


The Physical and Mental Health Challenges Experienced by 9/11 First Responders and Recovery Workers: A Review of the Literature

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Conflicts of interest/funding: Funding support was received from the School of Medical and Health Sciences at Edith Cowan University, Joondalup, Australia. The authors declare no conflicts of interest.

Keywords: 9/11; first responder; health; mental health; recovery worker

Abbreviations:

CVD: cardiovascular disease
EMS: Emergency Medical Services
EMT: emergency medical technician
FDNY: Fire Department of New York
LRS: lower respiratory symptoms
PTSD: posttraumatic stress disorder
WTC: World Trade Center

Received: September 18, 2018

Revised: February 26, 2019

Accepted: March 7, 2019

doi:[10.1017/S1049023X19004989](https://doi.org/10.1017/S1049023X19004989)

Abstract

Introduction: In the years following the September 11, 2001 terrorist attacks in New York (USA), otherwise known as 9/11, first responders and recovery workers began experiencing a range of physical and mental health challenges. Publications documenting these provide an important evidence-base identifying exposure-related health challenges associated with environmental exposures from the World Trade Center (WTC) site and describe the key lessons learned regarding both physical and mental health challenges (including symptoms and defined conditions) from the 9/11 disaster response.

Methods: A systematic literature review was conducted using the MEDLINE, PubMed, CINAHL, and PsychInfo databases (September 11, 2001 to September 11, 2018) using relevant search terms, truncation symbols, and Boolean combination functions. Publications were limited to journal articles that documented the physical or mental health challenges of 9/11 on first responders or recovery workers.

Results: A total of 156 publications were retrieved by the search strategy. The majority (55%) reported a quantitative methodology, while only seven percent reported the use of a qualitative research methodology. Firefighters were the group of responders most frequently reported in the literature (35%), while 37% of publications reported on research that included a mix of first responders and recovery workers. Physical health was the focus of the majority of publications (57%). Among the challenges, respiratory issues were the physical health condition most frequently reported in publications, while posttraumatic stress disorder (PTSD) was the most frequent mental health condition reported on. Publications were published in a broad range of multi-disciplinary journals (n = 75).

Discussion: These findings will go some way to filling the current gap in the 9/11 evidence-base regarding the understanding of the long-term health challenges for first responders and recovery workers.

Smith EC, Holmes L, Burkle FM Jr. The physical and mental health challenges experienced by 9/11 first responders and recovery workers: a review of the literature. *Prehosp Disaster Med.* 2019;34(6):625–631.

Introduction

The September 11, 2001 terrorist attacks, otherwise known as 9/11, on the World Trade Center (WTC) in New York (USA) killed 2,753 people, including approximately 413 first responders.¹ The local, state, federal, and global reaction to the 9/11 attacks on the WTC was unprecedented. In the ensuing search and rescue and recovery and cleanup efforts, emergency first responders (including firefighters, police, emergency medical technicians [EMTs], and paramedics) and recovery personnel related to metalwork, ironwork, steelwork, structural engineering, heavy machinery, and construction professions would descend on the site to offer their services and remained until the site was cleared in May 2002.

After the attacks, the media termed the WTC site “Ground Zero,” while first responder and recovery workers referred to it as “The Pile.” Tens of thousands of volunteers quickly descended on Ground Zero to help in the rescue and recovery efforts. Construction projects around the city came to a halt as workers walked off their current jobs to help at Ground Zero. Ironworkers, welders, steel burners, and others with such skills were in high-demand. By the end of the first week, over one thousand ironworkers from across North America had

arrived to help, along with countless others. Nearly 90,000 responders would ultimately spend time on the still-smoldering, toxic pile of debris, searching for victims and removing wreckage. Below the pile, subterranean fires would continue burning for around 100 days, a hostile and unstable pile of debris, heat, and acrid smoke. No one turned the volunteers away; the need for sheer numbers was immediate and dire.

But as the days wore on, and with hope of finding anyone else alive beginning to fade, the initial search and rescue activities changed to debris removal and remains management. The “bucket brigades” of first responders and recovery workers working together could be seen lining the surface of the pile like lines of ants. A human hand was found, placed in a bucket, and moved along the convoy line until it was sent to the temporary morgue on-site. A piece of bone, a fragment of flesh, a firefighter’s jacket with no body inside.

And it was a dangerous landscape to be working in. Aside from the long-term danger of breathing in the toxic dust that hung in the area and covered every surface, there was the risk of immediate injury from walking over the moving, smoldering pile of debris. In the years following 9/11, first responders and recovery workers have experienced on-going illness, disability, and devastation due to their involvement in the 9/11 response. Over 800 first responders and recovery workers have died due to causes related to their exposure to the 9/11 WTC site.¹ Around 7,000 responders are registered with the World Trade Center Health Program, which was created by the federal government in the aftermath of the attacks, and over 2,000 emergency first responders have had to retire on disability due to causes linked to 9/11.¹ Doctors with the World Trade Center Health Program have linked nearly 70 types of cancer to Ground Zero – cancers that are rare, aggressive, and particularly hard to treat.² They have also identified a 15% higher cancer rate among 9/11 responders than those who were not exposed to the toxic cloud that bellowed out from Ground Zero.³

Publications documenting the physical and mental health challenges of responding to 9/11 provide an important evidence-base for both the acute and chronic health consequences of being involved in one of the largest volunteer movements the United States had ever seen. These important publications identify exposure-related health risks associated with environmental exposures from the WTC site and describe the key lessons learned regarding both the physical and mental health challenges from the 9/11 disaster response.

Methodology

A systematic review of the literature was undertaken using the following databases: MEDLINE (US National Library of Medicine, National Institutes of Health; Bethesda, Maryland USA); PubMed (National Center for Biotechnology Information, National Institutes of Health; Bethesda, Maryland USA); CINAHL (EBSCO Information Services; Ipswich, Massachusetts USA); and PsychInfo (American Psychological Association; Washington DC, USA). All databases were searched from September 11, 2001 to September 11, 2018 using a combination of the following search terms: *September 11, 2001*; *September 11, 2001 terrorist attacks*; *9/11*; *9/11 terrorist attacks*; *World Trade Center*; *Ground Zero*; *first responder*; *firefighter*; *police*; *paramedic*; *emergency medical technician*; *EMT*; *Emergency Medical Service [EMS]*; *EMS*; *ambulance*; *prehospital*; *recovery workers*; *construction workers*; *ironworkers*; [Fire Department of New York] *FDNY*; [New York Police Department] *NYPD*; [Public Authority Police

Department] *PAPD*; *health*; *mental health*; *psychological health*; *psychological impact*; *psychosocial impact*.

Appropriate truncation symbols and Boolean combination functions were used in each database. Search results from each of the four databases were combined and duplicate results were removed. Two independent reviewers reviewed all records initially retrieved by the search strategies by title and abstract to identify potentially relevant publications. Two independent reviewers then conducted a full-text review of all potentially relevant records in order to identify publications that met the inclusion criteria for the review. Inclusion criteria were any publication that reported on either the physical or mental health (symptoms or conditions) of first responders and/or recovery workers who responded to the 9/11 terrorist attacks, either on September 11, 2001, or in the eight-month ensuing recovery period. The reference lists of all relevant publications were reviewed in order to identify additional publications, and authors known to publish in the field were contacted to determine if any publications were “In Press” or had been missed by the search strategies.

A data extraction form developed for this research project was utilized by two independent reviewers. Data extracted included: journal of publication; year of publication; type of responder (ie, firefighter, police, paramedic/EMT, recovery worker, other type of worker, or a mix of all of the former); focus of the challenge (ie, physical health or mental health); and the specific type of challenge.

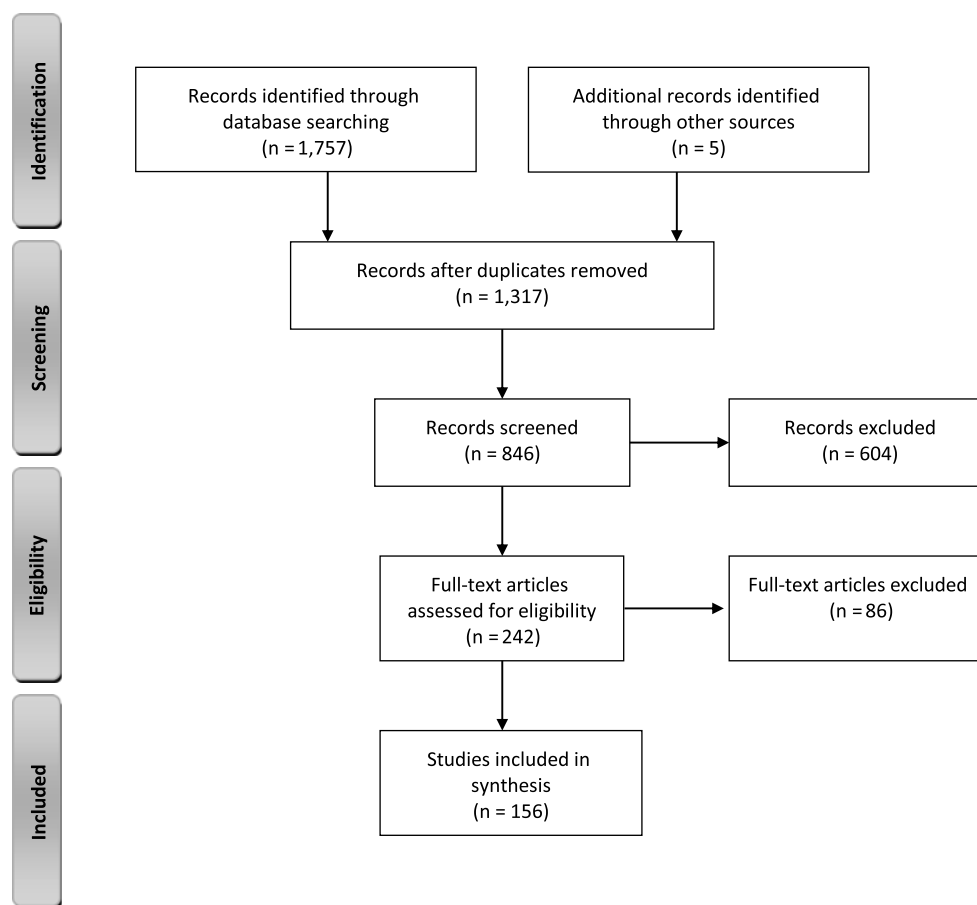
Cohen’s Kappa Value was calculated for the inter-rater reliability between the two researchers in identifying relevant publications. The Kappa Value is generally thought to be a more robust measure than simple percent agreement calculation, since κ takes into account the possibility of the agreement occurring by chance.

Results

The combined search strategies yielded 1,757 individual records after duplicates and obvious irrelevant publications were removed. Initial title review of these records identified 846 potentially relevant records. Subsequent abstract review refined the number of potentially relevant records to 242. Full-text review of these records identified 151 publications that met the inclusion criteria for this study. Reviewing references lists and contacting authors known to publish in the field identified five additional publications. These 156 publications informed the results of this literature review (Figure 1).

The kappa value for inter-rater reliability was 0.90, which indicated excellent agreement between reviewers in determining whether the records retrieved by the search strategy documented the physical and mental health challenges of responding to 9/11 on the first responders and recovery workers.

The publications predominantly reported a quantitative research methodology (55%), while only seven percent reported on the use of a qualitative methodology, such as interviews or focus groups. Only one percent of publications reported the use of a mixed methodology (one which utilizes both quantitative and qualitative methodologies within the same research). Less than 10% of all of the existing publications were literature reviews or systematic reviews covering topics related to either the physical or mental health challenges experienced by 9/11 first responders and/or recovery workers. No single review was identified by this search strategy that reported on a comprehensive literature review of all studies documenting either physical or mental health challenges



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Figure 1. PRISMA Flow Diagram of the Breakdown of Results of Search Strategies.

experienced by 9/11 on first responders and/or recovery workers. Around 30% of all publications identified reported the use of an observational or empirical research methodology. Among these publications, 27% reported on the review of existing databases, registries, or medical records.

Firefighters tended to be the focus of the majority of research exploring the health challenges associated with responding to 9/11, with 35% of all publications exploring issues within the firefighter community. Just under 40% of all publications included a mix of rescue workers, 13% of publications focused on police, 14% focused on relief and recovery workers (including volunteers from nongovernmental organizations and organizations like the Red Cross [Washington, DC USA]), and four percent focused on paramedics and EMTs. Only two percent of studies reflected on the health challenges for other types of responders (including 9-1-1 dispatchers, responders working at the Fresh Kills Landfill [New York USA], and the National Guard).

Over one-half (57%) of all publications explored the physical health challenges associated with responding to 9/11 on first responders and recovery workers. Within these publications, over one-half (53%) reported on respiratory issues (including abnormal lung function, persistent shortness of breath, cough, sinus or nasal problems, and asthma), while 28% reported on cancer, and six percent reported on gastro-esophageal disorders. The remaining 13% of publications addressed a range of physical health conditions, including movement and gait disorders, eyesight issues,

sarcoidosis, as well as elevated all-cause and heart disease mortality risks.

The mental health challenges on 9/11 first responders and recovery workers were the focus of 43% of all publications. Responders affected by 9/11 were more likely to report posttraumatic stress disorder (PTSD) symptoms six months after 9/11. However, a substantial number not directly affected also met the criteria for probable PTSD. Of all publications focusing on the mental health challenges, the majority (89%) reported on PTSD and probable PTSD. A further six percent focused on anxiety, with around three percent focusing on depression. Only eight percent of all publications focused on both physical and mental health conditions.

The publications were published in 75 discipline-diverse journals. The journals publishing the largest number of publications focusing on the physical and mental health challenges on 9/11 first responders and recovery workers included: *American Journal of Industrial Medicine* (Wiley; Hoboken, New Jersey USA); *Occupational and Environmental Medicine* (Faculty of Occupational Medicine of the Royal College of Physicians of London [United Kingdom]); and *Chest* (American College of Chest Physicians [Glenview, Illinois USA]). Table 1 lists the top ten journals publishing on this topic.

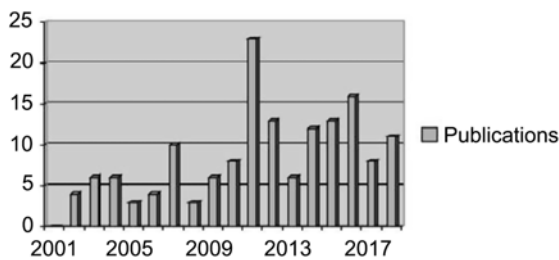
The overall trend in publication by year since 2001 is growth, with a peak in 2011 on the tenth anniversary of the 9/11 attacks ($n = 23$ publications). The number of publications by year is presented graphically in Figure 2.

Journal	% of Publications
American Journal of Industrial Medicine	11%
Occupational and Environmental Medicine	8%
Chest	6%
Environmental Health Perspectives	4%
Journal of Traumatic Stress	4%
Psychiatry Research	3%
MMWR	3%
New England Journal of Medicine	2%
Prehospital and Disaster Medicine	2%
Disaster Medicine and Public Health Preparedness	2%
Lancet	2%

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Table 1. Top Ten Journals Publishing on the Physical and Mental Health Challenges on 9/11 First Responders and Recovery Workers.

Abbreviation: MMWR, Morbidity and Mortality Weekly Report.



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Figure 2. Publications by Year.

Discussion

When the two hijacked planes crashed into the Twin Towers of the WTC on 9/11, 24,000 gallons of jet fuel ignited a fire that spread to 100,000 tons of organic debris and 230,000 gallons of transformer, heating, and diesel oils in the buildings, setting off a giant toxic plume of soot and dust from pulverized building materials. The fires continued to burn during the rescue and recovery operations at Ground Zero, and first responder and recovery workers were exposed to a myriad of unique chemicals like asbestos, carbon monoxide, hydrogen sulfide, crystalline silica, and other metals and particulates. The dust from the collapsed towers was incredibly toxic, made up of more than 2,500 contaminants including glass, lead, and mercury.⁴

Studies have shown that those exposed to WTC dust were more likely to develop lung problems, respiratory symptoms, sinus problems, or asthma. The World Trade Center Health Program also recognizes certain mental health conditions, digestive disorders, musculoskeletal disorders, and cancers as being related to 9/11.^{3,5-11}

A FDNY study found that nearly 9,000 firefighters who were exposed to the 9/11 dust may be at greater risk for cancer than those who were not exposed, and the city's World Trade Center Registry found small increases in the rates of prostate cancer, thyroid cancer, and the blood cancer multiple myeloma among nearly

34,000 rescue and recovery workers, compared to New York State residents.^{12,13}

Respiratory Symptoms and Conditions

Exposure to the toxic 9/11 dust increased the risk of developing respiratory issues among first responders and recovery workers. Rescue, recovery, and cleanup workers who arrived early at the WTC site, or worked at the WTC site for long periods of time, had higher levels of respiratory impact. Research also highlights that steep declines in pulmonary function among firefighters diagnosed within one year of 9/11 have largely persisted, even among those who never smoked. It is estimated that four-times as many firefighters and twice as many EMS workers had below-normal lung function for their ages six to seven years after 9/11. Lung function declines were greater for current smokers than for non-smokers. The prevalence of symptoms correlates with the degree of WTC site exposure, and both epidemiological and clinical studies demonstrate substantial co-morbidity of respiratory illness and mental health conditions in WTC-exposed groups. Ten years after the 9/11 attacks, lower respiratory symptoms (LRS) such as coughing, wheezing, trouble breathing, or using an inhaler still affected first responders and recovery workers. One-half of those with persistent LRS also had PTSD, depression, or generalized anxiety disorder. Respiratory illness and mental health conditions often occurred together in responders exposed to disaster.^{6,9,12,14-41}

Cancer

Several WTC cancer studies based on diagnoses have been published. This research suggests that long-term monitoring of cancer occurrence among WTC-exposed individuals is warranted. The FDNY found that nearly 9,000 firefighters with WTC exposure may be at greater risk of cancer than firefighters who were not exposed, and the WTC Health Program identified higher-than-expected prostate and thyroid cancer rates among rescue and recovery workers enrolled in the Program when compared to overall rates in New York, New Jersey, Connecticut, and Pennsylvania (USA), where the majority of workers lived.⁴²⁻⁴⁴

In two articles published in the June 2018 issue of the journal *JAMA Oncology* (American Medical Association [Chicago, Illinois USA]), researchers reported that firefighters who worked at the WTC site from September 11, 2001 to July 25, 2002 (the day the site closed to recovery efforts) were exposed to unprecedented environmental toxins and, as a result, have increased risks of many types of cancer, including prostate and thyroid cancer, melanoma, and multiple myeloma.^{45,46} In the first study, researchers isolated a group of white male firefighters with a mean age of 50 years who were at the WTC site in the days and months after 9/11. They then compared their projected risk of cancer compared to average New Yorkers of the same race, gender, and age. The researchers reported that WTC-exposed firefighters could expect a modestly higher number of cancers, specifically prostate, thyroid, and the skin cancer melanoma.

In the second study, researchers compared multiple myeloma and its precursors (non-cancerous cells that could be evidence of future disease) to a population of controls. Results suggest that the rate of multiple myeloma precursors, specifically those correlated with a rare form of light-chain precursors, was elevated among WTC first responders compared to controls who were demographically similar. Taken together, these recent publications provide important lessons that will help the fire department treat existing diseases and plan for its future.

But the results are not without controversy.⁴⁷ Firefighting is a dangerous profession and firefighters are exposed to acute risks on a daily basis. Furthermore, they are routinely exposed to known and suspected carcinogens at much higher rates than the average person. On 9/11, every available firefighter in the greater New York City area rushed to the scene. In the immediate aftermath, 413 emergency responders died, including 343 firefighters.¹ But the deaths have not stopped there. They have continued throughout the 17 years since the attacks in the form of cancers and other illnesses.

Previous research has called attention to these risks, many led by David Prezant, the Chief Medical Officer of the FDNY and a professor of pulmonary medicine at Albert Einstein College (Bronx, New York USA). On September 12, 2002, just one year after the WTC attack, Prezant and his colleagues published one of the first comprehensive studies of the health challenges associated with responding to 9/11 in the *New England Journal of Medicine* (Massachusetts Medical Society [Waltham, Massachusetts USA]) on “Cough and Bronchial Responsiveness in Firefighters at the World Trade Center Site.”³⁹

Heart Disease

The World Trade Center-Heart study published in 2018 includes 6,841 non-firefighter workers and untrained volunteers (83% men; average age 51). This includes staff from the medical examiner’s office who were involved with the processing of human remains, and the Port-Authority Trans-Hudson Corporation (New York and New Jersey USA) and others who were engaged in the cleanup, recovery, service restoration, and other tasks in the months following the attack. The research highlights that first responders and recovery workers who suffered more than one injury on 9/11 and have 9/11-related PTSD are three-times more likely to develop heart disease as people who were not injured and did not have PTSD. Male rescue and recovery workers are at higher risk for subsequent heart-related hospitalization. Those who developed PTSD faced more than double the risk of a heart attack and stroke compared to those who worked on New York City’s WTC site but did not develop PTSD. Although this study cannot prove a cause-and-effect relationship, it should be noted that PTSD can trigger a number of biological responses that might explain the association between PTSD and heart disease and stroke.^{48,49}

A major strength of this study is that it examined the impact of PTSD on heart disease in people 11 to 15 years after the 9/11 attacks. This meant that the participants were entering the age group at which heart disease risk and events rise dramatically. Another strength of the study was that it provided four years’ worth of data on those subjects. However, despite the large sample size, the study may not provide an accurate cross-sectional representation for the approximately 90,000 first responders and recovery workers who responded throughout the eight months following the WTC attack.

Most recently, a 2019 study of New York City firefighters conducted by the Albert Einstein College of Medicine, the Montefiore Health System (Bronx, New York USA), and the FDNY found that exposure to WTC dust is associated with a significantly increased long-term risk of cardiovascular disease (CVD). The study found that those who arrived first at the WTC site when the air-borne dust was thickest have a 44% increased risk of CVD compared to those who arrived later in the day. The increase in risk was significant, even taking into account known CVD risk

factors such as age, hypertension, elevated cholesterol, diabetes, and smoking.⁵⁰

PTSD

Approximately 20% of men and 26% of women who responded to the WTC site on and after the 9/11 attacks developed PTSD, which is at least twice the rate expected in the general population.⁵¹ Rescue and recovery workers who got to the WTC site on or soon after 9/11 were more likely to develop PTSD than those who arrived later. The longer someone worked at the site the greater the risk for PTSD. Rescue and recovery workers from non-emergency occupations, such as construction and sanitation workers, also suffered higher rates of PTSD than emergency responders. Responders who experienced trauma before or after 9/11, such as losing a job after the attacks, or urban or domestic violence, were at increased risk for developing PTSD. Ten years after the attack, 15% of World Trade Center Health Registry enrollees had PTSD symptoms. Importantly, PTSD was more likely to persist or get worse in people who were unable to get mental health treatment, had high 9/11-related exposure, were unemployed, or had little social support. Untrained first responders who engage in activities surrounding the aftermath of disasters are more likely to struggle with psychological challenges following their work than first responders who have received training.^{8,10,11,15,52–67}

Female police officers recruited and trained in exactly the same way as their male colleagues had much higher rates of PTSD following 9/11.⁵⁵ This result is in contrast to previous studies conducted with Gulf War veterans and police officers in general, which found no gender differences. Analyzing information collected from more than 4,000 police responders to assess the prevalence of PTSD, it was found that around 14% of female officers had PTSD compared with approximately seven percent of male officers.⁵⁵

Other Mental Health Challenges

A sample of paramedics and EMTs who responded to the 9/11 terrorist attacks reported a range of long-term psychosocial challenges, including PTSD, anxiety, depression, stress, survivor guilt, insomnia, relationship breakdowns and impact on family support systems, and addictive and risk-taking behaviors.⁶⁸ Ten years after the attacks, 15% of World Trade Center Health Registry enrollees who were responders reported depression and 10% reported both depression and PTSD. Five to six years after the attacks, responders who had the greatest exposure to the events of 9/11 or who had 9/11-related PTSD were around twice as likely to drink four to five drinks at a time (binge drinking). Smokers with mental health conditions were less likely to quit smoking, and needed additional support to do so.^{52,58–60,63,64,69}

The research identified by this systematic literature review documents both distinct conditions and symptoms. What they both represent are unique challenges, which are characteristic to 9/11 and a rapidly changing world. Consequently, this review uses the word “challenges” instead of “impacts,” as impact has primarily physical connotations only. The term “challenge” is more inclusive. The term “condition” has been used where there is a specific physical diagnosis made. As a final reflection, 9/11 is quite unique as a product of the times, both in terms of the complexity of the modern building and what toxins it produced, to the massive physical and mental health challenges it resulted in for such a large portion of the population.

Implications

This research has made an important new contribution of knowledge to a field of growing importance and recognition – being the physical and mental health challenges of responding to 9/11. Therefore, in spite of any limitations associated with the research study design, the novelty of these results should not be overlooked. Despite the contribution of this research to the existing 9/11 evidence-base, there remains an urgent need to continue monitoring a larger cohort of 9/11 responders and recovery workers to ensure that their stories are told and key lessons are learned. Future research should also include exploration of the unique health challenges of 9/11, with a particular focus on mental health, on the surviving first responder and recovery worker family members, including spouses, partners, and children.

Limitations

These findings should be understood in the context of some limitations. As with all systematic literature reviews, there is a possibility that some relevant literature was missed. The rigorous and comprehensive search strategies developed for each of the electronic databases utilized for this research should minimize this. Furthermore, the search was limited to articles published in English. Publication bias was not assessed, although it is unlikely that this bias influenced publication of 9/11 research. Finally, quality of individual research studies was not assessed beyond research design in this review, and for this reason, the themes identified in the literature do not take into account specific methodological

strengths and weaknesses of the included studies. Quality assessment is ideal to include and future research should focus on this.

Conclusion

This systematic review of the literature utilizing the MEDLINE, PubMed, CINAHL, and PsychInfo databases identified 156 publications that documented the range of physical and mental health challenges that have been reported by responders and recovery workers. The largely quantitative evidence-base focuses on firefighters and identifies respiratory issues, cancer, PTSD, depression, and anxiety as the key challenges faced by the 9/11 first responder community. The complexity of the challenges associated with responding to the 9/11 attacks is reflected in the growing number of studies published in 75 discipline-diverse journals. This review has identified the type of research being published, where the research is being published, and what the focus of the research was. By providing answers to these questions, this review is a valuable tool furthering the current understanding of existing physical and health consequences of responding to 9/11 and reveals potential knowledge gaps for future research.

Acknowledgements

The authors would like to acknowledge the valued contribution of Christopher Cotter as an independent reviewer, as well as the funding support from the School of Medical and Health Sciences at Edith Cowan University, Joondalup, Australia.

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