






# Assembling the Career Firefighter Health Study cohort: A methods overview

Rachel Zeig-Owens DrPH, MPH<sup>1,2,3</sup>  | Ankura Singh MPH<sup>1,2</sup>  |  
Suzanne Triplett BA<sup>4</sup> | Joke Salako MPH<sup>1,2</sup>  | Molly Skerker MPH<sup>1,2</sup>  |  
Ariana Napier MA, BA<sup>4</sup> | Eric Peele BA<sup>4</sup> | Marshica Stanley MA, BS<sup>4</sup> |  
Sridevi Sattaluri MS, BS<sup>4</sup> | David Prezant MD<sup>1,2,3</sup>  |  
Mayris P. Webber DrPH, MPH<sup>1,2,3</sup> 

<sup>1</sup>Bureau of Health Services, Fire Department of the City of New York, Brooklyn, New York, USA

<sup>2</sup>Pulmonary Medicine Division, Department of Medicine, Montefiore Medical Center, Bronx, New York, USA

<sup>3</sup>Division of Epidemiology, Department of Epidemiology and Population Health, Montefiore Medical Center and Albert Einstein College of Medicine, Bronx, New York, USA

<sup>4</sup>Survey Research Division, RTI International, Research Triangle Park, North Carolina, USA

## Correspondence

Rachel Zeig-Owens, DrPH, MPH, Bureau of Health Services, Fire Department of the City of New York, 9 MetroTech Center, 11E-03, Brooklyn, NY 11201, USA.  
Email: [rachel.zeig-owens@fdny.nyc.gov](mailto:rachel.zeig-owens@fdny.nyc.gov)

## Funding information

National Institute for Occupational Safety and Health, Grant/Award Number: U01 OH011309/U01 OH011934

## Abstract

**Background:** Studies of World Trade Center (WTC)-exposed rescue/recovery workers report the increased occurrence of health conditions after work at the WTC disaster site. However, the extent to which these associations are due to WTC exposure is unclear, in part due to the lack of suitable comparison groups. Accordingly, we identified a previously assembled National Institute for Occupational Safety and Health (NIOSH) cohort of career firefighters from three US cities ( $n = 29,992$ ). Here, we document the challenges in establishing this non-WTC-exposed firefighter cohort for the goal of tracking and comparing cancer and chronic health conditions in WTC-exposed and non-WTC-exposed firefighters.

**Methods:** Follow-up process included institutional review board applications, data use agreements, state cancer registry linkages and vital status determination for the NIOSH firefighter cohort. After completion of these steps, we undertook outreach to the three original city fire departments and union officials, before contact tracing and direct recruitment of 14,566 living firefighters to complete a confidential health survey. We staggered recruitment efforts by the city, using letters, postcards, emails, videos, and telephone outreach. Participants who completed the survey received \$10.

**Results:** A total of 4962 of 14,566 alive firefighters responded to the baseline survey (34.1% response rate). Respondents were older and more likely to be non-Hispanic white than nonrespondents.

**Conclusions:** We provide an overview of the process for the first survey to collect information on physical and mental health conditions among US firefighters. The data collected will have an important impact on studies of WTC rescue/recovery work, firefighting, and related health conditions.

## KEYWORDS

chronic diseases, cohort studies, firefighters, follow-up, World Trade Center

## 1 | INTRODUCTION

The attacks on the World Trade Center (WTC) on September 11, 2001 (9/11) exposed rescue/recovery workers as well as area residents and others to vast quantities of dust, smoke, and toxins as a result of the combustion of jet fuel and the collapse of the WTC Towers. The pulverized cement, glass, and building contents generated thousands of tons of particulate matter, components of which included asbestos, lead, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, organochlorine pesticides, and polychlorinated furans and dioxins.<sup>1,2</sup>

Hundreds of studies of WTC-exposed rescue/recovery workers and others have been published in the peer-reviewed literature. Many of these studies report the incidence and prevalence of conditions and symptoms that are thought to occur more commonly as consequences of exposure to the WTC disaster site. To date, studies have shown that WTC exposures, particularly among rescue/recovery workers, are associated with aerodigestive conditions (i.e., obstructive airways disease, chronic rhinosinusitis, and gastroesophageal reflux disease), mental health conditions (i.e., posttraumatic stress disorder and depression) and cancer.<sup>3–12</sup> However, the extent to which these associations are due to WTC exposure versus other occupational exposures or to unrelated factors is still under investigation because rates of these conditions in suitable comparison groups are generally unavailable.

One of the largest groups of WTC-exposed rescue/recovery workers is made up of firefighters from the Fire Department of the City of New York (FDNY). Firefighting has been associated with cancer and other health risks, such as asthma, because of the potential for inhalation and contact exposures to harmful substances.<sup>13–22</sup> Thus, firefighting exposures outside of work at the WTC site may confound studies of the association between WTC exposure and disease outcomes in WTC-exposed firefighters. Conversely, hiring standards for firefighters require that applicants meet stringent health criteria. This results in a physically superior workforce that may more easily withstand the effects of noxious exposures and as such, results may also be impacted by the healthy worker effect.<sup>23</sup>

To assess the health effects of WTC-related rescue/recovery work versus effects associated with non-WTC-related firefighting, a comparison cohort of firefighters from Chicago, Philadelphia, and San Francisco who did not respond to the WTC attacks were identified. This firefighter cohort was originally assembled by the National Institute for Occupational Safety and Health (NIOSH) for their multi-year study (1950–2009) of nearly 30,000 professional firefighters to assess the potential link between firefighting and cancer. We renamed the original NIOSH cohort the “Career Firefighter Health Study” cohort. This comparison cohort is important because, as stated, firefighting exposures outside of WTC work may confound studies of the association between WTC exposure and disease outcomes in WTC-exposed firefighters, and non-FDNY firefighters have similar prehire health requirements. Furthermore, although population-based comparisons may be available for cancer (e.g., Surveillance, Epidemiology, and End Results Program), mortality (National Death Index [NDI]), and occasionally for other diagnoses, external comparison populations present issues of comparability,<sup>24</sup> as the general

population may differ from the occupational group in the prevalence of pre-existing health conditions (e.g., heart disease) that interfere with their ability to work. Finally, maintenance of a non-WTC-exposed cohort will permit estimates of the incidence of adult-onset conditions like asthma, which are currently lacking. In future studies, the Career Firefighter Health Study cohort will be combined with non-WTC-exposed FDNY firefighters to give a broader picture of the health status of US firefighters.

The Career Firefighter Health Study cohort will be used for two primary purposes for WTC-related research: It serves as a non-WTC-exposed comparison population for cancer research via linkages to state cancer registry data. Secondly, it also serves as a non-WTC-exposed comparison population for the assessment of chronic physical and mental health conditions via health surveys.

To be able to compare rates of cancer in the WTC-exposed FDNY firefighter cohort to rates in the non-WTC exposed Career Firefighter Health Study cohort, we performed linkages with various state cancer registries, as previously described.<sup>12,14,25</sup> In this methodological report, we present only a brief overview of the time interval between the initial submission of 10 applications to state cancer registries to the final acquisition of data. The primary focus of the current account is to document the processes used for the identification and follow-up of firefighters from the Career Firefighter Health Study cohort and to detail the efforts required for their engagement and participation in the baseline health survey. Most of the follow-up outreach was performed in collaboration with our partners, RTI International, a nonprofit research institute that we hired for contact tracing, although these efforts were overseen and coordinated by the principal investigator and co-investigators from Montefiore Medical Center/Albert Einstein College of Medicine.

## 2 | MATERIALS AND METHODS

### 2.1 | Career Firefighter Health Study population

The source population provided by NIOSH was established from roster information supplied by the Chicago, Philadelphia, and San Francisco Fire Departments.<sup>14</sup> All Career Firefighter Health Study firefighters were employed by their respective departments for at least 1 day between January 1, 1950 and December 31, 2009 ( $n = 29,992$ ).

Recruitment for the baseline health survey was restricted to the subset of the cohort not known to be deceased at the initiation of follow-up in February 2019 ( $n = 14,566$  or 48.6%), based on vital status tracing, as outlined below. The Career Firefighter Health Study was endorsed by both management and unions from FDNY, the Chicago Fire Department, the Philadelphia Fire Department, and the San Francisco Fire Department, as well as by the International Association of Fire Fighters (IAFF). This study was approved by the Institutional Review Boards at Albert Einstein College of Medicine/Montefiore Medical Center and RTI International and informed consent was obtained for the surveys.

**TABLE 1** Original data from National Institute for Occupational Safety and Health (NIOSH) for the Career Firefighter Health Study Cohort

Variable	Full CFHS cohort (N = 29,992) N (%)	CFHS outreach cohort subpopulation (N = 14,566) N (%)
SSN	27,945 (93.2)	14,544 (99.8)
Date of birth	29,979 (>99.9)	14,566 (100)
Race	29,085 (97.0)	14,456 (99.2)
Sex	29,891 (99.7)	14,566 (100)
Mailing address	22,888 (76.3)	14,492 (99.5)

Abbreviations: CFHS, Career Firefighter Health Study; SSN, social security number.

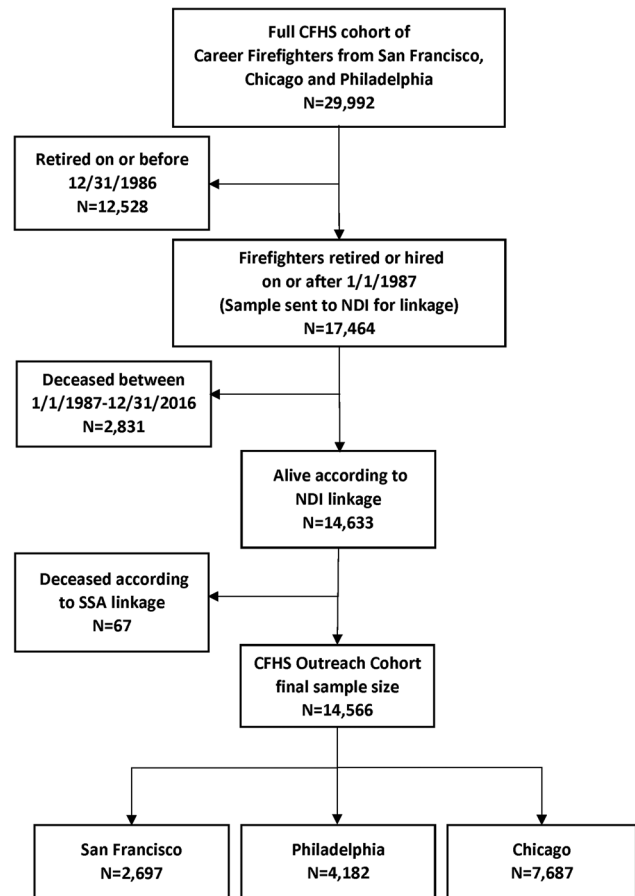
## 2.2 | Career Firefighter Health Study master file and tracing

For cancer analyses, initial Institutional Review Board (IRB) approvals and data use agreements with NIOSH, each fire department, and RTI International allowed for the Career Firefighter Health Study cohort of 29,992 firefighters to be sent to state cancer registries, and so we obtained the fire department roster information for the full cohort. NIOSH provided a master file containing first name, last name, social security number (SSN), sex, race, fire department (Chicago, Philadelphia, or San Francisco), and dates of birth, hire and retirement (if applicable) for 29,992 individuals. Full SSN was available for 93% of the cohort (Table 1). Additionally, address information including street address, city, state, and zip code was included when available.

To identify the subset of individuals who were alive and therefore potentially available for follow-up, hereafter referred to as the Career Firefighter Health Study Outreach Cohort, RTI conducted vital status tracing, limited to cohort members who were actively employed on or after January 1, 1987 ( $N = 17,464$ ) to both limit expenses and improve the likelihood of current identification (Figure 1). Accordingly, this subset of the population was linked to the Centers for Disease Control and Prevention's NDI for vital status as well as the cause of death data through December 31, 2016. We also submitted individuals' information to the Social Security Administration Limited Access Death Master File (SSA-LADMF), which had more recent vital status data available, although it is estimated to be missing some deaths and does not include cause of death information.

## 2.3 | Tracing activities for follow-up

Once the Career Firefighter Health Study Outreach Cohort was identified by NDI and SSA-LADMF matches ( $N = 14,566$ ), RTI conducted batch tracing at two timepoints using specialized vendors to



**FIGURE 1** Establishment of Career Firefighter Health Study Outreach Cohort. CFHS, Career Firefighter Health Study; NDI, National Death Index; SSA, Social Security Administration

update home addresses and obtain recent telephone numbers and e-mail addresses. This automated process reduced the number of individuals requiring manual locating during data collection. Of those not known to be deceased, 98% were found via these tracings, resulting in new or additional contact information. Tracing was continuously updated throughout the data collection period for individuals whose contact information was inaccurate, such as a phone number returning a disconnected signal. These expanded efforts included manually searching a portfolio of proprietary search engine databases and credit bureaus for contact information. Through these manual efforts, the additional contact information was obtained for 759 firefighters.

## 2.4 | Career Firefighter Health Study survey

We developed the web-based survey instrument for the Career Firefighter Health Study based on surveys regularly completed by FDNY firefighters during routine medical monitoring visits, since October 2001.<sup>26-28</sup> The survey covers demographic information as well as important health topics that affect firefighters' health and safety, such as physical and mental health symptoms and doctor

diagnoses, work exposures, and tobacco and alcohol use.<sup>29–31</sup> The development process involved reviewing the FDNY survey and identifying questions that needed to be included for comparability to information available for the FDNY cohort, which, in addition to survey data, incorporates information from employment sources (e.g., race) or verified diagnoses and dates with medical records. The additional questions were added by adapting questions from reliable sources such as the National Health and Nutrition Examination Survey and then showing the questions to a group of FDNY firefighters for input. Lastly, we modified response options to limit acceptable responses to specific ranges and included “Don't know” so a participant could continue the survey despite unknown or private information.

Once the questions were finalized, the FDNY Bureau of Technology Development and Systems programmed the survey to be taken on the internet using either a computer or tablet. Initially, the surveys were checked in the testing environment so that data files could be output and reviewed to identify and resolve problems with range checks, skip logic, and missing data. Then the survey was deployed into production on the secure FDNY Cloud which is run on the Oracle Cloud platform. Additionally, an application programming interface—computing interface which defines interactions between multiple software intermediaries—was developed so that an RTI-staffed call centre could process data for reports for outreach calls. Trained CFHS interviewers and supervisors worked at RTI Research Operations Center and conducted phone interviews with participants who preferred this modality. Once a participant completed the survey, a process was put in place to send a \$10 Amazon eGift Card to the email address provided during the survey. If a participant requested a \$10-cash card instead, the system was programmed to alert the research staff of this choice. It took 10 months to fully program the survey and deploy it to production on the study website.

## 2.5 | Recruitment and outreach

After batch tracing was complete, we began contact activities; these included sending all participants multiple letters and postcards explaining the study goals, describing endorsements by local and national fire officials, and inviting them to participate by completing the survey. Recruitment was staggered to focus energy and effort on one city fire department at a time: San Francisco was the first beginning February 12, 2019, Philadelphia the second beginning May 8, 2019, and Chicago the final study site beginning October 21, 2019. All sites were recruited following a similar strategy. The first invitation letter was sent in collaboration with each fire department and the local unions—firefighters from San Francisco received a letter signed by the San Francisco Chief of Department and the San Francisco Firefighters Union Local 798 President. Firefighters from Philadelphia received a letter signed by the Philadelphia Fire Commissioner and the Philadelphia Firefighters and Paramedics' Union IAFF 22 President. Firefighters from Chicago received a letter signed by the Chicago Fire Commissioner and the Chicago Firefighters Union Local

2 Vice President. Members of the city fire departments and the President of IAFF each recorded short promotional videos for the study. A link to these videos was provided in all communication. In addition, email invitations were sent to those participants who had an email address obtained through batch tracing. All methods of communication included information on the purpose of the Career Firefighter Health Study, credentials to complete the survey via the internet, and a toll-free number for questions and for survey completion by telephone, if desired. To promote the study effectively, we regularly consulted each fire department and tailored our messages to appeal to as broad a population of firefighters as possible. For example, all printed materials included photographs specific to each fire department. Outreach began for each city once the invitation letter was approved by each city fire department and local union. The number of attempts differed by city based on communication with the individual fire departments and response rates.

In addition to mail and email contacting activities, RTI conducted outreach telephone calls to non-respondents. Ten telephone interviewers and four supervisors assigned to this project were trained on the study background, confidentiality and informed consent requirements, refusal avoidance techniques, and quality control and performance expectations. We developed a comprehensive training manual for phone interviewers to refer to during the project. As part of their training, they had to complete at least two practice interviews and accurately explain the purpose and goals of the study and provide technical assistance for lost password information. Before placing a prompting call to a study participant, interviewers reviewed case notes for each case. If the interviewer reached the participant's voicemail, a project-approved message was left on the voicemail. Algorithms were programmed to prompt interviewers when and if to leave a message for each person. The call center system also had callback delays programmed so that the cases were not contacted too close to or distant from previous attempts.

## 2.6 | Quality control and management

To facilitate collaboration with RTI, we established weekly phone calls and/or emails with the study team to discuss the progress of the study. Once data collection started, we actively monitored production levels, including a daily report of the distribution of cases who started the survey, completed the survey and refused the survey. RTI also submitted weekly progress reports to keep FDNY apprised of the project's status regarding work accomplished. Reports provided an overview of tracing and data collection progress completed during the week and noted any anticipated problems or concerns.

## 2.7 | Statistical analyses

We calculated proportions (%), means ( $\pm$ SD) or medians (interquartile range [IQR]) to assess survey responses and demographic characteristics, as appropriate. The  $\chi^2$  test evaluated differences

between the demographics of Career Firefighter Health Study survey respondents and nonrespondents, and between the full Career Firefighter Health Study Outreach Cohort and the FDNY WTC-exposed firefighter population ( $N = 13,317$ ). All data analyses were performed in SAS (version 9.4; SAS Institute Inc).

### 3 | RESULTS

#### 3.1 | Cancer linkage results

Cancer outcomes were obtained via linkages with 10 state cancer registries. The methods for linkages were standard, but the time interval between submission of IRB applications to the state cancer registries and final acquisition of data varied greatly. Dates of state cancer registry IRB submissions ranged from August 8, 2017 to January 10, 2019, as the latest submission date was caused by a state that was unable to accept applications for ~18 months. Formal IRB approvals were received from September 21, 2017 to July 16, 2019. We received the linked cancer data files between July 12, 2019 and June 12, 2020. After the removal of identical cancer cases received from more than one state, we identified 6260 unique cases for the full Career Firefighter Health Study cohort of 29,992.

#### 3.2 | Career Firefighter Health Study survey

Of the 29,992 individuals provided in the master file from NIOSH, a total of 12,528 were classified as not contactable, and 2898 classified as deceased after linkages to NDI and SSA-LADMF. A flowchart detailing the results from these linkages is presented as Figure 1. All 14,566 individuals not known to be deceased were included in the Career Firefighter Health Study Outreach Cohort and eligible for survey data collection. The Career Firefighter Health Study Outreach Cohort had a greater proportion of older adults, females and non-Whites than the FDNY cohort of WTC-exposed firefighters (Table 2).

A total of 4962 participants responded to the baseline survey between February 15, 2019 and December 15, 2020 for an overall rate of 34.1%. The response rates varied by site, with San Francisco having the highest rate. The response rates by site were 43.1% ( $N = 1163$ ), 34.5% ( $N = 1442$ ), and 30.7% ( $N = 2357$ ) for San Francisco, Philadelphia, and Chicago, respectively. Postcard mailings produced the highest response rate compared with letters or email reminders: reminder postcards resulted in an average ( $\pm SD$ ) of  $40.2 \pm 47.7$ ,  $44.4 \pm 28.4$ , and  $63.2 \pm 34.2$  responses within 1 week following each postcard mailing in the San Francisco, Philadelphia, and Chicago groups, respectively. All participants who completed any survey questions in addition to the consent form at the start of the survey were counted as respondents for the purpose of calculating response rates. The response rates, including refusals by site, are described below (Table 3). The most common reasons for refusal were disinterest in the study and being too busy to participate. Approximately,

**TABLE 2** Demographic comparison of Career Firefighter Health Study Outreach Cohort and WTC-exposed FDNY Firefighters

Variable	Career Firefighter Health Study Outreach Cohort ( $N = 14,566$ )	WTC-exposed FDNY firefighters ( $N = 13,317$ )
Gender <sup>a</sup>		
Male	13,631 (93.6)	13,280 (99.7)
Female	935 (6.4)	37 (0.3)
Age <sup>a, b</sup>		
30–39	583 (4.0)	48 (0.4)
40–49	2239 (15.4)	1855 (13.9)
50–59	3927 (27.0)	4743 (35.6)
60–69	3819 (26.2)	4756 (35.7)
70–79	2788 (19.1)	1466 (11.0)
80+	1210 (8.3)	449 (3.4)
Race/ethnicity <sup>a</sup>		
Hispanic	1203 (8.3)	500 (3.8)
White, non-Hispanic	10,204 (70.0)	12,376 (92.9)
Black, non-Hispanic	2532 (17.4)	389 (2.9)
Other, non-Hispanic	517 (3.5)	49 (0.4)
Unknown	110 (0.8)	3 (0.02)

Abbreviations: FDNY, Fire Department of the City of New York; WTC, World Trade Center.

<sup>a</sup> $\chi^2 p < 0.001$ .

<sup>b</sup>Age as of December 31, 2020.

98% of those who completed the survey elected to receive their incentive via email, whereas 2% of respondents asked for an alternate option. Most participants (90%) completed the survey via the internet (Table 3). Firefighters median time to complete the survey was 35 min (IQR: 26.1–48.9), which was within the expected range.

We examined the demographic information of respondents and nonrespondents (Table 4). The respondent and nonrespondent groups had similar proportions of males and females. Respondents were older than nonrespondents, however, and more likely to identify as non-Hispanic White.

### 4 | DISCUSSION

Firefighting is a dangerous profession that has the potential for both short- and long-term health consequences, such as cancer and respiratory diseases.<sup>13–22</sup> Firefighters exposed to the WTC disaster may have substantially greater risks of these and other health conditions.<sup>12,25</sup> Disentangling routine firefighting exposures from the complex exposures present at the WTC site is challenging. The Career Firefighter Health Study cohort provides a suitable comparison

**TABLE 3** Final interviewing status and response rates by group from the Career Firefighter Health Study Outreach Cohort

Interview status	San Francisco (N = 2697)	Philadelphia (N = 4182)	Chicago (N = 7687)	Total (N = 14,566)
Completed interviews (phone)	122 (4.5)	149 (3.6)	172 (2.2)	443 (3.0)
Completed interviews (web)	940 (34.9)	1148 (27.5)	1907 (24.8)	3995 (27.4)
Partial completes <sup>a</sup>	101 (3.7)	145 (3.5)	278 (3.6)	524 (3.6)
Total interviews	1163 (43.1)	1442 (34.5)	2357 (30.7)	4962 (34.1)
Final noninterviews				
Final refusal by respondent	42 (1.6)	43 (1.0)	76 (1.0)	161 (1.1)
Final refusal by other	267 (9.9)	204 (4.9)	576 (7.5)	1047 (7.2)
Other final noninterviews	1148 (42.6)	1925 (46.0)	3421 (44.5)	6494 (44.6)
Subject not located	45 (1.7)	521 (12.5)	1161 (15.1)	1727 (11.9)
Total final noninterviews	1502 (55.7)	2693 (64.4)	5234 (68.1)	9429 (64.7)
Ineligible firefighters (deceased)	32 (1.2)	47 (1.1)	96 (1.2)	175 (1.2)
Total eligible firefighters	2665 (98.8)	4135 (98.9)	7591 (98.8)	14,391(98.8)

<sup>a</sup>Partial completes are firefighters that started the survey but did not complete the full survey.

**TABLE 4** Demographic comparison of respondents and nonrespondents from the Career Firefighter Health Study Outreach Cohort

Variable	Nonrespondents (N = 9604)	Respondents (N = 4962)
Gender		
Male	8972 (93.4)	4659 (93.9)
Female	632 (6.6)	303 (6.1)
Age <sup>a, b</sup>		
30–39	453 (4.7)	130 (3.4)
40–49	1619 (16.9)	620 (12.5)
50–59	2646 (27.6)	1281 (25.8)
60–69	2366 (24.6)	1453 (29.3)
70–79	1678 (17.5)	1110 (22.4)
80+	842 (8.8)	368 (7.4)
Race/ethnicity <sup>b</sup>		
Hispanic	842 (8.8)	361 (7.3)
White, non-Hispanic	6358 (66.2)	3846 (77.5)
Black, non-Hispanic	2016 (21.0)	516 (10.4)
Other, non-Hispanic	309 (3.2)	208 (4.2)
Unknown	79 (0.8)	31 (0.6)

<sup>a</sup>Age as of December 31, 2020.

<sup>b</sup> $\chi^2 p < 0.001$ .

population for WTC-exposed firefighters so that health outcomes in WTC disaster-exposed workers can be evaluated, independent of firefighting exposures. Here we detail some of the steps and challenges in the identification and recruitment of a suitable comparison population.

One of the main objectives of our study was to compare cancer risk in the WTC-exposed FDNY cohort to risk in other urban firefighters, namely, those in the Career Firefighter Health Study cohort. To do this, we obtained IRB approvals from 10 state cancer registries and linked the Career Firefighter Health Study cohort to each. However, the time interval between submission of state registry IRB applications and receipt of data were longer than we anticipated: It took 34 months or nearly 3 years to obtain cancer data from all 10 states. This process was also complicated in part due to changes in key personnel (both legal and administrative) in the local Fire Departments and in the union management in the years since the original cohort was first assembled. Our intention was for this manuscript to provide valuable information on the procedures and processes that might be used in future studies of firefighters or other occupational populations for long-term follow up. Some of our findings point to areas for improvement in response rates, contacting protocols, instrumentation and analysis. These lessons learned and their implications are detailed in the sections below.

The biggest challenge for all studies of this type, including our own, was the survey response rate; our survey response rate was lower than we had hoped. Approximately one-third of the 14,566 individuals eligible for data collection responded to the survey, primarily via the web-based version (~90% of respondents). While one-third of the eligible population is a proportion consistent with published data on survey response rates in epidemiological studies,<sup>32,33</sup> the response rate was likely impacted by several factors.

First, and most importantly, there were challenges with contacting firefighters and updating contact information. The original sample file included data from firefighters followed through 2009, which was nearly a decade before we initiated contact tracing. Additionally, while over three quarters of the cohort had an address in the original sample file, much of the data were out-of-date, which made it hard to know if nonrespondents received the mailings,

telephone prompting calls or emails. To increase the number of respondents, several steps were taken. The data collection period was extended, and more experienced personnel were trained to trace and conduct interviews. We also monitored response rates and found that postcard mailings produced the highest rate compared with letters or emails. Therefore, we sent out additional postcard mailings when it became clear that the number of final completed interviews was going to be lower than expected. For future investigators attempting outreach in a demographically similar population, we would therefore emphasize the importance of obtaining current mailing addresses via batch tracing; mailing address may be the most reliable form of contact information for a source population consisting primarily of middle-aged and older men. In addition, we contacted members of the individual fire departments and/or unions to discuss other outreach options (e.g., putting an ad in the union newsletter). These measures increased the absolute number of completed surveys but did not substantially change response rates. Finally, our response rate may have become depressed, especially in Chicago, due to the coronavirus disease 2019 pandemic. Other national surveys have observed a similar impact in response rates during this period.<sup>34</sup>

Lower response rates impact both sample size and study generalizability.<sup>35</sup> As shown in Table 4, those who responded to the survey were slightly older and whiter than the eligible population. Given this, we plan to continue to reach out to the fire departments and local unions as well as establish relationships with firefighting fraternities (e.g., African American Firefighter and Paramedic League and the Vulcan Society) that represent the subgroups with lower response rates.

The Career Firefighter Health Study survey is the first to collect information on chronic physical and mental health conditions among US firefighters. The data collected from nearly 5000 survey respondents will inform WTC-related research as well as general firefighting research. For the cancer comparison analyses, we obtained additional years of cancer data for the full Career Firefighter Health Study cohort of 29,992 firefighters through linkages with state cancer registries, and now have IRB protocols in place which enable us to continue matching at 5-year intervals. The survey and cancer data will have an important impact on studies of WTC rescue/recovery work, firefighting and related health conditions. First, as a comparison population to the FDNY WTC-exposed firefighters, it will be used to determine the extent to which the observed association between WTC exposure and chronic physical and mental health conditions among WTC-exposed firefighters may be confounded by firefighting exposures. Additionally, we have expanded on the scope of the original study of firefighting and cancer conducted by Daniels et al. (2014) by collecting self-reported health outcomes as well as important health covariates such as smoking history. Lastly, we have established a cohort that will be followed longitudinally to assess the health impact of firefighting over time, especially if we can replenish the Career Firefighter Health Study Cohort with members who joined these fire departments after 2009.

## ACKNOWLEDGMENT

This study was funded by the National Institute for Occupational Safety and Health (Cooperative Agreement numbers: U01 OH011309/U01 OH011934).

## CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

## DISCLOSURE BY AJIM EDITOR OF RECORD

John Meyer declares that he has no conflicts of interest in the review and publication decision regarding this article.

## AUTHOR CONTRIBUTIONS

Rachel Zeig-Owens and Mayris P. Webber participated in the conception and design of the work. Rachel Zeig-Owens, Mayris P. Webber, and David J. Prezant participated in the acquisition and/or methodology of the funding for the work. Ankura Singh, Joke Salako, Molly Skerker, Ariana Napier, Eric Peele, Marshica Stanley, and Sridevi Sattaluri participated in data curation. Ankura Singh and Rachel Zeig-Owens conducted analyses and interpretation of data for the work. Drafting the work or revising it critically for important intellectual content was done by Rachel Zeig-Owens, Ankura Singh, Joke Salako, Ariana Napier, Mayris P. Webber, and Suzanne Triplett. All authors provided the final approval of the version to be published. Rachel Zeig-Owens and Mayris P. Webber agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

## DATA AVAILABILITY STATEMENT

The deidentified data that support the findings of this study are available from the corresponding author upon reasonable request after approval by the investigators and National Institute for Occupational Safety and Health.

## ETHICS APPROVAL AND INFORMED CONSENT

This study was performed at the Fire Department of the City of New York. The Institutional Review Boards for Albert Einstein College of Medicine/Montefiore Medical Center and RTI International approved this study. Informed consent was obtained from all participants completing the survey.

## ORCID

Rachel Zeig-Owens  <http://orcid.org/0000-0002-8679-2306>

Ankura Singh  <https://orcid.org/0000-0002-8495-4850>

Joke Salako  <https://orcid.org/0000-0003-2417-9810>

Molly Skerker  <https://orcid.org/0000-0002-7511-610X>

David Prezant  <https://orcid.org/0000-0001-9562-0330>

Mayris P. Webber  <http://orcid.org/0000-0002-8322-4573>

## REFERENCES

1. Lioy PJ, Weisel CP, Millette JR, et al. Characterization of the dust/smoke aerosol that settled east of the World Trade Center (WTC) in

- lower Manhattan after the collapse of the WTC 11 September 2001. *Environ Health Perspect*. 2002;110(7):703-714.
2. McGee JK, Chen LC, Cohen MD, et al. Chemical analysis of World Trade Center fine particulate matter for use in toxicologic assessment. *Environ Health Perspect*. 2003;111(7):972-980.
  3. Sudenis T, Hall K, Cartotto R. The duration of an exposure response gradient between incident obstructive airways disease and Work at the World Trade Center Site: 2001-2011. *PLoS Curr*. 2015;36:7-305.
  4. Li J, Cone JE, Kahn AR, et al. Association between World Trade Center exposure and excess cancer risk. *JAMA*. 2012;308(23):2479-2488.
  5. Liu C, Putman B, Singh A, et al. Abnormalities on chest computed tomography and lung function following an intense dust exposure: a 17-year longitudinal study. *Int J Environ Res Public Health*. 2019;16(9):1655.
  6. Liu X, Yip J, Zeig-Owens R, et al. The effect of world trade center exposure on the timing of diagnoses of obstructive airway disease, chronic rhinosinusitis, and gastroesophageal reflux disease. *Front Public Health*. 2017;5:2.
  7. Prezant DJ, Weiden M, Banauch GI, et al. Cough and bronchial responsiveness in firefighters at the World Trade Center site. *N Engl J Med*. 2002;347(11):806-815.
  8. Solan S, Wallenstein S, Shapiro M, et al. Cancer incidence in world trade center rescue and recovery workers, 2001-2008. *Environ Health Perspect*. 2013;121(6):699-704.
  9. Soo J, Webber MP, Gustave J, et al. Trends in probable PTSD in firefighters exposed to the World Trade Center disaster, 2001-2010. *Disaster Med Public Health Prep*. 2011;5(Suppl 2):S197-S203.
  10. Weakley J, Webber MP, Gustave J, et al. Trends in respiratory diagnoses and symptoms of firefighters exposed to the World Trade Center disaster: 2005-2010. *Prev Med*. 2011;53(6):364-369.
  11. Wisnivesky JP, Teitelbaum SL, Todd AC, et al. Persistence of multiple illnesses in World Trade Center rescue and recovery workers: a cohort study. *Lancet*. 2011;378(9794):888-897.
  12. Zeig-Owens R, Webber MP, Hall CB, et al. Early assessment of cancer outcomes in New York City firefighters after the 9/11 attacks: an observational cohort study. *Lancet*. 2011;378(9794):898-905.
  13. Bigert C, Martinsen JI, Gustavsson P, Sparén P. Cancer incidence among Swedish firefighters: an extended follow-up of the NOCCA study. *Int Arch Occup Environ Health*. 2020;93(2):197-204.
  14. Daniels RD, Kubale TL, Yiin JH, et al. Mortality and cancer incidence in a pooled cohort of US firefighters from San Francisco, Chicago and Philadelphia (1950-2009). *Occup Environ Med*. 2014;71(6):388-397.
  15. Glass DC, Pircher S, Del Monaco A, Hoorn SV, Sim MR. Mortality and cancer incidence in a cohort of male paid Australian firefighters. *Occup Environ Med*. 2016;73(11):761-771.
  16. Harris MA, Kirkham TL, MacLeod JS, Tjepkema M, Peters PA, Demers PA. Surveillance of cancer risks for firefighters, police, and armed forces among men in a Canadian census cohort. *Am J Ind Med*. 2018;61(10):815-823.
  17. International Agency for Research on Cancer. *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Painting, Firefighting, and Shiftwork*. Vol 98. Lyon, France: IARC; 2010.
  18. Kirstine Ugelvig Petersen K, Pedersen JE, Bonde JP, Ebbelhoej NE, Hansen J. Long-term follow-up for cancer incidence in a cohort of Danish firefighters. *Occup Environ Med*. 2018;75(4):263-269.
  19. LeMasters GK, Genaidy AM, Succop P, et al. Cancer risk among firefighters: a review and meta-analysis of 32 studies. *J Occup Environ Med*. 2006;48(11):1189-1202.
  20. Pedersen JE, Ugelvig Petersen K, Ebbelhoej NE, Bonde JP, Hansen J. Risk of asthma and chronic obstructive pulmonary disease in a large historical cohort of Danish firefighters. *Occup Environ Med*. 2018;75(12):871-876.
  21. Pukkala E, Martinsen JI, Weiderpass E, et al. Cancer incidence among firefighters: 45 years of follow-up in five Nordic countries. *Occup Environ Med*. 2014;71(6):398-404.
  22. Ribeiro M, de Paula Santos U, Bussacos MA, Terra-Filho M. Prevalence and risk of asthma symptoms among firefighters in São Paulo Brazil: a population-based study. *Am J Ind Med*. 2009 52(3):261-269.
  23. Kirkeleit J, Riise T, Bjørge T, Christiani DC. The healthy worker effect in cancer incidence studies. *Am J Epidemiol*. 2013;177(11):1218-1224.
  24. Slotte P, Yzermans CJ, Korevaar JC, Hooiveld M, Vermeulen RCH. The population-based Occupational and Environmental Health Prospective Cohort Study (AMIGO) in The Netherlands. *BMJ Open*. 2014;4(11):e005858.
  25. Moir W, Zeig-Owens R, Daniels RD, et al. Post-9/11 cancer incidence in World Trade Center-exposed New York City firefighters as compared to a pooled cohort of firefighters from San Francisco, Chicago and Philadelphia (9/11/2001-2009). *Am J Ind Med*. 2016;59(9):722-730.
  26. Webber MP, Glaser MS, Weakley J, et al. Physician-diagnosed respiratory conditions and mental health symptoms 7-9 years following the World Trade Center disaster. *Am J Ind Med*. 2011;54(9):661-671.
  27. Webber MP, Gustave J, Lee R, et al. Trends in respiratory symptoms of firefighters exposed to the world trade center disaster: 2001-2005. *Environ Health Perspect*. 2009;117(6):975-980.
  28. Yip J, Webber MP, Zeig-Owens R, et al. FDNY and 9/11: clinical services and health outcomes in World Trade Center-exposed firefighters and EMS workers from 2001 to 2016. *Am J Ind Med*. 2016;59(9):695-708.
  29. Weakley J, Webber MP, Ye F, et al. Agreement between obstructive airways disease diagnoses from self-report questionnaires and medical records. *Prev Med*. 2013;57(1):38-42.
  30. Weakley J, Webber MP, Ye F, et al. Agreement between upper respiratory diagnoses from self-report questionnaires and medical records in an occupational health setting. *Am J Ind Med*. 2014;57(10):1181-1187.
  31. Zeig-Owens R, Kablanian A, Webber MP, et al. Agreement between self-reported and confirmed cancer diagnoses in New York City firefighters and EMS workers, 2001-2011. *Public Health Rep*. 2016;131(1):153-159.
  32. Sinclair M, O'Toole J, Malawaraarachchi M, Leder K. Comparison of response rates and cost-effectiveness for a community-based survey: postal, internet and telephone modes with generic or personalised recruitment approaches. *BMC Med Res Methodol*. 2012;12(1):132.
  33. Jepson C, Asch DA, Hershey JC, Ubel PA. In a mailed physician survey, questionnaire length had a threshold effect on response rate. *J Clin Epidemiol*. 2005;58(1):103-105.
  34. Rothbaum J, Bee A. Coronavirus Infects Surveys, Too: Nonresponse Bias During the Pandemic in the CPS ASEC. 2020. <https://www.census.gov/content/dam/Census/library/working-papers/2020/demo/sehsd-wp2020-10.pdf>. Accessed December 21, 2020.
  35. Blair E, Zinkhan GM, From the editor: nonresponse and generalizability in academic research. *J Acad Market Sci*. 34(1), 2006:4-7.

**How to cite this article:** Zeig-Owens R, Singh A, Triplett S, et al. Assembling the Career Firefighter Health Study cohort: A methods overview. *Am J Ind Med*. 2021;1-8. <https://doi.org/10.1002/ajim.23266>