CHEST

# Longitudinal Lung Function Decrements in Firefighters Who Responded to the World Trade Center Disaster

## Important Insights for the Preservation of Lung Function in Future Disasters

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On September 11, 2001, the twin towers of the World Trade Center (WTC) in New York City were attacked by two hijacked commercial airplanes and subsequently collapsed. This heinous act of terrorism resulted in the deaths of 2,753 individuals, including 343 New York City firefighters who responded to the disaster.[1,2] In this issue of *CHEST*, Aldrich et al[3] report the results of a 13-year longitudinal study of spirometry results among 10,641 surviving firefighters with known smoking and body weight histories who were exposed to aerosolized dust following the collapse of the twin towers. This dust contained a highly toxic combination of pulverized building materials and chemical by-products of combustion and pyrolysis. The report published in this issue is a follow-up to two previous reports on lung function among firefighters at 1 year and 7 years following exposure to WTC dust.[4,5] As such, it is the longest and most comprehensive study of longitudinal spirometry data among rescue and recovery workers who were exposed to toxic material during the response to a major environmental disaster. The results of this study are therefore extremely important for understanding the long-term effects of inhaling toxic aerosolized dust on lung function. Just as importantly, it is also the first study to report the effects of smoking and smoking cessation on longitudinal lung function decline caused by toxic exposures during a major environmental disaster.

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The most discouraging finding reported in this study[3] is that, after 13 years of follow-up, there is little recovery of lung function from the substantial average $FEV_1$ decline of approximately 10% which was observed among firefighters during the first year following exposure to WTC dust. Those firefighters who arrived at the WTC site on the morning of the disaster had the heaviest dust exposure and continued to have significantly greater declines in $FEV_1$ at the end of the 13-year follow-up period compared with firefighters arriving at later times. Of importance, the investigators cite references which show that the use of respiratory protection by firefighters, such as masks and respirators, was minimal during the first week following the collapse of the twin towers.[6,7] The persistent and statistically significant dose-related decline in $FEV_1$ following exposure to WTC dust indicates that the persistent lung function decrement was primarily the result of the toxic exposure alone, rather than the result of excess individual risks of developing abnormal lung function.

The magnitude of the persistent decline in $FEV_1$ following exposure to WTC dust has important implications for firefighters. Most significantly, the persistent long-term lung average function decrement of approximately 10% that was observed in this cohort of firefighters is unusual compared with the lung function decrements reported for smoke inhalation alone. For example, it has been reported that firefighters who experience heavy smoke exposure without the use of respiratory protection may have acute $FEV_1$ declines in the range of 5% shortly after the exposure, but lung function typically returns to normal within days to weeks after the exposure.[8-10] This finding suggests that the combined effects of the pulverized building materials and the chemical by-products of combustion and pyrolysis contained in WTC

dust are significantly more toxic to the respiratory system than the effects of heavy smoke inhalation alone. Fortunately, despite the substantial and persistent decline in $FEV_1$ during 13 years of follow-up, most firefighters exposed to WTC dust continued to have $FEV_1$ values in the normal range. As Aldrich et al[3] point out, this outcome can be attributed to the firefighters' excellent pre-exposure respiratory function and overall excellent health status. At the same time, it has been shown that the average 10% decline in $FEV_1$ that occurred among firefighters during the first year after exposure to WTC dust is equivalent to 10 to 12 years of normal age-related $FEV_1$ decline.[5] Thus, the persistence of this large $FEV_1$ decline over a period of 13 years raises considerable concern about the future adequacy of respiratory function as the firefighters exposed to WTC dust continue to age.

The pathophysiologic mechanisms underlying the increased toxicity of WTC dust have yet to be elucidated. However, from a purely practical point of view, the results of the study by Aldrich et al[3] highlight two important considerations. First, they indicate that pre-employment lung function testing and rigorous employment standards are important for ensuring that firefighters have sufficient lung function reserve to maintain normal lung function following an acute decline in $FEV_1$ of at least 10% that could result from a toxic inhalational exposure while responding to a major disaster. Second, this study highlights the utmost importance of firefighters wearing protective "turnout gear," including a self-contained breathing apparatus for the entire period of time they are responding to a fire that involves the collapse of a building or other structure. In this regard, it is prudent to recommend that firefighters should not remove their protective gear immediately after fires are extinguished if a structural collapse occurs. As this study points out, inhalation of dust containing pulverized building material and the chemical by-products of combustion or pyrolysis may cause substantial long-term lung dysfunction, even after a fire has been extinguished.

Another important finding in this study[3] is the effect of smoking status on the magnitude of longitudinal lung function decline among firefighters exposed to WTC dust. Compared with never smokers, the average $FEV_1$ at the end of the study period was 78 ml lower for former smokers who quit between September 11, 2001, and March 10, 2008; 198 ml lower for smokers who quit after March 10, 2008, and September 10, 2014; and 312 ml lower for current smokers. Each of these average $FEV_1$ decrements was statistically significant compared with the average $FEV_1$ of never smokers. The difference in average $FEV_1$ between never smokers and former smokers who quit before September 11, 2001 was not statistically significant. Thus, former smokers had average $FEV_1$ decline rates that were intermediate between never smokers and current smokers. Furthermore, the earlier former smokers quit smoking relative to WTC dust exposure the greater the postexposure $FEV_1$.

The effect of smoking status on the average $FEV_1$ of firefighters exposed to WTC dust has several important implications. First, it suggests that smoking status should be carefully evaluated during the pre-employment medical evaluation of future firefighters, and evidence of smoking cessation should be provided by smokers prior to being hired. Second, it provides strong evidence that the assessment of smoking status and aggressive smoking prevention or smoking cessation initiatives should be integral components of the preventive health care and health maintenance of all active duty firefighters. Finally, it demonstrates that the evaluation of smoking status and aggressive smoking prevention or smoking cessation initiatives should be integral components of all medical surveillance programs for firefighters who experience potentially toxic inhalational exposures during the response to a major disaster.

Although the recommendations made in this editorial may be intuitive to most pulmonologists, the results reported in the excellent article by Aldrich et al[3] provide sufficient and long-needed evidence for all fire departments to consider adopting them as a matter of policy. The brave men and women who serve in our fire departments deserve no less.

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