



# FIRE DEPARTMENT

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Date: 9/3/2023

To: World Trade Center Health Program  
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CDR Brittany Rizek, M.P.H  
Acting Division Administrative Director, WTC Health Program, NIOSH

Re: Petition to add cardiovascular diseases to the list of WTC-covered conditions under the  
Zadroga Act – including reference list with abstracts

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The Directors of the World Trade Center (WTC) Clinical Centers of Excellence unanimously recommend to the WTC Health Program Administrator, that cardiovascular diseases be added to the list of WTC-covered certifiable conditions under the Zadroga Act.

We petition the Administrator to add the following conditions: myocardial infraction, unstable angina, obstructive coronary artery disease, ischemic cardiomyopathy, ischemic congestive heart failure, arrhythmias (due to any of the above), stroke, and peripheral vascular disease.

Our request for expanding WTC-covered condition list would NOT include valvular disease, or endocarditis. It would NOT include systemic hypertension, aneurysms, arrhythmias or cardiomyopathy unless it was due to the above noted conditions.

To date, cardiovascular conditions have only been covered if associated with a WTC-certified condition such as pulmonary sarcoidosis or end-stage lung disease (ex. pulmonary hypertension / Cor Pulmonale from severe emphysema, COPD or pulmonary fibrosis).

We have reviewed the Administrator's recent published rule making policy for adding non-cancers as WTC-covered conditions. Our petition is based on evidence from multiple high-quality epidemiologic studies that demonstrate a consistently strong statistically significant association between WTC exposure and new-onset cardiovascular diseases (including stroke) in

Responders and Survivors (1-9). Below, we summarize why we believe this evidence meets WTC Health Program criteria for a “Category I (substantial likelihood for causal association)” designation and therefore qualifies for further review and a favorable decision.

A considerable amount of scientific, peer-reviewed, evidence has been published demonstrating an association between WTC exposure and cardiovascular and cerebrovascular (stroke) diseases (1-9).

The WTC Health Registry at the NYC Dept. of Health & Mental Hygiene has studied this extensively. Their first study found that members arriving on 9/11 (day 1 of exposure) had significantly higher risk of self-reported new-onset cardiovascular disease than those who arrived on 9/18 or later (1). Similar associations were found for those injured on 9/11 and those with WTC-related PTSD. And the association was significant for BOTH responders and survivors. A second study using hospitalization records confirmed that the risk for cardiovascular disease and stroke was significantly higher in those arriving on 9/11 and in those with WTC-PTSD (2). This association was significant for responders but not for survivors. A third study again using hospitalization records, found that the risk for cardiovascular disease was significantly higher in those with WTC-injuries with or without PTSD (3). A fourth study confirmed the association with 9/11 exposure intensity as well as with WTC-related injuries (4). A fifth study using self-reported stroke diagnoses found that the risk was greater in those with intense dust cloud exposure and/or WTC-related PTSD (5). And this was confirmed by a sixth study using hospitalization rates for stroke (6).

And the WTC Health Registry has been confirmed in the other cohorts. A study from FDNY using medical record confirmation, found the risk for cardiovascular diseases was higher in those arriving on day 1 as compared to arriving later (7). A study from the General Responder Cohort (GRC) found that members arriving on 9/11 (day 1 of exposure) had significantly higher risk for self-reported cardiovascular disease than those who arrived on 9/12 or later (8). This study also noted that the risk appeared to be greater in younger responders than would be expected from general population studies (8). In a subset of GRC responders who worked cleaning debris at the site, WTC-related PTSD was a risk for medically confirmed myocardial infarct and stroke while exposure was not (9). All studies were adjusted for confounders such as age.

To date there has been no study on the incidence of cardiovascular disease or stroke from the WTC Survivor Program. But this is because their cohort design does not allow them to calculate incidence or prevalence because the Zadroga Act only allows the Survivor Program to enroll persons with symptoms suggestive of WTC-covered illnesses. However, the WTC Health Registry did find an association between WTC exposure and self-reported cardiovascular diseases in a separate analysis of Survivors based on self-reports (1), but not when using hospitalization records (2).

Has there been any negative studies? None, if understood correctly. A study of NYC police officers evaluated CT calcium scoring and found that these officers had low calcium scores (10). In fact, 74% had a score of 0, indicating extremely low risk for cardiac ischemia. However, this negative study was a short-term study done shortly after 9/11 and evaluated a risk for cardiac ischemia rather than the actual occurrence of cardiac ischemia. And because coronary artery

calcifications take years to develop, this study only serves to demonstrate that these individuals did not have pre-existing non-WTC coronary artery disease. A negative study that supports our contention that new-onset cardiac ischemia after 9/11 is associated with WTC exposure.

Two mortality studies, one from the WTC health Registry and another using pooled data on Responders from the WTC Health Registry, FDNY and the GRC showed lower than expected cardiovascular mortality rates when compared to the general population (11,12). Because the same was true for all-cause mortality and for cancer-mortality, this is likely the result of the healthy worker effect and excellent healthcare than a reduced incidence of cardiovascular disease.

In summary, we strongly believe that the literature clearly demonstrates an increased risk for developing cardiovascular disease (including stroke) in WTC responders and survivors. We also believe this increased risk is an underestimate of the true risk. Due to WTC health program regulations, there is limited ability to use program funds to diagnose cardiovascular diseases (including stroke) unless such symptoms overlap with WTC-covered pulmonary symptoms/disease. This likely leads to falsely low rates due to inability to afford diagnostic testing in those without health insurance – an issue of particular concern in survivors. An additional bias towards the null may have occurred because without acceptance as a WTC-covered condition there is no financial benefit to reporting cardiovascular disease (including stroke), thereby disincentivizing WTC Health Program enrollment, retention and cardiovascular disease reporting.

We have reviewed the Administrator's published recent published process needed to add non-cancers as WTC-covered conditions. We believe that covering cardiovascular diseases is consistent with this policy. In fact, we believe the evidence for cardiovascular disease is far stronger than that used by the Administrator to cover many of the cancers.

Our petition is based on evidence from multiple high-quality epidemiologic studies that demonstrate a strong statistically significant association between WTC exposure and new-onset cardiovascular diseases (including stroke) in Responders and Survivors (1-9). Because the evidence is high quality and consistently significant across all cohorts and all published studies, we believe the evidence meets criteria for a Category I (substantial likelihood for causal association) designation.

However, under the unlikely possibility that the Administrator may consider the evidence to be more consistent with a Category II designation (high rather than substantial likelihood for causal association), we still believe our petition should move forward. According to the WTC Health Program's Policy for adding non-cancer health conditions to the list of WTC-related health conditions, petitions based on Category II evidence allow the Administrator to consider additional data from the following sources:

1. Sources of highly relevant scientific information regarding non-9/11 exposures published (or funded) by the US government, including Environmental Protection Agency (EPA)
2. Evaluation of additional highly relevant scientific information regarding non-9.11 exposures – bioplausibility based on physical and mental health exposures.

3. Findings and recommendations solicited from the WTC Clinical Centers of Excellence and Data Centers, and the WTC Health Registry at the New York City Department of Health and Mental Hygiene
4. Findings and recommendations from other sources of information relevant to 9/11 exposures, including expert judgment from the NIOSH WTC Science Team and the NIOSH WTC Scientific Advisory Committee (STAC)
5. Information from the public solicited through a request for information published in the *Federal Register*

Using the same considerations as the WTC Health Program Administrator used for decisions to include cancers as WTC-covered conditions, our rationale for a favorable decision on our petition using evidence from each of the five additional sources is as follows:

1. The Environmental Protection Agency (EPA) evaluates agents in the environment that are of public health concern. Over the last decades, the EPA has published or funded air pollution research demonstrating a clear link between many of the products found at the WTC-site (13) including PM<sub>2.5</sub>, diesel exhaust products, ozone, etc. and cardiovascular disease (14-19; cited on the EPA website as EPA studies). Fine particulate air pollution PM<sub>2.5</sub> mm in diameter is a major environmental threat to global public health (20). More than one-half of all PM<sub>2.5</sub> related deaths are from cardiovascular causes (21). As such, the American Heart Association (22), European Society of Cardiology (23), the American Thoracic Society, and European Respiratory Society (24), as well as the U.S. Environmental Protection Agency (EPA) (25) have recognized PM<sub>2.5</sub> as a causal risk factor for cardiovascular disease (including stroke).
2. Additional highly relevant scientific information regarding non-9/11 exposures.
  - A. Bioplausibility based on physical environmental exposures Short-term exposures increase the risk for myocardial infarction (MI), stroke, heart failure, and sudden death (26-30). A 10- $\mu\text{g}/\text{m}^3$  increase in PM<sub>2.5</sub> ambient levels increases these event rates by up to 1% to 2% in the population during the ensuing few days. Chronic exposures over months to years increase these risks to an even greater degree ( $\geq 10\%$  per 10- $\mu\text{g}/\text{m}^3$  increase). Numerous mechanisms have been shown to contribute to the adverse cardiovascular outcomes including: vascular dysfunction, elevated blood pressure, metabolic derangements (ex. insulin resistance, metabolic syndrome), enhanced thrombosis-coagulation, heightened arrhythmia potential, increased atherosclerosis and plaque vulnerability. PM<sub>2.5</sub> exposure elicits systemic responses through a variety of mediated pathways including the triggering of systemic inflammation and oxidative stress, autonomic imbalance, neuro-hormonal activation, and/or the release of secondarily-generated endogenous factors (e.g., oxidized lipids) or pollutant constituents (e.g., metals, nanoparticles) from the pulmonary into the systemic circulation.
  - B. Bioplausibility based on mental health exposures: many people witnessed traumatic events on 9/11 as well as continued personal reminders of the attack. The association between WTC exposure and cardiovascular disease (including stroke) has been demonstrated (1,5,6,9). This is not unexpected as there has been extensive research

documenting a linkage between PTSD and cardiovascular diseases in both civilian (30,31,32) and veteran populations (33,34).

3. Findings and recommendations from the WTC Clinical Centers of Excellence Program Directors: based on published peer-reviewed papers (1-5) and annual reports, the WTC Health Program has at least 4,402 patients with confirmed cardiovascular diseases (including stroke) whose WTC-certification requests would be affected by this regulatory change (see table below). This is an underestimate as this data is not currently available from the Survivor Program and has not been recently updated by the programs. For the reasons presented above, the Directors are unanimous in our request that cardiovascular diseases (including stroke) be added to the list of WTC-covered conditions.

	FDNY <sup>a</sup>	General Responders <sup>b</sup>	WTC Registry <sup>c</sup>
<b>Cardiovascular Diseases (including stroke)</b>	609 (6.2%)	2,358 (6.3%)	1,435 (3.0%)
<i>a = new onset 2002 through 2017(confirmed)</i> <i>b = new onset 2002 through 2019 (self-report)</i> <i>c = new onset 2001 through 2010 (hospitalization)</i>			

4. Findings, recommendations and expert judgment from others including the NIOSH WTC Science Team and the NIOSH WTC Scientific Advisory Committee (STAC): given that the statistical evidence for an association between WTC exposure and new-onset cardiovascular diseases is consistently strong, and in fact stronger than for many cancers already covered by the WTC Health Program, we are confident that our petition will receive serious consideration and ultimately their support.
5. We are confident that public comment will be favorable. The science, the impact these conditions have on quality of life, and the availability of FDA approved treatments that unquestionably improve quality of life and prognosis, should provide the basis for such support.

In summary, the WTC Health Program Directors from all of the WTC Clinical Centers of Excellence (FDNY, Mt. Sinai, Stony Brook, Northwell, NYU, Robert Wood Johnson and the Survivor Program at Bellevue), unanimously and respectfully request that the WTC Administrator allow the NIOSH WTC Health Program Science Team and the STAC to review whether WTC Health Program coverage can be extended to include cardiovascular diseases (including stroke). To maintain the program's credibility and its fiduciary responsibility, we recommend that such coverage require the same exposure requirements as required for WTC cancers – an incidence occurring post-9/11 and only in those with significant WTC exposure.

Respectfully,

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Iris Udasin, MD  
Director, WTC Health Program Clinical Center of Excellence at Robert Wood Johnson

Joan Reibman, MD  
Director, WTC Health Program Clinical Center of Excellence at Health & Hospitals

*Attached: Reference list with abstracts*

## References:

### A. Association between WTC exposure and Cardiovascular diseases:

1. Hannah T Jordan, Sara A Miller-Archie, James E Cone, Alfredo Morabia, Steven D Stellman. Heart disease among adults exposed to the September 11, 2001 World Trade Center disaster: results from the World Trade Center Health Registry. *Prev Med.* 2011 Dec;53(6):370-6. doi: 10.1016/j.ypmed.2011.10.014. Epub 2011 Oct 28. PMID: 22040652 DOI: 10.1016/j.ypmed.2011.10.014

#### Abstract

**Objective:** To examine associations between 9/11-related exposures, posttraumatic stress disorder (PTSD), and subsequent development of heart disease.

**Methods:** We prospectively followed 39,324 WTC Health Registry participants aged  $\geq 18$  on 9/11 for an average of 2.9 years. Heart disease was defined as self-reported physician-diagnosed angina, heart attack, and/or other heart disease reported between study enrollment (2003-2004) and a follow-up survey (2006-2008) in enrollees without previous heart disease. A PTSD Checklist (PCL) score  $\geq 44$  was considered PTSD. We calculated adjusted hazard ratios (AHR) and 95% confidence intervals (CI) to examine relationships between 9/11-related exposures and heart disease.

**Results:** We identified 1162 heart disease cases (381 women, 781 men). In women, intense dust cloud exposure was significantly associated with heart disease (AHR 1.28, 95% CI 1.02-1.61). Injury on 9/11 was significantly associated with heart disease in women (AHR 1.46, 95% CI 1.19-1.79) and in men (AHR 1.33, 95% CI 1.15-1.53). Participants with PTSD at enrollment had an elevated heart disease risk (AHR 1.68, 95% CI 1.33-2.12 in women, AHR 1.62, 95% CI 1.34-1.96 in men). A dose-response relationship was observed between PCL score and heart disease risk.

**Conclusion:** This exploratory study suggests that exposure to the WTC dust cloud, injury on 9/11 and 9/11-related PTSD may be risk factors for heart disease.

2. Hannah T Jordan, Steven D Stellman, Alfredo Morabia, Sara A Miller-Archie, Howard Alper, Zoey Laskaris, Robert M Brackbill, James E Cone. Cardiovascular disease hospitalizations in relation to exposure to the September 11, 2001 World Trade Center disaster and posttraumatic stress disorder. *J Am Heart Assoc.* 2013 Oct 24;2(5):e000431. doi: 10.1161/JAHA.113.000431. PMID: 24157650 PMCID: PMC3835258 DOI: 10.1161/JAHA.113.000431

#### Abstract

**Background:** A cohort study found that 9/11-related environmental exposures and posttraumatic stress disorder increased self-reported cardiovascular disease risk. We attempted to replicate these findings using objectively defined cardiovascular disease hospitalizations in the same cohort.

**Methods and results:** Data for adult World Trade Center Health Registry enrollees residing in New York State on enrollment and no cardiovascular disease history ( $n = 46,346$ ) were linked to a New York State hospital discharge-reporting system. Follow-up began at Registry enrollment (2003-2004) and ended at the first cerebrovascular or heart disease hospitalization, death, or December 31, 2010, whichever was earliest. We used proportional hazards models to estimate adjusted hazard ratios (AHRs) for heart disease ( $n = 1151$ ) and cerebrovascular disease ( $n = 284$ ) hospitalization during 302,742 person-years of observation (mean follow-up, 6.5 years per person), accounting for other factors including age, race/ethnicity, smoking, and diabetes. An elevated risk of HD hospitalization was observed among women (AHR 1.32, 95% CI 1.01 to 1.71) but not men (AHR 1.16, 95% CI 0.97 to 1.40) with posttraumatic stress disorder at enrollment. A high overall level of World Trade Center rescue and recovery-related exposure was associated with an elevated heart disease hospitalization risk in men (AHR 1.82, 95% CI 1.06 to 3.13;  $P$  for trend = 0.05), but findings in women were inconclusive (AHR 3.29, 95% CI 0.85 to 12.69;  $P$  for trend = 0.09). Similar associations were observed specifically

with coronary artery disease hospitalization. Posttraumatic stress disorder increased the cerebrovascular disease hospitalization risk in men but not in women.

Conclusions: 9/11-related exposures and posttraumatic stress disorder appeared to increase the risk of subsequent hospitalization for heart disease and cerebrovascular disease. This is consistent with findings based on self-reported outcomes.

3. Robert M Brackbill, James E Cone, Mark R Farfel, Steven D Stellman. Chronic physical health consequences of being injured during the terrorist attacks on World Trade Center on September 11, 2001. *Am J Epidemiol*. 2014 May 1;179(9):1076-85. doi: 10.1093/aje/kwu022. Epub 2014 Feb 20. PMID: 24561992 PMCID: PMC4047283 DOI: 10.1093/aje/kwu022.

#### Abstract

Few studies have focused on injuries from the World Trade Center disaster on September 11, 2001. Severe injury has health consequences, including an increased mortality risk 10 years after injury and the risk of mental health problems, such as posttraumatic stress disorder (PTSD). The World Trade Center Health Registry identified 14,087 persons with none of a selected group of preexisting chronic conditions before 2002 who were present during and soon after the World Trade Center attacks, 1,980 of whom reported sustaining 1 or more types of injury (e.g., a broken bone or burn). Survey data obtained during 2003-2004 and 2006-2007 were used to assess the odds of reporting a diagnosis of chronic conditions (heart disease, respiratory disease, diabetes, cancer) up to 5-6 years after the attacks. Number of injury types and probable PTSD were significantly associated with having any chronic conditions diagnosed in 2002-2007. Persons with multiple injuries and PTSD had a 3-fold higher risk of heart disease than did those with no injury and no PTSD, and persons with multiple injuries and with no PTSD had a 2-fold higher risk of respiratory diseases. The present study shows that injured persons with or without comorbid PTSD have a higher risk of developing chronic diseases. Clinicians should be aware of the heightened risk of chronic heart and respiratory conditions among injured persons.

4. Howard E Alper, Shengchao Yu, Steven D Stellman, Robert M Brackbill. Injury, intense dust exposure, and chronic disease among survivors of the World Trade Center terrorist attacks of September 11, 2001. *Inj Epidemiol*. 2017 Dec;4(1):17. doi: 10.1186/s40621-017-0115-x. Epub 2017 Jul 3. PMID: 28626847 PMCID: PMC5511809 DOI: 10.1186/s40621-017-0115-x

#### Abstract

Background: The World Trade Center attack of September 11, 2001 in New York City (9/11) exposed thousands of people to intense concentrations of hazardous materials that have resulted in reports of increased levels of asthma, heart disease, diabetes, and other chronic diseases along with psychological illnesses such as post-traumatic stress disorder (PTSD). Few studies have discriminated between health consequences of immediate (short-term or acute) intense exposures versus chronic residential or workplace exposures.

Methods: We used proportional hazards methods to determine adjusted hazard ratios (AHRs) for associations between several components of acute exposures (e.g., injury, immersion in the dust cloud) and four chronic disease outcomes: asthma, other non-neoplastic lung diseases, cardiovascular disease, and diabetes, in 8701 persons free of those conditions prior to exposure and who were physically present during or immediately after the World Trade Center attacks. Participants were followed prospectively up to 11 years post-9/11.

Results: Heart disease exhibited a dose-response association with sustaining injury (1 injury type: AHR = 2.0, 95% CI (Confidence Interval) 1.1-3.6; 2 injury types: AHR = 3.1, 95% CI 1.2-7.9; 3 or more injury types: AHR = 6.8, 95% CI 2.0-22.6), while asthma and other lung diseases were both significantly associated with dust cloud exposure (AHR = 1.3, 95% CI 1.0-1.6). Diabetes was not associated with any of the predictors assessed in this study.



Conclusion: In this study we demonstrated that the acute exposures of injury and dust cloud that were sustained on 9/11/2001 had significant associations with later heart and respiratory diseases. Continued monitoring of 9/11 exposed persons' health by medical providers is warranted for the foreseeable future.

5. Shengchao Yu, Howard E Alper, Angela-Maithy Nguyen, Robert M Brackbill  
Risk of Stroke Among Survivors of the September 11, 2001, World Trade Center Disaster.  
*J Occup Environ Med.* 2018 Aug;60(8):e371-e376. doi: 10.1097/JOM.0000000000001361.  
PMID: 29851739 DOI: 10.1097/JOM.0000000000001361

Abstract

Objective: The aim of this study was to investigate the association between 9/11-related posttraumatic stress disorder (PTSD), dust cloud exposure, and subsequent development of stroke among 42,527 enrollees in the World Trade Center (WTC) Health Registry.

Methods: Using four waves of longitudinal data from the WTC Health Registry surveys, we employed Cox proportional hazards regression models to assess the associations.

Results: Incidence of stroke was higher among those with PTSD or intense dust cloud exposure than those without, and it was even higher for those who had experienced both. In fully adjusted models, participants with PTSD had an increased risk of developing stroke [adjusted hazards ratio (AHR) 1.69, 95% confidence interval (95% CI) 1.42 to 2.02], as did those with intense dust exposure (AHR 1.29, 95% CI 1.09 to 1.53).

Conclusion: We found that individuals with 9/11-related PTSD and/or intense dust exposure may have an increased risk of developing stroke.

6. Shengchao Yu, Howard E Alper, Angela-Maithy Nguyen, Junaid Maqsood, Robert M Brackbill.  
Stroke hospitalizations, posttraumatic stress disorder, and 9/11-related dust exposure: Results from the World Trade Center Health Registry. *Am J Ind Med.* 2021 Oct;64(10):827-836. doi: 10.1002/ajim.23271. Epub 2021 Jul 19. PMID: 34558721 DOI: 10.1002/ajim.23271

Abstract

Background: Few studies have examined the association between disaster-related factors and stroke by subtype or number. We investigated the association between 9/11-related posttraumatic stress disorder (PTSD), dust exposure, and stroke subtype as well as recurrent strokes.

Methods: The study included 29,012 individuals enrolled in the World Trade Center Health Registry. Stroke cases were obtained by matching Registry enrollees to the New York State Department of Health's discharge records for inpatient visits between 2000 and 2016. Cox proportional hazards regression models were performed to examine the association between 9/11-related risk factors and stroke by subtype. Multinomial logistic regression models were conducted to assess the associations between the same risk factors and the number of stroke hospitalizations.

Results: Having PTSD significantly increased the risk of developing ischemic and hemorrhagic stroke, with adjusted hazards ratios (AHRs) of 1.64 (95% confidence interval [CI]: 1.28-2.10) and 1.73 (95% CI: 1.10-2.71), respectively. The point estimate for dust cloud exposure, although not significant statistically, suggested an increased risk of ischemic stroke (AHR = 1.20, 95% CI: 0.96-1.50). PTSD was significantly associated with recurrent strokes with an adjusted odds ratio of 1.79 (95% CI: 1.09-2.95).

Conclusions: PTSD is a risk factor for both ischemic and hemorrhagic stroke and is associated with recurrent strokes. Dust exposure on 9/11 is a possible risk factor for ischemic stroke but not for hemorrhagic stroke and was not associated with recurrent strokes. Our findings warrant additional research on stroke-morbidity and mortality associated with 9/11-related PTSD and dust exposure.

7. Hillel W Cohen, Rachel Zeig-Owens, Cynthia Joe, Charles B Hall, Mayris P Webber, Michael D Weiden, Krystal L Cleven, Nadia Jaber, Molly Skerker, Jennifer Yip, Theresa Schwartz, David J Prezant. Long-term Cardiovascular Disease Risk Among Firefighters After the World Trade Center Disaster. *JAMA Netw Open*. 2019 Sep 4;2(9):e199775. doi: 10.1001/jamanetworkopen.2019.9775. PMID: 31490535 PMCID: PMC6735414 DOI: 10.1001/jamanetworkopen.2019.9775

**Abstract**

**Importance:** Published studies examining the association between World Trade Center (WTC) exposure on and after September 11, 2001, and longer-term cardiovascular disease (CVD) outcomes have reported mixed findings.

**Objective:** To assess whether WTC exposure was associated with elevated CVD risk in Fire Department of the City of New York (FDNY) firefighters.

**Design, settings, and participants:** In this cohort study, the association between WTC exposure and the risk of CVD was assessed between September 11, 2001, and December 31, 2017, in FDNY male firefighters. Multivariable Cox regression analyses were used to estimate CVD risk in association with 2 measures of WTC exposure: arrival time to the WTC site and duration of work at the WTC site. Data analyses were conducted from May 1, 2018, to March 8, 2019.

**Main outcomes and measures:** The primary CVD outcome included myocardial infarction, stroke, unstable angina, coronary artery surgery or angioplasty, or CVD death. The secondary outcome (all CVD) included all primary outcome events or any of the following: transient ischemic attack; stable angina, defined as either use of angina medication or cardiac catheterization without intervention; cardiomyopathy; and other CVD (aortic aneurysm, peripheral arterial vascular intervention, and carotid artery surgery).

**Results:** There were 489 primary outcome events among 9796 male firefighters (mean [SD] age on September 11, 2001, was 40.3 [7.4] years and 7210 individuals [73.6%] were never smokers). Age-adjusted incident rates of CVD were higher for firefighters with greater WTC exposure. The multivariable adjusted hazard ratio (HR) for the primary CVD outcome was 1.44 (95% CI, 1.09-1.90) for the earliest arrival group compared with those who arrived later. Similarly, those who worked at the WTC site for 6 or more months vs those who worked less time at the site were more likely to have a CVD event (HR, 1.30; 95% CI, 1.05-1.60). Well-established CVD risk factors, including hypertension (HR, 1.41; 95% CI, 1.10-1.80), hypercholesterolemia (HR, 1.56; 95% CI, 1.28-1.91), diabetes (HR, 1.99; 95% CI, 1.33-2.98), and smoking (current: HR, 2.13; 95% CI, 1.68-2.70; former: HR, 1.55; 95% CI, 1.23-1.95), were significantly associated with CVD in the multivariable models. Analyses with the all-CVD outcome were similar.

**Conclusions and relevance:** The findings of the study suggest a significant association between greater WTC exposure and long-term CVD risk. The findings appear to reinforce the importance of long-term monitoring of the health of survivors of disasters.

8. Nancy L Sloan, Moshe Z Shapiro, Ahmad Sabra, Christopher R Dasaro, Michael A Crane, Denise J Harrison, Benjamin J Luft, Jacqueline M Moline, Iris G Udasin, Andrew C Todd, Susan L Teitelbaum. Cardiovascular disease in the World Trade Center Health Program General Responder Cohort. *Am J Ind Med*. 2021 Feb;64(2):97-107. doi: 10.1002/ajim.23207. Epub 2020 Dec 14. PMID: 33315266 PMCID: PMC8215565 DOI: 10.1002/ajim.23207

**Abstract**

**Background:** Over 90,000 rescue and recovery responders to the September 2001 World Trade Center (WTC) attacks were exposed to toxic materials that can impair cardiac function and increase cardiovascular disease (CVD) risk. We examined WTC-related exposures association with annual and cumulative CVD incidence and risk over 17 years in the WTC Health Program (HP) General Responder Cohort (GRC).

Methods: Post 9/11 first occurrence of CVD was assessed in 37,725 responders from self-reported physician diagnosis of, or current treatment for, coronary artery disease, myocardial infarction, stroke and/or congestive heart failure from WTC Health Program GRC monitoring visits. Kaplan-Meier estimates of CVD incidence used the generalized Wilcoxon test statistic to account for censored data. Cox proportional hazards regression analyses estimated the CVD hazard ratio associated with 9/11/2001 arrival in responders with and without dust cloud exposure, compared with arrival on or after 9/12/2001. Additional analyses adjusted for comorbidities.

Results: To date, 6.3% reported new CVD. In covariate-adjusted analyses, men's CVD 9/11/2001 arrival risks were 1.40 (95% confidence interval [CI] = 1.26, 1.56) and 1.43 (95% CI = 1.29, 1.58) and women's were 2.16 (95% CI = 1.49, 3.11) and 1.59 (95% CI = 1.11, 2.27) with and without dust cloud exposure, respectively. Protective service employment on 9/11 had higher CVD risk.

Conclusions: WTC Health Program GRC members with 9/11/2001 exposures had substantially higher CVD risk than those initiating work afterward, consistent with observations among WTC-exposed New York City firefighters. Women's risk was greater than that of men's. GRC-elevated CVD risk may also be occurring at a younger age than in the general population.

9. Molly Remch, Zoey Laskaris, Janine Flory, Consuelo Mora-McLaughlin, Alfredo Morabia. Post-Traumatic Stress Disorder and Cardiovascular Diseases: A Cohort Study of Men and Women Involved in Cleaning the Debris of the World Trade Center Complex. *Circ Cardiovasc Qual Outcomes*. 2018 Jul;11(7):e004572. doi:10.1161/CIRCOUTCOMES.117.004572.PMID: 29991645 PMID: PMC6044466 DOI: 10.1161/CIRCOUTCOMES.117.004572

#### Abstract

Background: We sought to determine whether post-traumatic stress disorder (PTSD) is a risk factor for myocardial infarction (MI) and stroke, beyond the expected effects from recognized cardiovascular risk factors and depression.

Methods and results: World Trade Center-Heart is an observational prospective cohort study of 6481 blue-collar first responders nested within the World Trade Center Health Program in New York City. Baseline measures in 2012 and 2013 included blood pressure, weight and height, and blood lipids. PTSD, depression, smoking, and dust exposure during the 2001 cleanup were self-reported. During the 4-year follow-up, outcomes were assessed through (1) interview-based incident, nonfatal MI, and stroke, validated in medical charts (n=118); and (2) hospitalizations for MI and stroke for New York city and state residents (n=180). Prevalence of PTSD was 19.9% in men and 25.9% in women, that is, at least twice that of the general population. Cumulative incidence of MI or stroke was consistently larger for men or women with PTSD across follow-up. Adjusted hazard ratios (HRs) were 2.22 (95% confidence interval [CI], 1.30-3.82) for MI and 2.51 (95% CI, 1.39-4.57) for stroke. For pooled MI and stroke, adjusted HRs were 2.35 (95% CI, 1.57-3.52) in all and 1.88 (95% CI, 1.01-3.49) in men free of depression. Using hospitalization registry data, adjusted HRs were 2.17 (95% CI, 1.41-3.32) for MI; 3.01 (95% CI, 1.84-4.93) for stroke; and for pooled MI and stroke, the adjusted HR was 2.40 (95% CI, 1.73-3.34) in all, HR was 2.44 (95% CI, 1.05-5.55) in women, and adjusted HR was 2.27 (95% CI, 1.41-3.67) in men free of depression. World Trade Center dust exposure had no effect.

Conclusions: This cohort study confirms that PTSD is a risk factor for MI and stroke of similar magnitude in men and women, independent of depression.

10. Nikolas Wanahita, Jia Lin See, Kenneth N Giedd, Patricia Friedmann, Nir N Somekh, Steven R Bergmann. No evidence of increased prevalence of premature coronary artery disease in New York City police officers as predicted by coronary artery calcium scoring. *J Occup Environ Med*. 2010 Jun;52(6):661-5. doi: 10.1097/JOM.0b013e3181e36457. PMID: 20523232 DOI: 10.1097/JOM.0b013e3181e36457

#### Abstract

**Objectives:** To investigate the prevalence of coronary artery disease (CAD) in active New York City police officers as detected by coronary artery calcium (CAC) scoring.

**Methods:** We assessed 2064 New York City police officers who underwent electron beam computed tomography for quantification of CAC.

**Results:** The mean age of study subjects was 42 +/- 6 years. A CAC score of 0 was present in 74% of men and 80% of women. A subset of 75 officers with known early exposure to World Trade Center dust were evaluated separately.

**Conclusion:** New York City police officers do not have an increased prevalence of CAD compared with the general population as assessed with CAC scoring. At 5 years, exposure to World Trade Center dust does not appear to increase the risk of premature CAD.

## B. WTC Exposure and Cardiovascular Disease Mortality Rates

11. Hannah T Jordan , Cheryl R Stein, Jiehui Li, James E Cone, Leslie Stayner, James L Hadler, Robert M Brackbill, Mark R Farfel. Mortality among rescue and recovery workers and community members exposed to the September 11, 2001 World Trade Center terrorist attacks, 2003-2014. *Environ Res.* 2018 May;163:270-279. doi: 10.1016/j.envres.2018.01.004. Epub 2018 Feb 22. PMID: 29477875 DOI: 10.1016/j.envres.2018.01.004

### Abstract

**Background:** Multiple chronic health conditions have been associated with exposure to the September 11, 2001 World Trade Center (WTC) terrorist attacks (9/11). We assessed whether excess deaths occurred during 2003-2014 among persons directly exposed to 9/11, and examined associations of 9/11-related exposures with mortality risk.

**Materials and methods:** Deaths occurring in 2003-2014 among members of the World Trade Center Health Registry, a cohort of rescue/recovery workers and lower Manhattan community members who were exposed to 9/11, were identified via linkage to the National Death Index. Participants' overall levels of 9/11-related exposure were categorized as high, intermediate, or low. We calculated standardized mortality ratios (SMR) using New York City reference rates from 2003 to 2012. Proportional hazards were used to assess associations of 9/11-related exposures with mortality, accounting for age, sex, race/ethnicity and other potential confounders.

**Results:** We identified 877 deaths among 29,280 rescue/recovery workers (3.0%) and 1694 deaths among 39,643 community members (4.3%) during 308,340 and 416,448 person-years of observation, respectively. The SMR for all causes of death was 0.69 [95% confidence interval (CI) 0.65-0.74] for rescue/recovery workers and 0.86 (95% CI 0.82-0.90) for community members. SMRs for diseases of the cardiovascular and respiratory systems were significantly lower than expected in both groups. SMRs for several other causes of death were significantly elevated, including suicide among rescue recovery workers (SMR 1.82, 95% CI 1.35-2.39), and brain malignancies (SMR 2.25, 95% CI 1.48-3.28) and non-Hodgkin's lymphoma (SMR 1.79, 95% CI 1.24-2.50) among community members. Compared to low exposure, both intermediate [adjusted hazard ratio (AHR) 1.36, 95% CI 1.10-1.67] and high (AHR 1.41, 95% CI 1.06-1.88) levels of 9/11-related exposure were significantly associated with all-cause mortality among rescue/recovery workers (p-value for trend 0.01). For community members, intermediate (AHR 1.13, 95% CI 1.01-1.27), but not high (AHR 1.14, 95% CI 0.94-1.39) exposure was significantly associated with all-cause mortality (p-value for trend 0.03). AHRs for associations of overall 9/11-related exposure with heart disease- and cancer-related mortality were similar in magnitude to those for all-cause mortality, but with 95% CIs crossing the null value.

**Conclusions:** Overall mortality was not elevated. Among specific causes of death that were significantly elevated, suicide among rescue/recovery workers is a plausible long-term consequence of 9/11 exposure, and is potentially preventable. Elevated mortality due to other causes, including non-

Hodgkin's lymphoma and brain cancer, and small but statistically significant associations of 9/11-related exposures with all-cause mortality hazard warrant additional surveillance.

12. Jiehui Li, Charles B Hall, Janette Yung, Rebecca D Kehm, Rachel Zeig-Owens, Ankura Singh, James E Cone, Robert M Brackbill, Mark R Farfel, Baozhen Qiao, Maria J Schymura, Moshe Z Shapiro, Christopher R Dasaro, Andrew C Todd, David J Prezant, Paolo Boffetta. A 15-year follow-up study of mortality in a pooled cohort of World Trade Center rescue and recovery workers. *Environ Res.* 2023 Feb 15;219:115116. doi: 10.1016/j.envres.2022.115116. Epub 2022 Dec 19. PMID: 36549491 DOI: 10.1016/j.envres.2022.115116.

#### Abstract

**Introduction:** Hazardous exposures from the World Trade Center (WTC) terrorist attacks have been linked to increased incidence of adverse health conditions, often associated with increased mortality. We assessed mortality in a pooled cohort of WTC rescue/recovery workers over 15 years of follow-up.

**Materials and methods:** We analyzed mortality through 2016 in a pooled and deduplicated cohort of WTC rescue/recovery workers from three WTC-exposed cohorts (N = 60,631): the Fire Department of the City of New York (FDNY); the WTC Health Registry (WTCHR); and the General Responder Cohort (GRC). Standardized mortality ratios (SMRs) were estimated to assess mortality vs. the US and NY state populations. Multivariable Cox proportional hazards models were used to examine associations of WTC exposures (date of first arrival, working on the WTC debris pile) with mortality risk.

**Results:** There were 1912 deaths over 697,943.33 person-years of follow-up. The SMR for all-cause mortality was significantly lower-than-expected, both when using US (SMR 0.43, 95% confidence interval [CI] 0.42-0.45) and NYS (SMR 0.51, 95% CI 0.49-0.53) as reference populations. SMRs were not elevated for any of the 28 major causes of death. Arriving at the WTC site on 9/11-9/17/2001 vs. 9/18/2001-6/30/2002 was associated with 30-50% higher risk of all-cause, heart disease and smoking-related mortality in non-FDNY/non-GRC members. Conversely, arriving on 9/11/2001 vs. 9/18/2001-6/30/2002 was associated with 40% lower all-cause and smoking-related mortality risk in FDNY members. Working on vs. off the WTC pile was associated with an increased risk of all-cause mortality in non-FDNY/non-GRC members (adjusted hazard ratio [aHR] 1.25, 95% CI 1.04-1.50), and cancer-specific mortality in GRC members (aHR 1.39, 95% CI 1.05-1.84), but lower mortality risks were found in FDNY members.

**Conclusions:** We did not observe excess mortality among WTC rescue/recovery workers compared with general populations. However, significantly increased mortality risks among some sub-groups with high WTC exposure warrant further investigation.

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