



## Early View

Research letter

# Pre-COVID-19 Lung Function and Other Risk Factors for Severe COVID-19 in First Responders

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## **Pre-COVID-19 Lung Function and Other Risk Factors for Severe COVID-19 in First Responders**

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Summary: We examined risk factors for COVID-19 infection and severe disease (hospitalization or death) in NYC first responders. Greater pre-pandemic rate of FEV<sub>1</sub> decline was associated with severe COVID-19, as was emergency medical service work vs. firefighting.

*To The Editor:*

Starting 1/3/2020, New York City (NYC) suffered an intense COVID-19 outbreak caused by the SARS-CoV-2 virus. By 31/5/2020, there were 203,248 diagnosed patients, 52,301 hospitalizations and

17,756 confirmed deaths in NYC.[1] Cardiac arrests with resuscitation increased 3-fold compared with the same time 2019 period.[2] Despite proper personal protective equipment (PPE) and compliance with Centers for Disease Control guidelines,[3] medical leave for suspected/confirmed COVID-19 in Fire Department of the City of New York (FDNY) responders was substantial, affecting 40.7% of emergency medical service providers (EMS) and 34.5% of firefighters.[4] We examined risk factors for COVID-19 diagnosis and severe COVID-19 disease (hospitalization or death) in FDNY responders.

Our study population included FDNY firefighters and EMS who were actively employed on 1/3/2020 and had received  $\geq 2$  pulmonary function tests (PFTs) between their hire date and 29/2/2020. COVID-19 diagnoses, hospitalizations and deaths between 1/3/2020-31/5/2020 were obtained from the FDNY electronic medical record. Responders who had a positive nucleic-acid COVID-19 test had confirmed COVID-19, and those with reported symptoms consistent with COVID-19 but not tested were classified as suspected COVID-19. Additionally, those who had both a confirmed diagnosis and a COVID-19-related hospitalization or death were classified as severe COVID-19. Multivariate logistic regression assessed whether class of employment (firefighter or EMS), longitudinal rate of FEV<sub>1</sub> decline/year between participants' first PFT and 1/3/2020, smoking history, age, sex, race, BMI, blood glucose and HDL cholesterol levels were associated with either severe COVID-19, confirmed COVID-19 or suspected COVID-19. Analyses were performed using SAS, version 9.4. We followed STROBE reporting guidelines. The Montefiore Medical Center/Albert Einstein College of Medicine Institutional Review Board approved this study (#2020-11983).

Of 15,670 FDNY responders employed on 1/3/2020, the study population (N=14,290) was comprised of 3501 EMS and 10,789 firefighters. Participants had a mean age of  $40.4 \pm 9.2$  years, a mean BMI of  $29.8 \pm 4.5$  kg/m<sup>2</sup>, and were 8.0% female, 67.8% white, 11.2% Black, 16.6% Hispanic, and 4.4% other races/ethnicities. Sixty-eight percent were never-smokers, 25.1% were former-smokers, 4.1% current-smokers, and 2.9% had missing smoking status. The mean  $\pm$  SD number of FEV<sub>1</sub>

measurements used in calculating FEV<sub>1</sub> decline was 10.9±4.9, and the mean duration was 11.9±6.1 years. From 1/3/2020-31/5/2020, 9115 responders had no COVID-19 diagnosis, 5,175 (362.1/1000) were confirmed or suspected COVID-19 cases, and 62 (4.4/1000) were hospitalized. Three participants died in hospital, and one died at home (0.3/1000). Adults aged 18-44 had a lower rate of COVID-19-related hospitalizations (3.0/1000) and experienced no COVID-19-related deaths, despite having an elevated infection rate (405.3/1000). EMS had more cases of severe COVID-19 than firefighters (42/3501 [1.2%] vs. 21/10789 [0.19%]; Fisher's exact p-value<0.001). EMS were slightly younger than firefighters (mean±SD: 38.7±10.2 vs. 41.0±8.8 years), and had a larger proportion of females (29.3% vs. 1.1%) and non-whites (60.7% vs. 22.9%). After adjustment for confounders, multivariate logistic regression showed that EMS had a 4.23-fold increased odds of severe disease (95% CI=2.20-8.15) when compared with firefighters (Table). EMS also had a modest increase in odds of confirmed and a non-significant increase in odds of suspected COVID-19 (Table).

A greater rate of FEV<sub>1</sub> decline prior to 1/3/2020 was associated with severe COVID-19, but was not associated with confirmed or suspected COVID-19 infection. Compared with never smokers, ever-smokers did not have increased odds of severe or confirmed COVID-19. Higher age, BMI, blood glucose level and non-white race were independent risk factors for severe COVID-19.

Overall, between 1/3/2020-31/5/2020, we observed that the COVID-19 infection rate among FDNY responders was 362/1000 – 15 times the NYC rate (24/1000).[1] EMS had over a four-fold increased risk of severe COVID-19 and a 26% increased risk of confirmed COVID-19 disease when compared with firefighters. It is likely that their higher-intensity COVID-19 exposures contributed to the increased risk and severity of COVID-19 illness. Although both FDNY firefighters and EMS responded to the pandemic-related surge in 9-1-1 emergency medical calls and followed the same PPE protocols,[4] EMS had greater COVID-19 exposure than firefighters due to greater COVID-related call volume and being solely responsible for patient transport, nebulization of bronchodilators and intubation.

Despite having a higher COVID-19 case rate than NYC, FDNY responders had a lower rate of severe COVID-19 than the city as a whole (4.1/1000 vs 6.2/1000 hospitalizations and 0.3/1000 vs 2.1/1000 deaths).[1] This may be due to the healthy worker effect, i.e. lower prevalence of comorbidities in FDNY responders than the general NYC population. The lower hospitalization and death rates observed in this study may be a result of differences in the age distributions of the FDNY cohort and the general NYC population. The COVID-19-related hospitalization rate in FDNY responders aged 18-44 was similar to that of NYC residents in the same age group (3.0/1000 vs. 2.8/1000), though the infection rate was over 15-fold higher (405.3/1000 vs. 25.5/1000).[1]

As seen in other healthcare worker cohorts, higher age was associated with lower risk of COVID-19 infection.[5] This may be due to age-related changes in behavior. Alternatively, since immunity to coronaviruses increases with age,[6] cross-reactive cellular immunity to other coronaviruses may provide protection from contracting SARS-Cov-2.[7]

The FDNY longitudinal medical monitoring program enabled assessment of FEV<sub>1</sub> decline rate prior to the COVID-19 pandemic as a potential risk factor. We previously found that greater FEV<sub>1</sub> decline rates were associated with asthma and COPD in World Trade Center-exposed FDNY responders.[8] In our current study, we observed greater FEV<sub>1</sub> decline rates to be associated with severe COVID-19 disease. Further investigation of parameters of lung health associated with severe COVID-19 are needed in other longitudinal cohorts. Interestingly, we observed confirmed COVID-19 diagnosis was not associated with smoking and that ever-smoking was less prevalent in severe COVID-19 disease, a surprising finding as smoking increases expression of the SARS-Cov-2 receptor in human lung epithelium.[9, 10] However, the impact of smoking on COVID-19 is complex, and while our findings are consistent with ecological epidemiology studies where smoking was less prevalent in hospitalized patients, further studies are needed before reaching any conclusion.[11-14] Lastly, similar to other reports, we found that non-white race was strongly associated with COVID-19-related hospitalization.[15]

This study has limitations. The data are derived from a single occupational cohort, limiting its generalizability. As with all observational studies, there may be residual confounding. Since molecular testing for COVID-19 was limited early on in the NYC outbreak, a majority of FDNY responders who had symptoms of COVID-19 did not have confirmed COVID-19 diagnosis via a positive nucleic-acid test. The similarity in risk factors for suspected and confirmed COVID-19 in this cohort lends support to the accuracy of symptom screening for COVID-19 diagnosis in high prevalence settings; however, respiratory symptoms related to smoking or seasonal influenza may reduce the specificity of suspected COVID-19 diagnosis. These limitations are balanced by the strength of a closed cohort with extensive information from prior monitoring exams and with paid medical leave, reducing the likelihood of selection bias as well as ascertainment biases.

In summary, our study emphasizes the elevated risk of disease FDNY responders had during the COVID-19 pandemic, particularly EMS and those with greater pre-pandemic lung function decline. To protect healthcare workers, including pre-hospital responders, requirements of proper PPE use, environmental controls, influenza vaccination (to minimize additional medical leave, mischaracterization and potential additional comorbidity) and COVID-19 vaccination, when available, are all critical. Without these measures, healthcare systems will be unable to maintain surge capacity during this pandemic.

#### Author Contributions:

MDW, DJP, RZO designed the study. MDW, AS, TS, YL, BV, AN, KH, SB, DJP performed data curation. MDW, RZO, AS performed data analyses. MDW prepared the first draft of the manuscript. MDW, RZO, AS, AN, KLC, DJP critically revised the manuscript. All authors have read and approved the manuscript. DJP takes the responsibility for the integrity of the data.

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Table: Multivariate Logistic Regression Model Predicting COVID-19-Related Outcomes<sup>a,b,c</sup>

Variables	Hospitalization/Death vs. No COVID-19 diagnosis N=63			Confirmed COVID-19 vs. No COVID-19 diagnosis N=1,569			Suspected COVID-19 vs. No COVID-19 diagnosis N=3,543		
	HR	95% CI	p	HR	95% CI	p	HR	95% CI	p
EMS vs. Firefighter	4.23	2.20-8.15	<0.001	1.28	1.10-1.49	0.001	1.07	0.96-1.20	0.228
FEV <sub>1</sub> decline per 100 ml/yr	1.70	1.12-2.59	0.012	0.93	0.81-1.06	0.265	1.01	0.92-1.11	0.803
Ever smoker	0.46	0.25-0.86	0.014	0.99	0.88-1.12	0.920	1.14	1.04-1.24	0.005
Age per 10 years	1.59	1.20-2.10	0.001	0.79	0.74-0.84	<0.001	0.68	0.65-0.71	<0.001
Male gender	1.55	0.60-4.02	0.365	1.12	0.88-1.44	0.355	1.07	0.90-1.29	0.438
Non-white race	2.46	1.34-4.51	0.004	1.21	1.06-1.38	0.004	1.24	1.13-1.37	<0.001
BMI	1.09	1.05-1.13	<0.001	1.02	1.00-1.03	0.029	1.00	0.99-1.01	0.665
Blood glucose mmol/L	1.13	1.02-1.25	0.015	0.95	0.89-1.01	0.093	1.01	0.97-1.05	0.626
HDL Cholesterol mmol/L	0.38	0.15-0.97	0.042	1.11	0.94-1.30	0.222	0.95	0.84-1.07	0.359

<sup>a</sup>N=13,879 due to missing covariates; <sup>b</sup>Model adjusted for first FEV<sub>1</sub> measurement after hire date; <sup>c</sup>Between 1/3/2020-31/5/2020