



A Clinician's Guide to Occupational Exposures in the Military

Joel Van De Graaff¹ · Jill A. Poole¹

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Abstract

Purpose of Review Adverse occupational and environmental exposures are common causes of respiratory disease and health consequences requiring medical care. Understanding how these various exposures affect patients and how to elicit an adequate history is critical for any clinician. Military personnel are often overlooked when discussing groups at risk for environmental exposure-associated airway disease. There are close to 20 million active duty and veterans in the USA, and nearly all clinicians will at some point care for a patient that has served in the military.

Recent Findings Exposures related to military work include burn pits, chemicals/toxins, sandstorms, and living conditions. Burn pits and military waste are increasingly recognized as potential hazards attributed to the ongoing conflicts in the Middle East. The link between these various military exposures and acute or chronic airway diseases remains difficult. Epidemiological studies are emerging to demonstrate correlations with chronic lung disease and prolonged burn pit exposure.

Summary This review provides an overview of potential occupational and environmental exposures that may affect current and/or former military service men and women.

Keywords Occupational exposure · Military exposure · Burn pits · Occupational respiratory disease

Introduction

There are more than 1.3 million active-duty military personnel and more than 800,000 reserve forces in the USA. This includes over 200,000 personnel deployed overseas [1]. Many of these individuals are exposed to various hazards that may adversely affect their health. Exposures range from particulate matter such as blowing sand, smoke from burn pits used for waste disposal, and urban smog to mold exposure in on-base housing [2, 3]. In addition, military personnel, like the general population, have underlying medical conditions that increase their risk for complications from occupational exposures. Service members with well-controlled asthma can continue to serve in active duty, and these men and women may, therefore, be at higher risk for adverse outcome [4]. While asthma prevents entrance into the military, under-diagnosis at the time of enlistment is common [5].

When caring for veterans, medical providers must keep in mind unique exposures not only from current wars and conflicts but from prior wars. US Navy vessels built prior to 1980 were laden with asbestos, and veterans of the Vietnam war may still present with cancers from Agent Orange exposure. Many clinicians may be accustomed to taking a thorough history of current exposures but exposures from 30 years ago can be easily forgotten. This review article provides a list of common exposures that a provider may encounter when treating US service men and women.

Burn Pits

The term burn pit is used in the military to refer to areas where solid waste is burned outside in the open air. This waste may include wood, chemicals, munitions, metal, medical and human waste, plastics, electronics, rubber, and food among other trash. Burn pits have long been used by the military but gained increasing notoriety during the wars in Iraq and Afghanistan (Fig. 1, Burn pit photo). Typically, materials are set in piles, rows, or holes in the ground and ignited with jet fuel. Burn pits are not without their benefit as they helped reduced the spread of infectious diseases. In addition,

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✉ Joel Van De Graaff
joel.vandegraaff@unmc.edu

¹ 985990 Nebraska Medical Center, Omaha, NE 68198, USA

Fig. 1 Burn pit. Balad, Iraq. 9/24/2004. Courtesy photo (28th Public Affairs Detachment) within public domain (<https://www.dvidshub.net/image/1741/burn-baby-burn>). The appearance of the US Department of Defense (DoD) visual information does not imply or constitute DoD endorsement



transporting waste to proper disposal facilities like landfills or incinerators can be dangerous in combat zones. However, this waste removal technique also releases smoke and potentially debris that is toxic to both the environment and personal health. These effects have resulted in multiple lawsuits from veterans, Department of Defense Civilians and military contractors [6]. During their peak in 2010, there were 273 active burn pits reported at military bases in Iraq and Afghanistan [7]. It was around this time that burn pits started to be phased out of military practice. As of July 2019, there were only 9 active burn pits found in Syria, Afghanistan, and Egypt.

It is difficult to define an individual's exposure to the burn pits and its potential for harmful effects. There is limited monitoring of burn pits and uncertainty about materials burned at any given time. There is also no defined "safe distance" from one the pits. There are several factors that may influence a person's risk which include the duration of time spent and distance to the burn pit, the type of waste material (e.g., plastics, electronics, and medical waste are of higher risk), seasonal weather patterns and wind direction, and personal medical history. Up until recently, there was limited data directly linking burn pits to long-term disease, although there has long been known risk from many of the chemicals found in burn pits. The Institute of Medicine formed a committee on Long-term Health Consequences of Exposure to Burn Pits in Iraq and Afghanistan in 2010. They compared people within two miles of burn pits to those stationed further than two miles. Their initial review of the literature only showed limited evidence to suggest an association between burn pit exposure and reduced lung function [8]. The evidence for chronic lung disease is changing as larger epidemiologic studies are being completed [9, 10].

The Veterans Affairs (VA) established the Airborne Hazards and Open Burn Pit Registry (AH&OBP) in 2014. This registry has over 200,000 participants now which has allowed for more robust data collection [11]. This registry is a voluntary database whereby veterans can submit their exposure and any health concerns through an online questionnaire. Additionally, there is a nonprofit registry founded in 2010 (burnpits360.org), which has more expansive medical questions [12]. Recent data from this registry has shown exposure to burn pits has significant association with a higher risk of self-reported emphysema, chronic bronchitis, and chronic obstructive lung disease [13••]. A recent retrospective cohort study ($n=55,760$) showed a significantly elevated rate of respiratory symptoms (incidence rate ratio of 1.52) as well as asthma (incidence rate ratio of 1.61) in military personnel deployed to Kabul, Afghanistan, as compared to military personnel stationed in other parts of the world [14••]. Interestingly, this study did not find an increased rate of chronic obstructive pulmonary disease, which is in contrast with some of the previous registry findings. It is also likely that more evidence of chronic lung disease will emerge as time from exposure elapses. Further longitudinal studies are likely needed with serial measurements of pulmonary function as well as exploration of potential novel biomarkers [15].

Exposure to particulate matter has long been known to be a risk factor for lung disease and death [16, 17]. Burn pits produce a high concentration of particulate matter due to slow burns at low heat. Burn pits release particulate matter levels that are higher than are what are generally considered safe by US regulatory agencies [18, 19]. In addition to generally high levels of particulate matter, there is a

higher concentration of potentially toxic material. Ambient levels of the toxic chemicals including polycyclic aromatic hydrocarbon, polychlorinated dibenzo-p-dioxins, and polychlorinated dibenzofurans have all been found in high concentrations at military bases [20]. The main source of these chemicals is the burn pit.

Aside from chronic lung disease, there are other potential risks posed by burn pits. Increased exposure to particulate matter has been shown to have adverse effects on birth outcomes including low birth weight and preterm delivery. As noted above, burn pits release high levels of dioxins which have been linked to neural tube defects. However, studies have not consistently shown a direct link between poor birth outcomes and burn pit exposure [21]. The AH&OBP registry has also shown an increase in rates of self-reported hypertension, insomnia, and liver disease [22]. The relationship between chronic rhinitis and/or sinusitis attributed to burn pit exposure has not been well described in the literature but would be interesting to capture to inform therapeutic approaches. The Kuwait Registry, comprised of Persian Gulf War veterans, reported that one of the most frequent diagnoses of medical symptoms related to the head and neck was chronic sinusitis [23]. There was also high development of chronic rhinosinusitis disease following exposure to the dust clouds of the World Trade Center collapse of 2001 [24]. Future studies could be warranted to investigate the association burn pits and their respective toxin exposures on upper airway disease manifestations.

On August 10, 2022, legislation known as the Pact Act was signed that expands medical care eligibility to veterans exposed to burn pits. The legislation will allocate an estimated \$280 billion over the next 10 years to any service member stationed in a combat zone over the last 32 years.

Noise Pollution

Hearing loss and military service has long been linked and is only increasing with recent military conflicts [25, 26]. Hearing loss is the most common service-connected disability and results in over \$1 billion annually in Department of Veteran Affairs compensation [27, 28]. Factors that contribute to hearing loss include high intensity noise from ammunition fire, detonation of explosive devices, construction sites, and urban living. Of soldiers returning from Iraq or Afghanistan, 71% report exposure to loud noise and more than 15% report ringing in their ears [29].

The Millennium Cohort Study was launched in 2001 and was designed to assess the health of military personnel over the course of at least 21 years. A study of this cohort has shown 7.5% of participants have self-reported new-onset hearing loss. Self-reported hearing does correlate with objective audiometric measures. Further, new-onset hearing

loss was associated with combat deployment, male sex, older age, and proximity to improvised explosive devices [30]. Military personnel returning from combat have a 63% increased risk for hearing loss [31] which indicates the need to screen these patients upon return from service. Multiple screening programs are available, and referral to an audiologist or otolaryngologist should be considered for many of these patients [32].

Prior Deployment Exposures

Although certain military exposures no longer exist, recognizing their role in potentially mediating disease in treating veterans is important due to the long-term impacts. For example, Agent Orange is an herbicide that was used primarily during the Vietnam War in Vietnam and Malaysia. The USA used it to remove large areas of foliage and trees. The military sprayed millions of gallons of Agent Orange during the war that led to both devastating environmental and health effects. One of the primary problems with Agent Orange is the high level of dioxin. The people of Vietnam suffered the worst of the exposure with one estimation of up to 3 million people suffering from illness caused by the chemical, including children. There is still elevated soil contamination of dioxin in parts of Vietnam over 30 years after the war, including on military bases [33]. There is a clear link with dioxin and birth defects, however, the degree to which Agent Orange exposure in Vietnam is associated with birth defects remains controversial [34]. Agent Orange has also been associated with multiple cancers including soft tissue sarcoma, non-Hodgkin lymphoma, chronic lymphocytic leukemia, Hodgkin's lymphoma, and multiple myeloma [35–37]. There has not been a clear link with chronic respiratory disease; however, there may be an association with lung cancers [38].

Asbestos was widely used by the Navy during World War II in shipbuilding and continued to be used up until the 1980s. Since the 1930s, asbestos has been recognized to elicit lung disease and was linked to lung cancer in the 1950s [39]. The US Navy workers continued to have exposure up until the 1980s, and therefore, obtaining military exposure history is critical because the development of mesothelioma can be delayed for decades following exposure.

At the close of the Gulf war in 1991, retreating Iraqi soldiers ignited more than 600 Kuwaiti oil wells. Thousands of US troops were enveloped in large amounts of thick, black smoke. Many of these veterans have later reported various respiratory symptoms presumed to be from a direct cause of this exposure. Similar to burn pits, oil well smoke contains potential carcinogens including benzene and polycyclic aromatic hydrocarbons. In contrast to burn pits, however, oil well smoke produces low amounts of these chemicals

Table 1 Summary of potential occupational exposures in military personnel

Exposure	Personnel affected	Potential risks and symptoms
Burn pits	Veterans of Iraqi War and Operation Enduring Freedom	Chronic lung disease/chronic sinusitis/birth defects and preterm delivery
Noise pollution	Most service members	Hearing loss/tinnitus
Agent Orange	Veterans of Vietnam War	Birth defects/cancers
Asbestos	Navy veterans up until the 1980's	Lung disease/mesothelioma
Oil fires	Veterans of the Gulf War	Asthma exacerbations and acute respiratory symptoms. Chronic symptoms unlikely
Sandstorms	Most Veterans deployed to the Middle East	Chronic lung disease/chronic rhinosinusitis
Chemical warfare	Certain veterans exposed to chlorine during Iraqi War	Acute respiratory distress/possible chronic lung damage

[40]. Oil well fire smoke also appears not to have observable changes in lung tissue based on autopsy reports when comparing soldiers exposed and not exposed to the smoke [41]. Finally, epidemiologic studies have not been able to confirm a link between oil well smoke and chronic respiratory disease [42].

Miscellaneous Military Exposures

Sandstorms are a common occurrence in the Middle East and almost unavoidable for military personnel deployed to this region. Masks are made available to soldiers but are often not worn due to heat. Sandstorms are a source of increased dust, air pollution, bacteria, mold, and allergens. Dust collected near a military base in Iraq compared to dust in California showed higher concentrations of endotoxin and trace metals. In addition, when the dust was exposed to lung epithelium chronically, the inflammatory response increased dramatically [43]. Sandstorms produce acute exacerbations of asthma as well as a myriad of other complaints including cough, rhinorrhea, headache, body aches, and sleep disturbances [44]. Chronic exposure may also lead to an increase in chronic lung disease. Asthma, intermittent laryngeal obstruction, rhinosinusitis, and decreased diffusion capacity are all increased in patients deployed to the Middle East [45].

Chemical warfare was first used in modern warfare during World War I even though international treaties had already existed banning their use. The use of chemical warfare has dramatically declined in recent conflicts; however, chlorine attacks were used by Iraqi insurgents during Operation Iraqi Freedom [46]. Chlorine reacts with water to produce hypochlorous and hydrochloric acid. These acids cause irritation to the airways. Typically, symptoms resolve within 3–5 days; however, there are reports of this causing long-term damage [47]. Fortunately, exposure to chemical warfare has been relatively uncommon for US military personnel.

Occupational exposures in the military often focuses on deployment and risks associated with foreign combat service. There are still exposures that can be seen in those stationed stateside. There are certain diseases that need to be considered in endemic parts of the country. For example, a provider seeing a patient in the Northwest may not be accustomed to considering coccidioidomycosis in a patient presenting with fever, but this should be considered for someone recently stationed in the Southwest USA.

The military also provides on-base housing to approximately one-third of all military personnel. Even though this housing is on a military base, it is managed by private institutions, which has led to some examples of poor quality in some locations. An investigation by the Army Inspector General office in 2019 found severe deficiencies and safety risks with housing [48]. The report found that roughly two-thirds of surveyed residents expressed dissatisfaction with their housing experience and 52% expressed environmental concerns. Problems included vermin infestations, lead paint, asbestos, and mold exposure. Following the report's release, there were efforts made to mitigate some of these problems, but budget constraints and legal hurdles remain [49]. A summary of these potential occupational exposures in military personnel is provided in Table 1.

Conclusions

There is a vast array of unique occupational exposures that medical providers need to consider when dealing with active-duty military personnel and veterans. Often there needs to be a multispecialty approach including, among others, primary care providers, pulmonary or allergy specialists, otolaryngologists, physical therapists, occupational therapists, and psychiatrists. Understanding the nature of exposures is a first step to appropriately caring for this population. There have been recent advancements in the recognition and assessment of military exposures. Previously,

study of exposures was limited to questionnaires and surveys which were deemed inadequate [50, 51•]. The military is now adopting new techniques to study the totality of exposures [52]. This involves assessing individuals and specific environments to determine the wide range of potentially hazardous exposures. An additional investigational goal is to assess and define biomarkers associated with exposure and disease consequences [53]. The Department of Defense has a large collection of over 50 million serum samples from soldiers dating back to 1989 which is a vast data source for in assessing potential predictive biomarkers of disease and exposure. An in-depth understanding of not only the type of exposure(s) but how the exposure (s) affect disease development and outcomes is warranted to assure the application of best care practices and institute preventative and/or therapeutic strategies to at-risk military exposed personnel.

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Compliance with Ethical Standards

Conflict of Interest The authors do not have existing conflict of interest.

Human and Animal Rights and Informed Consent This is a review article and therefore does not have informed consent or compliance with ethical standards of human and animal rights.

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