTC2 (42%). In WTC1, 90 people (36%) were from upper floors (77-110), 79 people (31%) were from the middle stratum (43-76) and 58 people (23%) were from the lower floors. Another 22 people (9%) were in elevators and two people did not specify a location. In WTC2, 94 people (51%) were from the upper stratum, 57 people (31%) were from the middle, and 28 people (15%) were from the lower levels of WTC2; five people did not specify a location. The distribution of accounts in the two buildings was not identical, but reports were obtained from the three strata in both buildings. The distribution is shown in **Table 1**.

The largest proportion of accounts came from evacuees who started from the higher floors. This may be a reflection of the media's interest in potentially more com-

Table 1. Initial location.

	WTC1, N=251	WTC2, N=184
Upper floors (77^{th}-110^{th})	90 people (36%)	94 people (51%)
Mid floors (43^{rd}-76^{th})	79 people (31%)	57 people (31%)
Lower floors (42^{nd}-Basement)	58 people (23%)	28 people (15%)
Elevator	22 people (9%)	––
Location not specified	2 people (1%)	5 people (3%)

Table 2. First cues of event within the towers.

First Cues	WTC1, N=212	WTC2, N=145
Building movement: felt building sway, tremble, jolt	146 (69%)	30 (21%)
Audible cues: heard explosion, crash, rumble	107 (50%)	69 (48%)
Visual cues: saw fire, incoming plane, debris, smoke	87 (41%)	96 (66%)
Contents movement: furniture movement, ceiling falling	66 (31%)	11 (8%)
Physically impacted: burned, knocked down, thrown out of chair	29 (14%)	1 (1%)
Warning from others	14 (7%)	34 (23%)
Smelled fumes or felt heat	12 (6%)	16 (11%)

pelling stories of those who had longer evacuations and might have more dramatic accounts of their experiences.

4.2. How did People Become Aware of the Initial Event

Table 2 shows the types of initial cues that alerted occupants of the two towers to the attack. As might be expected, since WTC1 was struck first, there are differences in the rankings of the earliest cues mentioned by survivors from the two towers. (Some people mentioned more than one cue.) Those in WTC1 were most likely to have become aware of the incident due to the swaying of the building or feeling a jolt or tremble (69%), while for the majority of those in WTC2 (66%), the first cue was visual – seeing fire, the plane, debris or smoke. For occupants of both towers, the second most frequently reported cues were audible (50% in WTC1 and 48 % in WTC2). These included hearing an explosion, crash or rumbling. For almost a quarter of these occupants in WTC2, the initial awareness of the event arose from warnings from others, not as a result of their own observations.

4.2.1. Knowledge of Situation

In reviewing the first-person accounts, an evaluation of each person's knowledge of the situation was made. Three categories were created. Those with a 'high' level of knowledge of the situation were those who knew that planes had hit the towers or that an explosion had occurred within the building, generally because they saw, heard or felt the impact. A 'moderate' level of knowledge was assigned to those who speculated about a bombing, who saw fire and debris, or who had reason to believe that an emergency situation existed. Those who were not aware of the reason for the evacuation were determined to have a 'low' level of knowledge of the situation.

This level of knowledge was determined for 330 of these survivors. Of the 330, 69 seemed to have a high level of knowledge of the situation – 37 in WTC1 and 32 in WTC2. Thirteen of those people in WTC1 were physically impacted by the initial attack, that is, knocked down or burned. The largest proportion of people, 214 in all, were judged to have moderate knowledge of the situation – 120 in WTC1 and 94 in WTC2. Of the 47 judged to have a low level of knowledge of the situation, 32 were in WTC1 and 15 were in WTC2.

Nine people mentioned attempting to contact authorities while still in their office, most likely attempting to gather information or ask for instructions or assistance. Three were on upper floors in WTC1 and one was in an elevator. One was in WTC2 and called 911 before leaving her office area. The others were on mid- or lower floors in WTC1.

Fifteen phoned their boss or colleagues while still in their offices, either to ask for instructions or to tell them what was happening and that they were evacuating.

4.3. The Evacuation of WTC1

WTC1 was struck between the 94^{th} and 98^{th} floors in such a way that no stairwell was accessible from above the impact zone. The building collapsed one hour and 42 min after it was struck. This section describes conditions in the tower after impact, delays before beginning evacuation, obstructions that were encountered during evacuation and the time taken to evacuate the building.

Table 3. Adverse conditions on floor at impact.

	WTC1, N=134
Debris (collapse)	72 (54%)
Smoke	74 (55%)
Fire	41 (31%)
No power, dark	20 (15%)
Smell of fumes	13 (10%)
Dust	9 (7%)
Water	7 (5%)
Door jammed	7 (5%)
Crowds, people injured	2 (1%)
Trapped	5 (4%)

4.3.1. Conditions on Floors in WTC1

Although six people mentioned that conditions remained normal on their floor after the building was struck, many reported adverse conditions as a result of impact. (More than one condition could be recorded.) The majority mentioned debris or collapse damage and smoke on their floor. Almost one third mentioned fire on their floor. The complete list is shown in **Table 3**.

4.3.2. Delay in Starting Evacuation in WTC1

Due to the nature of the source material, estimates of times to begin evacuation were often expressed in qualitative terms such as 'shortly' or in mentions of being 'stuck' These imprecise terms leave the actual time duration open to interpretation. Given that limitation, in the media accounts reviewed in this project, almost half (47%) indicated that they began evacuating 'immediately.' Another 13% indicated that they left 'shortly after' the first cue; 22% reported some delay in their evacuation; 11% indicated that they initially remained on their floors; and 7% said they were 'stuck' (i.e., physically prevented from leaving).

Among those who decided to stay at first were two who were part of a group of 16 employees who gathered in a conference room on the 64th floor and discussed the situation for approximately an hour before deciding to leave. Among others in WTC1 who delayed their evacuation, but were not physically prevented from leaving, the largest share (33%) were engaged in activities such as searching their floor, securing documents, making telephone calls or giving instructions. Another 27% were helping others or waiting for assistance. Nineteen percent simply decided to stay where they were.

4.3.3. Obstructions During Evacuation

Of the 251 subjects in WTC1, 153 mentioned encountering obstructions during their evacuation. Most frequency reported were crowdedness (46%), smoke (32%), debris (24%), and jammed door and lack of power (both 13%). Of the 20 people in WTC1 who reported encountering jammed or locked doors, all but three were located on upper floors, closer to the point of impact.

Table 4. Time out of WTC1.

Time/Benchmark Event	
8:48 – 9:02 a.m.(before WTC2 impact)	19
9:03 – 9:30 a.m.	45
9:31 – 9:58 a.m.(before WTC2 collapse)	72
9:59 – 10:27 a.m.(after WTC2 collapse)	70
10:28 a.m.(after WTC1 collapse)	5
TOTAL	211

4.3.4. Time to Exit the Building

People often used the events of the morning as benchmarks to describe the time they left the building, rather than actual times. Of the 211 occupants of WTC1 for whom exit time was reported, 9% were out of the building before WTC2 was struck, 30% escaped before 9:30 a.m., and 64% were out before WTC2 collapsed. (See **Table 4**.) Five people for whom first-person accounts were available survived the collapse of WTC1, and were rescued by firefighters, in some cases several hours after the collapse.

4.4. The Evacuation of WTC2

Although WTC2 was not directly involved in the initial attack, the evacuation of WTC2 began immediately for many occupants in the sample (52%). As shown in **Table 1**, more than half of the study subjects in WTC2 were located at or above the 77th floor when events began to unfold that morning. Almost all of those people had descended below the impact point in the building before it was struck, 16 min after WTC1 was struck. The tower collapsed after burning intensely for 56 min.

This section will describe the delays before beginning evacuation, conditions in the tower after impact, the delays before beginning evacuation, obstructions that were encountered during evacuation and the time taken to evacuate the building.

4.4.1. Delay in Starting Evacuation in WTC2

As mentioned above, just over half of the subjects in WTC2 began their evacuation immediately after receiving the first cue that something was happening, and for most people, that cue was the attack on WTC1. Another 17 % said they left shortly after that, and 31% mentioned that they delayed their evacuation or decided to stay.

At approximately 9:00 a.m., an announcement was made over the public address system indicating that evacuation was not necessary. (Survivors reported hearing the announcement just minutes before WTC2 was hit.) More than half of the WTC2 occupants included in this study reported hearing this announcement. The majority of them

Table 5. Adverse conditions on floor at impact.

	WTC2, N=57
Debris (collapse)	38 (67%)
Smoke	25 (44%)
Fire	20 (35%)
No power, dark	18 (32%)
Smell of fumes	7 (12%)
Dust	10 (18%)
Water	3 (5%)
Door jammed	2 (4%)
Crowds, people injured	7 (12%)
Trapped	2 (4%)

disregarded the announcement and continued their evacuation. Sixteen of them (17% of those who mentioned hearing the announcement) remained in their offices or attempted to return to their offices after hearing the message. Those trying to return to their offices, however, did not have time to travel very far before their building was attacked. At that point, all of the subjects resumed their evacuation.

4.4.2. Conditions on Floors in WTC2

Seven people mentioned that conditions remained normal on their floor after the building was struck; however, the majority mentioned debris or collapse damage. Almost half mentioned smoke on their floor, and approximately one third mentioned fire on their floor or no power. The complete list is shown in **Table 5**.

4.4.3. Obstructions During Evacuation

Almost half of the subjects from WTC2 who mentioned encountering obstructions during their evacuations reported encountering crowds and injured people in the stairs and that this interfered with their evacuation to some degree. Smoke and debris were the obstacles also mentioned frequently (both by more than one third of the subjects).

4.4.4. Time to Exit the Building

Of the 183 subjects from WTC2 for whom exit time was reported, 20% were out of the building before WTC2 was struck, 57% escaped before 9:30 a.m. (See **Table 6**). An important reason for the significantly larger percentage of people who were out of the building before it was struck was that occupants of WTC2 were able to use elevators, while those in WTC1 were generally forced to use the stairs.

Two of the occupants in WTC1 reported using the elevator to evacuate at least part of the way, compared to 18 of the occupants in WTC2 who used the elevators and another 26 who used a combination of stairs and elevator.

Table 6. Time out of WTC2.

Time/Benchmark Event	
8:48 – 9:02 a.m.(before WTC2 impact)	37
9:03 – 9:30 a.m.	68
9:31 – 9:58 a.m.(before WTC2 collapse)	77
9:59 – 10:27 a.m.(after WTC2 collapse)	0
10:28 a.m.(after WTC1 collapse)	1
TOTAL	183

All but two of the 18 people in WTC2 who used the elevator were above the 78th floor when WTC1 was struck, and 12 of them were out of the building before it was struck and the others were in the lobby at impact.

One person was rescued by firefighters after the collapse of both towers.

4.5. Interactions among Evacuees

Studies of human behavior in fire consistently find altruistic rather than panic behavior is the norm, and the evacuation of the World Trade Center towers on September 11 was no exception [5]. Several people mentioned providing assistance to others during the evacuation – 20 mentioned that they assisted people with disabilities and 14 reported that they helped injured people to evacuate. One account from WTC1 reported that hundreds of people on the stairs moved aside so that she and the severely injured woman assisted by her could pass quickly. She estimates that she traveled from the 78th floor to the outside of the building in less than 20 min.

Of the 435 subjects in this study, 203 (47%) mentioned receiving help from others during the evacuation. The largest share mentioned being helped by Port Authority personnel (37%) (The towers had been managed by the Port Authority, and the Authority occupied office space in the WTC1). Firefighters directly assisted 29%, and other first responders, such as New York police officers also assisted 29%. Fifteen percent reported being assisted by co-workers (Some people reported receiving assistance from more than one source, so percentages total more than 100%).

Besides assistance in the evacuation, 166 people reported receiving comfort and reassurance from firefighters they encountered during their evacuation.

4.6. Influence of and Perception of Others

Studies have shown that people act within their roles in emergencies, for example, customers in a store look to staff for direction when an alarm sounds; wait staff take care of their customers in a restaurant [6, 7]. Other studies have shown that being alone or with others can influence people's actions [8]. The media accounts were searched for evidence that role or the presence of others might have been a factor in influencing decisions to evacuate or to wait.

Of the 192 cases where influence of others was shown, 97 people seemed to be influenced by groups of people and coworkers, while 28 were influenced by authority figures, such as their boss or manager, and complied with their instructions. One person appeared to be influenced by both authority figures and the group. Another 66 people indicated that they influenced others, by directing them to the stairs, searching for others, giving orders, or in other ways organizing the evacuation. Men were more likely to report themselves as taking on a leadership role (41%) than women (22 %). Women were more likely to report being influenced by the group (59 %) than men were (46%).

Where available, each survivor's perception of others was recorded. The categories were: calm, momentarily panicked, upset and helpful. 'Momentarily panicked' included reports of people pushing, shoving or generally displaying behavior associated with chaos. 'Upset' included cases of people crying, shouting, nervous or anxious, yet rational. Multiple categories could be recorded for each person. Most people mentioned that those around them were calm and orderly (57%). Almost one-third (31%) described people as upset, and 29% reported incidents of momentary panic. Twenty-two percent found others to be helpful. In many cases where people were reportedly upset or anxious, others around them stepped in to reassure them and help them relax.

For most of the people in WTC2 who were characterized as 'momentarily panicked,' that behavior occurred when WTC2 was struck, and for two others, it was reported at the time when each tower collapsed.

4.7. Impact of the 1993 Evacuation

Only nine percent of the survivors represented in the first-person accounts mentioned being present when the World Trade Center was bombed in 1993. Of those 41 people, five mentioned that this time they were prepared with evacuation kits that included flashlights, masks, glow sticks, whistles and water. Another three mentioned that, because of their experience in 1993, they decided to begin their evacuation immediately. Eighteen people who were not present in 1993 mentioned that the evacuation experience of that day was on their minds. One wheelchair user who was present in 1993 credits an evacuation chair and the 10 people who assisted him with it, with saving his life. Evacuation chairs were among the improvements made at the World Trade Center after the bombing.

5. Comparison to the 1993 Evacuation

On February 26, 1993, a bomb exploded in a truck parked in the garage below the World Trade Center complex. Six people, all of whom were located on the basement level, were killed. The complex's emergency communications system, also located in the basement, was destroyed and electrical power to the towers was disrupted. The explosion caused a fire involving 25 to 30 vehicles, spread smoke and dust throughout the two towers and prompted a total evacuation of both towers in dark, smoky conditions. For some, the evacuation took up to six hours. A questionnaire study of the evacuation was undertaken, involving members of the fire safety team in the two towers. Complete details on the explosion and the evacuation can be found in the literature [9, 10].

Some of the key findings from the 1993 study were:

- Because the bomb was placed closer to WTC1 than WTC2, there were significant differences in the initial perception of severity between occupants of the two towers;
- People were found to be prepared to move through smoke, even into worsening conditions as they traveled down the stairs;
- Most occupants evacuated in total darkness;
- The mean time to start evacuation after initial awareness of the incident was 15 min for WTC1 and 35 min for WTC2; and
- Less than 10% of the occupants had participated in evacuation drills.

After the bombing incident, improvements were made in the two towers, in order to facilitate emergency evacuation. These included:

- Voice communication on each floor was improved;
- Photoluminescent material was used to mark the stairs and to illuminate travel paths in stairwells and transfer corridors;
- Photoluminescent signs were installed in the stairwells to indicate floor level and location of nearest unlocked doors onto office floors;
- A backup power supply was added for emergency systems;
- Battery backup was added to the emergency lights in the stairwells;
- Drills were held every six months with staff training;
- Evacuation chairs were provided for each mobility-impaired employee in the building; and
- A fire command center was created in the lobby of both towers.

The following discussion compares some of the findings from the 1993 study with findings related to the events on September 11, 2001.

5.1. Initial Awareness and Perception of Severity

In 1993, the first cue to the incident for most of the occupants in both towers was the explosion itself, but only 28% in WTC1 and 18% in WTC2 thought at first that the situation was extremely serious. The explosion was in a basement below the towers and many people thought it was something less dramatic, like a transformer explosion in the neighborhood. As a result, 33% of those in WTC1 and 44% in WTC2 thought the situation was no more than slightly serious.

The evacuation plan had been for occupants to move to the core of the tower in an emergency and wait there for instructions from the emergency control center. Because the explosion destroyed the emergency communications system in the basement, no announcements could be made to the building occupants.

In contrast, in 2001, occupants of the towers were presented with multiple, more powerful and far less ambiguous cues. Damage occurred in the buildings themselves, rather than remotely in the basement, which also presented immediate challenges to many in the building.

5.2. The Evacuations

In 2001, the occupants of WTC1 had only one hour and 42 min to leave the building before it collapsed. Occupants on the 90th and 91st floors reported leaving the building in as little as 45 min. In 1993, the median evacuation time from the 90th floor was 2.5 hours, and no one evacuated in less than two hours. If conditions had been the same in 2001 as in 1993, and the evacuation had taken as long, far more people would have been killed.

The occupants of WTC2 had less than one hour on September 11 to escape after their building was struck. In 1993, many in that building had been able to travel in an hour or less because they waited until conditions improved. However, delays as long as those taken in 1993 would have been fatal in 2001.

In 1993, although the median delay time was five minutes in WTC1 and 10 minutes in WTC2, delay times as long as four hours were reported in WTC1 and three hours in WTC2. There were several reasons for these delays, including ambiguous cues, lack of information and instructions, smokiness and crowdedness in the stairwells and lack of lighting. Some occupants were told by their employers to wait for assistance. In contract, in 2001, as mentioned above, almost half of the occupants in WTC1 and just over half of the occupants in WTC2 began their evacuation immediately.

Stairwell conditions were smoky and dark in 1993, as the power was disrupted and there was no battery backup to the emergency lighting in the stairs. In 2001, the stairwells were well-lit, making passage down the stairs easier. Photoluminescent markings along transfer corridors and down stairwells that were installed after the bombing provided guidance that, in 2001, some study subjects mentioned was beneficial to their evacuation.

In 1993, evacuation travel time varied from a few minutes to more than three hours. This is the time that occupants were making their way out of the building, not the elapsed time since the beginning of the incident. Approximately 14% of the occupants in WTC1 and 24% of the occupants in WTC2 took less than 30 min to travel out of the building. One quarter of the occupants of WTC1 and almost half of the occupants in WTC2 took between 30 min and one hour. Sixty percent of those in WTC1 took more than one hour to travel, with eight percent taking over three hours (The travel time for occupants in WTC2 was generally shorter because so many waited until the situation was stabilized and more assistance was available before they began their descent).

In both evacuations, calm, orderly and altruistic behavior was generally reported. In 2001, there were several reports of fairly rapid evacuation of even severely burned victims, because of the support of others in the stairwells during their descent.

6. Concluding Remarks

The study described in this paper, using first-person accounts from the media, was launched immediately after the events of September 11, with the realization that a more complete survey or interview based study might not be possible. There are significant limitations to such a study, but lessons can still be learned from such a study, and in the end, other larger studies were undertaken. Those limitations, lessons learned and the other studies are described in this section.

6.1. Limitations of the Study

There were several limitations inherent in a study such as this, based on content analysis of interviews and other first-person accounts that appeared in the media and on the internet, such as:

a) Unlike a survey or interview study, the questions asked by journalists are not known, and would not have been consistent between interviews or among journalists.

b) Not all details that were uncovered in an interview were published.

c) Details such as delays in beginning evacuation, time in the stairwells and total evacuation time were generally described in qualitative terms, leaving the actual times open to interpretation.

d) Although there was a good distribution of accounts from the three strata in the two towers, there was a higher proportion of accounts from the top tiers, especially in WTC2. This could be a reflection of the more dramatic accounts from people with the longest evacuation routes, which might be more appealing to the media for publication. As a result, however, the experiences and observations of these people may be over-represented in the findings.

e) The findings are representative of the sample, and cannot be generalized to the larger building populations. Although it is obvious, it must be stated that the actions of those who perished are not represented at all in the accounts, or in this study.

6.2. Lessons Learned

A main reason for conducting evacuation studies is to obtain information about what people do in real incidents; what choices they make and why; how long it takes them to begin evacuation; how long it takes them to travel down stairs; what factors impact their movement speeds; etc. This study, like others, has provided additional information to our store of data on evacuation in real situations.

Despite the magnitude of the initiating event on September 11, we found that initial awareness varied throughout the towers. Survivors were faced with, and overcame, significant obstructions in their evacuation path, including fire, smoke, structural collapse and crowding in the stairwell.

The 1993 bombing had an effect on more than just the people who had been present for that event. Even those who had not experienced the 1993 bombing were aware of that evacuation, and the extremely long time it took evacuees to reach the outside, and some reported that this hastened their response on September 11. Changes that were made in the towers after the bombing, such as distribution of evacuation kits and evacuation wheelchairs, and photoluminescent striping in the transfer corridors, were mentioned by some of the evacuees as providing benefit during the evacuation on September 11.

Similar to other studies of emergency evacuations, a high degree of altruistic (helping) behavior was observed, even among strangers. It was clear from the accounts that were published that the survivors' interactions with firefighters in the stairwells were generally positive, and provided comfort and reassurance.

6.3. Other WTC Evacuation Studies

This paper has described the results obtained from a review of first-person accounts of 435 people who evacuated the twin towers on September 11, 2001. In the years following the study, three other studies were undertaken, each with a slightly different methodology and goal.

In 2002, Mailman School of Public Health at Columbia University and the Centers for Disease Control and Injury Prevention (CDC) began a four-year, five-phase qualitative and quantitative study of the evacuation of the twin towers [11, 12]. Their goal was to assess individual, organizational and structural factors that affected the evacuation. The first phase of the project involved 56 participants, some of whom completed in-depth interviews and others participated in focus groups in 2003. That work lead to the development of a self-administered study questionnaire that was completed by 1,441 evacuees. Their analysis of this data set identified the factors associated with time to begin evacuation and length of time to complete evacuation. Based on these risk factors, the authors provided recommendations for improvements at the individual, organizational and structural level.

Also in 2002, the National Institute of Standards and Technology (NIST) launched a three-year technical investigation into the World Trade Center incident, which included a component that would look at the evacuation aspect. In this study, telephone and face-to-face interviews were conducted with over 1,000 evacuees, and five focus groups were conducted [1]. This report includes an important section on the use of elevators in the evacuation of WTC2. The NIST study used the results of the first-person account study described in this paper in the development of their telephone survey and to identify individuals with particularly important stories who should be interviewed directly.

In 2004, three U.K. universities began collaboration on a 3.5-year project that ultimately interviewed 271 evacuees from the twin towers, using a combination of free-flow narrative and semi-structured interviews [13]. The goal of this project was to record the evacuation experience, structure the information into an accessible database and use the information in the development of building codes and evacuation simulation models.

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