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Landmark Residential Fire Study Shows How Crew Sizes and Arrival Times Influence Saving Lives and Property

A firefighter conducts a second-story ventilation at a controlled fire during a fire fighter safety and resource deployment study funded by the U.S. Department of Homeland Security and led by the National Institute of Standards and Technology.

Credit: International Association of Fire Fighters

WASHINGTON, D.C.—A landmark study issued today by the U.S. Department of Commerce's National Institute of Standards and Technology (NIST) shows that the size of firefighting crews has a substantial effect on the fire service's ability to protect lives and property in residential fires.

Performed by a broad coalition in the scientific, firefighting and public-safety communities, the study found that four-person firefighting crews were able to complete 22 essential firefighting and rescue tasks in a typical residential structure 30 percent faster than two-person crews and 25 percent faster than three-person crews.

The report is the first to quantify the effects of crew sizes and arrival times on the fire service's lifesaving and firefighting operations for residential fires. Until now, little scientific data have been available.

"The results from this rigorous scientific study on the most common and deadly fires in the country—those in single-family residences—provide quantitative data to fire chiefs and public officials responsible for determining safe staffing levels, station locations and

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appropriate funding for community and firefighter safety," said NIST's Jason Averill, one of the study's principal investigators.

The four-person crews were able to deliver water to a similar-sized fire 15 percent faster than the two-person crews and 6 percent faster than three-person crews, steps that help to reduce property damage and lower danger to the firefighters.

"Fire risks grow exponentially. Each minute of delay is critical to the safety of the occupants and firefighters, and is directly related to property damage," said Averill, who leads NIST's Engineered Fire Safety Group within its Building and Fire Research Laboratory.

"Our experiments directly address two primary objectives of the fire service: extinguishing the fire and rescuing occupants," said Lori Moore-Merrell of the International Association of Fire Fighters (IAFF) and a principal investigator on the study.

The four-person crews were able to complete search and rescue 30 percent faster than two-person crews and 5 percent faster than three-person crews, Moore-Merrell explained. Five-person crews were faster than four-person crews in several key tasks. The benefits of five-person crews have also been documented by other researchers for fires in medium- and high-hazard structures, such as high-rise buildings, commercial properties, factories and warehouses.

This study explored fires in a residential structure, where the vast majority of fatal fires occur. The researchers built a "low-hazard" structure as described in National Fire Protection Association Standard 1710 (NFPA 1710), a consensus standard that provides guidance on the deployment of career firefighters. The two-story, 2000-square-foot test facility was constructed at the Montgomery County Public Safety Training Academy in Rockville, Md. Fire crews from Montgomery County, Md., and Fairfax County, Va., responded to live fires within this facility.

NIST researchers and their collaborators conducted more than 60 controlled fire experiments to determine the relative effects of crew size, the arrival time of the first fire crews, and the "stagger," or spacing, between the arrivals of successive waves of fire-fighting apparatus (vehicles and equipment). The stagger time simulates the typically later arrival of crews from more distant stations as compared to crews from more nearby stations.

Crews of two, three, four and five firefighters were timed as they performed 22 standard firefighting and rescue tasks to extinguish a live fire in the test facility. Those standard tasks included occupant search and rescue, time to put water on fire, and laddering and ventilation. Apparatus arrival time, the stagger between apparatus, and crew sizes were varied.

The United States Fire Administration reported that 403,000 residential structure fires killed close to 3,000 people in 2008—accounting for approximately 84 percent of all fire deaths—and injured about 13,500. Direct costs from these fires were about $8.5 billion. Annually, firefighter deaths have remained steady at around 100, while tens of thousands more are injured.

Researchers also performed simulations using NIST's Fire Dynamic Simulator to examine how the interior conditions change for trapped occupants and the firefighters if the fire develops more slowly or more rapidly than observed in the actual experiments. The fire modeling simulations demonstrated that two-person, late-arriving crews can face a fire that is twice the intensity of the fire faced by five-person, early arriving crews. Additionally, the modeling demonstrated that trapped occupants receive less exposure to toxic combustion products—such as carbon monoxide and carbon dioxide—if the firefighters arrive earlier and involve three or more persons per crew.

"The results of the field experiments apply only to fires in low-hazard residential structures as described in the NFPA Standard 1710, but it provides a strong starting point," said Moore-Merrell. Future research could extend the findings of the report to quantify the effects of crew size and apparatus arrival times in medium- and high-hazard structures, she said.

The next step for this research team is to develop a training package for firefighters and public officials that would enable them to have both quantitative and qualitative understanding of the research, a project also funded by FEMA's Assistance to Firefighters Grant Program.

The study's principal investigators were Averill, Moore-Merrell and Kathy Notarianni of Worcester Polytechnic Institute. Other organizations participating in this research include the International Association of Fire Chiefs, the Commission on Fire Accreditation International-RISK and the Urban Institute.

The report was funded by the U.S. Department of Homeland Security, Federal Emergency Management Agency's (FEMA) Assistance to Firefighters Grant Program and released today in Washington, D.C., before the start of the annual Congressional Fire Services Institute meeting that draws top fire safety officials from across the nation.

The *Report on Residential Fireground Field Experiments,* NIST Technical Note 1661, can be downloaded at: www.nist.gov/bfrl/fire_research/residential-fire-report_042810.cfm.

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