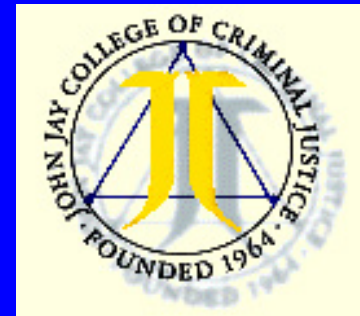# A CONCEPTUAL MODEL FOR MEASUREMENT OF **FIRE** SERVICE EQUIVALENCY UNDER NFPA 1710
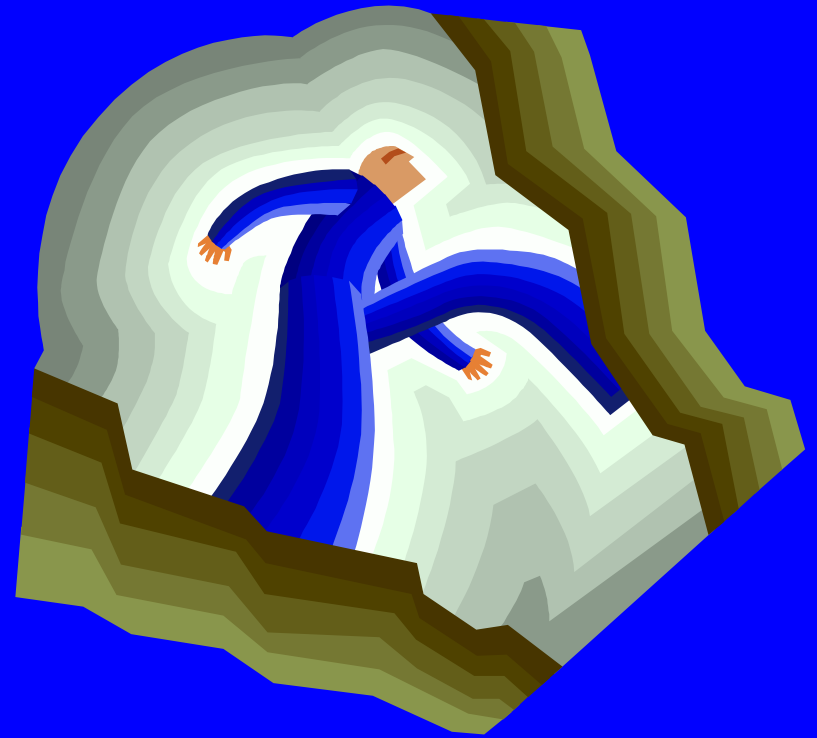
Second International Conference
On Fire Service Deployment -- 2002

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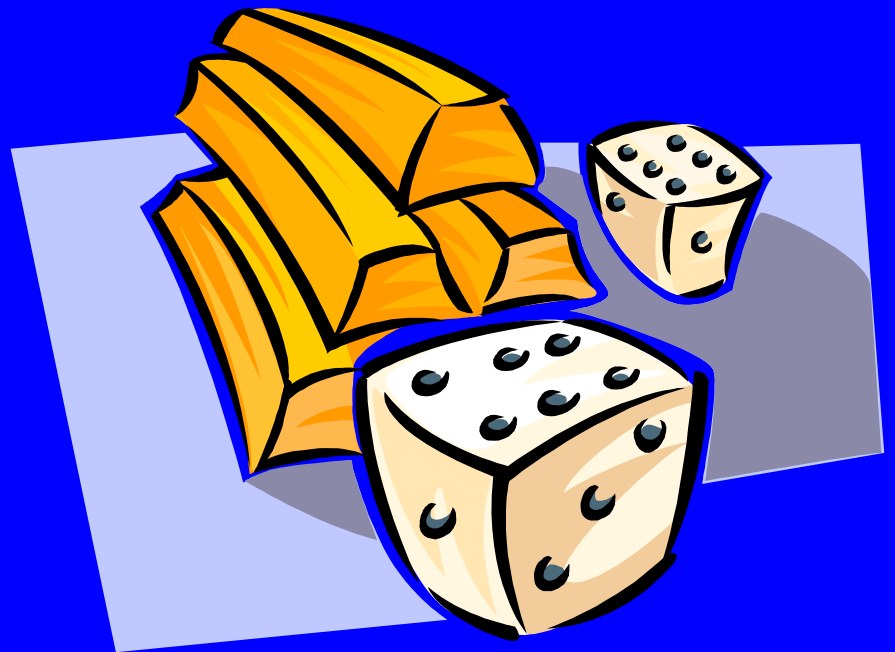
City University of New York

Also known as:

- NFPA 1710: Rescuing Rationality and Public Finance

Or more popularly known as ...

- Risking lives for money!

Problem #1

- NFPA 1710, intended to "specify minimum criteria addressing the **effectiveness and efficiency** of the career fire service operations . . . [and] protecting the public of the jurisdiction and the **occupational safety and health of fire department employees**" contains strict mandates for response time, unit staffing, and services provided.

Emphasis added

The Equivalency Clause!

- On appeal to the Standards Council, the following was added:

- **1.3 Equivalenc**y. Nothing in this standard is intended to prohibit the use of systems, methods, or approaches of equivalent or superior performance to those prescribed in this standard. Technical documentation shall be submitted to the Authority Having Jurisdiction to demonstrate equivalency.[1]

[1] NFPA Standards Council Decision **D#01-11,** Standards Council Agenda Item: **SC#01-67/01-68** Date of Decision: 11 July 2001.

Two Key Components of Equivalency

- Systems, methods, or approaches of equivalent or superior performance to those prescribed in this standard

- Equivalency is judged by the local Authority Having Jurisdiction (AHJ)

The Standards Council opened the door to alternate means of achieving 1710's stated purpose

- Problem #2

- NFPA 1710 specifies outputs, not outcomes

- NFPA 1710 purports to support efficiency and effectiveness and safety

- So …

1710 Doesn't Specify Outcomes
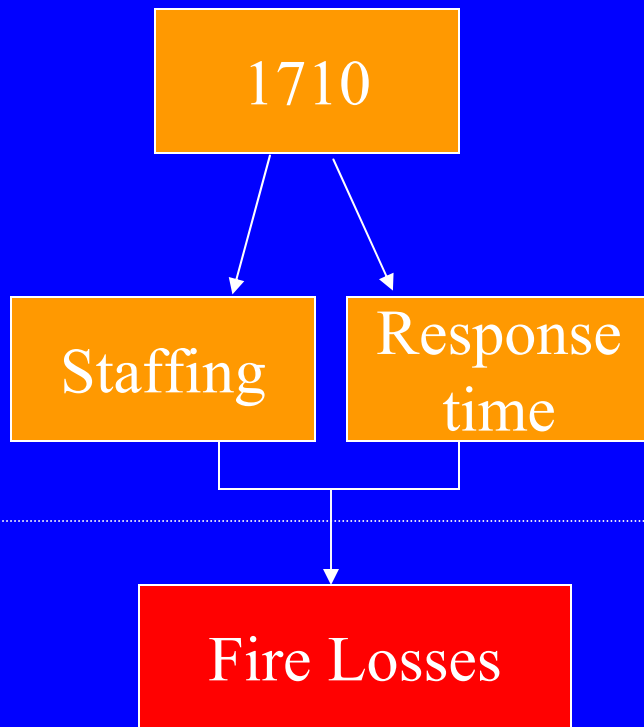
Outputs (apparatus, staffing, stations)

Outcomes (deaths, dollar loss, injuries)

Problem #3 -- Incomplete Relationship Between Outputs and Losses

1710

Staffing

Response time

Fire Losses

• 1710 implies that equal outputs will achieve equal outcomes
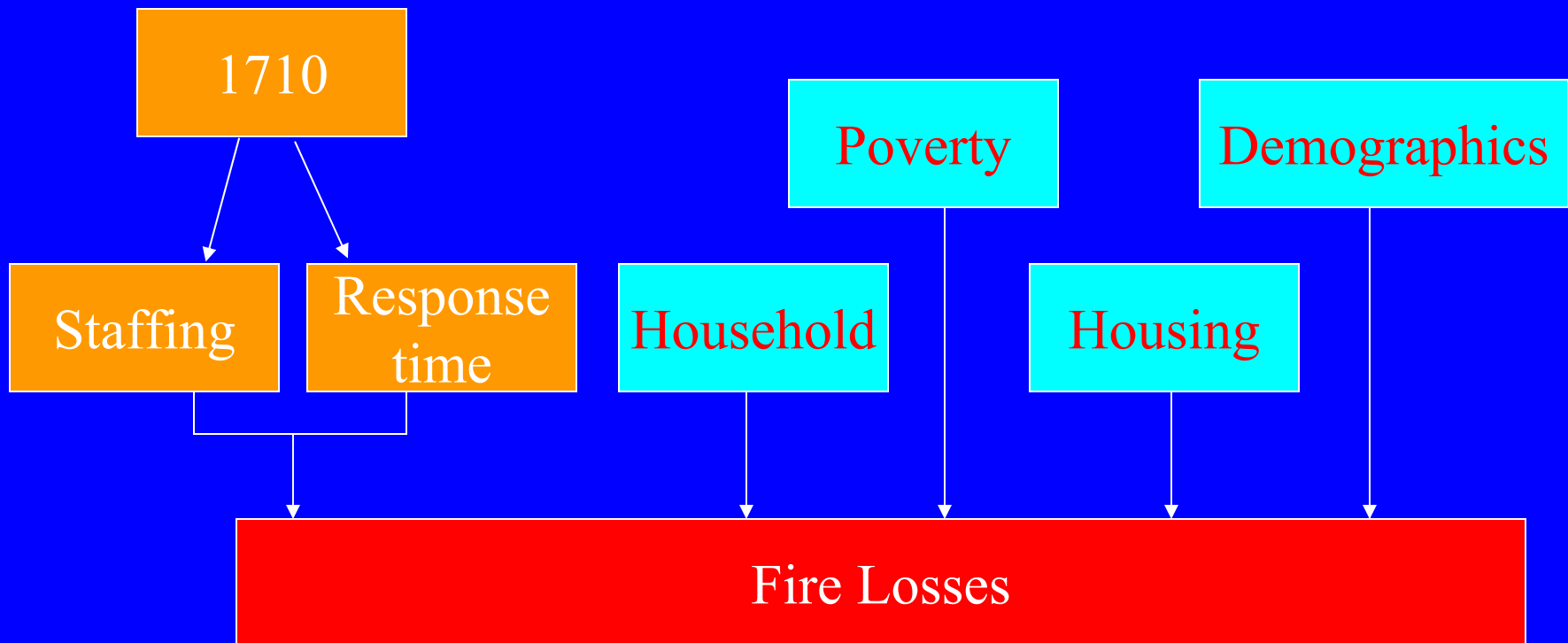• Incomplete Relationship

Outputs (apparatus, staffing, stations)

Outcomes (deaths, dollar loss, injuries)

Fire incidence and loss vary widely across communities

Conceptual Model of Fire Loss (Community-wide)

Previous studies clearly indicate that fire losses and incidence are related to:

- Housing stock makeup (single family, apartment)
- Demographic characteristics (children, elderly)
- Poverty
- Household System (single parent households, extended families, etc.)
- Vacancy/housing condition (vacancy strongly correlated with higher fire incidence)
- Dollar loss strongly related to property values

Source: Jennings. *Urban Residential Fires*: unpublished dissertation, 1996.

See also US Fire Administration report *Socioeconomic Factors and the Incidence of Fire.* FA 170/June 1997.

For each community,

- Given the *same level* of fire service output,
- Will experience *different losses* with regard to both human and dollar losses, as well as experience a different incidence of fire.
- Therefore, to define equivalency, we must know what our losses would be if we provided the outputs specified in NFPA 1710.

Response Time v. Fire Loss

- Used data from Memphis, TN (USA)
- 3 years of structure fires with loss
- Looked only at residential fires (included vacant) n=4990 incidents; then subsets
- Examined data to discern regularities in the relationship between response time and fire loss
- Looked into three measures – 1)dollar loss, 2) civilian casualties, and 3) firefighter injuries

Measuring Response Time and Fire Loss

- **Methodological Issue**
  - To filter out "noise" in the data, try segregating property types to get a truer and more comparable picture of the relationship.
  - Started with all residential fires, worked my way down to two different homogeneous sub-groups: 1 and 2 family dwellings and apartments.
  - Two analyses: Firefighter Safety and Response Times

Analyses Conducted

- Conducted a series of analyses:
- Correlation
  - $ Loss v. Response Time (RT)
  - Civilian Casualties v. RT
- Multiple Regression ($)
  - Examined RT, Day/Night, SD, Sprinklers

Findings of Time v. Loss

Correlations

» **Significant** Correlations between

» $ Loss v. Response Time (RT) (all categories)

» Insignificant Correlations

» Civilian Casualties v. RT*

Multiple Regression ($)

» **Significant** association with Response Time, Nighttime

» Insignificant but borderline association with working smoke detectors (negative association)

» Constant is largest, followed by nighttime, followed by SD, followed by RT

Interpreting the Findings

For One and Two Family Dwellings
» Each additional minute of response time adds ~$500 to loss.
» Night time fires add about $3800 to loss
» Working smoke detectors reduce loss ~$1200, but not statistically significant at same level

» *For Apartments (less questionable coding)*
» Each additional minute of response time adds ~$900 to loss.
» Night time fires add ~$5650 to loss
» Working smoke detectors reduce loss ~$3600, but not statistically significant at same level, but borderline

» So What?
» 3 Inspectors/educators going door to door installing/maintaining smoke detectors at a cost of <$400,000 could avoid losses equivalent to opening one fire company and reducing 3 minutes of response time to 3,000 households at a cost of > $1 million

Therefore we know …

- We can develop a local relationship between response time and fire loss using NFIRS data and multiple regression analysis.

- When $Loss is the dependent variable, we can find a statistically significant relationship with:

- Time of day, working smoke detector, and response time were significant in most analyses, and the magnitude of time of day and a working smoke detector were larger than response time.

- That is, presence of a working smoke detector is worth more than one minute of response time.

Summary of Previous Findings on Fire Loss and Incidence

- Although response times are significantly related to **fire losses**, the relative magnitude of influence is smaller than that associated with environmental conditions and protective systems

- **Fire incidence** is heavily related to community factors, and require targeted intervention by the fire department to have a major impact.

We can then determine, by using the coefficients in our local fire loss equation, how much dollar loss we could anticipate if we changed our response times.

By calculating our expected value at the NFPA 1710 level, We can then identify 1) how far we are from meeting the standard, 2) the fire loss consequences of compliance, 3) eventually, with a national data collection, we can begin to infer the fire loss effects of staffing levels. Given the current magnitude of coefficients for time of day, and smoke detector status, we do not expect staffing level to be a major determinant.

Response time

4 minutes
90 percent
(expressed
as average)

Statistical
inference
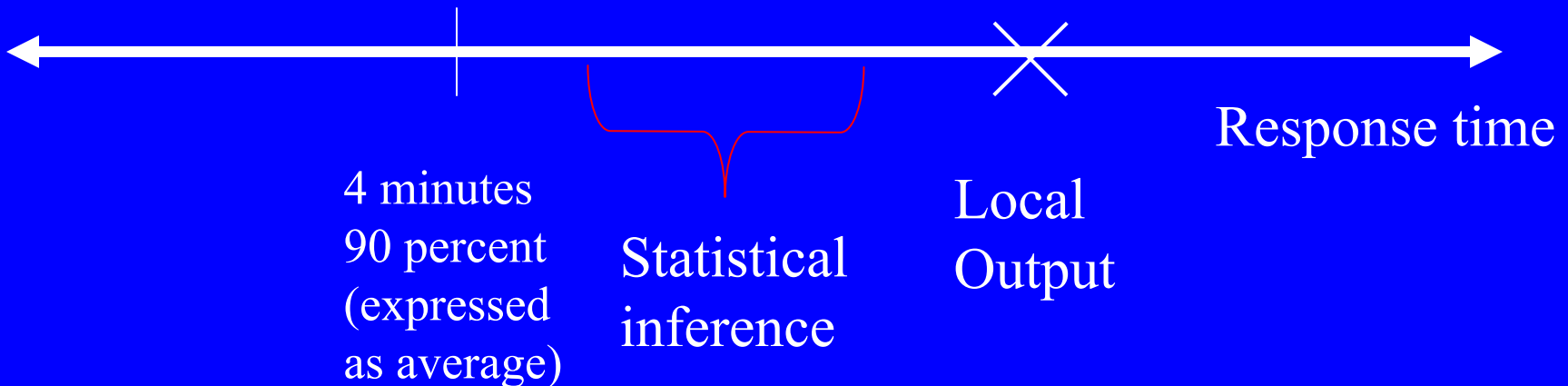
Local
Output

Review of Findings

1. 1710 provides no intended outcomes from its calls for investment in fire service response

2. The equivalency clause permits local officials to use alternate means to achieve "same (unspecified) results"

3. Using regression analysis, we can infer the potential impact of compliance, along with relevant alternative technologies and approaches for fire loss reduction

4. Given expansion of this data analysis, we could develop a set of "general equations" for different community and department types.

Principal Limitations of the Method

- Assumptions
  - Linear relationship between fire loss and response time
    - *Probably not critical since we are dealing with a narrow window of response times*
  - No control for variation in property values between communities
    - *Adjustments could be made by tying fire loss to assessed valuation of property using assessor's records, but much of this could be controlled by grouping communities*

Ideal State of Affairs

- We could discover a great deal about the nature of fire loss and incidence through an effort to collect and analyze data on a larger group of communities (regionally and typologically distributed)

- This data could be supplemented by field studies that could examine "outliers" with noticeably <u>better</u> or <u>poorer</u> outcomes.

  - Targeted prevention, leadership, sprinkler ordinances, etc.

Conclusions

- It may not be perfect, but this method allows for meaningful utilization of the equivalency clause.

- Given the magnitude of potential investment required by local governments, rationality demands that we fully explore the impacts of expenditures and maximize their value in terms of reducing fire losses of all kinds.

Thank you!

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