Protecting First Responders: An Analysis of Firefighter Casualties

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MATH 340 Final Project

FEMA

1.0 Executive Summary

Background

Model 1: Methodology, Results, Discussion

Model 2: Methodology, Results, Discussion

Model 3: Methodology, Results, Discussion

Model 4: Methodology, Results, Discussion

Impact

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1.0 Background

FEMA and USFA

- All on-duty firefighter fatalities that occurred in the United States and in the US territories
- After being notified about a fatal firefighter incident, USFA verifies the incident, location, jurisdiction, and the fire department or agency involved.

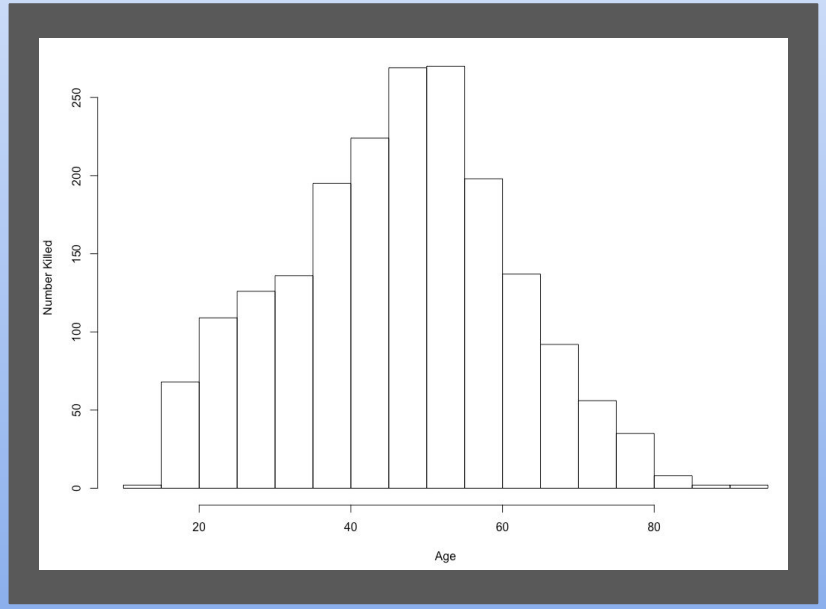
Fatality Dataset

- The dataset includes 2,289 observations on 16 variables.
- Firefighter age, rank, classification, duty, and activity, incident date, death date, cause of death, nature of death, emergency, property where the individual was responding
- Added 'Date Spread' variable

1.1 Model 1: Methodology

Gaussian Model

Cause of Death
+
Activity
⟶ Age



Background | Methodology | Results | Discussion | Impact

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1.2 Model 1: Results

Gaussian Model

When a firefighter dies from stress/overexertion while completing search and rescue operations, his/her expected age at death equals 45.0183 years, on average.

Adjusted R^2	F-Statistic	DF	P-Value
0.2394	17.86	36, 1892	< 2.2e-16

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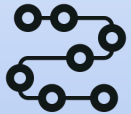
1.3 Model 1: Discussion



- Certain causes of death are associated with different ages at death
- Specific activities are associated with different ages at death

- Including *rank* in the model would have been beneficial
- Possible confounding variable *experience*

- USFA and FEMA should consider additional or continued training for younger firefighters
- consider training for age-specific job functions

Background **Methodology** **Results** **Discussion** **Impact**

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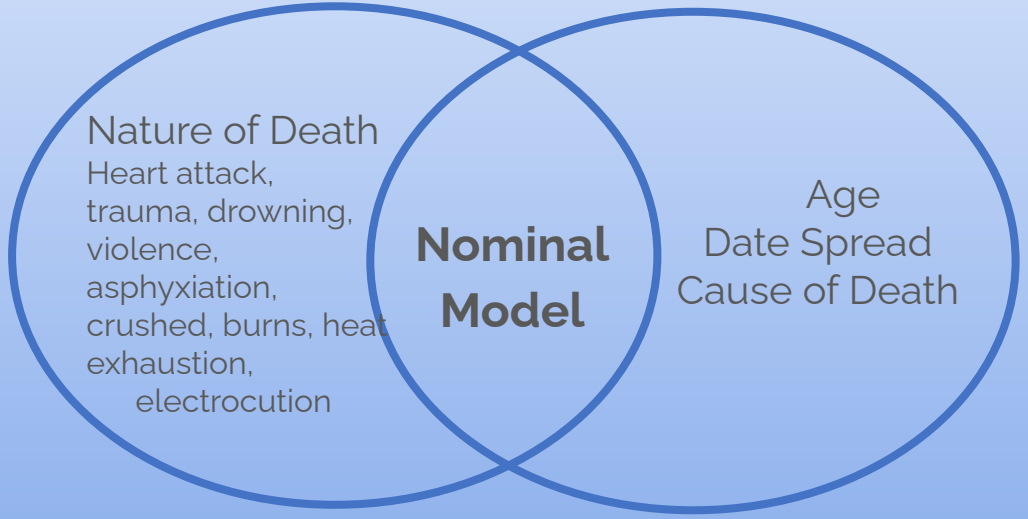
2.1 Model 2: Methodology



1	Nominal Model	No natural ordering of nature of death
2	Considered multiple variables	Rank had too many levels
3	AIC Model selection	Lowest AIC of 2412
4	Selecting Reference group	Heart Attack had the most number of counts

2.2 Model 2: Results

Examining the effect of age, date spread and cause of death on the odds of a particular nature of death rather than a heart attack.

```
Coefficients:
                         (Intercept) factTable$Date_spread factTable$Age
                          -0.21890537           0.001373422  -0.004338707
Asphyxiation              -15.64986197          -0.006509738  -0.034207825
Burns                     -16.80864064           0.001561467  -0.030916402
Cerebrovascular Accident   -0.92562384          -0.002320645  -0.002845048
Crushed                   -15.80541931          -0.014998950  -0.009229318
Drowning                   -9.75795706          -0.003250264  -0.050438869
Electrocution              -0.07928497           0.001187266  -0.035367884
Heat Exhaustion           -10.53061944          -0.005712251  -0.127173988
Other                      -1.52004132           0.001591729  -0.016085841
Trauma                     -0.38250652           0.001066557  -0.025444847
Unknown                   -14.55376857          -0.003246335  -0.059145066
Violence                   -9.43862586          -0.002261463  -0.028741034
```

Cause of Death

- Assault → Violence
- Trapped → Asphyxiation & burns
- Out of air → burns & drowning
- Struck → Crushed & violence

Background **Methodology** **Results** **Discussion** **Impact**

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2.3 Model 2: Discussion

Holding all else constant, for every increase in date spread, the odds of dying from asphyxiation, cerebrovascular Accident, crushed, drowning, heat exhaustion, and violence lower than the odds of dying from heart attack. Burns, Electrocution, Other, and Trauma have an odds greater than 1.

- Certain nature of deaths have a shorter death period and lower chances of survival, thus need more training and attention to prevent these deaths

Holding all else constant, as age increase, the odds of death by any nature other than heart attack is multiplied by less than one, showing a lower odds of dying from other natures of death than dying from heart attack.

- The older the firefighter, the more experienced
- Less likely to die from more technical errors such as drowning or asphyxiation which can be prevented through training and experience

Background | Methodology | Results | Discussion | Impact

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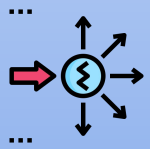
3.1

Model 3: Methodology

Performed a **multiple logistic regression** in which we wanted to predict whether or not a situation was classified as an Emergency (1) or Not (0)



Explanatory variables: Activity, Property Type, Age

Background | Methodology | Results | Discussion | Impact

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3.2 Model 3: Results

Predicting Emergencies

Relatively high pseudo R^2, with low corresponding adjusted VIF values

Originally wanted to use Rank instead of Property Type, but this variable would have overloaded the model

BIC	Pseudo R^2
1779.383	0.4262672

```
> vif(log.Emer)
                    GVIF Df GVIF^(1/(2*Df))
Activity        2.373456 23        1.018968
Property_type   2.256688 12        1.034494
Age             1.152726  1        1.073651
```

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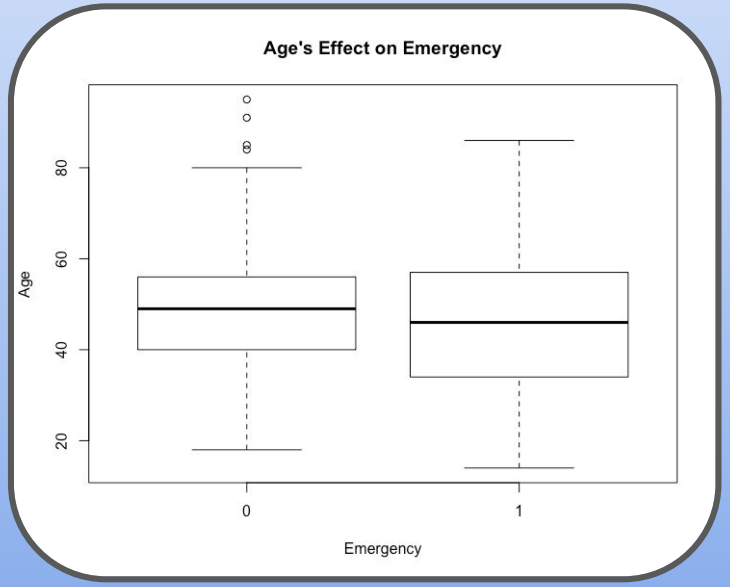
3.3 Model 3: Discussion



Age (nonsignificant): All other variables constant, every one unit increase in Age corresponds to a 0.005875 increase in log likelihood that a situation be classified an Emergency

Activity (significant): Baseline category is Search and Rescue, most model predictors < 0, showing that being in these categories decreases log likelihood of an Emergency compared to Search & Rescue

Property Type (significant): Baseline category is Store/Office, very mixed between positive & negative variables

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Model 4: Methodology

Performed an **ordinal logistic regression** in order to predict the level of danger (Duty) a firefighter was involved in at the time of death

Explanatory Variables: Nature of Death, Age, Property Type

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4.2 Model 4: Results

Est. Danger Level

Although counts of each Duty type did not match order, order shown on the left captures intrinsic danger endemic to each type of Duty

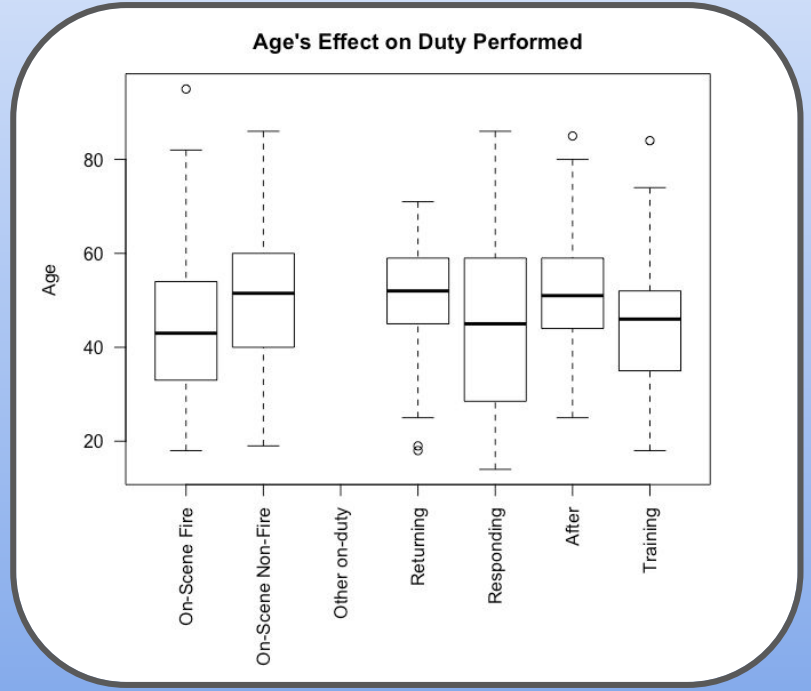
Better supports 9/11 data

AIC	Pseudo R^2
4286.47	0.2453759

Intercepts:

	Value	Std. Error	t value
On-Scene Fire|On-Scene Non-Fire	-2.7333	0.2692	-10.1550
On-Scene Non-Fire|Other on-duty	-2.0507	0.2662	-7.7025
Other on-duty|Returning	-2.0507	0.2662	-7.7025
Returning|Responding	-1.9045	0.2656	-7.1709
Responding|After	-0.8349	0.2610	-3.1990
After|Training	0.4495	0.2611	1.7211

4.3 Model 4: Discussion



Age (significant): For every one unit increase in Age, this corresponds to a 0.018534 unit increase in log likelihood that a firefighter be performing a more dangerous type of duty

Nature of Death (significant): Baseline category is Heart Attack. Many excruciating deaths had positive values (Burns, Crushed, etc) indicating that these categories correspond to increased likelihood of performing a more dangerous Duty

Property Type (significant): Baseline category is Office/Store. Mix of positive and negative variables

5.1 Impact

Analysis of circumstances regarding firefighter deaths

Develop actionable insights

Increased safety precautions

Background | Methodology | Results | Discussion | Impact

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5.1 Source

U.S. Fire Administration. (2019), "Firefighter fatalities in the United States," *Federal Emergency Management Agency* [online]. Available at *https://apps.usfa.fema.gov/firefighter-fatalities/*.

Questions?