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**Grand Rounds Series**

February 8, 2007

1



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**World Trade Center  
Evacuation Study**

February 8, 2007

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Principal Investigator



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**Guest Speaker**

Robyn R.M. Gershon, MHS, DrPH  
Principal Investigator

3



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5



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6



## Human Behaviors in Emergencies

### What is Known:

1. Will generally not go towards smoke
2. Seek out groups and stay with group even if it is not the best option
3. Group size is important
4. Familiarity helps groups to form and minimizes panic
5. Information serves as motivator and helps groups to form

7



## Human Behaviors in Emergencies

6. The faster groups form – the faster they evacuate (clustering, milling, flocking)
7. Individual and group panic dependent on several key factors
8. Leadership is especially important in public spaces – both for shaping group behaviors and for guidance

8



## Design Features of High Rise Buildings

- High rise building: 10 stories above street level, or 75 feet or higher
- High rises are robust and redundant
- Not usually designed for rapid, full building evacuation
- Not designed to withstand impact of fuel-laden large aircraft in use today
- Rescue of occupants located in inaccessible areas of high rises above the point of impact is not possible

9



## Background

### High Rise Emergencies:

- WTC, 1993
- Oklahoma City, Murrah Building, 1995
- Chicago High Rise Fires, 2003, 2004
- WTC, 2001

10



## WTC Bombing, 1993

- Feb. 26, 1993, 12:17 pm
- Explosion under plaza
- 1300 lbs of explosives
- 6 deaths
- 1,000 injuries
- 40,000 evacuated
- 6 hours after evacuation, people were found at their desks
- Many changes to WTC made afterwards



Photo by Bureau of ATF 1993 Explosives Incidents Report


11



## WTC Complex




12



## WTC, 2001

<p><b><u>North Tower Impact</u></b></p> <ul style="list-style-type: none"> <li>• 8:46am</li> <li>• 767, 10K gallons</li> <li>• Impact at 94-98<sup>th</sup> floors</li> <li>• Collapsed 1 hour and 42 minutes after impact</li> </ul>	<p><b><u>South Tower Impact</u></b></p> <ul style="list-style-type: none"> <li>• 9:02am</li> <li>• 767, 10K gallons</li> <li>• Impact at 79-84<sup>th</sup> floors</li> <li>• Collapsed 57 minutes after impact</li> </ul>
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13



## WTC Fatalities, 2001

- 11% of occupants died, most above point of impact
- 421 first responders
- 147 jetliner crew and passengers
- 1,462 in North Tower
- 630 in South Tower
- 18 bystanders (on the ground)
- 24 location unknown in WTC 1 and WTC 2
- Total deaths: 2,749


14



## 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


15



## 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)


16



## Variables That Could Affect Outcomes

- Individual
- Organizational
- Structural

17



## Variables That Could Affect Outcomes

**Individual:**

- Health status
- Sensory input
  - Smelling or seeing smoke, fire, etc
- Familiarity with building
- Prior experiences, knowledge
- Influences of others
- Delaying activities
- Post-event experiences and treatment

18

**Variables That Could Affect Outcomes**

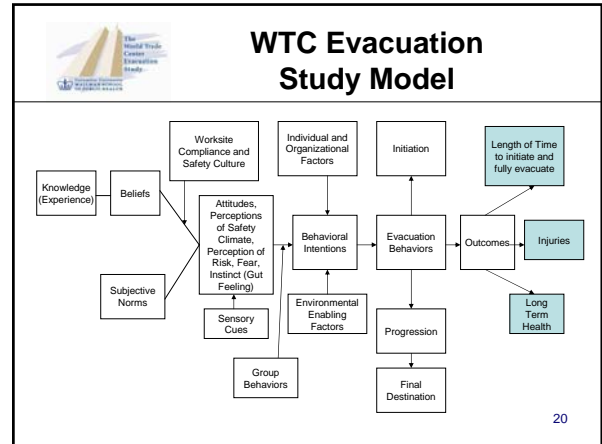
**Organizational:**

- Preplanning, emergency preparedness culture and climate, leadership
- Risk communication

**Structural:**

- Egress factors
- Communication infrastructure

19



**Demographics**

- Responses: 1767 total
- Of these, 1444 (82%) evacuated on 9/11/01
- 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+
  - Employment: 84% private company
  - Union membership: 7%

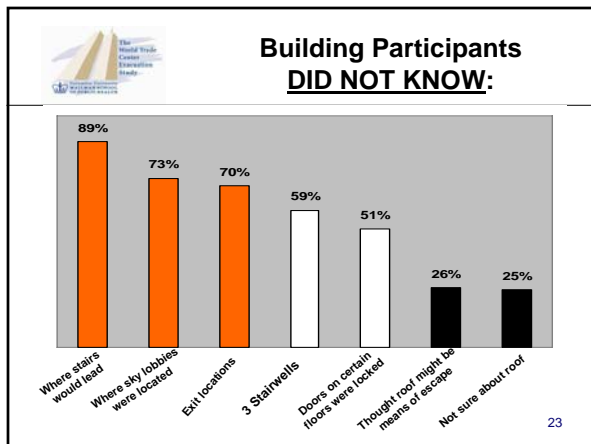
21

**Health Status**

- Pre-existing disability or medical condition: 23%
- Including...
  - Respiratory: 28%
  - Mobility: 28%
  - Mental Health: 17%
  - Heart Condition: 16%
  - General Medicine: 7%
  - Sensory Deficit: 6%
  - Smoking: 19%

29% of those with a disability/medical condition said their disability affected their ability to walk down large number of stairs

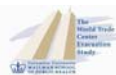
22



**Lack of Familiarity with Building**

- 56% somewhat familiar
- 22% slightly/not at all familiar
- 50% did NOT know enough about building to leave on their own
- 27% had evacuated the building at least once
- 16% reluctant to evacuate

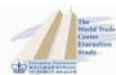
24



## Preparedness for Persons with Disabilities

- 28% reported having a person with a disability on their floor
- 11% said a plan for evacuation of persons with disabilities was in place
- 10% said co-workers were assigned to assist persons with disabilities

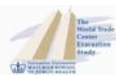
25



## Preparedness for Persons with Disabilities

- 8% said there was special equipment for the evacuation of persons with disabilities
- 5% said there was a designated area for persons with disabilities to gather

26



## Communication Factors

- 42% could not hear or recall ANY PA system announcements
- 26% reported false alarms once a month or more

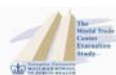
27



## Organizational Factors Related to Preparedness

- 74% were never provided with written fire safety instructions
- 82% never provided with evacuation plans
- 84% reported no plans regarding where to gather after evacuating
- 84% no plans for head count

28



## Organizational Factors Related to Preparedness

- 94% had never exited the building as part of a drill
- 81% had participated in fire drills
- However, only 11% of those participating had ever entered a stairwell

29



## Most Important Factors that Helped the Evacuation

- Staying calm (“Behaving”)
- Instincts
- Mutual support
- Leadership (group)
- Directions/encouragement of first responders/NY/NJ Port Authority
- Integrity and condition of stairwells
- Lack of overcrowding on stairwells

30



## Characteristics of Leaders They Followed

1. Calm
2. Authoritative Voice
3. Directive (about what to do)
4. Knowledgeable

31



## Outcome Variables

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)

32



## Individual Factors Associated with **Initiation**

Mean = 6 minutes to initiate; Range = 1 – 44 minutes

### Slowed:

- Age
- Disabilities/medical conditions
- Any trauma injury
- Military/first responders experience
- Management status
- Smoking history
- Performing activities
- Lack of familiarity with building
- Looking for groups
- Fear for employment
- Told to wait at desk

33



## Delaying Activities

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

- Gather items (40%)
- Seek out friends/co-workers (33%)
- Search for others (26%)
- Make phone calls (18%)
- Shut down/PC-related (8%)
- Wait for direction (7%)
- Gather safety equipment (5%)
- Change shoes (3%)
- Try to obtain permission to leave (1%)

34



## Individual Factors Associated with **Initiation**

Mean = 6 minutes to initiate

Range = 1-44 minutes

### Quickened:

- Gut instinct
- High level of knowledge
- Participation in drills

35




## Organizational Factors Associated with **Initiation**

### Slowed:

- Low level of emergency preparedness
- Lack of trained leadership

36



### Environmental/Structural Factors Assoc. with **Initiation**


**Slowed:**

- Lack of communication systems
- Damage to immediate surroundings
- Hearing PA announcement (WTC 2)

**Quickened:**

- Sensory input (seeing or smelling smoke, etc)

37




### Length of Time to Descend

**WTC 1**  
 Mean: 42 minutes  
 Rate\*: 59 Seconds/floor  
 Range: 1-96 minutes

**WTC 2**  
 Mean: 27 minutes  
 Rate\*: 31 Seconds/floor  
 Range: 0-70 minutes

\* Controlling for floor/elevator use

38




### Individual Factors Associated with **Length of Time**

**Slowed:**

- Lack of knowledge
- Disability/medical condition
- Making phone calls
- Stopping
- Injuries

39




### Environmental/Structural Factors Associated w/ **Length of Time**

**Slowed:**

- Any damage
- Multiple sources of information
- Any environmental condition
- Overcrowding


40



### Condition of Stairwells

- 58% Over-crowding
- 30% Water
- 26% Smoke or dust
- 14% Structural damage/debris
- 9% Doors that would not open
- 9% Poor lighting
- 5% Fire/intense heat
- 4% Poor/confusing signage

41



### Sources of Communication

- Obtained info from:
  - Face-to-face communications (42%)
  - PA announcement (12%)
  - Telephone (7%)
  - Cell phone (7%)
  - Television (7%)
  - Radio (4%)
  - Wireless handheld devices (4%)
  - Computer (2%)

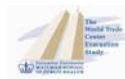
42



### Outcomes: Injuries/ Long Term Health

- **Physical Injuries: 37%**
  - 12% Surface trauma
  - 11% Inhalation injury
  - 7% Orthopedic injury
  - 4% Eye injury
  - 4% General trauma
- **Psychological Injuries: 25%**
- **Severity of those injured:**
  - 63% sought medical care
  - 7% were hospitalized

43



### Individual Factors Associated with Injuries

- Female gender
- Problem with shoes
- Seeking permission
- Disability/Medical condition
- Lack of familiarity
- Less participation in drills
- Fear for employment
- Starting from higher floor
- Not feeling personally responsible for own safety
- Stopping
- Making phone calls

44



### Organizational Factors Associated with Injuries

- Lack of emergency preparedness
- Inadequate training
- Difficulty in following stairway route

45



### Environmental/Structural Factors Assoc. w/ Injuries

- Any environmental condition
- Any structural damage
- Multiple sources of information

46



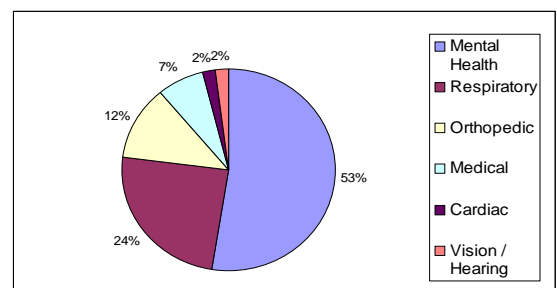
### Outcomes: Long Term Health Patterns

- 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

47



### Long Term Injury Patterns



48



### Individual Factors Assoc. w/ Long Term Health Problems

- Female gender
- Inadequate shoes
- No spouse/partner
- Not physically capable
- Low level of knowledge
- Less participation in drills
- Sensory input (seeing/hearing)
- Lack of familiarity
- Fear for employment
- Wanting to get permission
- Stopping for any reason
- Not feeling personally responsible

49



### Organizational Factors Assoc. w/ Long Term Health Problems

- Lack of emergency preparedness
- Inadequate training

50



### Environmental/Structural Factors Assoc w/ Long Term Health Problems

- Any structural damage
- No outside information sources

51



### Participatory Action Team (PAR) Recommendations

Improvements at the individual level:

- Self-assessment
- Active role in preparedness/training

52



### Improvements at the Organizational Level

- Emergency preparedness safety climate
  - Culture shift needed
  - Senior leadership
- Foster familiarity among workgroups
  - By floors
  - With emergency leadership
- Preplanning for those with health problems
- Leadership *and* follower-ship skills building

53



### Improvements at the Structural Level

- Redundant and supplementary communication links
- Automatic unlocking of doors

54



## PAR Recommendations

- **Drills, including:**
  - Stairwells
  - Transfer hallways
  - At least partial evacuation
  - Leaders chosen with experience
- **Training:**
  - Mandatory
  - New hires
  - Annual
  - Orientation
  - For disability evacuation teams
  - Active learning technique

55



## Next Steps

- **In NYC, a new local law was enacted: the Emergency Action Plan**
- **Design, implement, evaluate model high-rise workplace emergency preparedness plans**

56



## Research Team

### Core Research Team:

- **Dr. Kristine Qureshi: Co-Investigator**
- **Dr. Victoria Raveis: Co-Investigator**
- **Dr. Martin Sherman: Study Statistician**
- **Dr. Ayxa Calero-Breckheimer: Study Evaluator**
- **Ms. Marcie Rubin: Project Director**

57



## Research Team

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- **The City University of New York: John Jay College of Criminal Justice**
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  - Dr. Glenn Corbett, Fire Protection Engineer & Asst. Prof. of Fire Science
- **Other Colleagues**
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  - Dr. Tracy Durrah, NYC Department of Mental Health and Hygiene

58



## Expert Consultants

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- Mr. Mike Hurley, Port Authority of New York and New Jersey
- Ms. Edwina Juillet, Disability Safety Planning
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59



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**Website for final NIST:**  
<http://wtc.nist.gov/NISTNCSTAR1-7.pdf>

60



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61



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63