



Comparative Loss of Life and Injury Analysis in Commercial, Industrial and Education Institution Housing

**SUPDET
Orlando, FL
February 26, 2013**

**Jim Milke, Ph.D., P.E.
Dept. of Fire Protection Engineering**

Acknowledgements



❖ Student assistants:

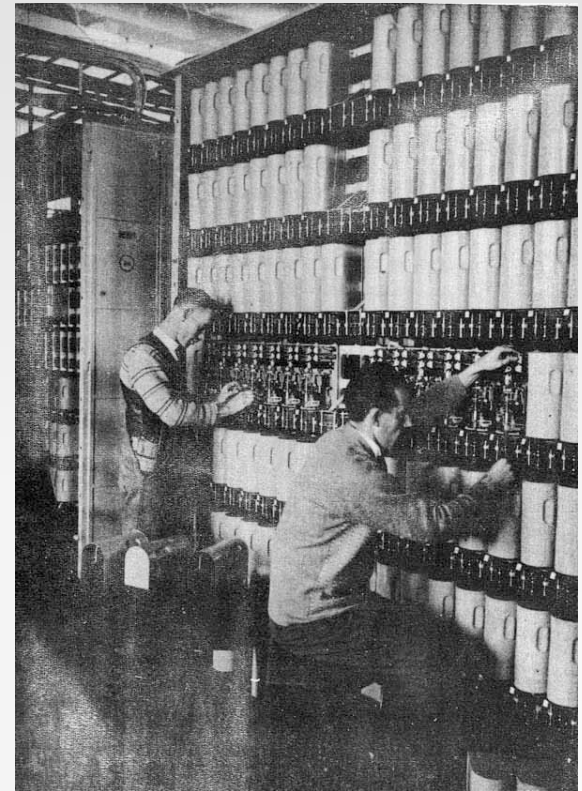
- Robert Hanson
- Daniel Mizrach

❖ Support for this project was provided by the National Electrical Manufacturers Association

Background

❖ Initially (1960's & 1970's) smoke detectors more prominent in commercial occupancies

- Factory Insurance Association [1971] recommended smoke detection be included as one of the 10 essential aspects of fire protection in all electronic equipment spaces



Background

❖ Completed similar project in 2011

- Purpose: indicate the relative performance of detectors and sprinklers in one- and two-family dwellings and apartments, commercial residential (i.e. hotels), and health-care occupancies
- Approach
 - Review data from experimental programs
 - Review analyses of fire incident data in open literature
 - Analysis of NFIRS data by UMD project team

Do Trends from 2011 Project Apply to Other Occupancies?

- ❖ **What is the value added by providing either or both types of fire protection systems in commercial and industrial occupancies?**

Scope of Current Project

- ❖ **Compare number of casualties (fatal and non-fatal) and primary cause of casualties in commercial, industrial and education institution housing for:**
 - **Fully sprinklered-only occupancies**
 - **Smoke detector-only occupancies**
 - **Combination of sprinkler and smoke detector-protected occupancies**

Research Plan

- ❖ **Task 1: Analyze performance in commercial and Industrial occupancies**
 - **Review published U.S. research reports (NFPA) to identify statistical information to determine the cause of single and multiple deaths from fire.**
 - **Conduct analysis of NFIRS data to assess relative performance of sprinklers and detectors**

Research Plan

- ❖ **Task 2: Collaborate with Center for Campus Fire Safety in the NEMA-sponsored Campus Fire Data Reporting System**
 - **collect, analyze and report on fire incident data from college and university US campuses including on and off-campus housing.**
 - **provide detailed insights into the causes for the fatal and non-fatal casualties.**

Task I



- ❖ **Analyze performance of smoke detectors and sprinklers in commercial and industrial occupancies**

Performance Parameters

❖ Fire incident data

- Proportion of fires judged to be too small for activation of smoke detectors or sprinklers
- Casualty rates (fatal and non-fatal) in incidents where smoke detectors or sprinklers were present
- Response of sprinklers and detectors

Sprinklers: fires too small

2005-2009 structure fires

Occupancy	# fires	# fires too small	<u>% fires too small</u> # fires
Commercial	19820	4510	23
Residential	26710	2680	10
Total	46530	7190	15

Hall, U.S. Experience With Sprinklers, NFPA, 2011

Sprinklers: reduction in civilian deaths

2005-2009 structure fires

Occupancy	Fire death rate ¹ without auto extinguishing	Fire death rate with wet pipe sprinkler	% reduction
All public assembly	0.4	0.0	100
Residential	7.4	1.2	84
Store/Office	1.2	0.2	81
Manufacturing	1.8	0.3	84
Warehouse	1.2	2.0	-67
Total	6.2	0.9	85

¹ Fire death rate: civilian deaths/1000 fires

Hall, U.S. Experience With Sprinklers, NFPA, 2011

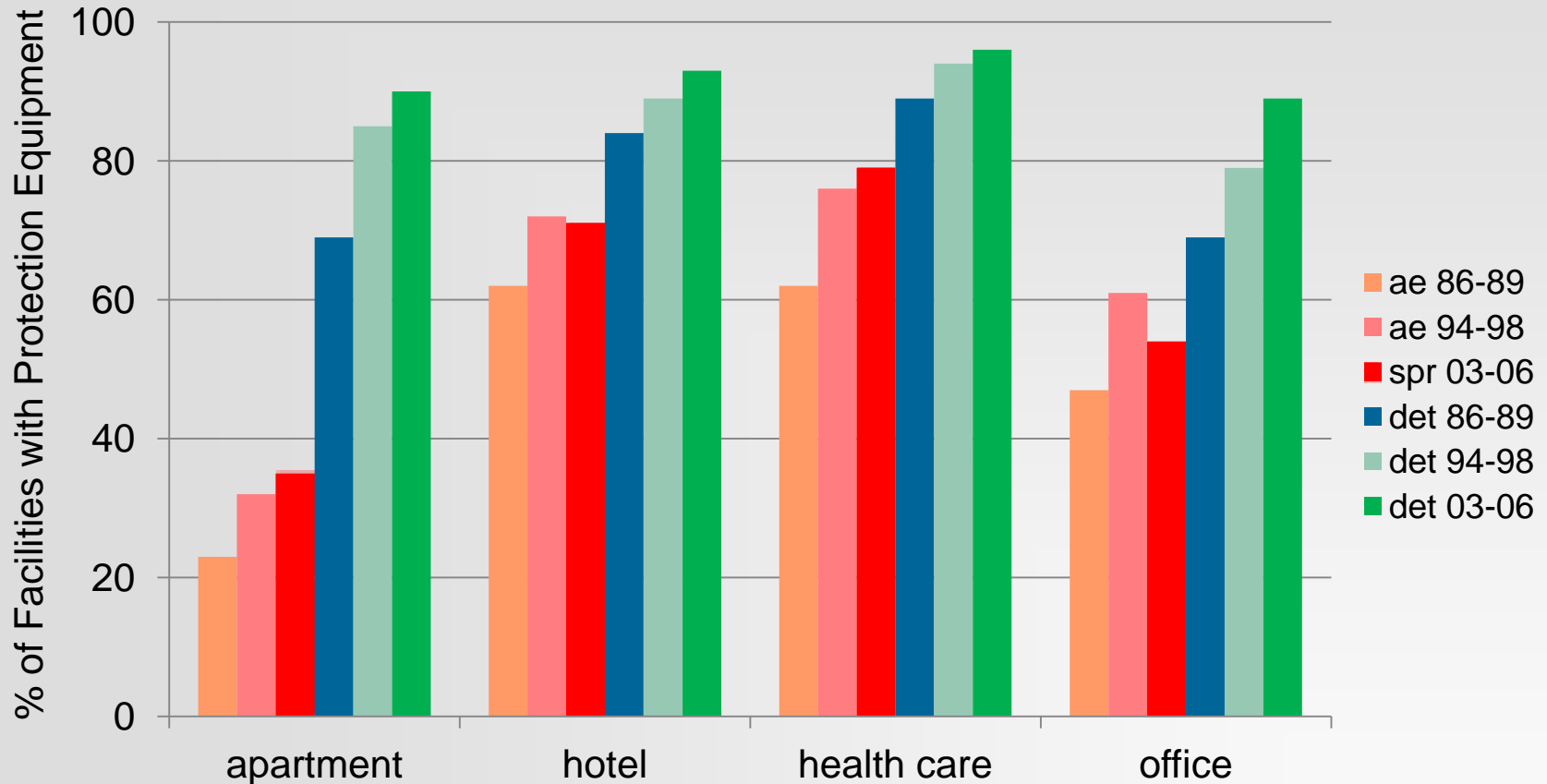
Sprinklers: characteristics of civilian deaths

2005-2009 structure fires

Victim Characteristic	# fatalities (% of total fatalities per year)	
	without auto extinguishing	with wet pipe sprinkler
Victim in area of origin	1470 (52)	24 (90)
<i>Intimate with fire ignition</i>	1110 (39)	23 (84)
<i>Not intimate with fire ignition</i>	360 (13)	1 (7)
Intentional fire	390 (14)	1 (3)
Clothing on fire	210 (8)	6 (22)
Victim age 65+	820 (29)	15 (57)
Victim return to fire, unable to act or acted irrationally	590 (21)	11 (42)

Hall, U.S. Experience With Sprinklers, NFPA, 2011

Installation: sprinklers (AE) & detectors



Hall, High-rise Building Fires, NFPA, 2009

NFIRS Analysis by UMD

Commercial	Industrial
Restaurant or cafeteria	Electric-generating plant
Bar/tavern or nightclub	Manufacturing plant
Elementary school, kindergarten	Warehouse
High school, junior high	
College, adult education	
Clinic, clinic-type infirmary	
Doctor/dentist office	
Prison or jail, not juvenile	
Food and beverage sales	
Household goods, sales, repairs	
Business office	
Laboratory/science laboratory	

NFIRS Fire Incidents

Protection Equipment	Commercial	Industrial
None	12,571	10,758
Smoke Detectors Only	10,101	6,108
Sprinklers Only	1,234	1,773
Smoke Detectors & Sprinklers	6,993	6,308
Total	30,899	24,947

Casualties - Commercial Occupancies

Casualty Symptom	None	Smoke Detectors Only	Sprinklers Only	Smoke Detectors & Sprinklers
A	40	9	23	45
B	15	2	3	12
C	38	6	19	32
D	4	1	1	2
E	0	0	0	0
F	4	0	3	0

Legend for casualty symptoms:

Intimate with the fire (in the room of origin), with symptom:

- A. burns
- B. smoke inhalation
- C. combination of burns and smoke inhalation

Not intimate with the fire (not in the room of origin), with symptom:

- D. burns
- E. smoke inhalation
- F. combination of burns and smoke inhalation

Casualties - Industrial Occupancies

Casualty Symptom	None	Smoke Detectors Only	Sprinklers Only	Smoke Detectors & Sprinklers
A	18	31	4	18
B	9	14	0	9
C	31	21	4	31
D	8	14	1	8
E	1	0	0	1
F	1	0	0	1

Legend for casualty symptoms:

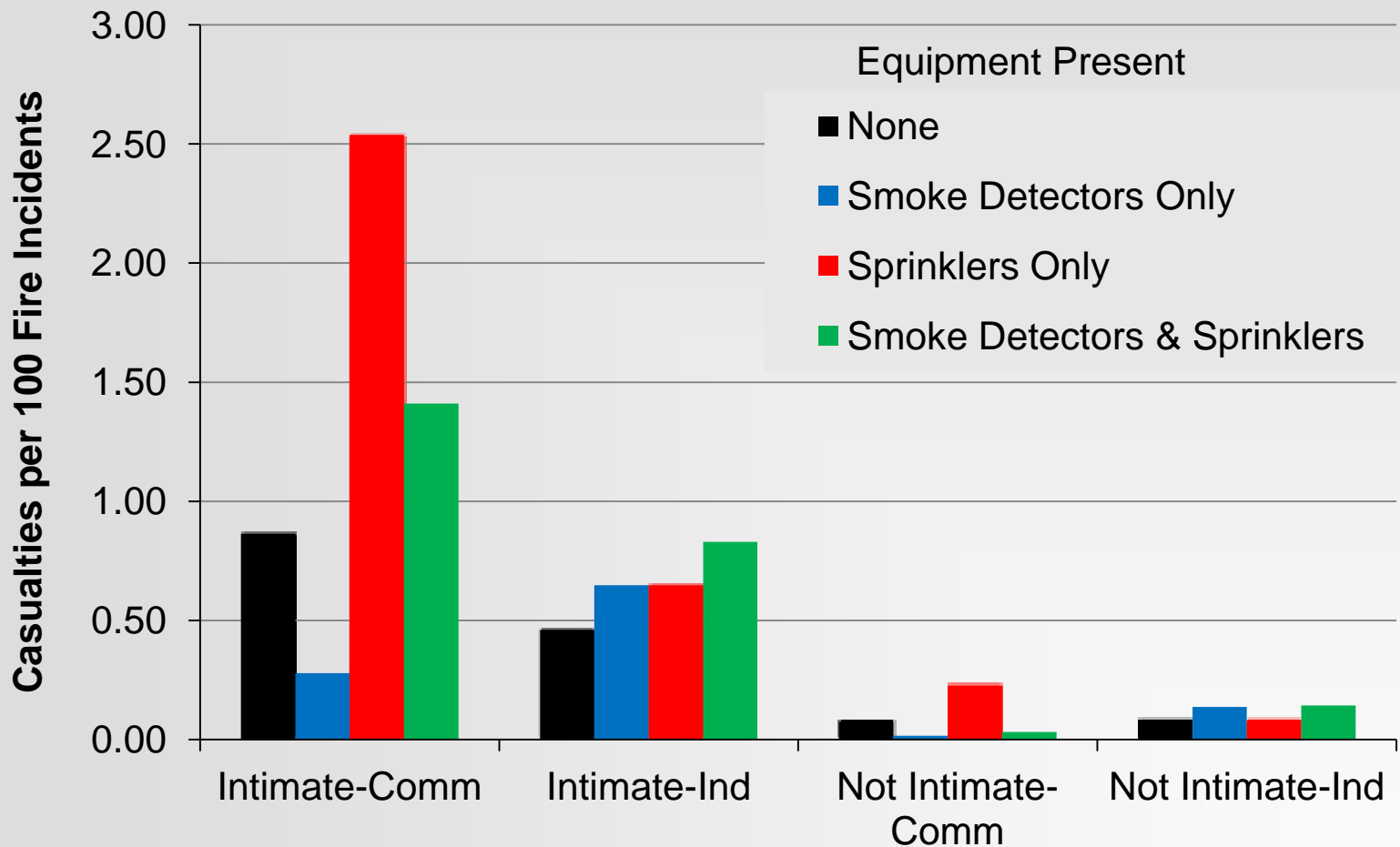
Intimate with the fire (in the room of origin), with symptom:

- A. burns
- B. smoke inhalation
- C. combination of burns and smoke inhalation

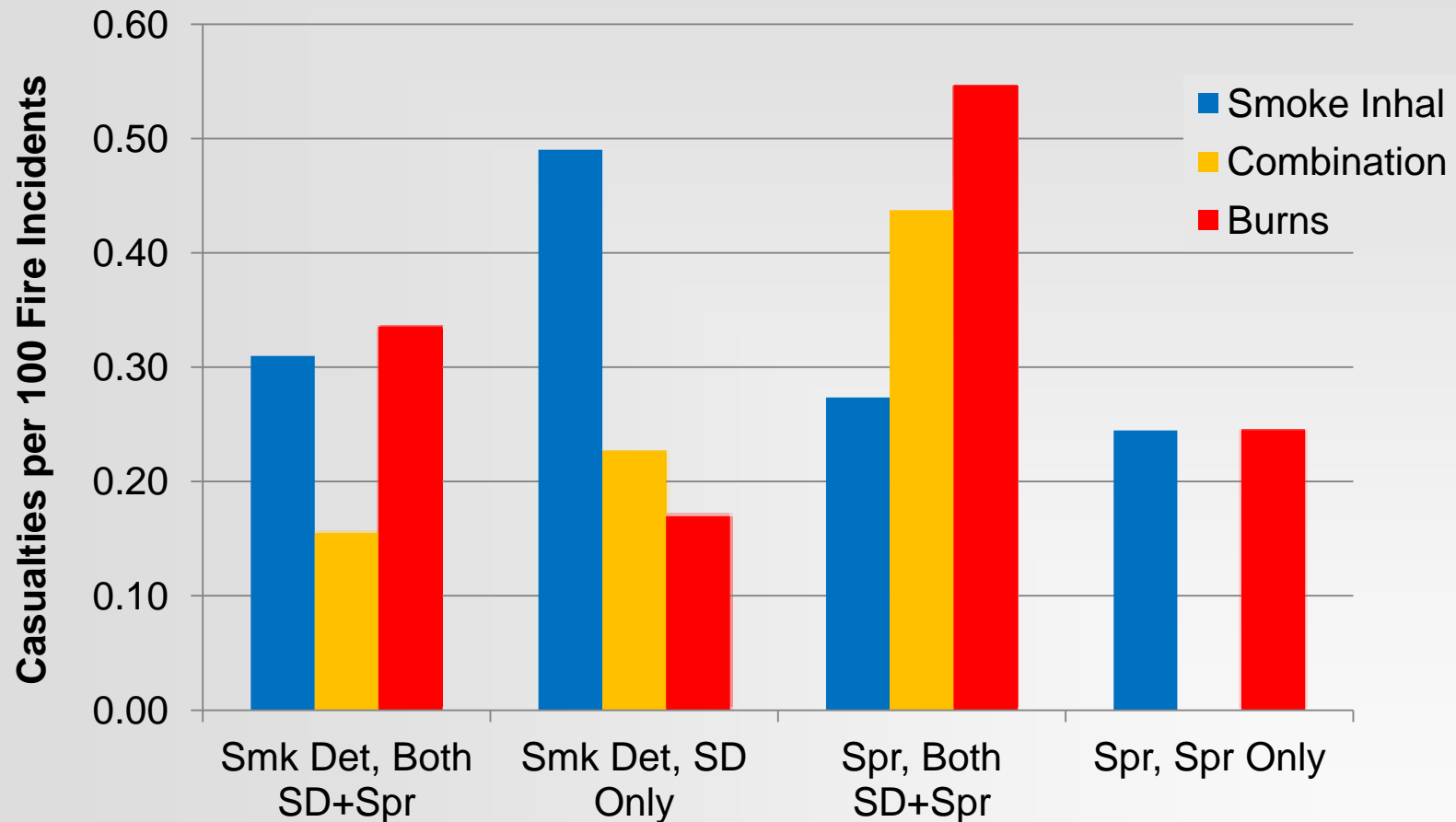
Not intimate with the fire (not in the room of origin), with symptom:

- D. burns
- E. smoke inhalation
- F. combination of burns and smoke inhalation

Casualty Rates



Casualty Rates vs. Operation of FP System

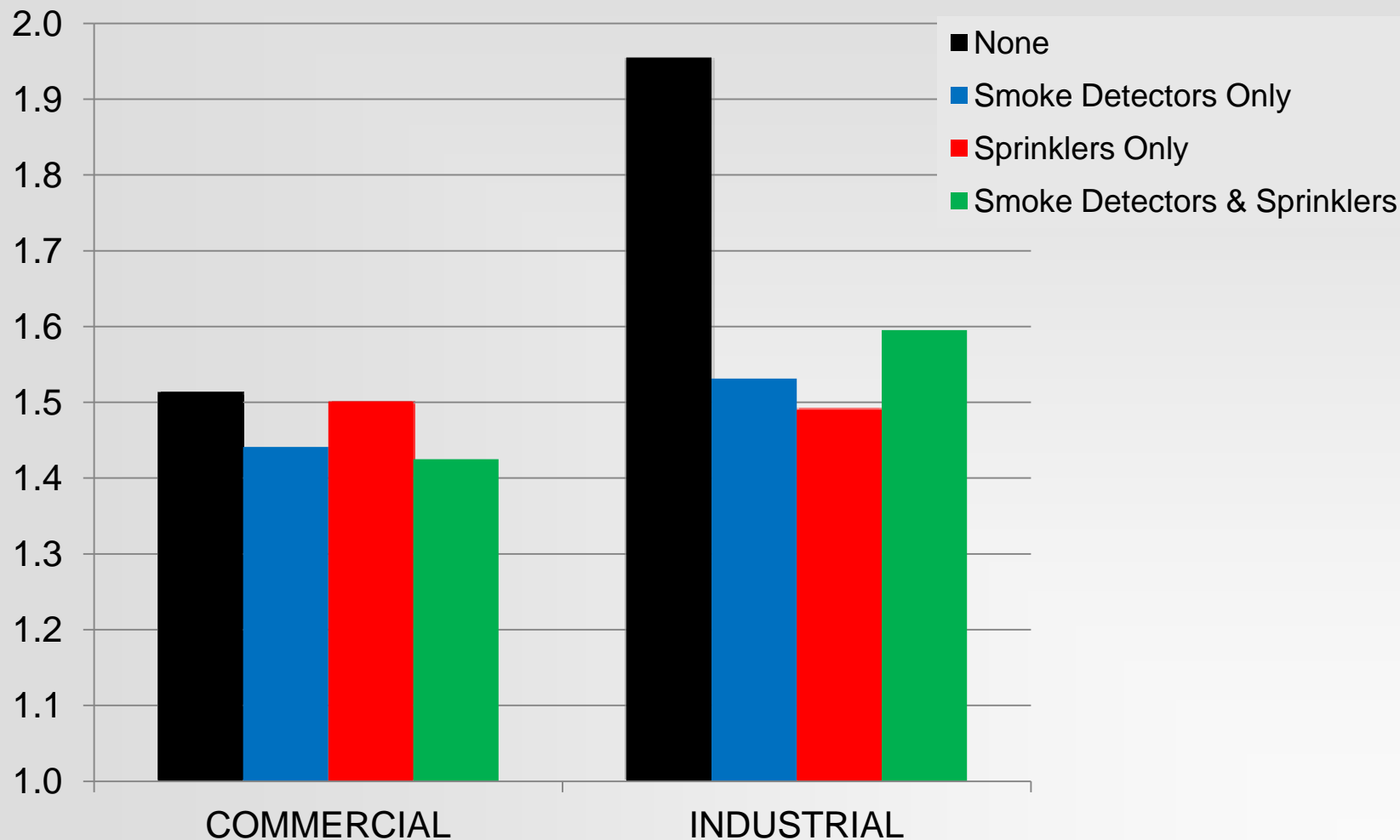


Commercial Occupancies, Occupant Intimate with Ignition

Casualty Rates: Severity Codes

- 1. Minor.** The patient is not in danger of death or permanent disability. Immediate medical care is unnecessary.
- 2. Moderate.** Little danger of death or permanent disability. Quick medical care is advisable. Includes injuries such as fractures or lacerations requiring sutures.
- 3. Severe.** The situation is potentially life threatening if the condition remains uncontrolled. Immediate medical care is necessary even though body processes may still be functioning and vital signs normal.
- 4. Life threatening.** Death is imminent; body processes and vital signs are not normal. Immediate medical care is necessary. Includes cases such as severe hemorrhaging, severe multiple trauma, and multiple internal injuries.
- 5. Death**

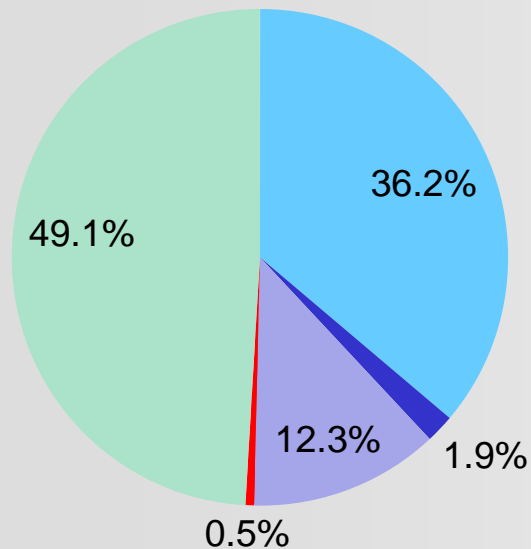
Average Casualty Severity



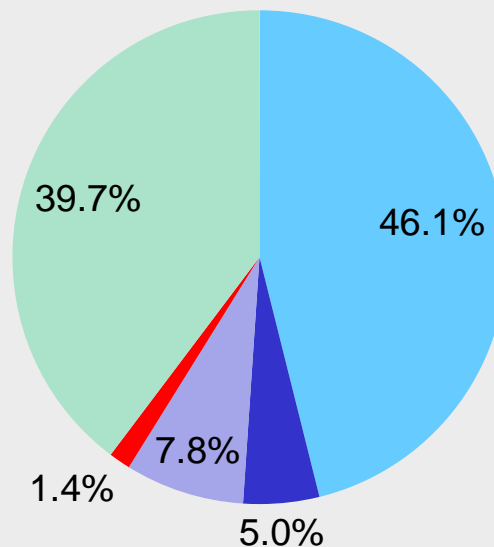
Response by Occupants

Commercial Occupancies

% Fires



% Casualties



- Alerted & responded
- Alerted & failed to respond
- No occupants
- Failed to alert
- Unknown

Note: in residential incidents, 'alerted & responded occupants' occurred in 86.5% of the incidents

Casualty Rates¹: Fires Too Small

Occupancy	Too Small for Smoke Detector	Too Small for Sprinkler	Ratio: Sprinkler/Smoke Detector
Commercial	0.66	0.80	1.2
Industrial	0.18	1.42	7.9
1- & 2-Family and Multi-Family Residential	0.36	1.47	4.1
Commercial Residential	0.11	1.70	15.5
Health-care	1.06	3.08	2.9

¹ Casualty rates: # of casualties per 100 fire incidents

Task II

- ❖ **Collaborate with Center for Campus Fire Safety in the NEMA-sponsored Campus Fire Data Reporting System**

Campus Fire Data Reporting System

DETECTION

Present of Detectors: None Present (if you checked none, proceed to Automatic Extinguishing Systems)

Detector Type: (choose one) Carbon Monoxide Combo Smoke & Heat Combo Smoke & Carbon Monoxide Heat More than one type
 Other Pull Station, Local Pull Station, Supervised Smoke, Ion Smoke, Photo Smoke, Ion & Photo
 Sprinkler, waterflow detection, Suppression System Folw/Activation Undetermined

Detector Power Supply: Battery only, Hardwire only, Plug-in, Hardwire with battery, Plug-in with battery Mechanical
 Multiple detectors and power supplies, Other, Undetermined Fire Alarm System

Detector Operation: Failed to operate correctly (Complete "Detector Failure Reason" below) Fire too small to activate
 Occupant witness event prior to alarm Operated (Complete "Detector Effectiveness" below) Undetermined

Detector Effectiveness: Alerted Occupants, occupants responded Alerted occupants, occupants failed to respond Failed to alert occupants
 There were no occupants Undetermined

Detector Failure Reason: Battery discharged or dead Battery missing or disconnected Defective Improper installation or placement
 Lack of maintenance, includes not cleaning Other Power failure, shutoff or disconnected Pull Station, Disabled
 Pull Station, Failed to Operate Undetermined

Campus Fire Data Reporting System

AUTOMATIC EXTINGUISHER SYSTEMS

Presence of Automatic Extinguishing System: (if none, proceed to Fire Extinguishers) None Present Present, Undetermined

Type of Automatic Extinguishing System: Carbon dioxide (Co2) Dry chemical Dry-pipe sprinkler Foam Halogen type Other sprinkler system Other special hazard system Undetermined Wet-pipe sprinkler

Number of sprinkler heads operating: _____

Operation of Automatic Extinguishing System: Failed to operate (Complete " Reason for Automatic Extinguishing System Failure" below) Fire too small to activate Operated/effective Operated/not effective Other Undetermined

Reason for Automatic Extinguishing System Failure: Agent discharged but did not read fire Fire not in area protected Lack of maintenance Manual intervention Not enough agent discharged System components damaged System shut off Wrong type of system Undetermined Other

Center for Campus Fire Safety

- ❖ Data from 978 fire incidents reported by campus safety officer to CCFS
- ❖ Data entries reviewed by CCFS staff
- ❖ Of those 978 incidents, 745 included an entry related to the presence of protection equipment:

Protection	Number of Incidents	Number of Casualties
Both detector and sprinkler	200	2
Detector only	280	4
Sprinkler only	6	1
Neither	259	0

Types of Detection in Campus Fires

Type	Number of Incidents
Combination smoke and CO	2
Combination smoke and heat	19
Heat	7
More than one type present	41
Pull station, supervised	2
Smoke, both ionization and photoelectric	16
Smoke, ionization	35
Smoke, photoelectric	171
Sprinkler, water flow detection	2
Undetermined	40
No entry	235

Casualties, Campus Fires

❖ **6 total (745 incidents with sprinklers and/or detectors present): 0.81 casualties/100 fire incidents**

❖ **Details**

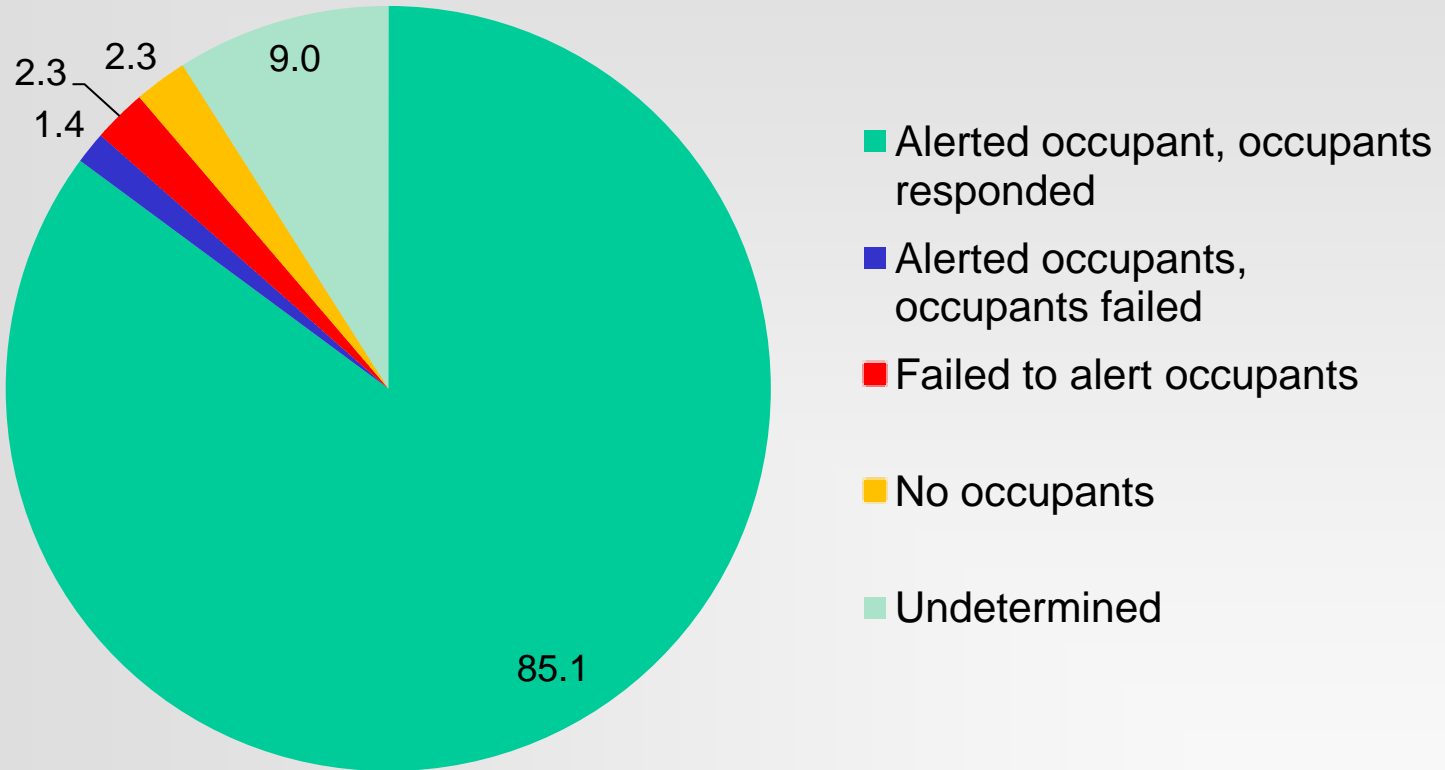
➤ **For 3 with sprinklers present**

- sprinklers operated and effective: 1
- Fire “too small” for sprinklers to activate: 2

➤ **For 6 with detectors present**

- detectors operated, occupants responded: 4 (2 unknown)

Detector Performance, Campus Fires



% fire incidents with detectors present

Response of Sprinklers and Detectors, Campus Fires

	Detector (%) ¹		Sprinkler (%) ¹
Fire Too Small	6.9	Fire Too Small	48.9
Occupant witnessed event prior to alarm	13.1	Operated/effective	5.8
Operated	71.4	Operated, Not Effective	0.7
Undetermined	7.3	Other	5.8
		Undetermined	38.8

¹ percentage of fire incidents where detectors or sprinklers were present

Summary

- ❖ **Smoke detectors and sprinklers have different functions.**
 - **Smoke detectors operate prior to sprinklers, giving occupants earlier indication of fire**
 - **Sprinklers limit fire spread**

Summary: Severity of Casualties

- ❖ **Percentage of average severity of casualties with protection equipment present vs. those with no protection equipment present.**

Protection Equipment	Commercial	Industrial
Detector, No Sprinkler	94	82
Sprinkler, No Detector	99	76
Both Detector and Sprinkler	95	78

Summary: Fires Too Small

❖ % of Incidents with Equipment Present

Occupancies	Smoke Detectors	Sprinklers
Commercial	26	50
Industrial	24	42
Campus	7	49
1-, 2-, & Multi-Fam. Resid., NFPA	5	54
1-, 2-, & Multi-Fam. Resid., UMD	12.8	38.9
Commercial Residential, UMD	10.8	54.2
Health-care, NFPA	-	72
Health-care, UMD	18	65

Summary: Fires Too Small

- ❖ **Ratio of casualty rates in “fires’ too small” incidents with sprinkler operation to that for operation of smoke detectors.**

Occupancy	Ratio: Sprinkler/ Smoke Detector
Commercial	1.2
Industrial	7.9
1- & 2-Family & Multi-Family Residential	4.1
Commercial Residential	15.5
Health-care	2.9