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Morbidities Associated with Drinking Water Contamination After a 2021 Petroleum Leak — Oahu, Hawaii, March 2023

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Abstract

OBJECTIVE: On November 20, 2021, petroleum fuel contaminated the Red Hill well, which provides water to about 93,000 persons on Oahu, Hawaii. Initial investigations recommended further evaluations of long-term health effects of petroleum exposure in drinking water. We reviewed electronic health records of those potentially exposed to contaminated water to understand prevalence of conditions and symptoms.

METHODS: A sample of persons potentially exposed during November 20, 2021–March 18, 2022 who sought care within the military health system through February 24, 2023 was identified. Abstracted records were categorized as worsening preexisting or persistent new for conditions and symptoms.

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AUTHOR CONTRIBUTIONS:

D.N., C.M., K.S., D.C., L.B., I.M., A.F., J.P., N.T., T.H., M.O., and S.K. and conceived and planned the medical record abstraction. D.N. and S.K. provided administrative and logistical support. D.N., C.M., K.S., D.C., L.B., I.M., A.F., J.P., N.T., T.H., and S.K. carried out the record review and/or quality control and assurance. C.M., I.M., and A.F. designed the database, worked out technical details, and carried out the analysis. D.N., C.M., K.S., D.C., L.B., N.T., T.H., contributed to the interpretation of the results. D.N. and C.M. took the lead in writing the manuscript. All authors provided critical feedback and helped shape the research, analysis, and manuscript.

DISCLAIMER:

The findings and conclusions in this report are those of the authors and do not necessarily represent the official positions of the U.S. Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry.

COMPETING INTERESTS:

The authors declare none.

RESULTS: Of 653 medical charts reviewed, 357 (55%) had worsening preexisting or persistent new conditions or symptoms. Most-documented conditions included worsening preexisting migraine (8%; 50/653) and chronic pain (4%; 26/653), and persistent new migraine (2%; 14/653) and adjustment disorder (2%; 13/653). Most-documented symptoms included worsening preexisting headache (8%; 49/653) and anxiety (6%; 42/653), and persistent new rash (7%; 46/653) and headache (5%; 34/653).

CONCLUSIONS: Approximately half of the abstracted medical records demonstrated worsening preexisting or persistent new conditions or symptoms and might benefit from sustained access to physical, mental, and specialized health care support systems. Continued monitoring for long-term health outcomes is recommended.

Keywords

Environmental Exposure; Drinking Water; Disaster Planning; Medical Records; Military Medicine

INTRODUCTION

On November 20, 2021, petroleum jet propellant-5 (JP-5) fuel was released from a fire-suppression line, eventually leaking into the Joint Base Pearl Harbor Hickam (JBPHH) Water Distribution System on Oahu, Hawaii and contaminating the water supply for an estimated 93,000 people. This system predominantly serves military residences and buildings (i.e., offices, schools), although some civilians were also exposed. Approximately one week later, the Hawaii State Department of Health (HDOH) began receiving complaints of a fuel-like odor from the tap water among consumers of the JBPHH water system, and on November 29, 2021, issued a drinking water advisory for consumers to avoid using the water for drinking, cooking, bathing, dishwashing, laundry or oral hygiene (i.e., brushing teeth). Literature is limited on potential long-term human health effects from exposure to JP-5, relying on studies of other jet fuels.^{1–4} HDOH therefore requested the U.S. Centers for Disease Control and Prevention (CDC)/Agency for Toxic Substances and Disease Registry (ATSDR) conduct Assessment of Chemical Exposures (ACE) investigations to assess health effects associated with the contamination event.^{5,6} On March 18, 2022, HDOH amended the drinking water advisory to safe for all uses. Six months after that amendment, a follow-up ACE investigation found that 75% of participants were still reporting ≥1 symptoms in the past 30 days.⁶ That investigation recommended a detailed medical review to evaluate ongoing health effects of potential JP-5 exposure. This might help guide decisions on health services needed in this community and determine the necessity for follow-up studies. Thus, the U.S. Department of Defense (DoD), Defense Health Agency (DHA) requested CDC/ATSDR assistance in reviewing medical charts within the military health system (MHS) to evaluate continued health concerns in the community served by the contaminated water.

METHODS

The CDC/ATSDR team reviewed electronic health records (EHRs) at Tripler Army Medical Center from February 24 to March 17, 2023. Each team member completed training regarding electronic health system use and best practices for patient confidentiality. DHA subsequently provided restricted on-site access to EHRs. Overall record abstraction was

time-constrained due to completing necessary tasks upon arrival to Oahu, including gaining MHS familiarity and designing a REDCap database to store abstracted data.

The water contamination event was defined as occurring on the fuel release date of November 20, 2021, and the exposure window continued through March 18, 2022, when HDOH fully amended the drinking water advisory. A roster of persons served by the contaminated water source during the exposure window was obtained from the Defense Occupational and Environmental Health Readiness System (DOEHRS)⁷. It was used to identify persons who sought medical care through the military health networks during November 20, 2021–February 24, 2023. Persons were convenience sampled from the roster based on non-mutually exclusive subgroups of *International Classification of Diseases, Tenth Revision* diagnostic codes (Supplemental Table 1). This included codes for toxic effects and symptoms of clinical interest. Additionally, we selected from all eligible pregnancy-related codes during November 20, 2021–June 18, 2022, and 10% random samples of pediatric (ages 0 to <18 years old) and adult persons with codes from multiple visits.

Deidentified data, including demographics, medical history, laboratory and imaging results, medications, vital signs, referrals and visit summaries, and pediatrics and pregnancy information, were abstracted into the REDCap database. The final sample included records with limited missing demographic information. Medical histories included conditions defined as recorded clinical diagnoses, and symptoms defined as manifestations of diseases recorded from patient complaints. Our case definition categorized conditions and symptoms as the following: preexisting, if documented before November 20, 2021; worsening preexisting, if documented as present before November 20, 2021 with evidence of worsening in >2 visits after November 20, 2021; persistent new, if documented on or after November 20, 2021 and lasting ≥ 3 months; or acute, if first documented on or after November 20, 2021 and lasting for <3 months. Persons with conditions or symptoms classified as worsening preexisting or persistent new were highlighted in this brief report to better understand potential chronic comorbidities. Laboratory and vitals data conducted during clinical visits were collected beginning November 20, 2020, to establish a baseline and help determine worsening preexisting conditions. Pregnancy records included pregnancy outcomes for singleton or multiple births (i.e., livebirth [full-term birth ≥ 37 weeks or preterm birth <37 weeks], miscarriage, stillbirth, and loss to follow-up). To preserve patient confidentiality and reduce misinterpretation of unstable data, we suppressed any count data with less than five persons reported except when data is reported as missing.

This activity was reviewed by CDC, deemed not research, and was conducted consistent with applicable federal law and CDC policy (45 C.F.R. part 46.102 [2], 21 C.F.R. part 56; 42 U.S.C. Sect. 241[d]; 5 U.S.C.0 Sect.552a; 44 U.S.C. Sect. 3501 et seq.); consenting was not required under DoD Manual 6025.18.

RESULTS

With the limited field time, full medical chart abstraction was completed for 653 of 28,601 persons on the roster. We included 405 (62%) persons with codes for toxic effects, and

170 (26%) persons with codes of clinical interest. We abstracted records for 239 (37%) persons ages 0–17 years and 45 (7%) pregnancies. Of the 653 persons, most were adults (63%; 411/653), female (55%; 359/653), and identified as White (49%; 319/653) or non-Hispanic (64%; 420/653) [Table 1]. Most were military dependents (i.e., not active duty military but able to access military healthcare services due to affiliation, such as spouse or child of an active duty military member) (64%; 416/653); the most-affiliated service branches were Army (35%; 231/653), Navy (31%; 200/653), and Air Force (27%; 175/653). Most military service members were enlisted (82%; 172/211), as opposed to commissioned officers who are of higher rank and require a higher education for their commanding roles. Approximately two-thirds (69%; 449/653) had documentation (e.g., response clinic intake form) of exposure to the water contamination event within EHRs.

Approximately half (55%; 357/653) were identified with worsening preexisting or persistent new conditions or symptoms. The most frequently documented worsening preexisting conditions included migraine (8%; 50/653), chronic pain (4%; 26/653), and gastroesophageal reflux (3%; 16/653); most frequently documented persistent new conditions included migraine (2%; 14/653), adjustment disorder (2%; 13/653), and eczema or atopic dermatitis (2%; 12/653) (Table 2). The most frequently documented worsening preexisting symptoms included headache (8%; 49/653), anxiety (6%; 42/653), and depression or low mood (4%; 23/653); most frequently documented persistent new symptoms included rash (7%; 46/653), headache (5%; 34/653), and fatigue or malaise (4%; 29/653). Adults more commonly had documented neurological (e.g., migraine or headache) or neuropsychological (e.g., anxiety or adjustment disorder) conditions and symptoms, whereas children (ages 0 to <18 years old) more commonly had dermatological (e.g., eczema or rash) or gastrointestinal (e.g., abdominal pain) conditions and symptoms.

Of 45 pregnant women, 38% (17/45) had worsening preexisting and 38% (17/45) had persistent new conditions or symptoms. In total, 80% (36/45) experienced a singleton full-term birth, and 13% (6/45) experienced a miscarriage. Outcomes for those experiencing a singleton preterm birth and lost to follow-up after 20 weeks gestation had counts less than five and were thus not reported.

DISCUSSION

Exploratory results in this pilot investigation demonstrate certain chronic conditions worsened and new conditions persisted after the November 2021 water contamination event. Most persons in our sample of records did not develop a condition during the study period. We observed certain impaired neurological functions, such as migraine-related sensory impairments (i.e., vision, movement/vertigo/dizziness) and fatigue or malaise, and neuropsychological functions, such as anxiety, attention deficit/hyperactivity disorder, depression, mental health and psychiatric disorders, and gastrointestinal distress after potential exposure to JP-5.

This is consistent with previous, but limited, literature examining exposure to hydrocarbons, such as JP-8.^{3,8,9} Although we were unable to systematically confirm any direct routes of exposure within EHRs, we hypothesized multifactorial exposure routes, including ingestion

and dermal absorption, given the range of conditions and symptoms presented. Aside from direct exposure to contaminated water, other aspects of this event, such as housing relocation, distrust of systems, and stress, might inform these observed health effects.¹⁰ Of note, this water contamination exposure event occurred during the COVID-19 pandemic, which might have influenced some conditions or symptoms experienced.

LIMITATIONS

This investigation used convenience sampling, which may introduce selection bias, and was unable to quantify exposure, establish a dose-response, or determine causal associations between exposure to the contamination event and health outcomes experienced. The DOEHRS roster only includes DoD-affiliated individuals, and we were only able to assess 2% of the roster over the course of three weeks. Regardless, the exposure occurred through the Navy water system which predominantly serves DoD-affiliated households. We strategically sampled from the potentially exposed population based on toxic effects and comprehensively evaluated EHRs to understand overall prevalence of conditions and symptoms. Information bias might be present and attributable to data availability or collection methods, variations in patient reporting behaviors or provider charting, or abstraction procedures. EHRs and patient tracking were limited by availability within MHS. However, we largely did not have access to records for purchased care, those who were referred or sought care outside of this network. Future analyses might use purchased-care records to incorporate data from specialized referrals outside of this network, as affected persons might seek external care because of distrust or lack of confidence in military providers.

Approximately one-third of reviewed charts lacked documentation of exposure. Among persons with documented exposure, the type and extent of documentation varied. During disaster or emergency responses, data should be systematically collected using standardized resources and methods. Misclassification can occur during abstraction when synthesizing and performing a secondary analysis on EHRs. To minimize subjective clinical impressions, the team was co-located during abstraction to allow for routine consultations spanning our breadth of clinical and epidemiological specialties.

CONCLUSIONS

Approximately half of abstracted records had documented worsening preexisting or persistent new conditions or symptoms after the water contamination event. This investigation highlights the need to continue addressing the burden of morbidities among this population and extensively monitor persons affected for long-term health outcomes. Future efforts might focus on effects of exposure among sensitive populations, particularly children and pregnant women, and comparison to a control population to better understand the nature of any increased risk among exposed persons and to assess the impact on the overall population. Access to medical care, including mental health resources and specialty providers, and monitoring for long-term health outcomes among potentially exposed communities will be important.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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LIST OF ABBREVIATIONS:

ATSDR	Agency for Toxic Substances and Disease Registry
CDC	Centers for Disease Control and Prevention
DHA	Defense Health Agency
DoD	Department of Defense
DOEHRS	Defense Occupational and Environmental Health Readiness System
EHR	Electronic Health Record
HDOH	Hawaii State Department of Health
ICD-10	International Classification of Diseases, Tenth Revision
JP-5	Jet Propellant-5
MHS	Military Health System

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Table 1.

Characteristics of persons sampled from the Defense Occupational and Environmental Health Readiness System for medical chart abstraction — Oahu, Hawaii, March 2023 (N = 653).

Variable	All		Worsening preexisting conditions or symptoms		Persistent new conditions or symptoms		Acute conditions or symptoms	
	No.	% ^a	No.	% ^a	No.	% ^a	No.	% ^a
Age	411	63	177	27	171	26	293	45
	239	37	45	7	239	37	173	26
	3	<1	3	<1	2	<1	3	<1
Sex	359	55	136	21	138	21	250	38
	292	45	89	14	103	16	218	33
	2	<1	0	0	0	0	0	0
Race	12	2	5	1	<5	<1	11	2
	15	3	5	1	7	1	11	2
	81	12	39	6	41	6	64	10
	27	4	14	2	13	2	21	3
	319	49	107	16	120	18	219	34
	8	1	<5	<1	<5	<1	<5	<1
	104	16	34	5	37	6	83	13
	87	14	19	3	70	11	56	9
Ethnicity	78	12	29	4	32	5	60	9
	420	64	155	24	156	24	305	47
	155	24	41	6	53	8	104	16
Service Branch ^c	231	35	81	12	92	14	174	27
	175	27	63	10	65	10	118	18
	20	3	<5	<1	<5	<1	14	2
	16	2	7	1	8	1	3	<1
	<5	<1	<5	<1	<5	<1	<5	<1
	200	31	65	10	67	10	137	21
	10	2	6	1	5	1	9	1
Beneficiary Category	166	26	70	11	81	12	120	18
Active Duty								

^cNo sampled persons were in the Office of Secretary of Defense, Public Health Service, National Oceanic and Atmospheric Administration, or Foreign Army.

Table 2. Most Prevalent conditions and symptoms among abstracted medical records for persons sampled from the Defense Occupational and Environmental Health Readiness System for medical chart abstraction — Oahu, Hawaii, March 2023 (N = 653).

WORSENING PREEXISTING		PERSISTENT NEW	
ALL	653		653
Conditions	No. (%)	Conditions	No. (%)
	191 (29)		144 (22)
	Migraine	Migraine	14 (2)
	Chronic Pain	Adjustment Disorder	13 (2)
	Gastroesophageal Reflux	Eczema or Atopic Dermatitis	12 (2)
	Eczema or Atopic Dermatitis	Anxiety	11 (2)
	Depression	Gastroesophageal Reflux	8 (2)
Symptoms	No. (%)	Symptoms	No. (%)
	155 (24)		205 (31)
	Headache	Rash	46 (7)
	Anxiety, Worry, or Fear	Headache	34 (5)
	Depression or Low Mood	Fatigue or Malaise	29 (4)
	Rash	Abdominal Pain	25 (4)
	Muscle Aches or Joint Pain	Anxiety, Worry, or Fear	24 (4)
PEDIATRIC ^a	239		239
Conditions	No. (%)	Conditions	No. (%)
	37 (15)		42 (18)
	All	All	6 (3)
	Eczema or Atopic Dermatitis	Allergic Rhinitis	6 (3)
	Attention-Deficit/Hyperactivity Disorder	Eczema or Atopic Dermatitis	6 (3)
Symptoms		Symptoms	
	All	All	53 (22)
	Rash	Rash	20 (8)
		Abdominal Pain	11 (5)
		Headache	9 (4)
		Fatigue or Malaise	8 (3)
		Cough	8 (3)

WORSENING PREEXISTING		PERSISTENT NEW	
ADULTS	411		411
Conditions	No. (%)	Conditions	No. (%)
	All 155 (38)		All 101 (25)
	Migraine 48 (12)		Adjustment Disorder 12 (3)
	Anxiety 37 (9)		Migraine 12 (3)
	Chronic Pain 25 (6)		Hypertension 10 (2)
Symptoms		Symptoms	
	All 126 (31)		All 150 (37)
	Headache 47 (11)		Rash 25 (6)
	Anxiety, Worry, or Fear 38 (9)		Headache 25 (6)
	Depression or Low Mood 21 (5)		Fatigue or Malaise 21 (5)
	Muscle Aches or Joint Pain 19 (5)		Anxiety, Worry, or Fear 19 (5)
	Sleeping Difficulty 15 (4)		Dizzy or Vertigo 18 (4)

^aPediatric persons defined as ages 0 to <18 years.

Note: Conditions or symptoms with n<5 not presented. Some persons had more than 1 symptom and/or condition. Data on age was missing on 2 persons.