HHS Public Access

Author manuscript

Occup Environ Med. Author manuscript; available in PMC 2024 April 01.

Published in final edited form as:

Occup Environ Med. 2023 April ; 80(4): 192–195. doi:10.1136/oemed-2022-108714.

Health outcomes among offspring of United States Coast Guard responders to the Deepwater Horizon oil spill, 2010–2011

Clinton Hall[1,2], **Ava Marie S. Conlin**[1], **Monica Burrell**[1,2], **Celeste J. Romano**[1,2], **Anna T. Bukowinski**[1,2], **Gia R. Gumbs**[1,2], **Emily W. Harville**[3], **Dana L. Thomas**[4], **Hristina Denic-Roberts**[5,6], **Jennifer A. Rusiecki**[5]

[1]Deployment Health Research Department, Naval Health Research Center, San Diego, CA

[2]Leidos, Inc., San Diego, CA

[3]Department of Epidemiology, Tulane University School of Public Health and Tropical Medicine, New Orleans, LA

[4]United States Coast Guard Headquarters, Directorate of Health, Safety, and Work Life, Washington, DC

[5]Department of Preventive Medicine and Biostatistics, Uniformed Services University, Bethesda, MD

[6]Oak Ridge Institute for Science and Education, Bethesda, MD

Abstract

Objective: To evaluate the potential for adverse health outcomes among infants born to United States Coast Guard (USCG) responders to the Deepwater Horizon (DWH) oil spill disaster.

Methods: Department of Defense Birth and Infant Health Research program data identified a cohort of singleton infants born 2010–2011 to USCG personnel in the DWH Oil Spill Coast Guard Cohort study. Infants were included if their military parent ("sponsor") responded to the oil spill during a selected reproductive exposure window (i.e., three months preconception for male sponsors and periconception through pregnancy for female sponsors), or if their sponsor was a non-responder. Chi-squared tests and multivariable log-binomial regression were used to compare the demographic and health characteristics of infants born to spill responders and non-responders.

Results: Overall, 1974 infants with a male sponsor (n=182 responder, n=1792 non-responder) and 628 infants with a female sponsor (n=35 responder, n=593 non-responder) in the DWH Oil Spill Coast Guard Cohort were identified. Health outcomes were similar among the offspring of male responders and non-responders. The frequency of any poor live birth outcome (i.e., low birthweight, preterm birth, or birth defect) was higher among infants born to female responders (17.1%, n=6) than non-responders (8.9%, n=53); the maternal age-adjusted association was suggestively elevated (risk ratio: 1.93, 95% confidence interval: 0.89, 4.16).

Conclusion: Infant health outcomes were comparable between the offspring of male USCG oil spill responders and non-responders. Findings were limited by the small number of infants identified, particularly among female responders, and should be interpreted with caution.

Introduction

The Deepwater Horizon (DWH) oil spill, considered one of the worst environmental disasters in world history, released up to 210 million gallons of crude oil into the Gulf of Mexico from 20 April 2010 until the well was effectively capped 87 days later.[1,2] The United States Coast Guard (USCG) led the national clean-up response and deployed nearly 9,000 personnel to support response efforts.[3]

During clean-up efforts, USCG spill responders were potentially exposed to physical and psychological stressors and hazardous environmental agents, in particular crude oil and its constituents (e.g., volatile organic compounds and polycyclic aromatic hydrocarbons). Recent studies have shown that USCG spill responders exposed to crude oil exhibit increased risk for adverse respiratory, neurological, and cardiovascular health outcomes.[3–7] However, despite crude oil having known teratogenic effects, there is a dearth of associated research on offspring outcomes. The objective of this study was to evaluate the potential for adverse infant health outcomes among the offspring of USCG responders to the DWH oil spill disaster.

Methods

Data Sources

This study used data from the Department of Defense Birth and Infant Health Research (BIHR) program and the DWH Oil Spill Coast Guard (DWH-CG) Cohort study. The BIHR program is an ongoing surveillance and research effort that identifies infants born to military families and captures information on associated health outcomes.[8] Briefly, BIHR data consist of military demographic and personnel data from the Defense Manpower Data Center and the Defense Enrollment Eligibility Reporting System, and administrative medical encounter data from the Military Health System Data Repository; infant health data are routinely captured through the first year of life. For BIHR infants, estimated gestational age (EGA) is derived from International Classification of Diseases (ICD) codes, date of last menstrual period (LMP) is estimated by subtracting EGA from delivery date, and date of conception is calculated by adding two weeks to date of LMP. Same-sex multiples are excluded from BIHR data due to difficulties distinguishing their neonatal medical records.

The DWH-CG has been previously described in detail.[3] Briefly, it includes USCG personnel who either responded to the DWH oil spill (“responders”) or did not respond to the oil spill (“non-responders”) and were on active duty or in the Selected Reserve for at least one day between 20 April and 17 December 2010, which marked the beginning of the oil spill and the end of the main operational phase of the oil spill response, respectively.[1] Sixty-five percent of spill responders completed an exit survey that included information on deployment-related exposures (e.g., crude oil, exhaust).

Study Population

BIHR data were used to identify singleton infants born to Service members in the DWH-CG. Because BIHR data inherently exclude same-sex multiples, opposite-sex multiples were not included in this study for consistency. Infants born to responders were included if their

military parent ("sponsor") deployed to the oil spill during a critical reproductive exposure window for at least one day between 20 April and 17 December 2010. For male sponsors, the exposure window was the three months before conception, reflecting the period of spermatogenesis; for female sponsors, the exposure window spanned three months before date of LMP through the infant's birth date, reflecting the period of periconception through pregnancy. To account for temporal trends in pregnancy outcomes unrelated to the oil spill, infants born to non-responders were included if their sponsor's reproductive exposure window overlapped with any time from 20 April to 17 December 2010.

Characteristics and Outcomes

Sponsor characteristics at infant birth were obtained from BIHR data via military personnel files and included age, race and ethnicity (Asian/Pacific Islander, Hispanic, non-Hispanic Black, non-Hispanic White, other/unknown), military rank (enlisted, officer), military component (active duty, Selected Reserve, unknown), and marital status (married, unmarried/unknown). Maternal age at infant birth was available for the entire study population; paternal age was only available for the offspring of male sponsors. Sponsor crude oil and exhaust exposure during deployment were collected by survey and dichotomized as ever or never exposed when non-missing.[3] Infant health outcomes, including low birthweight (<2500 grams), preterm birth (<37 weeks' gestation), major structural birth defects, and any poor live birth outcome (i.e., low birthweight, preterm birth, and/or birth defects), were ascertained from BIHR medical encounter data using ICD codes (see Supplemental File for details). Infant sex was derived from BIHR data via enrollment records and the proportion of males was assessed as an indicator of overall population reproductive health.[9]

Statistical Analysis

Parental, sponsor, and health characteristics of study infants were reported as frequency and percentage, stratified by sponsor sex and spill responder status (responder or non-responder); cells with fewer than five observations were blinded. The primary analysis compared the offspring of responders and non-responders. Differences in parental and sponsor characteristics were assessed using t-tests for continuous variables and chi-squared tests for categorical variables, and differences in infant health outcomes were assessed using parental age-adjusted log-binomial regression models that estimated risk ratios (RRs) and 95% confidence intervals (CIs). Infant outcomes with fewer than five cases were not assessed.

An exploratory analysis compared the offspring of male responders who reported ever crude oil exposure during deployment to those who reported no crude oil exposure; due to sample size limitations, only male sex and any poor live birth outcome were assessed.

Statistical analyses and data management were performed using SAS Enterprise Guide, version 7.1 (SAS Institute Inc., Cary, NC, USA).

Results

The DWH-CG Cohort included 53,519 USCG personnel eligible for infant linkage using BIHR data. Overall, 1974 singletons with a male sponsor (n=182 born to responders; n=1792 born to non-responders) and 628 singletons with a female sponsor (n=35 born to responders; n=593 born to non-responders) were identified.

Maternal and paternal age, sponsor race and ethnicity, and sponsor marital status were comparable between the offspring of responders and non-responders (Table). Responders were more likely to be of officer military rank than non-responders. Generally, male responders reported ever exposure to crude oil and exhaust more frequently than female responders; however, sponsor exposure data were missing for the 35–51% of infants born to responders who did not complete a survey ascertaining exposures.

The offspring of male responders and non-responders were similar with respect to male sex (aRR: 1.00, 95% CI: 0.86, 1.16), preterm birth (aRR: 1.20, 95% CI: 0.72, 2.01), birth defects (aRR: 0.80, 95% CI: 0.32, 1.95), and any poor live birth outcome (aRR: 1.01, 95% CI: 0.65, 1.59). The offspring of female responders and non-responders were similar with respect to male sex (aRR: 1.04, 95% CI: 0.74, 1.44). There was an elevated risk for any poor live birth outcome in the offspring of female responders, though CIs included unity (aRR: 1.92, 95% CI: 0.89, 4.16).

In exploratory analyses (not shown in Table), the offspring of male responders who reported ever vs. never exposure to crude oil during deployment were similar with respect to male sex (49.3% vs. 54.9%, respectively; aRR: 0.91, 95% CI: 0.64, 1.29) but had a suggestively reduced risk for any poor live birth outcome (4.5% vs. 15.7%, respectively; aRR: 0.36, 95% CI: 0.10, 1.26).

Discussion

The frequency of adverse health outcomes was comparable between the offspring of male oil spill responders and non-responders included in this study. While the proportion of infants with any poor live birth outcome was higher among those born to female responders vs. non-responders, the interpretation of this finding was limited by small numbers. Spill responders may have been exposed to a variety of physical and psychological stressors and environmental hazards, including crude oil. Here, seven infants were born to female responders with self-reported crude oil exposure, only one of which was classified as having a poor live birth outcome. Overall, these findings indicate that the offspring of USCG spill responders were not at increased risk for the adverse outcomes under study. Still, crude oil is a known teratogen and exposure during pregnancy can disrupt fetal development and increase risk for congenital malformations. Keeping with current USCG policy, pregnant personnel should continue to be exempt from missions that involve exposure to chemical or toxic agents and environmental hazards.[10]

This study was strengthened by linking DWH-CG sponsor and exposure data with BIHR infant outcome data. Further, all Service members were employed and belonged to a universal health insurance system designed for equal access; while these characteristics

enhanced visibility of offspring medical care, they also limited the generalizability of study findings. Other limitations included lack of information on prior crude oil exposure and a reliance on ICD codes to define infant health outcomes, EGA, and dates of LMP and conception. This latter limitation introduced the possibility of non-differential misclassification of outcomes and exposures, and could have contributed to the null results observed in this study. However, a prior validation study revealed that ICD codes provided an accurate assessment of EGA and birthweight in BIHR data,[11] therefore limiting the potential for bias due to coding errors. Still, the exposure windows employed were broad, particularly for maternal sponsors, and the assessment of more targeted windows of susceptibility (e.g., first trimester exposure) was precluded by sample size.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Disclaimer

ASC and DLT are military service members or employees of the U.S. Government. This work was prepared as part of their official duties. Title 17, U.S.C. §105 provides that copyright protection under this title is not available for any work of the U.S. Government. Title 17, U.S.C. §101 defines a U.S. Government work as work prepared by a military service member or employee of the U.S. Government as part of that person's official duties. Report No. 22-76 was supported by the U.S. Navy Bureau of Medicine and Surgery under work unit no. 60504. The views expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the Department of the Navy, United States Coast Guard, Department of Defense, Department of Homeland Security, Department of Energy, Uniformed Services University of the Health Sciences, Oak Ridge Institute for Science and Education, nor the U.S. Government.

The study protocol was approved by the Naval Health Research Center Institutional Review Board in compliance with all applicable Federal regulations governing the protection of human subjects. Research data were derived from an approved Naval Health Research Center Institutional Review Board protocol, number NHRC.1999.0003. The DWH-CG Cohort Study was approved by the USU Institutional Review Board, Protocol G187P9.

The DWH-CG Cohort Study was supported by a National Institutes of Health grant (RO1ES020874). One of the authors (HDR) was supported by an appointment to the Department of Defense Research Participation Program administered by the Oak Ridge Institute for Science and Education (ORISE) through an interagency agreement between the U.S. Department of Energy (DOE) and the Department of Defense. ORISE is managed by ORAU under DOE contract number DE- SC0014664.

References

1. On Scene Coordinator report, Deepwater Horizon oil spill, submitted to the National Response Team, September 2011. Non-series Report. 2011;
2. Crone TJ, Tolstoy M. Magnitude of the 2010 Gulf of Mexico oil leak. Science. Oct 29 2010;330(6004):634. doi:10.1126/science.1195840 [PubMed: 20929734]
3. Rusiecki J, Alexander M, Schwartz EG, et al. The Deepwater Horizon Oil Spill Coast Guard Cohort study. Occup Environ Med. Mar 2018;75(3):165–175. doi:10.1136/oemed-2017-104343 [PubMed: 28899964]
4. Rusiecki JA, Denic-Roberts H, Thomas DL, et al. Incidence of chronic respiratory conditions among oil spill responders: Five years of follow-up in the Deepwater Horizon Oil Spill Coast Guard Cohort study. Environ Res. Jan 2022;203:111824. doi:10.1016/j.envres.2021.111824 [PubMed: 34364859]
5. Krishnamurthy J, Engel LS, Wang L, et al. Neurological symptoms associated with oil spill response exposures: Results from the Deepwater Horizon Oil Spill Coast Guard Cohort Study. Environ Int. Oct 2019;131:104963. doi:10.1016/j.envint.2019.104963 [PubMed: 31382236]

6. Denic-Roberts H, Rowley N, Haigney MC, et al. Acute and longer-term cardiovascular conditions in the Deepwater Horizon Oil Spill Coast Guard Cohort. Environ Int. Jan 2022;158:106937. doi:10.1016/j.envint.2021.106937 [PubMed: 34688052]

7. Alexander M, Engel LS, Olaiya N, et al. The deepwater horizon oil spill coast guard cohort study: A cross-sectional study of acute respiratory health symptoms. Environ Res. Apr 2018;162:196–202. doi:10.1016/j.envres.2017.11.044 [PubMed: 29331799]

8. Bukowinski AT, Conlin AMS, Gumbs GR, Khodr ZG, Chang RN, Faix DJ. Department of Defense Birth and Infant Health Registry: select reproductive health outcomes, 2003–2014. MSMR. Nov 2017;24(11):39–49. [PubMed: 29211493]

9. James WH, Grech V. Can sex ratios at birth be used in the assessment of public health, and in the identification of causes of selected pathologies? Early Hum Dev. Mar 2018;118:15–21. doi:10.1016/j.earlhumdev.2018.02.003 [PubMed: 29428574]

10. COMMANDANT INSTRUCTION 1000.9: PREGNANCY IN THE COAST GUARD (2011).

11. Barrett JP, Sevick CJ, Conlin AM, et al. Validating the use of ICD-9-CM codes to evaluate gestational age and birth weight. J Registry Manag. Summer 2012;39(2):69–75. [PubMed: 23599031]

Key messages

What is already known on this topic?

- United States Coast Guard responders to the Deepwater Horizon oil spill were potentially exposed to physical and psychological stressors and hazardous chemicals including crude oil, a known teratogen.
- In previous studies, this population has demonstrated increased risk for adverse short- and long-term respiratory, cardiovascular, and neurologic outcomes, but there is a dearth of research on offspring health outcomes.

What does this study add?

- Addressing a research gap, this study characterized the health profile of infants born to United States Coast Guard personnel who responded to the Deepwater Horizon oil spill during a critical reproductive exposure window.
- Adverse health outcomes were generally comparable between infants born to male oil spill responders and non-responders, though there was a suggestive risk for any poor live birth outcome among infants born to female spill responders.

How might this study affect research, clinical practice, or policy?

- Military policies should continue to exempt pregnant personnel from missions that involve chemical or environmental hazards; however, if exposure inadvertently occurs, prompt guidance should be provided regarding potential risks and any remediation efforts, such as the establishment of active registries to monitor those exposed.

Table.

Parental, sponsor, and health characteristics of infants born to United States Coast Guard responders to the Deepwater Horizon oil spill and non-responders, stratified by sponsor sex, Deepwater Horizon Oil Spill Coast Guard Cohort and Department of Defense Birth and Infant Health Research program data, 2010–2011.

	Male sponsor[a]					Female sponsor[b]				
	Responder		Non-responder			Responder		Non-responder		
Characteristic	**n**	**(%)**	**n**	**(%)**	**p-value[c]**	**n**	**(%)**	**n**	**(%)**	**p-value[c]**
Total infants	182	-	1792	-	-	35	-	593	-	-
Parental and sponsor demographics[d]										
Maternal age, M±SD	28.5 ± 4.6		28.3 ± 4.5		0.46	28.2 ± 3.7		27.6 ± 4.8		0.52
Paternal age, M±SD	30.1 ± 5.5		29.5 ± 4.8		0.12	-		-		-
Sponsor race and ethnicity					0.10					0.96
Asian/Pacific Islander	7	(3.9)	42	(2.3)		<5	-	27	(4.5)	
Hispanic	15	(8.2)	224	(12.5)		5	(14.3)	65	(11.0)	
Non-Hispanic Black	9	(4.9)	60	(3.4)		<5	-	35	(5.9)	
Non-Hispanic White	141	(77.5)	1307	(72.9)		23	(65.7)	404	(68.1)	
Other/Unknown	10	(5.5)	159	(8.9)		<5	-	62	(10.5)	
Sponsor rank					0.03					0.01
Enlisted	145	(79.7)	1536	(85.7)		21	(60.0)	470	(79.3)	
Officer	37	(20.3)	256	(14.3)		14	(40.0)	123	(20.7)	
Sponsor component					0.02					0.09
Active duty	166	(91.2)	1710	(95.4)		29	(82.9)	550	(92.8)	
Selected Reserve	16	(8.8)	78	(4.4)		5	(14.3)	38	(6.4)	
Unknown	0	(0.0)	<5	-		<5	-	5	(0.8)	
Sponsor marital status					0.73					0.99
Married	181	(99.5)	1778	(99.2)		29	(82.9)	492	(83.0)	
Unmarried/Unknown	<5	-	14	(0.8)		6	(17.1)	101	(17.0)	
Sponsor oil spill response exposures										
Ever oil exposed[e]					-					-
Yes	67	(36.8)	-	-		7	(20.0)	-	-	

	Male sponsor[a]					Female sponsor[b]				
	Responder		Non-responder			Responder		Non-responder		
Characteristic	**n**	**(%)**	**n**	**(%)**	**p-value[c]**	**n**	**(%)**	**n**	**(%)**	**p-value[c]**
No	51	(28.0)	-	-		15	(42.9)	-	-	
Missing	64	(35.2)	1808	(100.0)		13	(37.1)	580	(100.0)	
Ever exhaust exposed[f]					-					-
Yes	78	(42.9)	-	-		12	(34.3)	-	-	
No	23	(12.6)	-	-		5	(14.3)	-	-	
Missing	81	(44.5)	1808	(100.0)		18	(51.4)	580	(100.0)	
Infant health outcomes										
Male sex	93	(51.1)	914	(51.0)	0.99	18	(51.4)	294	(49.5)	0.83
Low birthweight (<2500 grams)	<5	-	60	(3.4)	-	<5	-	20	(3.4)	-
Preterm birth (<37 weeks' gestation)	15	(8.2)	126	(7.0)	0.48	<5	-	41	(6.9)	-
Major structural birth defect	5	(2.8)	62	(3.5)	0.62	<5	-	11	(1.9)	-
Any poor live birth outcome[g]	19	(10.4)	187	(10.4)	0.95	6	(17.1)	53	(8.9)	0.10

Note: M, mean; SD, standard deviation.

[a] Includes infants with a paternal sponsor for whom three months preconception overlapped with, for responders, deployment during 20 April to 17 December 2010 or, for non-responders, any time from 20 April to 17 December 2010.

[b] Includes infants with a maternal sponsor for whom periconception through pregnancy overlapped with, for responders, deployment during 20 April to 17 December 2010 or, for non-responders, any time from 20 April to 17 December 2010.

[c] P-values for parental and sponsor demographics were derived using t-tests for continuous variables and chi-square tests for categorical variables; p-values for infant health outcomes were derived from log-binomial regression models that adjusted for paternal and maternal age (paternal models) or maternal age (maternal models).

[d] Parental and sponsor demographic characteristics were captured at infant month of birth.

[e] Refers to self-reported crude oil exposure via inhalation, direct skin contact, ingestion, and/or submersion

[f] Refers to self-reported inhalation of exhaust fumes

[g] Includes infants with low birthweight, preterm birth, or major structural birth defects.