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Mortality among rescue and recovery workers and community members exposed to the September 11, 2001 World Trade Center terrorist attacks, 2003–2014

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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.

Abbreviations: CI, 95% confidence interval; AHR, Adjusted hazard ratio; COPD, Chronic obstructive pulmonary disease; ICD-10, International Classification of Disease codes, 10th revision; LTAS, Life Table Analysis System; MN, Malignant neoplasm; NDI, National Death Index; NIOSH, National Institute for Occupational Safety and Health; NYC, New York City; ref, Reference group; SMR, Standardized mortality ratios; the Registry, World Trade Center Health Registry; WTC, World Trade Center

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1. Introduction

During the September 11, 2001 World Trade Center (WTC) terrorist attacks (9/11) and the months-long recovery period that followed, hundreds of thousands of New York City (NYC) metropolitan area first responders, construction and clean-up workers, and community members experienced an array of potentially toxic environmental exposures (Murphy, 2009; Claudio, 2001). The detonation of two jet planes and resulting collapse of the WTC towers created a vast cloud of particulate matter and fumes that engulfed many survivors. Subsequent fires and the re-suspension of dust during rescue, recovery, and clean-up efforts prolonged the opportunities for 9/11-related environmental exposures (Claudio, 2001; Landrigan et al., 2004; Lioy et al., 2002; Clark et al., 2003).

Several chronic illnesses have since been linked to 9/11-related exposures (Landrigan et al., 2004; Brackbill et al., 2009; Cleven et al., 2017; Farfel et al., 2008; Wisnivesky et al., 2011). A number of these conditions, including asthma and other lower respiratory diseases, could potentially cause or contribute to premature mortality. Preliminary findings suggest that 9/11-related exposures may be linked to an elevated risk of cardiovascular disease, another potential cause of excess mortality (Jordan et al., 2011a, 2013). Although not definitively linked to 9/11 exposure, cancer, and therefore cancer-related mortality, is also of concern in this population because the dust that blanketed lower Manhattan during and after the attacks contained several known carcinogens (Lioy et al., 2002). Excess cases of incident thyroid and prostate cancers have been reported in three WTC-exposed cohorts (Zeig-Owens et al., 2011; Li et al., 2012; Solan et al., 2013). A subsequent study using three additional years of follow-up data found excess incident skin melanomas in both rescue/recovery workers and community participants, and excess incident non-Hodgkin's lymphoma cases among community participants (Li et al., 2016a).

Despite the biologic plausibility of increased mortality due to 9/11-related health conditions, neither of the two studies published to date of mortality among 9/11-exposed persons identified excess deaths during the decade following the attacks (Jordan et al., 2011b; Stein et al., 2016). These findings were based on comparisons of mortality rates from the WTC Health Registry (the Registry) and the WTC Health Program cohorts to rates in the general New York City and United States populations, respectively. An analysis conducted within the Registry cohort found that higher levels of 9/11-related exposure were associated with increased all-cause and cardiovascular mortality during 2003–2009 among community enrollees, in comparison to lower exposure (Jordan et al., 2011b). However, similar internal analyses of the Registry and Health Program cohorts did not consistently identify associations between 9/11-related exposures and mortality among rescue/recovery workers (Jordan et al., 2011b; Stein et al. 2016).

It is possible that these studies were performed too early to detect excess mortality related to 9/11; many 9/11-related conditions have long median survival times, and healthy worker and volunteer effects are likely to be strongest during the early years of observation of these cohorts (Pearce et al. 2007). The statistical power of the Registry's previous mortality study was also constrained by the limitation of the analytic sample to participants who resided in New York City at enrollment. Therefore, we built upon the earlier Registry study by gathering mortality data on the full cohort and extending the observation period for an additional five years. We sought to determine whether excess deaths have occurred since the Registry's inception, and to assess whether a clear relationship between 9/11-related exposures and mortality risk has emerged.

2. Materials and methods

We used data from the Registry, a longitudinal cohort study of rescue/recovery workers and lower Manhattan area community members (area workers, residents, students, and passers-by on 9/11) who were exposed to the 9/11 attacks in New York City or participated in rescue and recovery efforts. The Registry invited potentially-exposed persons identified through government agencies and lower Manhattan employers (list-identified enrollees) or through a broad-based, multilingual outreach campaign (self-identified enrollees) to be screened for eligibility, and ultimately enrolled 71,431 voluntary participants. During September 2003 through November 2004, enrollees completed telephone-administered (95%) or in-person (5%) interviews regarding 9/11 exposures, socio-demographic information, and physical and mental health conditions and symptoms. Additional information on the Registry's methods has been published previously (Farfel et al., 2008). The US Centers for Disease Control and Prevention and New York City Department of Health and Mental Hygiene institutional review boards approved the Registry's protocol.

2.1. Study sample

For the current study, we excluded enrollees who withdrew from the Registry as of 1/12/2017 (N = 1033); had been enrolled posthumously by proxies (n = 161); provided insufficient data to enable linkage to mortality records (n = 282); or did not provide age (n = 99). We also excluded participants whose only 9/11-related exposures were on the Staten Island landfill or barges (n = 934), due to insufficient information regarding the types and amount of exposures experienced, leaving an analytic sample of 68,923.

2.2. Ascertainment of deaths

We identified deaths among enrollees through a data linkage to the National Death Index (NDI), a centralized repository of US vital records, from January 1, 2003 through December 31, 2014. The record linkage was conducted by the NDI, and Registry staff manually reviewed potential matches as described previously (Jordan et al., 2011b). International Classification of Disease codes, 10th revision (ICD-10), for the underlying cause of death were obtained from the NDI records.

2.3. Definitions

Enrollees who performed rescue/recovery work, including volunteers, were considered rescue/recovery participants. Within rescue/recovery participants, those who were firefighters, emergency medical personnel, police officers (NYC or Port Authority), New York State troopers, or federal law enforcement officers were considered traditional rescue/recovery workers, as they were likely to have had some training in disaster response; other rescue/recovery workers and volunteers were considered non-traditional. Enrollees who had not performed any rescue/recovery work were categorized as community participants. Consistent with our previous mortality study (Jordan et al., 2011b), we used responses to questions about 9/11-related exposures from the 2003–2004 enrollment questionnaire to determine whether an enrollee had been exposed to the massive cloud of dust and debris resulting from the collapse of multiple buildings on 9/11, and to categorize the level of other rescue-recovery-related and community-related exposures as high, intermediate, or low (see Text box 1).

We obtained socio-demographic information and history of chronic illnesses from the enrollment questionnaire. Enrollees who reported clinician-diagnosed coronary artery disease, angina, heart attack, or any other heart disease before 9/11 were considered to have pre-9/11 heart disease, and those who reported clinician-diagnosed cancer (excluding non-melanoma skin cancer) before 9/11 were considered to have pre-9/11 cancer. Enrollees who reported clinician-diagnosed heart disease, cancer, stroke, emphysema, or diabetes before 9/11 were categorized as having pre-9/11 chronic disease.