

A Short Review of Cancer Associated with Exposure to World Trade Center Dust

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ABSTRACT

Objectives: To review the status of knowledge of cancer outcomes associated with exposure to the World Trade Center attacks of September 11, 2001.

Methods: A review of the literature was conducted. The search engines included CINHAL, Google Scholar, and PubMed. The results included articles published up to and including the year 2020. **Results:** A total of 23 articles were included for review. The articles examined the cancer outcomes associated with the WTC collapse. Articles focused on generalized cancer outcomes, but also examined specific cancers. The specific cancers included hematopoietic cancers, head and neck cancers, and prostate cancer. Additional articles that offered background information are also included.

Conclusions: Multiple studies indicated that individuals who were exposed to the events of September 11, 2001 at the World Trade Center suffer from an increased risk of cancer. However, all the studies are not conclusive at this time. More research needs to be conducted to understand the cancer outcomes associated with the World Trade Center attacks.

KEYWORDS: cancer, September 11, 2001, 9/11, World Trade Center

Introduction

On September 11, 2001, the United States suffered the worst terrorist attack in its history. Terrorists hijacked four airline passenger planes and utilized them as weapons. Two planes struck the Twin Towers of the World Trade Center (WTC) Complex in Lower Manhattan, New York City. The damage to the structures resulted in their collapse and released a cataclysmic cloud of dust. The dust, called WTC dust, was comprised of particulate matter and toxicants. In the immediate aftermath of the collapse, scientists expressed concern about the long-term health effects from exposure to the WTC dust. One of the concerns included the potential for carcinogenesis (Hitt, 2001). Almost two decades after 9/11, multiple studies have focused on the cancer rates in those exposed to WTC dust. This paper will review the current status of knowledge on WTC cancer.

Methodology

A literature search of CINHAL, Google Scholar, and PubMed was conducted. A total of 23 articles were included for discussion. All articles were published between 2001 and 2020. Additional articles that elucidate the nature of carcinogenesis are included in the paper.

Toxicants and Carcinogenesis

The WTC dust contained a number of known carcinogens among the toxicants. These toxicants included polycyclic aromatic hydrocarbons (PAHs). PAHs include over one hundred various chemicals associated with the incomplete combustion of organic matter. Exposure to PAHs has been linked to several cancers, including lung cancer, skin cancer, and bladder cancer (Boffetta et al., 1997).

Studies indicate that exposure to PAHs may lead to the formation of DNA adducts. DNA adducts refer to a segment of the DNA that binds to a known carcinogen. The formation of PAH-DNA adducts increases cancer risk for individuals (Perera et al., 2005). Other potential causes for concern in the WTC dust included Volatile Organic Compounds (VOCs) and Dioxins. Benzene, a VOC, is a Group 1 Carcinogen per the International Agency for Research on Cancer (IARC, 2012). Dioxins and furans also occurred in the WTC dust. "Dioxin exposure is associated with increased cancer mortality, and increased rates of soft tissue sarcoma, lymphoma, and respiratory tract cancers have been seen in individuals with significant dioxin exposure" (Moline et al, 2006). One of the chemicals to receive significant attention in the weeks following the collapse was asbestos. The WTC buildings utilized asbestos during their construction in the late 1960s. Asbestos is a well-known carcinogen. However, initial reports indicated that the level of asbestos in the WTC dust would be insufficient to cause cancer and the risk was negligible (Samet et al, 2007; Nolan et al., 2005).

The latency period between chemical exposure and a cancer diagnosis ranges from approximately five years for benzene (National Cancer Institute, 2020) to over twenty years for asbestos (Frost, 2013). In the nearly twenty years since the tragedy of 9/11, a number of studies have focused on the development of cancer in the population exposed to WTC dust. The studies have focused on specific cancers, as well as generalized cancer studies.

Generalized Studies

An early report studied the cancer incidence among the WTC rescue and recovery workers (RRWs) from 2001 to 2008. The WTC RRWs suffered from a prolonged exposure to the WTC dust. Solan et al (2013) identified cancer among the WTC Health Program. The researchers determined that there were increased rates for thyroid cancer, prostate cancer, combined hematopoietic, and lymphoid cancers. The researchers “estimated a 15% increase in all cancer sites combined among all responders” (Solan et al, 2013). Zeig-Owens et al (2011) indicated that WTC-exposed firefighters had approximately a ten percent higher cancer incidence ratio than a similar demographic. However, the authors cautioned that the findings should not be generalized as the firefighters represented a unique cohort.

In 2012, Li et al. published an observational study of 55,778 New York State residents who were enrolled in the World Trade Center Health Registry between 2003 and 2004. The cohort included RRWs. The researchers followed the cohort until December 31, 2008. They diagnosed 1,187 cancers in the cohort. Overall, the standardized incidence ratio (SIR) for all cancer sites was not elevated to a significant level. However, among the RRWs, the SIRs were increased significantly for three cancers by 2007-2008. The cancer sites included prostate cancer, thyroid cancer, and multiple myeloma.

Li et al (2016) examined the ten-year cancer incidence in RRWs and civilians who suffered an exposure to the WTC attacks. They determined that both prostate cancer and skin melanoma were elevated among both cohorts. Increased rates of thyroid cancer occurred only among the RRWs, while both breast cancer and non-Hodgkin’s lymphoma cases were elevated only among the civilian population. They still cautioned that there was limited evidence for a causal relationship between WTC dust exposure and cancer.

A comparison study of three different longitudinal studies from different populations was published in 2016. The study focused on three published cancer studies. The studies were conducted by the Fire Department of New York City (FDNY), The World Trade Center Health Registry, and the World Trade Center Health Consortium. The researchers concluded that the cancer SIRs appeared consistent across the three studies despite the various methodologies utilized. The authors suggested that long-term follow-up be continued for WTC-exposed individuals (Boffetta et al., 2016).

A ten-year study focused on the cancer incidence among general responders enrolled in the World Trade Center Health Programs through the years 2003 to 2013. Shapiro et al (2020) determined that there were “elevations in cancer incidence for all cancer sites combined and for prostate and thyroid cancers and leukemia.” However, unlike previous studies which will be discussed later, the authors did not find any increase in multiple myeloma (MM). They still cautioned that continued surveillance was needed for MM. In addition, the authors did not find any dose-response relationship between exposure and cancer risk. One study that focused on WTC -exposed firefighters indicated that there were no increased relative rates (RRs) for all cancers in the cohort when compared to a pooled cohort of firefighters from three major cities (Moir et al, 2016).

In 2018, researchers estimated the future cancer burden among RRWs who were exposed to WTC dust. They estimated the number of cases at 2,960, which is a greater burden than a demographically similar population. The cohort was 96.8% male and 87.1% white. The article discussed the importance of cancer prevention and routine screening in all WTC RRWs (Singh et al., 2018). Durmus et al (2020) described the characteristics of cancer patients in the WTC Environmental Health Center (WTCEHC). A total of 11,038 individuals were enrolled in the WTCEHC. There were 2,840 cancer patients. In this group, 279 individuals had non-melanoma skin cancer. Of the remaining 2,561 cancer patients, there were a combined 2,999 cancer diagnoses. Among the female patients, breast cancer remained the most common diagnosis (46%). Lung cancer accounted for 11%, followed by thyroid cancer (9%) and lymphoma (6%). For male patients, prostate cancer was the most diagnosed malignancy (30%). Additional diagnoses included lymphoma (8%), lung (7%), and head and neck site cancer (7%).

Multiple Myeloma

Moline et al (2009) reported on several cases of MM among WTC responders. The cases were diagnosed between September 11, 2001 and September 10, 2007. MM refers to cancer of plasma cells. Benzene exposure is associated with the development of cancers of the blood (National Cancer Institute, 2020). A total of eight cases were observed in a population of 28,252 responders. Four cases occurred in responders younger than forty-five years of age. Only 1.2 cases could be expected in this population, indicating a slight increase in MM in responders less than forty-five years old. The early article indicated the need for continued surveillance of the population. A 2018 study further indicated that sixteen white male firefighters who were exposed to the WTC dust were diagnosed with MM. In addition, the study indicated that “environmental exposure to the WTC disaster site is associated with myeloma precursor disease” (Landgren et al., 2018).

Thyroid Cancer

Van Gerwen et al (2019) indicated that the incidence of thyroid malignancies was elevated in the WTC cohort, but questioned if this might be due to a surveillance bias. Colbeth et al (2020) also suggested that the increased incidence of thyroid cancers in the WTC cohort might be due to surveillance bias and the diagnosis of asymptomatic individuals. Tuminello et al (2019) indicated that individuals with thyroid tumors from the WTC cohort had smaller tumors that were diagnosed at similar ages as a non-WTC cohort. The researchers stated that these results did not support the suggested surveillance bias hypothesis. However, they also cautioned that further research is needed to understand the risk factors for thyroid cancer.

Head and Neck Cancer

Multiple studies indicated increased rates of head and neck cancer (HNC) among the population. Graber et al (2018) reported sixteen cases diagnosed between 9/12/2005 and 12/31/2016. They suggested that it is biologically plausible for there to be an association between WTC exposure and HNC and demanded further investigation. Leeman et al (2018) offered a short report indicating they noted increased cases of HNC among the WTC-exposed population at their institution. However, they cautioned that there could be several reasons to explain the increased cases, including human papilloma virus (HPV) exposure, as well as the population aging.

A second report by Graber et al (2019) also indicated that there were increased cases of HNC among the WTC population. This study acknowledged a selection bias and did not control for alcohol use, a potential risk factor for HNC. Alcohol consumption was not determined to be a risk factor in this population in another study (Manderski et al 2020). Manderski et al (2020) recommended improved detection for WTC exposed individuals who engaged in cigarette smoking or had multiple sexual partners. A nested case-control study focused on general responders in the WTC Health Program. Sixty-four cases and 136 controls were matched on age, sex, and race/ethnicity. Known risk factors for HNC, such as tobacco and alcohol use, sexual activity, and occupational exposure, were considered. General responders had an increased odds ratio (OR: 2.51, 95% CI, 1.09 to 5.82) of HNC when compared to those in other occupations. The OR was 2.51. The authors suggested increased risk factor mitigation for high-risk responders. Mitigation may include smoking cessation and HPV vaccination (Manderski et al 2019).

Prostate Cancer

Researchers determined that prostate cancer is one of the most common cancers diagnosed for male RRWs. However, in one interesting study, the researchers examined the association between re-experiencing memories and stress responses associated with the event and the later development of prostate cancer. Responders who did not suffer from re-experiencing stress had the lowest incidence of prostate cancer. Responders with severe re-experiencing stress had the highest incidence. The article was the first research project to indicate a positive association between prostate cancer incidence and re-experiencing a stressful event (Clouston et al., 2019).

Gong et al. (2019) showed evidence that prostate cancer in individuals exposed to the WTC dust “displayed a distinct gene expression pattern that could be the result of specific carcinogens.” Furthermore, Hashim et al., (2018) indicated that there was a “significant association of higher clinical stage with the highest exposure level that includes exposure to the 9/11 dust cloud.” The article discusses the lack of protective equipment for the workers and individuals in the area. The individuals who were exposed to the WTC dust also were generally healthier at the time of exposure when compared to the general population. The cohort therefore had a lower risk of cancer at the time of the event.

Recommendations

Multiple studies indicate that there is an increased risk of cancer for those who were exposed to the WTC dust. Primary health care providers need to recognize that individuals with WTC dust exposure do not only live in New York and New Jersey. Rather, the WTC Health Program serves individuals across the country. Providers should ensure that they have adequate histories on all patients regarding cancer risk. Exposure to WTC dust must be included in this history. Providers who treat those with WTC dust exposure should be vigilant about screening for cancer. More studies are needed to establish the link between cancer and the WTC. However, as nearly twenty years have passed as of this writing, the risk of cancer naturally will increase in the WTC population due to advancing age. The increased risk of cancer due to advanced age must be considered for all future studies.

Conclusion

The collapse of the World Trade Center on September 11, 2001 resulted in significant exposure to a wide range of chemicals, including multiple known carcinogens. The World Trade Center Dust contained PAHs, VOCs, and dioxins. Since 9/11, multiple studies have focused on carcinogenesis among those exposed to the WTC dust. While some studies have indicated an increased risk of cancer for site-specific cancers, other studies have not shown the same risk. Future studies must continue to examine the health outcomes of one of the most significant toxicological exposures of modern times.

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