

Short report

SARS-CoV-2 seroprevalence among firefighters in Los Angeles, California

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ABSTRACT

Objective We estimate the seroprevalence of SARS-CoV-2 antibodies among a sample of firefighters in the Los Angeles (LA), California fire department in October 2020 and compare demographic and contextual factors for seropositivity.

Methods We conducted a serological survey of firefighters in LA, California, USA, in October 2020. Individuals were classified as seropositive for SARS-CoV-2 if they tested positive for IgG, IgM or both. We compared demographic and contextual factors for seropositivity.

Results All firefighters in LA, California, USA were invited to participate in our study, but only roughly 21% participated. Of 713 participants with valid serological data, 8.8% tested positive for SARS-CoV-2 antibodies, and among the 686 with complete survey data 8.9% tested positive for antibodies. Seropositivity was not associated with gender, age or race/ethnicity. Seropositivity was highest among firefighters who reported working in the vicinity of LA International Airport, which had a known outbreak in July 2020.

Conclusions Seroprevalence among firefighters in our sample was 8.8%, however, we lack a full workplace seroprevalence estimate to compare the relative magnitude against general population seroprevalence (15%). Workplace safety protocols, such as access to personal protective equipment and testing, can mitigate increased risk of infection at work, and may have eliminated differences in disease burden by geography and race/ethnicity in our sample.

INTRODUCTION

First responders—including firefighters—have been working throughout the pandemic, which increases the likelihood of contracting SARS-CoV-2. While we may expect higher exposure to lead to higher rates of infectivity among first responders relative to the general population, preventive measures such as using personal protective equipment (PPE), conducting workplace screening or implementing protocols to minimise exposure to infected patients may mitigate the increased risk of contracting SARS-CoV-2 among first responders. Measuring seroprevalence of SARS-CoV-2 among first responders will improve our understanding of risk and transmission in front line worker populations.

Several studies have estimated seroprevalence in firefighter populations during the first 6 months of the pandemic in 2020. On the lower end, seroprevalence estimates ranged from 1.1% and 1.5% in Rochester (May) and Arizona (April/May), respectively.^{1 2} In

Key messages

What is already known about this subject?

- First responders—including firefighters—have higher rates of exposure to COVID-19 which may lead to risk of infectivity compared with the general population. Estimated COVID-19 seroprevalence among firefighters has been highly variable across published studies.

What are the new findings?

- In a study of 713 firefighters in Los Angeles, CA, 8.8% tested positive for IgG, IgM, or both types of antibodies in October 2020.
- Seropositivity was highest among firefighters who reported working in the vicinity of the Los Angeles International Airport (31.3% vs 8.3%, $p=0.010$), which had a known outbreak in July 2020.

How might this impact on policy or clinical practice in the foreseeable future?

- Workplace protocols to mitigate risk of exposure to COVID-19 may reduce large differences in infectivity between workers in high risk occupations and the general community.
- Workplaces that have relatively easy access to PCR testing may benefit from more systematic testing to identify asymptomatic or mildly symptomatic infections and limit workplace exposure.

May/June, seroprevalence was 5.4% in Cleveland and 6.9% in Detroit.^{3 4} In a single fire department located at the epicentre of an outbreak in South Florida, seroprevalence was 8.9% in April.⁵ Across all published studies, seroprevalence was highest among New York City firefighters: 22.5% in May–July.⁶ Although it has been demonstrated that healthcare workers with high levels of patient contact experience greater odds of seropositivity than the general population or other public service employees,^{4 7} seroprevalence among first responders or firefighters do not appear to significantly deviate from community estimates.^{1 2 6}

In this study, we conducted a serological survey to estimate the prevalence of SARS-CoV-2 antibodies among a sample of firefighters in the Los Angeles Fire Department (LAFD) and tested for associations between seroprevalence and individual characteristics.



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Table 1 SARS-CoV-2 seropositivity and association with individual characteristics among firefighters in Los Angeles, California, USA

Characteristics	No (%)	% Seropositive (95% CI)			P value (IgG or IgM)
		IgG only	IgM only	IgG or IgM	
Total (with valid survey data)	686 (100.0)	8.2 (6.1 to 10.2)	6.0 (4.2 to 7.8)	8.9 (6.8 to 11.0)	
Age group (years)					
18–29	93 (13.6)	6.5 (1.5 to 11.4)	2.2 (–0.8 to 5.1)	6.5 (1.4 to 11.5)	0.612
30–44	287 (41.8)	8.7 (5.4 to 12.0)	7.7 (4.6 to 10.8)	10.1 (6.6 to 13.6)	
45–60	270 (39.4)	8.5 (5.2 to 11.8)	5.9 (3.1 to 8.8)	8.9 (5.5 to 12.3)	
≥60	36 (5.2)	5.6 (–1.9 to 13.0)	2.8 (–2.6 to 8.1)	5.6 (–1.9 to 13.1)	
Gender					
Female	83 (12.1)	4.8 (0.2 to 9.4)	2.4 (–0.9 to 5.7)	4.8 (0.2 to 9.4)	0.132
Male	601 (87.6)	8.6 (6.4 to 10.9)	6.5 (4.5 to 8.5)	9.5 (7.1 to 11.8)	
Non-binary/other	2 (0.3)	0.0 (n/a)	0.0 (n/a)	0.0 (n/a)	
Race/ethnicity					
Non-Hispanic white	357 (52.0)	6.4 (3.9 to 9.0)	4.5 (2.3 to 6.6)	7.3 (4.6 to 10.0)	0.582
Non-Hispanic black	46 (6.7)	6.5 (–0.6 to 13.7)	8.7 (0.6 to 16.8)	8.7 (0.5 to 16.8)	
Non-Hispanic Asian	64 (9.3)	12.5 (4.4 to 20.6)	10.9 (3.3 to 18.6)	12.5 (4.4 to 20.6)	
Hispanic	197 (28.7)	10.2 (5.9 to 14.4)	6.6 (3.1 to 10.1)	10.7 (6.4 to 15.0)	
Other/mixed race	22 (3.2)	9.1 (–2.9 to 21.1)	4.8 (–4.3 to 13.9)	9.1 (–2.9 to 21.1)	
Ever had a Covid test (PCR)?					
No	100 (14.6)	6.0 (1.3 to 10.7)	5.0 (0.7 to 9.2)	7.0 (2.0 to 12.0)	<0.001
Yes, tested negative	529 (77.1)	2.8 (1.4 to 4.3)	2.1 (1.0 to 3.3)	3.2 (1.7 to 4.7)	
Yes, tested positive	52 (7.6)	67.3 (54.6 to 80.1)	48.1 (34.5 to 61.7)	71.2 (58.8 to 83.5)	
Don't know or yes and don't know test result	5 (0.7)	0.0 (n/a)	0.0 (n/a)	0.0 (n/a)	
Experienced COVID-19 symptoms since start of pandemic?					
No	396 (57.7)	5.3 (3.1 to 7.5)	3.3 (1.5 to 5.1)	5.6 (3.3 to 7.8)	<0.001
Yes	290 (42.3)	12.1 (8.3 to 15.8)	9.7 (6.3 to 13.1)	13.4 (9.5 to 17.4)	
Experienced COVID-19 symptoms in past 2 weeks?					
No	627 (91.4)	7.0 (5.0 to 9.0)	5.3 (3.5 to 7.0)	7.8 (5.7 to 9.9)	0.004
Yes	59 (8.6)	20.3 (10.1 to 30.6)	13.6 (4.8 to 22.3)	20.3 (10.1 to 30.6)	
Respondent thought it was likely they have had COVID-19					
No	543 (79.2)	3.3 (1.8 to 4.8)	2.2 (1.0 to 3.5)	3.5 (2.0 to 5.0)	<0.001
Yes	143 (20.8)	26.6 (19.3 to 33.8)	20.3 (13.7 to 26.9)	29.4 (21.9 to 36.8)	
Respondent likely had contact with anyone with known or suspected COVID-19					
No	306 (44.6)	4.9 (2.5 to 7.3)	4.3 (2.0 to 6.5)	5.6 (3.0 to 8.1)	0.005
Yes	380 (55.4)	10.8 (7.7 to 13.9)	7.4 (4.8 to 10.0)	11.6 (8.4 to 14.8)	
*Respondent works in LAX zip code					
No	615 (97.5)	7.6 (5.6 to 9.6)	5.5 (3.8 to 7.3)	8.3 (6.1 to 10.4)	0.010
Yes	16 (2.5)	31.3 (8.5 to 54.0)	25.0 (3.8 to 46.2)	31.3 (17.4 to 45.1)	

Notes: Serological survey conducted in October 2020. Sixty-three out of 713 (8.8%) participants with valid serological data tested positive for IgG, IgM or both types of antibodies.

*Only N=631 have valid zip code data; there was a known outbreak of COVID-19 in July 2020 in the LAX zip code. LAX, Los Angeles International Airport; n/a, not available.

METHODS

Study design

This is a prospective cohort study of firefighters employed by LAFD conducted in partnership between the University of Southern California, the LA County Department of Public Health, LAFD, Gauss Surgical and Cedars Sinai Medical Center. Firefighters were invited to complete a questionnaire and received PCR and antibody tests. Written informed consent was obtained from all study participants.

Study participants and data

An estimated 3371 firefighters actively employed by LAFD were eligible for study participation. Participants were recruited through an employee intranet between July and October 2020. Participant onboarding was performed through a proprietary web-based and mobile-based application developed by Gauss Surgical (Menlo Park, California, USA.) Onboarding involved

describing study aims and methods to the participant, consenting the participant to complete PCR and antibody tests, and scheduling test dates. Data on participant age, sex, race/ethnicity, workplace location, symptoms, hospitalisations, patterns of PPE use and PCR-confirmed SARS-CoV-2 infection history were collected through electronic surveys (Qualtrics International, Seattle, Washington, USA).

PCR and antibody testing

PCR and antibody testing occurred between 20 October 2020 and 28 October 2020. Participants who self-reported symptoms on a COVID-19 symptom screener on the test day were excluded from the study (N=4). PCR tests were performed on oropharyngeal specimens self-collected by participants under study staff observation. Reverse transcription PCR (RT-PCR) was conducted against E and S mRNA transcripts at Cedars-Sinai

Medical Center Department of Pathology (LA, California, USA.) For seroprevalence assessments, certified phlebotomists collected approximately 5 mL of venous blood from each participant. SARS-CoV-2-specific IgM and IgG antibodies were measured using the Abbott Architect instrument (Abbott Laboratories, Chicago, Illinois, USA). Manufacturer recommended signal-to-cutoff (S/CO) ratios of >1.4 and >1.0 were used as thresholds for seropositivity for IgG and IgM antibodies, respectively.

Statistical analysis

Participants were defined as seropositive if they had IgG, IgM or both types of antibodies. Descriptive statistics for survey responses were summarised for the study cohort. We tested for differences in seropositivity by participant characteristics using two-sided tests and a significance level of $p < 0.05$. We also performed secondary analyses, including multivariable logistic regression and testing for differences in firefighter seroprevalence by contextual characteristics of workplace zip codes. We conducted sensitivity analysis using a modified S/CO threshold based on results from a validation study.⁸ Results for the secondary and sensitivity analyses are presented in the online supplemental appendix 1. All statistical analyses were performed using Stata version 15 (StataCorp).

RESULTS

A total of 713 out of 715 firefighters who participated in the study—roughly 21% of the LAFD population—had valid serological data, and 686 participants had complete survey data. The mean age of survey respondents was similar to that of the full LAFD population (42 and 43, respectively). Women were over-represented in our sample (12.1% vs 3.6% in the LAFD population). While the distribution of race/ethnicity in our sample was generally similar to that of the full LAFD population, non-Hispanic Asians were overrepresented (9.3% in sample vs 6.0% in LAFD overall) and non-Hispanic Blacks were under-represented (6.7% in sample vs 11.7% in LAFD overall).

Seroprevalence was not sensitive to the underlying sample: among the 713 firefighters with valid serological data, 63 (8.8%) tested positive for either IgG, IgM or both types of antibodies, and among the 686 firefighters with non-missing data for survey questions, 61 (8.9%) tested positive for antibodies (online supplemental appendix table 1). We limited our analysis sample to the 686 participants with no missing values for survey questions (table 1). Approximately 14% of our respondents reported that they have not received a previous PCR test and 7.0% of respondents who reported not receiving a PCR test were antibody positive. Additional undiagnosed cases occurred among those who received a previous PCR test and got a negative result, with estimated seroprevalence of 3.2%.

Gender, race and age were not statistically significant predictors of seropositivity. Our results were robust to weighting to account for differences in demographics between our sample and the full LAFD population (online supplemental appendix table 2). Seropositivity was lower among females (OR 0.48, 95% CI 0.17 to 1.3), but the difference between men and women was not statistically significant. Seroprevalence was not statistically different across race or ethnicity, but point estimates were highest among non-Hispanic Asian participants (OR 1.82, 95% CI 0.78 to 4.2). We found no statistical differences in seroprevalence by age, but the point estimate was lowest among firefighters aged over 60 years (OR 0.85, 95% CI 0.16 to 4.42). Seroprevalence was highest (31.3% (OR 4.98, 95% CI 1.67 to

14.9) among participants who reported working in the zip code containing the LA International Airport.

Results for secondary analyses are provided in the online supplemental appendix 1. Specifically, we compare seropositivity using manufacturer S/CO and a modified S/CO (online supplemental appendix table 3) and conduct a multivariable logistic regression (online supplemental appendix table 4). Finally, we present serological results for contextual characteristics of firefighter workplace zip code (online supplemental appendix table 5).

DISCUSSION

SARS-CoV-2 seroprevalence was 8.8% in our sample with valid serological data in October 2020. This estimate is 1–3 percentage points higher compared with estimates from other firefighter populations taken earlier in the pandemic (excluding NYC.) While firefighters have higher risk of contracting SARS-CoV-2 due to the nature of their work, seroprevalence in our sample is comparable to that in the general LA population during the same time frame (15%).^{9 10}

We found no evidence that firefighter demographics were associated with increased risk of seropositivity. The relatively small sample size in our study and corresponding low power for statistical tests provides one possible explanation for this result. Alternatively, lack of demographic differences in seropositivity may reflect uniform implementation of SARS-CoV-2 workplace protocols by LAFD such as wearing N95 masks, goggles and gloves for all EMS incidents as well as putting masks on patients at time of first contact.¹¹

This work should be viewed in light of its limitations. Our sample was self-selected, and only accounted for approximately 21% of the full LAFD employee population. Participation may have been influenced by prior testing results, household exposure or worker availability. Nevertheless, our sample demographics were representative of the overall LAFD population, and our results are robust to the use of weights to account for differences in demographics between our sample and the full LAFD population. Second, we did not ask respondents questions about their home environment—such as the total number of residents or the size of their home—which could have influenced their exposure to SARS-CoV-2. Furthermore, our sample collection period occurred in the months following the first wave of the pandemic, yet prior to the substantial rise in SARS-CoV-2 cases in LA County and the US beginning in November 2020.¹² Despite this, our study provides seroprevalence estimates and factors associated with SARS-CoV-2 infection for a population that is both at high risk of coming in contact with SARS-CoV-2, but also follows strong workplace protection practices.

Between 8.8% and 8.9% of firefighters in our sample were infected with SARS-CoV-2. Because our sample only represents 21% of the full LAFD population, it is possible prevalence in LAFD overall could have been higher. We did not observe significant differences in seroprevalence by demographic factors. Furthermore, our results suggest workers in occupations that adhere to similar protection or mitigation workplace protocols are likely to experience similar rates of SARS-CoV-2 infection irrespective of workplace location.

Contributors All authors were involved in the conceptualisation and design of the study. AHB, AH, KM, ME, KS, NS and OT were responsible for acquisition, analysis, or interpretation of the data. ABH, KM and OT drafted the manuscript, and all authors reviewed and provided critical revisions. AR was responsible for project administration. NS obtained funding and provided supervision for this study. Guarantor: NS

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