The World Trade Center Evacuation Study

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Presentation Outline

- Background Review: High rise building occupancy and emergency preparedness
- Review of WTC structure and worker protection programs in place on 9/11
- The WTC Evacuation Study results on emergency preparedness
- Relationship between WTC emergency preparedness and evacuation-related outcomes
- Lessons learned and applied
- Remaining gaps and challenges
Triangle Shirtwaist Factory Fire, 1911
WTC Bombing, 1993
Photoluminescent Signs & Exit Markers
Preparing for Emergencies

- Port Authority NYINJ Instituted a new EP Program:
  - PLANNING
  - ORIENTATION
  - EDUCATION
  - PUBLIC ADDRESS ANNOUNCEMENTS
  - OCCUPANT FIRE SAFETY TEAMS
  - TEAM TRAINING
  - FIRE DRILLS
  - CRITIQUE
Murrah Building Oklahoma City, 1995
Restricted Approaches
World Trade Center (WTC) Towers (9/11/01)
WTC Complex
World Trade Center
Office Floor
WTC Worker Protection Programs in Place 9/11

- Codes met and exceeded NYC fire and other applicable safety Codes
- Port Authority Program
- Floor warden system
- Annual fire drills
- PA system
WTC Complex: 9/11/01
WTC, 2001
WTC Street Level
WTC Street Level
Basic Facts about 9/11 WTC Attacks

North Tower Impact (WTC – 1)
- 8:46am
- 767, 10K gallons
- Impact at 94-98th floors
- Collapsed 1 hour and 42 minutes after impact

South Tower Impact (WTC – 2)
- 9:02am
- 767, 10K gallons
- Impact at 78-84th floors
- Collapsed 57 minutes after impact
The World Trade Center Evacuation Study*- Objectives

- To identify the individual, organizational, and environmental/structural (building) factors that affected evacuation from the WTC on 9/11/01
- To inform policies and practices that support safe evacuation of high-rise structures
- To inform preparedness for other mass evacuations

*Funded by CDC/NIOSH
Major Study Outcomes

1. Initiation of evacuation
2. Rate of evacuation = minutes per floor
   - Length of time to descend controlled by floor and elevator use
3. Injuries (physical)
4. Long term health impact (physical and psychological)
Study Outcomes
Length of Time to Initiate* Evacuation (N=1444)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>WTC 1</td>
<td>6 minutes</td>
<td>1 minute</td>
<td>44 minutes</td>
</tr>
<tr>
<td>WTC 2</td>
<td>6 minutes</td>
<td>1 minute</td>
<td>44 minutes</td>
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* Start of Evacuation - First Awareness (Sensory input)
Delaying Activities

Once they decided to leave, but BEFORE they began to...

- Gathering items (40%)
- Seeking out friends/co-workers (33%)
- Searching for others (26%)
- Making phone calls (18%)
- Shutting down/PC-related (8%)
- Waiting for direction (7%)
- Gathering safety equipment (5%)
- Changing shoes (3%)
- Trying to obtain **permission** to leave (1%)
### Study Outcomes

**Length of Time* to Descend**

<table>
<thead>
<tr>
<th>WTC 1</th>
<th>WTC 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean:</strong> 40 minutes</td>
<td><strong>Mean:</strong> 22 minutes</td>
</tr>
<tr>
<td><strong>Rate</strong>*: <strong>60 Seconds/floor</strong></td>
<td><strong>Rate</strong>*: <strong>30 Seconds/floor</strong></td>
</tr>
<tr>
<td><strong>Range:</strong> 1-102 minutes</td>
<td><strong>Range:</strong> 1-72 minutes</td>
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</table>

* Controlling for floor/elevator use
WTC Stairwell
WTC Stairwell
Study Outcomes

Injuries

- Physical Injuries: 37% (n=530)
  - Surface Trauma 12% (n=172)
  - Inhalation Injury 11% (n=164)
  - Orthopedic Injury 7% (n=104)
  - Eye injury 4% (n=60)
  - General Trauma 4% (n=51)

- Psychological Injuries: 25% (n=357)

- Severity:
  - 63% sought medical care
  - 7% were hospitalized
Study Outcomes

Long Term Injury Patterns

- 221 persons (15.4%) of the evacuees reported at least one long-term injury related to evacuation of the WTC on 9/11 (some reported more than one condition).
- Long-term mental health problems were most common.

<table>
<thead>
<tr>
<th>Condition</th>
<th>n</th>
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<tbody>
<tr>
<td>Mental Health</td>
<td>132</td>
</tr>
<tr>
<td>Respiratory</td>
<td>61</td>
</tr>
<tr>
<td>Orthopedic</td>
<td>30</td>
</tr>
<tr>
<td>Medical</td>
<td>18</td>
</tr>
<tr>
<td>Cardiac</td>
<td>5</td>
</tr>
<tr>
<td>Vision / Hearing</td>
<td>5</td>
</tr>
</tbody>
</table>

Long term injury patterns

- Mental Health 53%
- Respiratory 24%
- Orthopedic 12%
- Medical 7%
- Vision / Hearing 2%
WTC Results on Emergency Preparedness

- 89%
- 73%
- 70%
- 59%
- 51%
- 26%
- 25%
WTC Results on Emergency Preparedness Knowledge

KNOWLEDGE: 10- item scale mean=3.42, median =3.00, mode=2.00

- Where stairs would lead: 89%
- Where sky lobbies were located: 73%
- Exit locations: 70%
- 3 Stairwells were locked: 59%
- Roof might not be means of escape: 51%
- Not sure about roof: 26%
- Not sure about roof: 25%
WTC Results on Emergency Preparedness

• Knowledge Related to Preparedness (10 Questions)
  • Mean 3.3
  • Median 3.0
  • Mode 2.0
  • Range 0-10
WTC Results on Emergency Preparedness Safety Climate

Emergency Preparedness Safety Climate: 8-items mean 2.83, med 3.0, mode 3.0

- Had NEVER exited the building as part of a drill: 94%
- Reported NO PLANS regarding where to gather after evacuating: 84%
- NO PLANS for head count: 84%
- NEVER PROVIDED with evacuation plans: 82%
- Had participated in fire drills, but of these, ONLY 11% HAD EVER ENTERED A STAIRWELL: 81%
- Were NEVER PROVIDED with written fire safety instructions: 74%
- WERE NOT familiar with who was in charge: 33%
Emergency Preparedness Safety Climate

- Workplace Preparedness for Emergencies (8 items)
  - Mean 2.8
  - Median 3.0
  - Mode 3.0
  - Range 0-8
Emergency Preparedness for Persons with Disabilities

Disability Preparedness Four-Item Scale (alpha=0.76)

Mean = 0.32
Median = 0.00
Mode = 0.00
Range = 0 - 4

Mean = 0.32, Median = 0.00, Mode = 0.00, SD = .83, N = 1444
Factors Significantly Associated with Length of Time

- Low level of knowledge
- Lack of emergency preparedness
- Pre-existing disability/health problem (OR=2.8)
- Injuries
- Multiple sources of information
- Any adverse environmental condition
- Stopping for any reason
- Overcrowding on stairs or in lobbies
Factors Significantly Associated with Injuries

- Female gender (OR=1.9)
- Disability/medical condition (OR=2.0)
- Physical capability was low (OR=2.8)
- Lack of preparedness
- Lack of familiarity
- Less participation in drills
- Unsure of stairs (OR=1.9)
- Fear for employment (OR=4.9)
- Supervisor would not approve (OR=6.4)
- Not feeling personally responsible for own safety
- Stopping
- Problem with shoes (changing shoes, OR=2.6)
Lessons Learned from the WTC Evacuation Study

• Human behaviors in this high rise fire were as predicted
  – Design features that support these behaviors will be most effective

• Training and drilling improved competency
  – These should be mandatory

• EP safety climate was associated with reduced evacuation times, injuries and long term mental health problems.
  – EP Best practices should be implemented in all high rise work settings
Most Important Lesson Learned

- EMERGENCY PREPAREDNESS = RESILIENCY
Regulatory Risk Reduction Strategies

1. NYC high-rise fire safety codes: Emergency Action Plan (EAP) §6-02
   - EAP must specify the procedures for:
     • Sheltering in-place
     • In-building relocation
     • Partial evacuation
     • Full evacuation
   - Pre-planning for persons with disabilities

2. Designation and certification of an Emergency Action Plan Director (EAPD) §9-08
   - EAPD has the authority to implement this in the absence of lawful authorities (i.e., they become the incident commander)
Lessons Learned...and Implemented

- 2005: NIOSH: Emergency Preparedness for Businesses
- 2005: FEMA Emergency management Guide for businesses
- 2007: NFPA Std on Disaster/Emergency Preparedness Management
Tribute in Lights
Freedom Tower 9/11/11
References


- Gershon RRM, Rubin MS, Qureshi KA, Canton AN, Matzner FJ. Participatory action research methodology in disaster research: results from the World Trade Center evacuation study. Disaster Medicine and Public Health Preparedness. 2008; 2(3):142-149.


