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Self-reported cardiovascular disease in career firefighters with and without World Trade Center exposure

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Abstract

Objective: To assess the effect of World Trade Center (WTC) exposure on cardiovascular disease (CVD) in career firefighters.

Methods: Firefighters from four US cities completed health questionnaires that provide information about demographics, CVD diagnoses, and CVD risk factors. Firefighters were also compared to respondents of the 2019 National Health Interview Survey (NHIS).

Results: Greater WTC exposure was positively associated with combined coronary artery disease, myocardial infarction, and angina (termed "CAD") when comparing WTC-exposed to non-WTC-exposed firefighters. Compared with the NHIS population, firefighters had lower odds of CAD and stroke.

Conclusion: An occupationally appropriate comparison is important to mitigate potential bias from the healthy worker effect. While the risk of CVD in WTC-exposed and non-WTC-exposed firefighters was significantly lower than a general US population, we observed an exposure gradient where greater WTC exposure was associated with greater odds of CVD.

Keywords: Cardiovascular disease, World Trade Center, firefighting, occupational exposure

SMART Learning Outcomes

1. Describe the association between World Trade Center exposure and cardiovascular disease when accounting for the firefighting occupation
2. Recognize how the healthy worker effect can bias association between World Trade Center exposure and cardiovascular disease

Introduction

On September 11, 2001 (9/11), the Fire Department of the City of New York (FDNY) firefighters and emergency medical service (EMS) providers were some of the first responders to the World Trade Center (WTC) disaster as their job tasks require them to respond to any emergency in New York City where their services might be required. Many FDNY firefighters and EMS providers, along with other rescue/recovery workers, continued work at the WTC disaster site for many months after 9/11. The WTC dust cloud included fine particulate matter,[1] which has been shown to be related to cardiovascular disease (CVD).[2,3] Approximately ten years after the disaster, researchers began to discover an association between rescue/recovery work at the WTC site and increased CVD risk.[4-8] Analyses of those enrolled in the WTC Health Registry, which includes WTC rescue/recovery workers and survivors, showed that WTC exposure may be a risk factor for self-reported heart disease or ischemic stroke.[5,8] In a cohort of general responders that included police officers, construction and communications workers, other skilled trades, and community volunteers, recent work suggests a dose-response relationship between arrival time to the WTC disaster site and CVD risk.[7] Similar results were found in a cohort of firefighters and EMS providers from FDNY, where age-adjusted incidence rates were higher for those with greater WTC exposure.[4]

However, other research has shown that firefighting alone may be independently associated with CVD. Aspects of firefighting, including physical and psychological stress,[9-12] shift work,[13] and exposures to smoke and other toxins,[14] have been linked to increased cardiovascular disease.[15] Current literature suggests a high prevalence of cardiovascular risk factors – hypertension (10-44%),[16-18] obesity (14-60%),[17,19,20] high cholesterol (20-57%),[17,21,22]

and smoking (11-42%)[23-26] – within firefighters. Cardiac-related events have accounted for the largest proportion of on-duty firefighter fatalities (44%) since 2009,[27] and most occur in those with additional CVD risk factors.[15,28]

Previous research regarding the association of WTC exposure with CVD has not adequately accounted for potential confounding by the firefighting occupation.[4,6,7] The primary aim of this study was to assess whether WTC-exposed firefighters have greater odds of self-reported CVD diagnoses compared with non-WTC-exposed firefighters, using data from the Career Firefighter Health Study cohort, which is comprised of career firefighters from New York City, Chicago, Philadelphia, and San Francisco.[29] To provide context for our findings, firefighters were compared also with respondents of the National Health Interview Survey (NHIS) as a way of comparing with a general US population sample.

Methods

Study Population

This study's source population included WTC-exposed and non-WTC-exposed firefighters from the Career Firefighter Health Study who were actively employed on 9/11 by their respective fire departments (i.e., FDNY, Chicago Fire Department, Philadelphia Fire Department, or San Francisco Fire Department), completed a self-administered health questionnaire, and provided written informed consent (n=13,517). This study was approved by XXXX and follows STROBE guidelines (Supplemental Digital Content 1, http://links.lww.com/JOM/B445).

WTC-Exposed Firefighters

Firefighters employed by FDNY who were alive at the start of administration of the non-WTC-exposed comparison cohort survey, February 16, 2019, were included in the study. Of the 10,095 in the source population, we excluded 128 firefighters who first arrived at the WTC site after 9/24/2001, 66 who were not exposed, 20 female firefighters, and 92 male firefighters who did not answer CVD-related questions on their health questionnaire. The final analytic WTC-exposed firefighter cohort was 9,789.

Non-WTC-Exposed Firefighters

As previously described,[30] using a non-WTC-exposed comparison group from FDNY was not possible due to small sample size (see above). Instead, we used data from non-WTC-exposed career firefighters from fire departments in Chicago, Philadelphia, and San Francisco whose roster information was originally obtained by the National Institute for Occupational Safety and Health (NIOSH).[31] A subset of this population was alive and eligible for follow-up, as described elsewhere.[29] Eligible non-FDNY members completed a self-administered health questionnaire similar to the FDNY health monitoring questionnaire between February 16, 2019 and May 26, 2021 (n=3,422). Respondents were demographically similar to non-respondents.[29] We excluded 329 non-FDNY firefighters who reported 9/11 exposure, 169 who did not provide a response to CVD questions, and 195 female firefighters. The final non-WTC-exposed firefighter cohort was 2,729.

WTC Exposure

Self-reported WTC exposure on FDNY participants' first post-9/11 health questionnaire was classified into high, moderate, and low exposure based on arrival time to the WTC site, as in our prior studies.[4,32-34] Those who reported first arrival at the site on the morning of 9/11 constituted the high exposure group as they were present during or immediately after the towers collapsed. The moderate exposure group included those who arrived in the afternoon of 9/11. The low exposure group included those who arrived between 9/12 and 9/24/2001. Non-FDNY firefighters from Chicago, Philadelphia, and San Francisco fire departments without WTC exposure were considered "non-WTC-exposed" and used as the reference group in firefighter analyses. Data from the NHIS were also used as a reference group for other comparisons.

CVD Risk Factors and Demographic Data

WTC-exposed and non-WTC exposed firefighters' demographic data, including sex, race, and birthdate were obtained from FDNY databases and fire department records from the other three cities. WTC-exposed firefighters complete a medical monitoring exam every 12 to 18 months that includes weight and height measurements for body mass index (BMI) and incorporates a self-administered, computer-based questionnaire, as previously described.[34] Non-WTC-exposed firefighters completed a similar questionnaire once, as described above. We obtained non-WTC-exposed firefighters' BMI from information provided on the questionnaire. All firefighters self-reported smoking status on their respective questionnaires as former, current, or never smokers. Former or current smokers were considered "ever smokers." CVD risk factors including hypertension, diabetes, and high cholesterol were self-reported on these health

questionnaires; participants reported ever receiving a physician diagnosis of hypertension, diabetes, or high cholesterol.

Self-Reported Cardiovascular Disease (CVD)

The FDNY questionnaire is self-administered during the WTC-exposed participants' annual medical monitoring exam. A self-reported CVD diagnosis at the most recent questionnaire was based on a positive response to the question, "In the past 12 months, has a doctor or other health professional told you that you had any of the following? 1. Stroke/CVA or TIA; 2. Coronary artery disease, MI (heart attack), angina (ischemia) or blockage." The non-WTC-exposed firefighters included in this study each took a baseline questionnaire which includes questions about "ever" being diagnosed with CVD conditions. A self-reported CVD diagnosis was based on a positive response to the following question, "Has a doctor or other health professional ever told you that you had any of the following? 1. Stroke/CVA or TIA; 2. Coronary artery disease, MI (heart attack), angina (ischemia) or blockage." To obtain an appropriate "ever" comparison in the WTC-exposed cohort, we combined all prior FDNY questionnaire information from September 12, 2001 through May 26, 2021. For both cohorts, self-reported diagnoses were categorized as (1) self-reported stroke/TIA, (2) self-reported coronary artery disease, MI, angina, or blockage, henceforth referred to as "CAD", and (3) self-reported stroke or CAD which included reporting either or both of the two conditions, referred to as "stroke/CAD".

Validated Cardiovascular Disease

As self-reported CVD outcomes may be differentially reported based on different WTC exposure levels, we assessed agreement between self-reported CVD and confirmed cases only within the WTC-exposed population through FDNY medical record review.[4] Medical record review was not available for the non-WTC-exposed firefighters.

National Health Interview Survey

We also compared firefighters to respondents of the 2019 NHIS cross-sectional interview survey of the US noninstitutionalized civilian population from all 50 states conducted by the National Center for Health Statistics.[35]

The 2019 version of the NHIS was chosen because the health questions were the most similar to the firefighter questionnaires. Data from NHIS participants were restricted to males aged 35+ years who did not reside in the South and answered CVD-related questions to be most comparable to the firefighter population and cities in this study, with a final sample population of 7,301 individuals. NHIS participants reported age in 2019, residence by region, race/ethnicity, height, weight, smoking status, and diagnoses of high cholesterol, diabetes, and hypertension. They also answered the questions, “Have you ever been told by a doctor or other health professional that you had: (1) a stroke?, (2) a heart attack, also called a myocardial infarction?, (3) angina, also called angina pectoris?, (4) coronary heart disease?” A positive answer to questions 2, 3, and 4 were classified as “CAD.” A positive answer to any of the above questions was classified as “stroke/CAD.” All diagnoses in this study are self-reported and henceforth will

be referred to as stroke, CAD, and stroke/CAD. Individuals who reported stroke and reported CAD are included as events for both separate diagnoses, as well as for stroke/CAD.

Statistical analyses

Demographics and other characteristics were represented as proportions (%) and means (±SD) for the firefighter groups. Among all firefighters, multivariable logistic regression was used to estimate the association between WTC exposure (as both a binary variable, exposed vs non-exposed, and categorized, as above) and diagnoses of stroke, CAD, and stroke/CAD as binary variables (ever/never diagnosed). Two models were run to account for missing data. Model 1 only included variables that did not have any missing observations—age, race, and BMI. Model 2 additionally controlled for high cholesterol, diabetes, hypertension, and smoking status.

Within only the WTC-exposed group we evaluated the agreement between self-reported CVD and medical records. Positive predictive value (PPV) and sensitivity of self-reports were reported for all three CVD outcomes. Internal analyses were then conducted to assess associations between WTC exposure intensity and CVD outcomes within WTC-exposed firefighters only, with low exposure as the referent group, using multivariable logistic regression models included covariates in the same manner as described above. Two separate logistic models estimated the WTC exposure association with self-reported and with validated CVD outcomes.

Results

Demographic and other characteristics of the study population are displayed in Table 1. WTC-exposed firefighters were, on average, slightly younger on 9/11 (40 vs. 44), less likely to report ever smoking (33% vs. 44%), and more likely to be white (94% vs. 75%) than non-WTC-exposed firefighters. Over half of the WTC-exposed firefighters first arrived at the WTC site on the afternoon of 9/11/2001 (moderate exposure). A greater percentage of non-WTC-exposed firefighters reported a diagnosis of stroke/CAD than WTC-exposed firefighters. 47 (0.5%) WTC-exposed and 28 (1%) non-WTC-exposed firefighters reported having stroke and also reported having CAD. A greater proportion of non-WTC-exposed firefighters reported having diabetes or hypertension, while fewer reported having high cholesterol. WTC-exposed firefighters had 166 (2%) participants missing data for diabetes, hypertension, and high cholesterol and two participants missing data for smoking status. Non-WTC-exposed firefighters had 6 participants missing data for diabetes and 7 missing data for smoking status.

Odds of self-reported CAD were greater in highly (OR=1.48, 95% CI: 1.18, 1.86) and moderately (OR=1.31, 95% CI: 1.10, 1.57) exposed WTC firefighters compared with non-exposed firefighters after adjusting for age, race, and BMI (Table 2a). There was a significant trend for exposure, with greater exposure having a greater association with CAD (p for trend<0.0001). The same was not seen for stroke. Models which additionally included CVD risk factors, also showed a significant exposure gradient for CAD and stroke/CAD, with greater exposure significantly associated with these outcomes (p for trend= 0.03 and 0.04, respectively, Table 2b).

When compared with the NHIS population, odds of all three CVD outcomes were significantly lower for both WTC-exposed and non-exposed firefighters when adjusting for age, race, and BMI (Table 3a). Models that additionally included CVD risk factors produced stronger protective estimates of CVD odds. Although all WTC-exposed firefighters had lower odds of all three CVD outcomes than the NHIS population, the magnitude of this protection was attenuated with increasing WTC exposure (p for trend <0.0001, Table 3b).

Medical record validation was only available for WTC-exposed FDNY firefighters. Agreement analyses restricted to WTC-exposed FDNY firefighters comparing self-reported CVD outcomes to medical record data showed a PPV of 56% and sensitivity of 79% for CAD and 37% PPV and 73% sensitivity for stroke. Multivariable logistic regression models within this firefighter population showed that the association between WTC exposure and all three medical record-validated CVD outcomes was attenuated compared to the association between exposure and self-reported CVD outcomes (Supplemental Tables 1a & 1b, http://links.lww.com/JOM/B446). However, a significant exposure gradient remained for both self-reported and validated outcomes for stroke/CAD.

Discussion

This study is the first to compare CVD outcomes in WTC-exposed firefighters to an occupationally similar non-WTC-exposed cohort. This comparison cohort allowed us to draw conclusions about the true association between WTC exposure and CVD outcomes while controlling for the potentially confounding variable of firefighter occupation. When adjusting for known risk factors, we observed a significant association of WTC exposure with CAD and

stroke/CAD outcomes. Results were consistent with findings from prior studies of WTC-exposed populations, regardless of whether the respective outcomes were self-reported or clinically validated.[4,5,7,8] Compared with a general US population (NHIS), all firefighters had lower odds of all three CVD outcomes.

While the association between WTC exposure level and stroke alone was not statistically significant, there were significant associations of the exposure gradient with CAD and stroke/CAD outcomes. Prior work in FDNY firefighters found a similar exposure response for CVD confirmed with medical records.[4] Earlier arrival to the WTC disaster meant greater exposure to various toxicants that were present in the dust cloud.[1] As many of these substances are known cardiopulmonary hazards,[36] our results, even after controlling for the firefighting occupation, support prior studies demonstrating a significant association between WTC exposure and a greater risk of CVD.

Most prior work that has estimated the association between WTC exposure and CVD within FDNY rescue/recovery workers has been conducted solely through internal comparison. As CVD is a chronic disease, the necessity for an adequate comparison group is particularly evident more than 20 years after 9/11. Non-FDNY WTC-exposed cohorts have used the New York State, New York City, or US general populations as comparison groups.

However, firefighter activities may present an increased risk for CVD. For example, exposures during firefighting (response, fire suppression, and rescue work) have been shown to increase risk of sudden cardiac events five- to seven-fold compared with non-emergency

activities.[11,37,38] This has been suggested to be largely due to activation and sustained arousal of the sympathetic nervous system, which can lead to increased cardiac stress.[28,39]

As such, US fire departments, including the four in this study, generally exclude individuals from hire or active duty that have been previously diagnosed with CAD, MI, angina, or stroke to ensure they will be able to perform essential job-tasks safely and effectively.[40] Our findings of a 28-49% reduction in any CVD odds in all firefighter groups compared with the general population is likely a result of the healthy worker effect. Prior work using data from the Career Firefighter Health Study investigating mortality through 2016 found mortality caused by heart/circulatory system diseases to be significantly lower for both WTC-exposed and non-exposed firefighters compared with the general population.[41] While the current study involves a subset of that source population of firefighters, those alive in 2019, the overall findings highlight the health differences between firefighters and the general population. Fire department hiring practices combined with the retention of healthier individuals in the firefighting workforce highlights the importance of having a non-WTC-exposed firefighter comparison for WTC-related health studies.

There are limitations to this investigation. The use of self-reported outcomes is subject to measurement/recall bias. However, when compared with medical records, PPV and sensitivity for self-reported CVD in the WTC-exposed group are similar to published estimates in non-firefighting cohorts.[42-44] Additionally, it is possible that the WTC-exposed may overreport diagnoses compared with the non-WTC-exposed due to exposure and membership in the WTC Health Program, which provides no-cost annual medical monitoring and treatment for certified

health conditions. However, our self-reported vs. medical record CVD agreement is higher than those in another WTC-exposed cohort (WTC Health Registry, which includes both 9/11 rescue/recovery workers and those who lived/worked in the vicinity).[45] Given that sensitivity proportions fall well within the published estimates, it is also likely that exposed and non-exposed firefighters may not be appreciably different from each other. Another limitation is that unmeasured confounding could have biased our results. For example, occupation data were not available for the 2019 NHIS. However, <1% of the US male population in 2019 were career firefighters.[46] Lastly, there could be differences in routine firefighting exposure or unique hiring considerations by city.

A strength of this study is that it is the first to account for the firefighting occupation when determining the association between WTC exposure and CVD. With respect to firefighters, we illustrated the need for an occupationally appropriate non-WTC-exposed comparison population when analyzing outcomes. Likely due to the healthy worker effect, the NHIS population may not be an adequate comparison population as it shows firefighting and WTC-exposure to be protective against CVD. Being able to account for the firefighting occupation provides improved comparison validity. This deserves consideration when studying other occupations where a healthy worker effect is expected.

Conclusion

The burden of disease was significantly greater in persons with a greater WTC exposure level, even though as a categorical variable, no WTC exposure level alone had statistically significantly greater CVD than the non-exposed firefighters when controlling for CVD risk factors. While the

risk of CVD in WTC-exposed firefighters and non-WTC-exposed firefighters was significantly lower than that of a general US population (NHIS), we did observe a statistically significant exposure gradient where greater exposure was associated with a lower healthy worker protection from CVD. Adding to the current body of literature that has observed similar WTC exposure gradients for CVD is important for identifying those at risk. Future studies are needed to further explore this exposure-response gradient in firefighters, ideally with medical record documentation or other validated measures of CVD.

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Table 1: Demographic and Selected Characteristics of WTC-exposed and Non-WTC-exposed Firefighters

	WTC-exposed	Non-WTC-exposed	NHIS
n	9789	2729	7301
Stroke/CAD[1]	961 (9.8%)	319 (11.7%)	1053 (14.4%)
Stroke[2]	219 (2.2%)	91 (3.3%)	337 (4.6%)
CAD[3]	789 (8.1%)	256 (9.4%)	851 (11.7%)
Diabetes	1212 (12.4%)	516 (18.9%)	929 (12.7%)
Cholesterol	6372 (65.1%)	1539 (56.4%)	2613 (35.8%)
Hypertension	4470 (45.7%)	1375 (50.4%)	3140 (43.0%)
Mean BMI[4] (SD)	30.0 (4.6)	29.0 (4.4)	28.4 (4.6)
Mean Age on 9/11[5] (SD)	40.0 (7.4)	44.0 (8.8)	
Mean Age in 2019[5] (SD)	58.5 (7.4)	62.5 (8.8)	58.4 (14.0)
Ever smokers	3228 (33.0%)	1187 (43.5%)	3461 (47.4%)
Race			
White	9216 (94.1%)	2069 (75.8%)	5917 (81.1%)
Black	236 (2.4%)	298 (10.9%)	444 (6.1%)
Hispanic	308 (3.2%)	220 (8.1%)	419 (5.7%)
Other	29 (0.3%)	142 (5.2%)	521 (7.1%)
WTC Exposure			
High[6]	1597 (16.3%)		
Moderate[7]	5278 (53.9%)		
Low[8]	2957 (29.8%)		

Unless otherwise specified, all values in parentheses are percentages.
[1]Includes any report of stroke or CAD
[2]Includes diagnoses of stroke/CVA or TIA
[3]Includes diagnoses of CAD, MI, or angina
[4]in Kg/m^2
[5]in years
[6]Arrived at the WTC site in the morning of 9/11/2001
[7]Arrived at the WTC site in the afternoon of 9/11/2001
[8]Arrived at the WTC site from 9/12-9/24/2001

WTC, World Trade Center; NHIS, National Health Interview Survey; CAD, coronary artery disease; BMI, body mass index; SD, standard deviation; CVA, cerebrovascular accident; TIA, transient ischemic attack; MI, myocardial infarction

Table 2a – Estimated odds ratios for self-reported CVD diagnoses by exposure status

	Stroke/CAD[1]		Stroke[2]		CAD[3]	
	OR (95% CI)		OR (95% CI)		OR (95% CI)	
	Model 1[4]	Model 2[5]	Model 1	Model 2	Model 1	Model 2
WTC-exposed	1.23 (1.06, 1.43)	1.03 (0.88, 1.20)	1.03 (0.79, 1.35)	0.93 (0.71, 1.22)	1.25 (1.06, 1.47)	1.03 (0.87, 1.21)
Non-exposed	ref	ref	ref	ref	ref	ref

Table 2b – Estimated odds ratios for self-reported CVD diagnoses by exposure level

	Stroke/CAD[1]		Stroke[2]		CAD[3]	
	OR (95% CI)		OR (95% CI)		OR (95% CI)	
	Model 1[4]	Model 2[5]	Model 1[4]	Model 2[5]	Model 1[4]	Model 2[5]
High exposure	1.45 (1.18, 1.79)	1.19 (0.96, 1.48)	1.18 (0.80, 1.75)	1.04 (0.70, 1.55)	1.48 (1.18, 1.86)	1.20 (0.95, 1.51)
Moderate exposure	1.31 (1.11, 1.54)	1.10 (0.93, 1.30)	1.07 (0.79, 1.44)	0.97 (0.72, 1.30)	1.32 (1.10, 1.57)	1.09 (0.91, 1.31)
Low exposure	1.00 (0.83, 1.21)	0.83 (0.69, 1.01)	0.90 (0.64, 1.27)	0.81 (0.57, 1.15)	1.03 (0.84, 1.26)	0.85 (0.69, 1.05)
Non-exposed	ref	ref	ref	ref	ref	ref
P for trend	*P<0.0001*	*P=0.01*	*P=0.33*	*P=0.74*	*P<0.0001*	*P=0.03*

[1]Includes any report of stroke or CAD
[2]Includes diagnoses of stroke/CVA or TIA
[3]Inclused diagnoses of CAD, MI, or angina
[4]Age, race, and BMI were also included in the model (complete case analysis, n=12,516)

[5]Age, race, BMI, high cholesterol, diabetes, hypertension, smoking were also included in the model (complete case analysis, n=12,435)

CVD, cardiovascular disease; CAD, coronary artery disease; WTC, World Trade Center; CVA, cerebrovascular accident; TIA, transient ischemic attack; MI, myocardial infarction; BMI, body mass index

Table 3a – Estimated odds ratios for self-reported CVD diagnoses in firefighters from all four cities compared with the NHIS population by exposure status

	Stroke/CAD[1]		Stroke[2]		CAD[3]	
	OR (95% CI)		OR (95% CI)		OR (95% CI)	
	Model 1[4]	Model 2[5]	Model 1[4]	Model 2[5]	Model 1[4]	Model 2[5]
WTC-exposed	0.81 (0.73, 0.90)	0.62 (0.55, 0.70)	0.62 (0.51, 0.74)	0.54 (0.44, 0.66)	0.86 (0.77, 0.97)	0.64 (0.57, 0.73)
Non-exposed	0.71 (0.62, 0.82)	0.59 (0.51, 0.68)	0.66 (0.51, 0.84)	0.60 (0.47, 0.76)	0.74 (0.64, 0.87)	0.60 (0.51, 0.71)
NHIS Population	ref	ref	ref	ref	ref	ref

Table 3b – Estimated odds ratios for self-reported CVD diagnoses in WTC-exposed FDNY firefighters compared with the NHIS population by exposure level

	Stroke/CAD[1]		Stroke[2]		CAD[3]	
	OR (95% CI)		OR (95% CI)		OR (95% CI)	
	Model 1[6]	Model 2[7]	Model 1[6]	Model 2[7]	Model 1[6]	Model 2[7]
High exposure	0.96 (0.80, 1.14)	0.71 (0.59, 0.86)	0.68 (0.48, 0.95)	0.58 (0.41, 0.82)	1.02 (0.84, 1.24)	0.74 (0.60, 0.91)
Moderate exposure	0.86 (0.76, 0.98)	0.66 (0.58, 0.76)	0.62 (0.49, 0.78)	0.55 (0.43, 0.69)	0.91 (0.79, 1.04)	0.68 (0.59, 0.79)
Low exposure	0.67 (0.58, 0.79)	0.51 (0.43, 0.60)	0.54 (0.40, 0.72)	0.47 (0.35, 0.63)	0.72 (0.61, 0.86)	0.53 (0.44, 0.63)
NHIS Population	ref	ref	ref	ref	ref	ref
P for trend	*P<0.0001*	*P<0.0001*	*P<0.0001*	*P<0.0001*	*P<0.0001*	*P<0.0001*

[1]Includes any report of stroke or CAD
[2]Includes diagnoses of stroke/CVA or TIA
[3]Inclused diagnoses of CAD, MI, or angina
[4]Age, race, and BMI were included in the model (complete case analysis, n=19,354)

[5]Age, race, BMI, high cholesterol, diabetes, hypertension, smoking were included in the model (complete case analysis, n=19,099)

[6]Age, race, and BMI were included in the model (complete case analysis, n=16,625)

[7]Age, race, BMI, high cholesterol, diabetes, hypertension, smoking were included in the model (complete case analysis, n=16,377)

CVD, cardiovascular disease; NHIS, National Health Interview Survey; CAD, coronary artery disease; CVA, cerebrovascular accident; TIA, transient ischemic attack; MI, myocardial infarction; BMI, body mass index

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2
Objectives	3	State specific objectives, including any prespecified hypotheses	2
Methods			
Study design	4	Present key elements of study design early in the paper	3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3-4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	3-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*3-6*
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	3-4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6-7
		(*b*) Describe any methods used to examine subgroups and interactions	6-7
		(*c*) Explain how missing data were addressed	6-7

		(*d*) If applicable, describe analytical methods taking account of sampling strategy	n/a
		(*e*) Describe any sensitivity analyses	7
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	3-4
		(b) Give reasons for non-participation at each stage	3-4
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7
		(b) Indicate number of participants with missing data for each variable of interest	7
Outcome data	15*	Report numbers of outcome events or summary measures	7
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8
Discussion			
Key results	18	Summarise key results with reference to study objectives	9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	10-11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9-10
Generalisability	21	Discuss the generalisability (external validity) of the study results	11

Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Supplemental Table 1a – Estimated odds of CVD by exposure level within *only* WTC-exposed FDNY firefighters

	Stroke/CAD[1]		Stroke[2]		CAD[3]	
	OR (95% CI)		OR (95% CI)		OR (95% CI)	
	Self-reported	Validated	Self-reported	Validated	Self-reported	Validated
High exposure	1.46 (1.19, 1.80)	1.37 (1.08, 1.74)	1.31 (0.87, 1.97)	1.64 (0.96, 2.79)	1.45 (1.15, 1.82)	1.31 (1.01, 1.70)
Moderate exposure	1.33 (1.13, 1.56)	1.16 (0.96, 1.40)	1.19 (0.87, 1.63)	1.08 (0.69, 1.69)	1.28 (1.08, 1.53)	1.17 (0.96, 1.44)
Low exposure	ref	ref	ref	ref	ref	ref
P for trend	*P<0.0001*	*P=0.01*	*P=0.17*	*P=0.09*	*P=0.001*	*P=0.04*

Models also included age, race, and BMI

Supplemental Table 1b – Estimated odds of CVD by exposure level within *only* WTC-exposed

	Stroke/CAD[1]		Stroke[2]		CAD[3]	
	OR (95% CI)		OR (95% CI)		OR (95% CI)	
	Self-reported	Validated	Self-reported	Validated	Self-reported	Validated
High exposure	1.41 (1.13, 1.75)	1.35 (1.06, 1.73)	1.22 (0.81, 1.85)	1.62 (0.95, 2.77)	1.38 (1.09, 1.75)	1.29 (0.98, 1.69)
Moderate exposure	1.32 (1.11, 1.56)	1.15 (0.95, 1.39)	1.18 (0.86, 1.62)	1.06 (0.68, 1.66)	1.28 (1.07, 1.54)	1.17 (0.95, 1.44)
Low exposure	ref	ref	ref	ref	ref	ref
P for trend	*P<0.001*	*P=0.02*	*P=0.29*	*P=0.10*	*P<0.01*	*P=0.06*

FDNY firefighters

Models also included age, race, BMI, high cholesterol, hypertension, diabetes, and smoking

[1]Includes any report of stroke or CAD
[2]Includes diagnoses of stroke/CVA or TIA
[3]Inclused diagnoses of CAD, MI, or angina

CVD, cardiovascular disease; NHIS, National Health Interview Survey; CAD, coronary artery disease; CVA, cerebrovascular accident; TIA, transient ischemic attack; MI, myocardial infarction; BMI, body mass index

Is World Trade Center (WTC) rescue/recovery work associated with cardiovascular disease in career firefighters?

12,518 male firefighters from New York, Chicago, Philadelphia, and San Francisco completed a survey assessing outcomes, including cardiovascular disease (CVD).

WTC-exposed firefighters had approximately 25% higher odds of self-reported CVD compared with non-WTC-exposed firefighters.

This study is the first to account for occupation when determining the association between WTC exposure and CVD – important for mitigating healthy worker effect bias.

Self-reported cardiovascular disease in career firefighters with and without World Trade Center exposure

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