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Assessing Health Outcomes after Environmental Exposures Associated with Open Pit Burning in Deployed U.S. Service Members

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Abstract

Objective—This study assessed the long-term health impact of environmental exposures associated with open pit burning in deployed U.S. service members.

Methods—200 individuals deployed to Balad, Iraq, and Bagram, Afghanistan, with known exposure to open pits, were matched to 200 non-deployed service members. Both cohorts were followed for adverse health outcomes after returning from deployment.

Results—Slight increased risks were observed for respiratory diseases in the Bagram cohort (adj RR: 1.259), and for cardiovascular disease in the Balad cohort (adj RR: 1.072), but the findings were not significant. The combined deployed cohort showed lower risks for adverse health outcomes, suggesting a healthy deployer effect.

Conclusions—In conclusion, this study did not find significantly increased risks for selected health outcomes after burn pit exposure during deployment among two deployed cohorts compared to a non-deployed cohort.

Introduction

Environmental exposures to military forces especially during deployments have received considerable attention and are of great concern going back to the Vietnam War. Deployed personnelare often exposed to elevated levels of ambient particulate matter, including sand, dust, combustion of fossil fuels, but also smoke generated from open pit burning with little or no air pollution control devices. (1) Burn pits operations are conducted until incinerators become available and have been used in deployed settings to dispose of solid waste materials, such as plastics, metals, rubber, paints, solvents, munitions, wood. The resulting emissions include particulate matter, volatile organic compounds, and polycyclic aromatic hydrocarbons, as well as heavy metals. (2,3) The Department of Veterans Affairs asked the

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Institute of Medicine (IOM) to form a committee to determine the long-term health effects from exposures during deployments such as open air burn pits. (4)The committee identified burn pit emissions as a concern because some of the concentrations sampled during 2007 and 2009 at Joint Base Balad (JBB) exceeded U.S. air quality standards and contained dioxins and dioxin-like compounds. (4) Thus, identification of environmental exposures during deployment became important in an effort to identify and mitigate future long-term adverse health outcomes.

One of the major health concerns associated with burn pit emissions is the impact on respiratory health. The health effects of particulate matter air pollution may amplify susceptibility to respiratory disease as well as increase chronic respiratory conditions depending on length of exposure and intensity. (1)However, when comparing respiratory encounter rates among deployed personnel to various locations, findings were similar for personnel deployed to bases with and without burn pits. (5-7)These findings echo the 2011 IOMreport on long-term health consequences of exposure to burn pits in Iraq and Afghanistan. (4-7)Many of the previous studies assessed environmental exposures at the installation-level, suggesting that all military personnel co-located with a burn pit on an installation had similar exposures rather than utilizing individual exposure-level monitoring data. (5-7) As a result, the risk for adverse respiratory health outcomes among those directly exposed to burn pit smoke may have been underestimated. Yet, a study of deployed personnel located within 2-, 3-, or 5-mile radii of a documented, open-air burn pit only found a slight increase in respiratory symptoms among Air Force personnel deployed within 2 miles of Joint Base Balad and found that there was no elevated risk for respiratory outcomes. (8) The findings of previous studies therefore seem to be inconclusive on risk for adverse health outcomes after potential exposure to environmental hazards during deployments. One major issue has been to identify the types and amounts of hazardous exposures to accurately assess their association to adverse health outcome.

The aim of this study is to assess the long-term health impact of environmental exposures associated with open pit burning in deployed U.S. service members. This study will compare health outcomes after deployment among those with known burn pit exposure at two locations and compare results to a non-deployed cohort. Deployed and non-deployed service members were matched by time in service. The health outcome results of the two cohorts will be compared to examine potential risk factors for adverse health outcomes.

Methods

Study Design

Data Source—This analysis was part of larger study and provided background information on the demographic characteristics and health encounters. The study population was identified utilizing the Defense Medical Surveillance System (DMSS) and the DoD Serum Repository (DoDSR) both operated and maintained by the Armed Forces Health Surveillance Branch, Public Health Division, Healthcare Operations Directorate, Defense Health Agency. For this analysis, only DMSS was used, which contains administrative records for all medical encounters of military service members who are hospitalized or

receive ambulatory care at a military treatment facility or through civilian purchased care as well as demographic and deployment-related information.

Study Population—A retrospective cohort study was conducted to compare health care utilization after return from deployment among service members who had spent at least 30 days in one of the U.S. Central Command (CENTCOM) deployment locations. The study compared a deployed cohort of 200 U.S. service members to a never deployed cohort of 200 U.S. service members. The 200 individuals from the deployed cohort consisted of 163 service members who were assigned to Joint Base Balad (JBB), Iraq, between 2006 and 2008, and 37 service members who were assigned to Bagram Airfield (BA), Afghanistan between 2011 and 2012. The service members deployed to JBB were randomly selected from a cohort of 362 individuals from a previous environmental health assessment and had known exposure to open air burn pits. The 37 service members deployed to BA, were selected from a cohort of 74 with known exposure to open pit burning during their deployment as a result of working as security guards or living near the burn pit. Criterion for inclusion into the study was the availability of pre- and post-deployment serum specimens for each participant. Each deployed service member was matched to a service member who had never deployed by time in service at the pre-deployment serum sample date. Non-deployed individuals were randomly selected from the DMSS. Criterion for inclusion in the study was the availability of two serum samples, which were collected +/- 360 days of the pre- and post-deployment sample dates of the matched exposed service member. The sera were used to analyze for exposure biomarkers, as a result, sera availability was an important component for inclusion in the study; yet, the results characterizing the exposure will be presented in three other manuscripts in this supplement. Limited serum availability in the quantity needed for this study of deployed service members with known exposure restricted the cohort size for this study, but the sample size is at the lower limits needed to achieve statistical significance.

Outcome Measures

Healthcare Encounters—Records of healthcare encounters from military treatment facilities and purchased care hospitalizations as well as ambulatory medical care were included in this study. First time encounters with an ICD-9 code of interest, regardless of diagnostic position, within the surveillance period were captured. The ICD-9 code groupings of interest were:

1. Other Specified Personal Exposure (v97)
2. Neoplasms of the Oral Cavity (140-148)
3. Neoplasms of the Respiratory Organs (160-165)
4. Soft Tissue Sarcoma/NHL (168-199)
5. Neoplasm of Lymphatic/Hematopoietic Tissue (200-208)
6. Diabetes (250)
7. Obstructive Sleep Apnea Syndrome (OSA) (327.2)

8. Disease of the Circulatory System (410-414)
9. Disease of the Respiratory System (460-466, 477, 490-496)
10. Other Lung Disease Due to External Agents (502-508, 515, 516, 518, 519)
11. Signs, symptoms, ill-defined conditions (SSIC) involving cardiovascular system (785)
12. SSIC involving respiratory system and other chest symptoms (786)
13. Toxic Effects (987)

Person-time—Person-time was calculated for the surveillance period, which was the follow-up time after returning from deployment. For the matched pairs (exposed/unexposed), the person time was calculated beginning on the date of return from a deployment. Person-time was censored at the earliest occurring date among the following events per individual: first encounter for an ICD-9 code of interest, separation from active service, the start of a subsequent deployment, or the end of the follow-up period (31 Dec 2013). An individual censored for one encounter remained in the study to identify other encounters of interest.

Statistical Analyses

Counts, incidence and 95% confidence intervals for first diagnoses (number of incident diagnoses per 1,000 person-years) of a health outcome were calculated for each condition for each cohort. Chi-square statistics were used to compare the non-deployed to the deployed cohort, as well as to compare the Balad to the Bagram cohort. Incident rate ratios and 95% confidence intervals were calculated to assess risk for the various health outcomes among the non-deployed and deployed cohorts. To study deployment effect by location, stratified survival analysis was conducted. For the univariate analysis, the relative risk (RR) was calculated using Cox proportional hazards regression modeling for outcomes with five or more encounters at $\alpha=0.05$ significance level. For the adjusted analysis and the multiple comparisons, Bonferroni correction was used to reduce the chances of obtaining false-positive results, and the significance level was set at $\alpha=0.025$.

Results

Baseline Characteristics

Demographic and service related covariates were compared between cohorts (Table 1). There were demographic differences in the deployed cohorts when compared to the non-deployed cohort. These differences were statistically significant for age, gender, race/ethnicity, Service, occupation and deployment history; rank was the only service-related characteristic which was not significantly different between the non-deployed and deployed cohorts. Overall, the two deployed cohorts consisted of a slightly younger population (64.5%, 20-29 years old) as compared to the non-deployed cohort (57%, 20-29 years old). The deployed cohorts were predominantly male (87.5%) and white (69%). There were unique differences between the JBB and BA cohorts; yet only rank, Service, and occupation were statistically significant different. The JBB cohort consists of Army service members

only, whereas the BA cohort consists of Air Force service members only. The non-deployed cohort consisted of members from all four Services and the Coast Guard. The population in the BA cohort as compared to the JBB cohortwas predominantly enlisted, whereas the JBB cohort had a larger component of officers (JBB: 13.5%; BA: 2.7%). JBB service membershad similar occupations compared to those in the non-deployed cohort. The occupations of the BA cohort were primarily categorized as “other” (91.9%) of which 91.2% were law enforcement guarding the burn pit operations. In comparison, the JBB “other” category only contained 5% law enforcement. Length of the deployment during the surveillance period was different between the two deployed cohorts and was statistically significant (Table 2). None of the service members in the BA cohort had deployed for more than 365 days, and 40.5% had deployed for 121-180 days only. In the JBB cohort, the majority had deployed for at least 181 days (95.1%) of which 22.6% had deployed for more than 365 days.

Clinical Outcomes

Among the health encounters of interest no encounters for neoplasms of the oral cavity and neoplasms of the respiratory organs were identified during the surveillance period for the deployed or non-deployed cohorts. The incidence of the remaining encounters of interest were assessed by cohort and stratified for the deployed cohort (Table 3).Encounters for neoplasms of lymphatic and hematopoietic tissue and other specified personal exposure were identified in the non-deployed cohort only. The most common encounters among the deployed and non-deployed were identified for diseases of the respiratory system (deployed: n=76, IR: 133.95 per 1,000 person-years [PY]; non-deployed: n=62, IR: 163.0 per 1,000 PY), and signs, symptoms, and ill-defined conditions (SSIC) involving respiratory system and other chest symptoms (deployed: n=33, IR: 69.47 per 1,000 PY; non-deployed: n=33, IR: 68.79 per 1,000 PY). Among the deployed cohort, encounters for OSA, diabetes, toxic effects, soft tissue sarcoma (NHL), disease of the circulatory system, and other lung diseases due to external agents were only identified in the JBB cohort. Incidence rates for SSIC involving cardiovascular system, soft tissue sarcoma/NHL, and other lung disease due to external agents were higher in the non-deployed cohort compared to the deployed cohort.

The incidence rate for diseases of the respiratory system among the deployed (193.95 per 1,000 PY) was 19% higher compared to the non-deployed. Among the deployed cohorts, the incidence of diseases of the respiratory system among the BA cohort was 79.5% higher (317.76 per 1,000 PY) compared to JBB cohort (176.99 per 1,000 PY). To identify potential risk factors, cases were stratified by demographic and service-related characteristics (Table 4). There were statistically significant differences between the cases in the deployed cohorts for age, Service, occupation, and length of deployment. Compared to the JBB cohort, he incidence rates for diseases of the respiratory system in the BA cohort were higher among the 20-29 year olds, “other” occupation category which was predominantly comprised of law enforcement, and those who had deployed for 121-180 days. In the JBB cohort, the incidence rates were highest among the 40+ year olds, “other” category, and those who deployed 180 days or less. There was not a statistically significant difference between the cases in the deployed cohorts in regards to prior history of respiratory diseases and the

number of prior deployments. History of respiratory diseases was also not statistically significant when comparing the non-deployed cohort to the deployed cohort.

Relative risks for health encounters of interest were calculated for outcomes with five or more total counts to have minimal power and confidence in the results (Tables 5,6). As a result, the unadjusted and adjusted analysis only assessed relative risk for four health outcomes:obstructive sleep apnea syndrome (OSA);signs, symptoms, and ill-defined conditions (SSIC) involving cardiovascular system; SSIC involving respiratory system and other chest symptoms; diseases of the respiratory system. Overall, the risk for the four health encounters of interest was lower for the deployed cohort compared to the non-deployed cohort. When comparing specific deployed cohorts, JBB had a slightly higher risks for OSA (RR: 1.167) and SSIC involving respiratory system and other chest symptoms (RR: 1.023) compared to the non-deployed cohort. Both BA and JBB had higher risks for diseases of the respiratory system compared to the non-deployed cohort, even though the overall risk for the combined deployed cohort showed a lower risk. None of the confidence intervals of the unadjusted analysis were statistically significant. After adjusting the risk analysis for each health outcome of interest for age, gender, race/ethnicity, occupation, deployment history, history of illness prior to deployment, and correcting for multiple comparisons using Bonferroni correction, the results did not change, and on the contrary, showed that the risks were even lower compared to the non-deployed cohort. None of the confidence intervals for the adjusted analysis were statistically significant.

Discussion

During the surveillance period, the JBB burn pit was the largest open-air burn pit in CENTCOM until 2009, when burn pits were replaced with incinerators. (9) Since burn pits were used to dispose of solid waste as well as plastics, paints, solvents and other hazardous materials, inhalation of the resulting smoke may be related to long-term adverse health outcomes, especially increase in respiratory diseases. (2,3) Previous studies assessed burn pit exposure at the installation-level and may have underestimated the risk of sub-populations who had been in direct contact with the smoke and environmental hazards of burn pits. (5-8) As a result, these studies did not clearly demonstrate a relationship between the environmental hazards of open pit burning and an increased risk for long-term adverse health outcomes. This study examined various health outcomes of interest in two deployed cohorts who had known exposure to burn pit sites due to the duties they had to perform while deployed. Encounters of health outcomes after returning from deployment were compared between the two cohorts as well as to a cohort of non-deployed service members.

Of the 13 health outcomes of interest, only four outcomes had sufficient counts for a risk analysis. When comparing the cohorts, the risks for the four health outcomes among the non-deployed were higher or equal compared to the deployed. When adjusting the results for covariates and multi-comparison, the overall outcome did not change. This suggest the potential presence of a healthy deployer effect. Deployed personnel have to be medically ready and physically fit before being cleared to deploy for more than 30 days. Since the comparison cohort had never deployed, this may suggests that individuals were less fit for duty and less healthy and therefore at a slightly higher risk for any of the four health

outcomes. Service members who do not deploy may have more chronic medical conditions than their deployed counterparts. When comparing the two deployed cohorts to the non-deployed cohort, JBB had slightly higher adjusted relative risk for SSIC involving cardiovascular system, and BA had a slightly higher adjusted relative risk for diseases of the respiratory system compared to the non-deployed cohort. The analyses by deployed location was necessary because the two cohorts deployed five years apart and the theaters were uniquely different. Further, the environmental exposure data is more accurate in the breathing zone samples that were collected for the BA cohort and presented in the Balash article in this supplement. In addition, meteorological conditions in Iraq were different in Afghanistan, and the source and types of environmental chemical exposures, including PAH and dioxin, were different at each location. The chemical analysis of the sera are presented in the Masiol articles in this supplement. This suggests that the results of the two deployed cohorts may more accurately reflect health outcome risks than the combined results.

Even though the confidence intervals did not show statistically significant results, the deployed cohorts have a slightly increased risk for certain health conditions. Since the majority of the BA cohort had no or only one previous deployment, higher incidence rates of respiratory diseases are likely due to environmental exposures from both off-base and on-base sources that contributed to the total contaminant burden and not necessarily to burn pit exposure alone. (4) The Institute of Medicine reported that service members on JBB were exposed to a combination of regionally and locally generated air pollutants of sources such as industrial activities, dust, local combustion, and volatile evaporative emissions, which suggests that service members on BA had similar exposure. (4) The differences in respiratory disease may be due to higher levels of on-base environmental exposures at BA compared to JBB as noted in ambient and breathing zone samples of the BA cohort (see Balash and Masiol articles in this supplement). Even though the evidence was not statistically significant, further studies of deployed populations with known burn pit exposure may be warranted and should be all inclusive of service members exposed to increase sample size and the power to detect a difference.

The findings of this study should be interpreted with consideration of several shortcomings. One limitation of this study is the lack of behavioral data during deployment, such as individual-level tobacco smoking data, which can contribute to confounding. Cigarette smoke is a complex mixture of chemical compounds, and researchers estimate that the smoke has 7,357 chemical compounds from many different classes. (10) It is therefore difficult to determine if the increased rates observed were due to environmental exposure or smoking. Another shortcoming is the potential of misclassification of diagnoses when utilizing administrative medical encounter data. Also, ICD-9 coded encounters provide little to no information on the severity of the condition and may underestimate the true health impact. Additionally, members were followed-up for different times after they returned from deployment. Some members may have left military service as well. As a result, the follow-up time was different among the cohorts. The BA cohort deployed five years after the JBB cohort, so the follow-up time for health outcomes of interest for the BA cohort was much shorter. Furthermore, members who retired or were discharged could have received medical care at a non-military or VA treatment facility. Since this data was not captured in this study,

this likely resulted in an under representation of the incidence rates and risk ratios in the BA cohort.

Conclusion

In conclusion, this study did not find significant increased risks for selected health outcomes after burn pit exposure during deployment among two deployed cohorts compared to a non-deployed cohort. Slight increased risks were observed for respiratory diseases in the Bagram cohort, and for cardiovascular disease in the Balad cohort, but the findings were not significant. To improve further analysis of this data, individual-level exposure data may be needed. Since obtaining environmental exposure data is often difficult because of the range of possible exposures and the inherent logistical and operational challenges a proposed alternative is to evaluate pre- and post-deployment serum samples, relying upon biological signatures of exposure and residues of agents that are persistent within the body. Prior research in exposure biomarkers demonstrates the capability of detecting environmental agents in the blood and sera of exposed individuals and success in therapeutic drug development using chemical signatures in blood or urine as the basis to detect adverse effects, even if the damaging agent cannot be detected. (11-13) Emerging evidence indicates that poly-aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and organo-chlorine pesticides, are able to alter hormone function and cause altered metabolic function, which can adversely influence health outcomes. (13) As a result, utilizing pre- and post-deployment serum samples to assess the influence of environmental exposure in the absence of individual-level environmental exposure data and linking this data to health encounters after deployment will be a focus of future efforts to determine the risk for adverse health outcomes. Knowledge of risks can be useful to identify countermeasures to protect service members from environmental agents including use of improved protective gear, and modifying how deployed personnel locations are established to minimize or eliminate potential exposures, and guide post-deployment management practices.

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References

1. Weese CB, Abraham JB. Potential health implications associated with particulate matter exposure in deployed settings in southwest Asia. InhalToxicol. 2009; 21(4):291–6.
2. Taylor, G., Rush, V., Deck, A., Vietas, JA. [accessed February 5, 2016] Screening Health Risk Assessment; Bum Pit Exposures Balad Air Base, Iraq and Addendum Report. Aberdeen Proving Ground, MD, Army Center for Health Promotion and *Preventive* Medicine. 2008. Available at http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=btml&identifier=ADA49314
3. Engelbreacht JP, McDonald EV, Gillies JA, Jayanty RKM, Casuccio G, Gertler AW. Characterizing mineral dusts and other aerosols from the Middle East-Part 1: Ambient Sampling. InhalToxicol. 2009; 21:297–326.
4. Institute of Medicine (IOM). Long-Term Health Consequences of Exposure to Burn Pits in Iraq and Afghanistan. Washington, DC: The National Academies Press; 2011.
5. Abraham JH, Eick-Cost A, Clark LL, Hu Z, Baird CP, DeFreites R, Tobler SK, Richards EE, Sharkey JM, Lipnick RJ, Ludwig SL. A retrospective cohort study of military deployment and

postdeployment medical encounters for respiratory conditions. Mil Med. 2014; 179(5):540-. [PubMed: 24806499]

6. Sharkey JM, Abraham JH, Clark LL, Rohrbeck PA, Ludwig SL, Hu Z, Baird CP. Post deployment Respiratory Health Care Encounters Following Deployment to Kabul, Afghanistan: A Retrospective Cohort Study. Mil Med. 2016; 181(3):265–271.
7. Powell TM, Smith TC, Jacobson IG, Boyko EJ, Hooper TI, Gackstetter GD, Philips CJ, Smith B. Millennium Cohort Study Team. Prospective assessment of chronic multisymptom illness reporting possibly associated with open-air burn pit smoke exposure in Iraq. J Occup Environ Med. 2012; 54(6):682–8. [PubMed: 22684320]
8. Smith B, Wong CA, Boyko EJ, Philips CJ, Gackstetter GD, Ryan MA, Smith TC. Millennium Cohort Study Team. The effects of exposure to documented open-air burn pits on respiratory health among deployers of the Millennium Cohort Study. J Occup Environ Med. 2012; 54(6):708–16. [PubMed: 22684321]
9. U.S. Army Public Health Command (USAPHC). Screening health risk assessment, Joint Base Balad, Iraq, 11 May—19 June 2009 With redaction of author information. Aberdeen Proving Ground, MD: U.S. Army Public Health Command; 2010.
10. U.S. Department of Health and Human Services. Rocksville, Maryland: 2010. A report of the surgeon general How tobacco smoke causes disease. The biology and behavioral basis for smoking-attributable diseases. http://www.ncbi.nlm.nih.gov/books/NBK53017/ [Accessed on 31 Jan 2016]
11. Deeter DP. The Kuwait Oil Fire Health Risk Assessment Biological Surveillance Initiative. Mil Med. 2011; 176(7 Suppl):52–5. [PubMed: 21916331]
12. McDiarmid MA, Gaitens JM, Hines S, Condon M, Roth T, Oliver M, Gucer P, Brown L, Centeno JA, Streeten E, Squibb KS. Biological monitoring and surveillance results for the department of veterans affairs' depleted uranium cohort: Lessons learned from sustained exposure over two decades. Am J Ind Med. 2015; 58(6):583–94. [PubMed: 25907888]
13. Jones DP, Park Y, Ziegler TR. Nutritional metabolomics: progress in addressing complexity in diet and health. Annu Rev Nutr. 2012; 32:183–202. [PubMed: 22540256]

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Table 1

Demographic and service-related characteristics of the study cohorts

	Non-deployed Cohort		Deployed Cohorts at two sites		
		Chisq	Balad, Iraq	Bagram, Afghanistan	Chisq
	Counts (%)	Non-deployed vs. Deployed	Counts (%)	Counts (%)	Balad vs. Bagram
All	200 (100)		163 (100)	37 (100)	
Age		0.0431			0.1480
17-19	5 (2.5)		0	0	
20-29	114 (57)		100 (61.4)	29 (78.4)	
30-39	59 (29.5)		40 (24.5)	5 (13.5)	
40+	22 (11)		23 (14.1)	3 (8.1)	
Gender		0.0014			0.4490
Female	50 (25)		19 (11.7)	6 (16.2)	
Male	150 (75)		144 (88.3)	31 (83.8)	
Race/Ethnicity		0.0037			0.5527
White	116 (58)		111 (68.1)	27 (73)	
Black	44 (22)		39 (23.9)	6 (16.2)	
Other	40 (20)		13 (8)	4 (10.8)	
Rank		0.3000			0.0251
E1-E4	79 (39.5)		54 (33.1)	21 (56.8)	
E5-E9	87 (43.5)		87 (53.4)	15 (40.5)	
O1-O3	23 (11.5)		17 (10.4)	0	
O4-O9	11 (5.5)		5 (3.1)	1 (2.7)	
Service		<0.0001			<0.0001
Army	63 (31.5)		163 (100)	0	
Coast Guard	1 (0.5)		0	0	
Air Force	31 (15.5)		0	37 (100)	
Marine Corps	24 (12)		0	0	
Navy	81 (40.5)		0	0	

	Non-deployed Cohort		Deployed Cohorts at two sites		
		Chisq	Balad, Iraq	Bagram, Afghanistan	Chisq
	Counts (%)	Non-deployed vs. Deployed	Counts (%)	Counts (%)	Balad vs. Bagram
Occupation		0.0389			<0.0001
Infantry, artillery, combat engineer	23 (11.5)		19 (11.7)	0	
Armor, motor transport	11 (5.5)		15 (9.2)	0	
Pilot, aircrew	15 (7.5)		8 (4.9)	0	
Repair mechanic, engineer	56 (28)		58 (35.6)	0	
Communications, intelligence	44 (22)		31 (19)	0	
Healthcare	21 (10.5)		12 (7.4)	3 (8.1)	
Other *	30 (15)		20 (12.3)	34 (91.9)	
Deployment History		<0.0001			0.2290
Never	200 (100)		74 (45.4)	23 (62.2)	
1	0		64 (39.3)	9 (24.3)	
2	0		15 (9.2)	4 (10.8)	
3 or more	0		10 (6.1)	1 (2.7)	

* law enforcement personnel in “other” category; non-deployed: 23.3%; Balad: 5%; Bagram: 91.2%

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Table 2

Length of Deployment by Cohort

	Exposed Cohort at two sites		
	Balad, Iraq	**Bagram, Afghanistan**	**Chisq**
	Counts (%)	**Counts(%)**	**p-value**
Total	163 (100)	37 (100)	<0.0001
0-120 days	6 (3.7)	0	
121-180 days	2 (1.2)	15 (40.5)	
181-365 days	120(73.6)	22 (59.5)	
365+ days	35 (21.5)	0	

Table 3

Incidence Rate (IR) of Health Encounters of Interest by Cohort

	Cohort	Counts (%)	Person Years (PY)	IR per 1,000 PY	CI
Obstructive Sleep Apnea Syndrome	Deployed	10 (50)	535	18.69	(7.11, 30.27)
	Balad	*10 (50)*	*473.3*	*21.13*	*(8.03, 34.23)*
	Bagram	*0*	*61.7*	*0*	
	Non-deployed	10 (50)	550.9	18.15	(6.90, 29.40)
Diabetes	Deployed	2 (50)	546	3.66	(0.44, 13.23)
	Balad	*2 (50)*	*484.3*	*4.13*	*(0.50, 14.92)*
	Bagram	*0*	*61.7*	*0*	
	Non-deployed	2 (50)	560.5	3.57	(0.43, 12.89)
Toxic Effects	Deployed	1 (50)	546	1.83	(0.05, 10.20)
	Balad	*1 (50)*	*484.3*	*2.06*	*(0.05, 11.50)*
	Bagram	*0*	*61.7*	*0*	
	Non-deployed	1 (50)	560	1.79	(0.05, 9.95)
Other Specified Personal Exposure	Deployed	0	551.2	0	
	Balad	*0*	*489.5*	*0*	
	Bagram	*0*	*61.7*	*0*	
	Non-deployed	1 (100)	566.1	1.77	(0.04, 9.84)
SSIC Involving Cardiovascular System	Deployed	8 (47.1)	535.6	14.94	(4.59, 25.29)
	Balad	*7 (41.2)*	*474.6*	*14.75*	*(3.82, 25.68)*
	Bagram	*1 (5.9)*	*61*	*16.38*	*(0.41, 91.29)*
	Non-deployed	9 (52.9)	544.6	16.53	(5.73, 27.33)
SSIC Involving Respiratory System and Other Chest Symptoms	Deployed	33 (50)	475	69.47	(45.77, 93.17)
	Balad	*30 (45.5)*	*418.1*	*71.76*	*(46.08, 97.44)*
	Bagram	*3 (4.5)*	*57*	*52.68*	*(10.86, 153.95)*
	Non-deployed	33 (50)	479.7	68.79	(45.32, 92.26)
Soft Tissue Sarcoma/NHL	Deployed	1 (25)	549.7	1.82	(0.05, 10.13)

	Cohort	Counts (%)	Person Years (PY)	IR per 1,000 PY	CI
Neoplasms of Lymphatic/Hematopoietic Tissue	*Balad*	*1 (25)*	*488*	*2.05*	*(0.05, 11.42)*
	Bagram	*0*	*61.7*	*0*	
	Non-deployed	3 (75)	555.3	5.40	(1.11, 15.79)
Disease of the Circulatory System	Deployed	0	551.2	0	
	Balad	*0*	*489.5*	*0*	
	Bagram	*0*	*61.7*	*0*	
	Non-deployed	1 (100)	561.6	1.78	(0.05, 9.92)
	Deployed	1 (50)	549.6	1.82	(0.05, 10.14)
	Balad	*1 (50)*	*487.9*	*2.05*	*(0.05, 11.42)*
	Bagram	*0*	*61.7*	*0*	
	Non-deployed	1 (50)	565.8	1.77	(0.05, 9.85)
Other Lung Diseases Due to External Agents	Deployed	2 (40)	540.1	3.70	(0.45, 13.38)
	Balad	*2 (40)*	*478.4*	*4.18*	*(0.51, 15.10)*
	Bagram	*0*	*61.7*	*0*	
	Non-deployed	3 (60)	559.7	5.36	(1.11, 15.66)
Diseases of the Respiratory System	Deployed	76 (55.1)	391.9	193.95	(150.34, 237.56)
	Balad	*61 (44.2)*	*344.7*	*176.99*	*(132.57, 221.41)*
	Bagram	*15 (10.9)*	*47.2*	*317.76*	*(156.95, 478.57)*
	Non-deployed	62 (44.9)	380.4	163.00	(122.43, 203.57)

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Table 4

Incidence Rates of Diseases of the Respiratory System by Cohort

	Non-deployed Cohort			Deployed Cohorts at two sites				
			Chisq	Balad, Iraq		Bagram, Afghanistan		Chisq
	Counts (%)	IR per 1,000 PY	Non-deploy vs. Deploy	Counts (%)	IR per 1,000 PY	Counts (%)	IR per 1,000 PY	Balad vs. Bagram
All	62 (100)	163		61 (100)	177	15 (100)	317.8	
Age			0.1325					0.0144
17-19	3 (4.8)	329.5		0	0	0	0	
20-29	31 (50)	159.4		28 (45.9)	134.9	13 (86.8)	372.4	
30-39	22 (35.5)	203.8		20 (32.8)	215.1	2 (13.2)	311.3	
40+	6 (9.7)	87.1		13 (21.3)	294.5	0	0	
Gender			0.0379					0.0625
Female	20 (32.3)	289.9		8 (13.1)	136.2	5 (33.3)	1099.5	
Male	42 (67.7)	134.9		53 (86.9)	185.4	10 (66.7)	234.4	
Race/Ethnicity			0.0405					0.2389
White	32 (51.6)	136.8		40 (65.6)	173.4	13 (86.8)	388.0	
Black	17 (27.4)	313.9		16 (26.2)	187.6	1 (6.6)	119.0	
Other	13 (21)	140.7		5 (8.2)	174.6	1 (6.6)	188.7	
SERVICE			<0.0001					<0.0001
Army	21 (33.9)	170.5		61 (100)	177	0	0	
Coast Guard	1 (1.6)	222.2		0	0	0	0	
Air Force	10 (16.1)	172.5		0	0	15 (100)	317.8	
Marine Corps	6 (9.7)	115.8		0	0	0	0	
Navy	24 (38.7)	167.9		0	0	0	0	
Occupation			0.1664					<0.0001
Infantry, artillery, combat engineer	5 (8.1)	97.2		3 (4.9)	54.5	0	0	
Armor, motor transport	2 (3.2)	88.4		5 (8.2)	139.5	0	0	
Pilot, aircrew	3 (4.8)	67.6		2 (3.3)	188.6	0	0	
Repair mechanic, engineer	20 (32.3)	175.5		19 (31.1)	178.5	0	0	

	Non-deployed Cohort			Deployed Cohorts at two sites				
			Chisq	Balad, Iraq		Bagram, Afghanistan		Chisq
	Counts (%)	IR per 1,000 PY	Non-deploy vs. Deploy	Counts (%)	IR per 1,000 PY	Counts (%)	IR per 1,000 PY	Balad vs. Bagram
Communications, intelligence	12 (19.4)	176.5		15 (24.6)	185.4	0	0	
Healthcare	10 (16.1)	371.4		5 (8.2)	248.3	1 (6.6)	272	
Other	10 (16.1)	188.5		12 (19.7)	336.7	14 (93.4)	321.6	
Deployment History			<0.0001					0.1911
Never	62 (100)	163		23 (37.7)	141.3	10 (66.7)	322.6	
1	0	0		24 (39.3)	167.5	4 (26.7)	512.8	
2	0	0		8 (13.1)	297.3	1 (6.6)	149.6	
3 or more	0	0		6 (9.9)	515.0	0	0	
History of Respiratory Diseases			0.4182					0.1077
Yes	44 (71)	210.8		42 (68.9)	224.8	7 (46.7)	260.8	
No	18 (29)	104.9		19 (31.1)	120.4	8 (53.3)	392.9	
Length of Deployment			<0.0001					<0.0001
0 days	62 (100)	163		0	0	0	0	
1-120 days	0	0		3 (4.9)	418.1	0	0	
121-180 days	0	0		1 (1.6)	927.0	8 (53.3)	536.6	
181-365 days	0	0		44 (72.1)	158.3	7 (46.7)	216.7	
365+ days	0	0		13 (21.4)	222.2	0	0	

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Table 5

Relative Risk for Health Encounters of Interest, unadjusted

	Cohort	Counts (%)	RR univariate	95% CI	P-value
Obstructive Sleep Apnea Syndrome	Deployed	10 (50)	0.667	0.188, 2.362	0.530
	Balad	*10 (50)*	*1.167*	*0.428, 3.182*	*0.730*
	Bagram	*0*	*0*	*0*	.
	Non-deployed	10 (50)	ref		
SSIC Involving Cardiovascular System	Deployed	8 (47.1)	1.000	0.351, 2.851	1.000
	Balad	*7 (41.2)*	*0.840*	*0.271, 2.600*	*0.729*
	Bagram	*1 (5.9)**	.	.	.
	Non-deployed	9 (52.9)	ref		
SSIC Involving Respiratory System and Other Chest Symptoms	Deployed	33 (50)	0.583	0.302, 1.128	0.109
	Balad	*30 (45.5)*	*1.023*	*0.581, 1.803*	*0.927*
	Bagram	*3 (4.5)**	.	.	.
	Non-deployed	33 (50)	ref		
Diseases of the Respiratory System	Deployed	76 (55.1)	0.976	0.631, 1.508	0.912
	Balad	*61 (44.2)*	*1.075*	*0.717, 1.611*	*0.689*
	Bagram	*15 (10.9)*	*1.444*	*0.751, 2.778*	*0.208*
	Non-deployed	62 (44.9)	ref		

* For case count <5 variance was too large and results were removed

Table 6

Relative Risk for Health Encounters of Interest, adjusted*

	Cohort	Counts (%)	RR adjusted	95% CI	P-value
Obstructive Sleep Apnea Syndrome	Deployed	10 (50)	0	.	1.000
	Balad	*10 (50)*	*0.541*	*0.051, 5.781*	*0.561*
	Bagram	*0*	*0*	*0, 1*	*0.995*
	Non-deployed	10 (50)	ref		
SSIC Involving Cardiovascular System	Deployed	8 (47.1)	0	.	1.000
	Balad	*7 (41.2)*	*1.072*	*0.130, 8.801*	*0.941*
	Bagram	*1 (5.9)***	.	.	.
	Non-deployed	9 (52.9)	ref		
SSIC Involving Respiratory System and Other Chest Symptoms	Deployed	33 (50)	0	.	1.000
	Balad	*30 (45.5)*	*0.414*	*0.152, 1.127*	*0.048*
	Bagram	*3 (4.5)***	.	.	.
	Non-deployed	33 (50)	ref		
Diseases of the Respiratory System	Deployed	76 (55.1)	0.723	0.271, 1.926	0.517
	Balad	*61 (44.2)*	*0.739*	*0.375, 1.455*	*0.317*
	Bagram	*15 (10.9)*	*1.259*	*0.436, 3.631*	*0.626*
	Non-deployed	62 (44.9)	ref		

* model was adjusted for: age, gender, race/ethnicity, occupation, deployment history, history of illness prior to deployment

** For case count <5 variance was too large and results were removed