

**NAVAL HEALTH RESEARCH CENTER**

# **DoD Birth and Infant Health Research Program: An Overview**

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# Disclaimer

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# DoD Reproductive Health Research

- Military-unique exposures and potential risk to reproductive health
  - Deployment-related exposures
  - Geographically diverse duty stations
  - Compulsory vaccinations
  - Reproductive factors impacting readiness
- Expanding number and role of women in the military
- Existing civilian registries cannot accurately assess such issues among military families
- Value in assessing highly utilized obstetric services



LIFE Magazine photo by Derek Hudson, Time-LIFE, Inc.



# DoD Birth and Infant Health Research Program

- Department of Defense (DoD) Birth and Infant Health Research program (a.k.a. "BIHR")
  - Predecessor established following a 1998 directive by the Assistant Secretary of Defense for Health Affairs
  - Retrospective assessment of birth defects and other adverse infant health outcomes
- Conduct surveillance for birth defects among DoD health care beneficiaries
- Monitor other indicators of infant health, such as preterm birth, birth weight, growth problems, male:female sex ratio
- Assess maternal health outcomes, including pregnancy loss, among DoD beneficiaries who may experience exposures of concern



# BIHR Program: Methodology

- The Military Health System Data Repository (a.k.a. “MDR”)
  - Administrative medical claims data
  - ICD-9-CM/ICD-10-CM and CPT® codes
  - Inpatient and outpatient health care encounters at military and civilian facilities
- Defense Manpower Data Center
  - Parental and military demographics
  - Service member immunizations
- Variable validation through data abstraction
  - AHLTA and Essentris®
- Data linkages
  - Millennium Cohort Study, US Navy physical fitness data, DoD Serum Repository, Deepwater Horizon Coast Guard responders, Joint DoD/VA Suicide Data Repository





# BIHR Program: Methodology

- Retrospective assessment
- National Birth Defects Prevention Network
  - Birth defects prevalence published annually since 2003, biennially beginning in 2021
- 1 inpatient or 2 outpatient diagnoses on different days
- First year of life among all live births
  - Select current efforts extending to 2 and 5 years of life



U.S. Navy photo by Jacob Sippel/Released



# Infant Health Surveillance Population

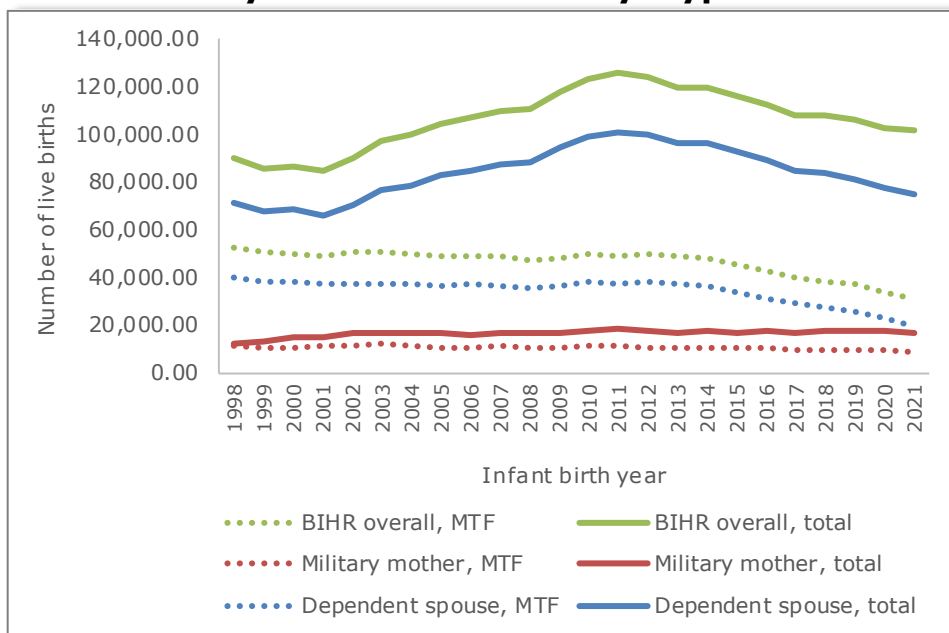
## ➤ Data from 1998–2021 show:

- >2.6 million infants born to DoD beneficiaries
- Median age of mothers: 27 years
- 13% born to active duty (AD) mothers
- 56% born to mid-enlisted-rank personnel (E4–E6)
- 43% births at military treatment facilities (MTFs), 57% at civilian facilities (CIV)
  - 58% MTF/42% CIV in 1998 → 30%/70% in 2021
- Births in all 50 states and >20 foreign countries
- Overall prevalence of birth defects: 3%
  - ASD, VSD, hypospadias, clubfoot, and pulmonary valve atresia and stenosis most prevalent

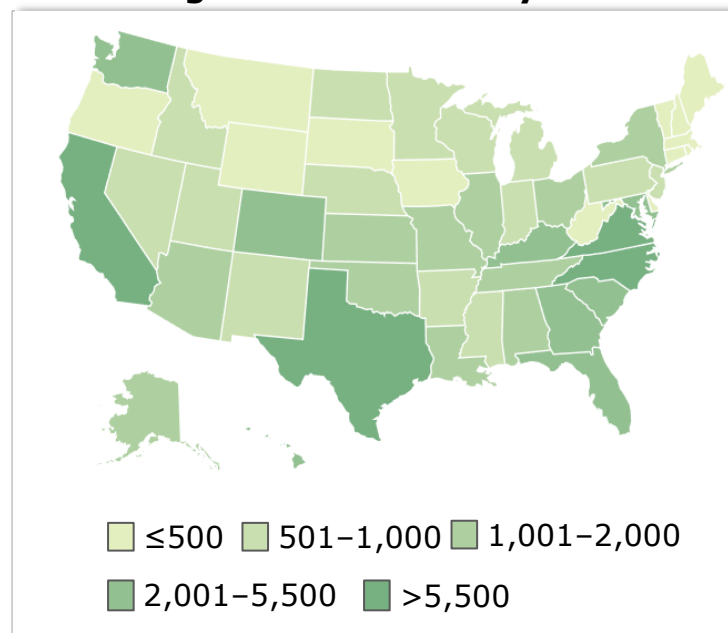


# BIHR Program Births by Location, 1998–2021

**Number of Annual Live Births, Total and at MTFs, by Maternal Beneficiary Type**



**Average Annual Births By State**





# BIHR Program 1998–2021: Population Characteristics

Characteristics	Total Population		Active Duty Women	
	Frequency	%	Frequency	%
Total infants, row %	2,555,093		330,130	12.9
Maternal age at infant birth	<35 years	2,200,608	302,180	91.5
	≥35 years	259,096	27,950	8.5
	Unknown	95,389	--	
Sponsor marital status	Married	2,243,402	241,084	73.0
	Not married	311,691	89,046	27.0
Sponsor race and ethnicity	American Indian/Alaskan Native	40,149	6,658	2.0
	Asian/Pacific Islander	117,675	18,975	5.7
	Hispanic	304,205	49,386	15.0
	Non-Hispanic Black	377,486	90,509	27.4
	Non-Hispanic White	1,638,278	153,554	46.5
	Other/unknown	77,300	11,048	3.3
Sponsor branch of service	Air Force	582,986	96,249	29.2
	Army	1,065,552	111,427	34.6
	Marine Corps	292,676	24,545	7.4
	Navy	528,573	88,134	26.7
	Other/unknown	85,306	6,928	2.1
Sponsor rank	Enlisted	1,881,854	281,670	85.3
	Officer	431,405	48,460	14.7
	Other/unknown	241,834	--	



# Active Duty Women Surveillance Population

## ➤ Data for AD women 1998–2021:

- 330,130 infants born to 236,448 AD women
- Median age of AD mothers: 25 years
- 70% births at MTFs, 30% at CIV
- 61% born to mid-enlisted-rank AD women (E4–E6)
- Broader range of data on exposures and outcomes available for this population (e.g., vaccinations, mortality)
- Subset of data from 2003–2014 available to examine pregnancy outcomes other than births (e.g., losses)
  - Post ICD-10 expansion (through 2021) is well underway



# Pregnancy Population Characteristics

Pregnancies and Outcomes Among Active Duty US Military Women (2003–2014)

Characteristics	All pregnancies, N (N=258,332)	Live deliveries, % (n=180,044)	Stillbirths, % (n=768)	Other losses <sup>a</sup> , % (n=41,278)	Unknown outcomes, % (n=36,242)
Total, row %		69.7	0.30	16.0	14.0
Maternal age at pregnancy end					
<35 years	234,860	70.9	0.30	15.2	13.6
≥35 years	23,472	58.0	0.28	23.7	18.0
Maternal marital status					
Married	177,436	74.0	0.27	14.6	11.1
Not married	80,896	60.2	0.35	19.0	20.4
Maternal race and ethnicity					
American Indian/ Alaskan Native	5,832	71.9	0.21	15.3	12.6
Asian/Pacific Islander	15,520	71.7	0.2	14.9	13.2
Hispanic	34,683	70.4	0.22	16.3	13.1
Non-Hispanic Black	74,169	66.2	0.46	16.5	16.9
Non-Hispanic White	121,727	71.2	0.23	15.7	12.8
Other/Unknown	6,401	70.2	0.34	17.2	12.3
Maternal branch of service					
Air Force	74,843	72.1	0.30	15.6	12.0
Army	93,489	64.6	0.30	17.6	17.5
Marine Corps	18,663	73.7	0.25	14.4	11.6
Navy	65,838	72.7	0.31	14.7	12.2
Other/unknown	5,499	72.4	0.22	14.6	12.8
Maternal rank					
Enlisted	224,245	69.3	0.31	16.0	14.4
Officer	34,087	72.2	0.21	16.1	11.5

<sup>a</sup>Pregnancies with indication of elective abortion were excluded from reporting.



# Strengths and Limitations

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- Surveillance is primarily limited to live births
  - Increasing capacity to accurately assess recent pregnancies
- Defects or disabilities diagnosed within the first year of life
  - Currently extending data through early childhood for select efforts
- ICD medical codes cannot describe constellations or severity of defects
- Visibility of health outcomes are limited to TRICARE coverage
- Efforts demonstrate accuracy of electronic diagnostic data
  - Limited to a sample of MTF-based data
- Ability to link to other data sources
  - Environmental and occupational exposure data
  - Self-reported data
  - Death data



# BIHR Past Research Products

## SUMMARY FINDINGS

**DoD Birth and Infant Health Research**  
 Deployment Health Research Department  
 Naval Health Research Center  
 140 Sylvester Road, San Diego, CA 92106-3521  
 (619) 553-9255, DSN 553-9255  
 USN.NHRC-BirthResearch@health.mil



- Background:** The United States (US) Department of Defense (DoD) is challenged with monitoring and protecting the health of its service members and their families. The growing number of women on active duty and the diverse occupational exposures associated with military service make reproductive health issues a special concern for the DoD. In response to this concern, the Assistant Secretary of Defense for Health Affairs directed the establishment of a birth defects registry for military families in 1998. The Deployment Health Research Department at the Naval Health Research Center (NHRC) in San Diego was given the responsibility of managing the DoD Birth and Infant Health Research (BIHR) program.
- Objective:** The primary objective of the BIHR program is to increase the understanding of the reproductive health effects of military service by providing systematic surveillance of DoD beneficiary births and scientifically rigorous research of maternal, pregnancy, and infant health outcomes, with the potential to assess the health of infants captured in the BIHR database into early childhood.
- Approach:** BIHR data analysts have established direct access to large databases for thorough capture of pregnancy and maternal outcomes among military beneficiaries, and all birth and health outcomes up to the first birthday in infants born to military families, or beyond for those with continuous care in the system through early school age. Scientific protocols are developed to evaluate epidemiologic associations between these outcomes and specific exposures of concern, including military occupations and military-unique exposures of concern.
- Value:** The BIHR program responds to the needs of military families in addressing their reproductive health concerns with strong science and surveillance. These projects focus research on appropriate health risks and contribute to the understanding and progress in the prevention of maternal, pregnancy, and infant health challenges.
- Collaboration:** The BIHR team has a long history of collaboration with leading experts from a variety of scientific disciplines. Past or ongoing collaborations include projects with professionals from the University of Notre Dame, Dartmouth College, the US Centers for Disease Control and Prevention (CDC), the Defense Health Agency Immunization Healthcare Division (DHA IHD), and several pharmaceutical companies. The BIHR program maintains ongoing collaborations with residents and staff at the Uniformed Services University of the Health Sciences and military treatment facilities.
- Support:** The BIHR program was funded by the DoD Health Affairs and US Department of Navy Bureau of Medicine and Surgery under work unit number 60504 through FY22, and is supported under DoD Health Affairs Policy Memo 99-006. Several specific research protocols received funding through competitive grants from the Congressionally Directed Medical Research Program, Peer-Reviewed Medical Research Program, administered by the US Army, as well as by DHA IHD. FDA post-marketing surveillance studies for specific vaccines receive funding from the vaccine manufacturer.
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*Through age two, preterm birth increased risk of maltreatment while parents' older age, physical health, and service in the Navy or Air Force decreased risk. These findings suggest the need for universal and targeted prevention efforts, beginning during pregnancy, which address risk factors for maltreatment in military families.*

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*This biennial report summarizes state-specific birth defects surveillance data, and includes complementary information from US military families for infants born 2014-2018.*

*The BIHR program began contributing to these reports for the NBDPN in 2003, with the first complete five-year increment of data (1998-2002) appearing in the 2005 publication. This sheet omits subsequent citations.*

Lutgendorf MA, Abramovitz LM, Bukowinski AT, Gumbs GR, Conlin AMS, Hall C. **Pregnancy and posttraumatic stress disorder: associations with infant outcomes and prenatal care utilization.** J Matern Fetal Neonatal Med. 2022;35(25):9053-9060. Epub 2021DEC09

*For pregnant Servicewomen with current posttraumatic stress disorder (PTSD), no associations with adverse infant outcomes were observed, and those women initiated prenatal care (PNC) earlier and had higher PNC utilization compared to pregnant Servicewomen without PTSD. Universal health care and utilization of PNC in this population may mitigate adverse pregnancy outcomes observed in other populations with PTSD.*

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Updated March 2023



# PTSD Among Pregnant Servicewomen

- Initial effort that described demographic and occupational characteristics, comorbidities, and psychotropic medication receipt associated with posttraumatic stress disorder (PTSD) diagnosis (ICD-9) during pregnancy, 2007–2014
  - 1.7% of pregnant AD individuals were affected by PTSD in pregnancy
  - PTSD cases were more likely to be non-Hispanic White, unmarried, previously deployed
  - High rates of comorbid depressive (61%), adjustment (43%), or anxiety disorders (39%)
  - Psychotropic medication during pregnancy received in 44% of PTSD cases (vs. 7.2% of non-cases)





# Pregnancy and PTSD: Infant Outcomes and Prenatal Care Utilization

- Follow-on effort assessed association of current PTSD in pregnancy with prenatal care (PNC) utilization and infant outcomes
  - Pregnant individuals with PTSD were more likely to initiate PNC during the first trimester (93% vs. 90%) and utilize higher levels of PNC (63% vs. 40%)
  - PTSD during pregnancy was not associated with infant preterm birth, small for gestational age, or major birth defects
  - Universal health care and PNC utilization in this population may mitigate adverse pregnancy outcomes observed in other populations with PTSD



# Pregnancy & PTSD – Select VA Efforts

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- Pregnancy-related anxiety was a robust predictor of postpartum depression in pregnancy

Goger et al. Predictors of early postpartum maternal functioning among women veterans. *Matern Child Health J.* 2022;26:149-155.

- PTSD diagnoses and life stressors predicted maternal alcohol misuse in the postpartum period

Holzhauser et al. Prenatal stress exposure and post-traumatic stress disorder associated with risk of postpartum alcohol misuse among women veterans. *Womens Health Issues.* 2021;31:596-602.

- Military sexual trauma, not warfare exposure, was associated with LBW infants, a slight increase in preterm birth, and increased likelihood of postpartum depression and/or anxiety

Nilni et al. The impact of military sexual trauma and warfare exposure on women veterans' perinatal outcomes. *Psychol Trauma.* 2022;14:730-737.



# Severe Maternal Morbidity Among Active Duty Women

- Linked personnel and medical encounter data to identify a cohort of delivery hospitalizations among AD women from January 2003 through August 2015
- Applied 21- and 20-condition algorithms (with and without blood transfusion) developed by CDC to identify cases of severe maternal morbidity
- Found that from 2003–2015, AD women experienced an increase in severe maternal morbidity that followed national trends, despite protective factors such as stable employment and universal health care
  - Similar to other populations, military women of color were at higher risk for severe maternal morbidity relative to non-Hispanic White military women

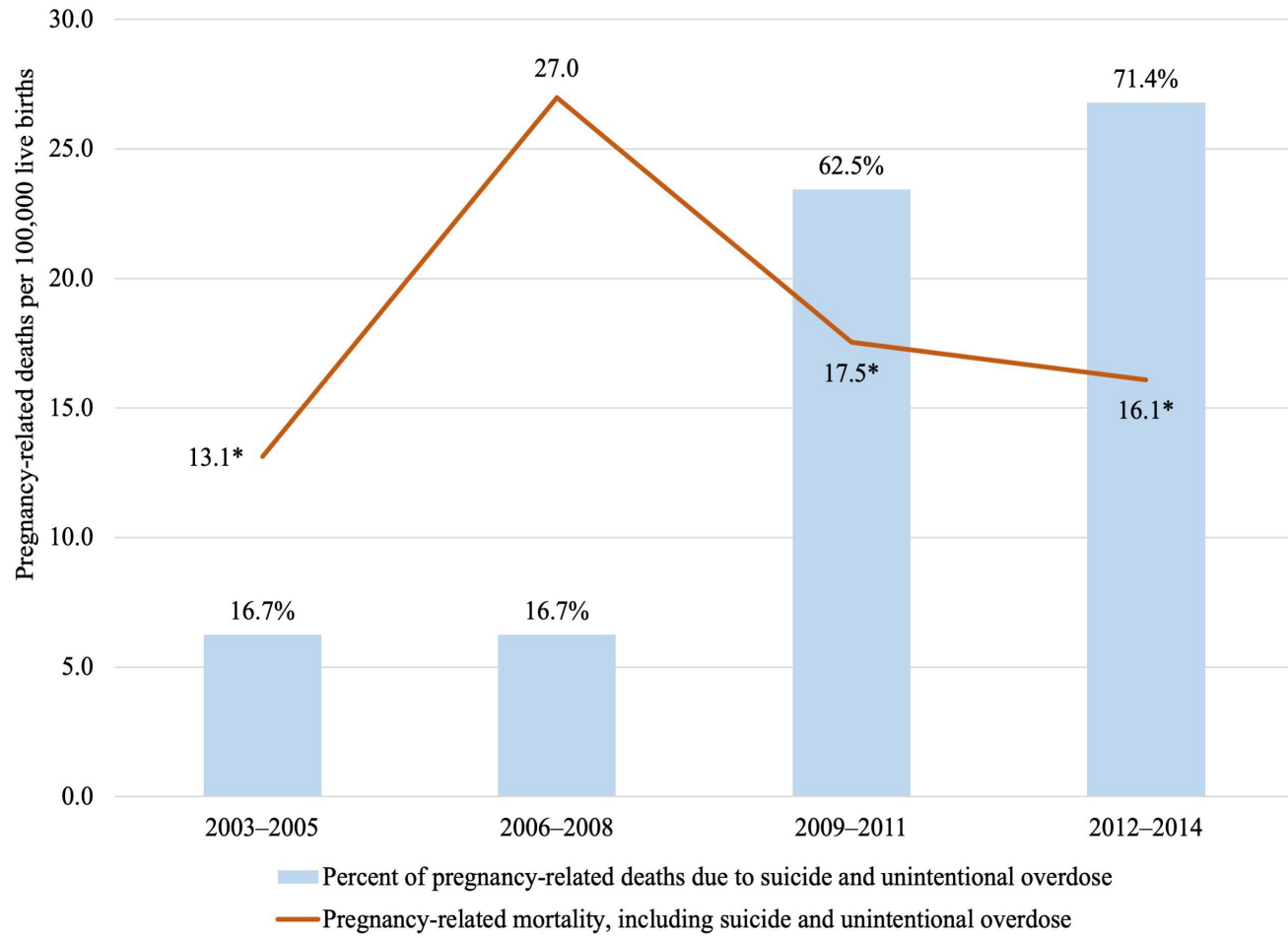


# Pregnancy Associated and Pregnancy-Related Maternal Deaths

- Linked pregnancy data to National Death Index Plus data from the Joint DoD/VA Suicide Data Repository
- Deaths were categorized as pregnancy-associated if the death occurred during pregnancy or  $\leq 1$  year after pregnancy end date, regardless of cause
  - Among these, deaths were categorized as pregnancy-related based on cause-of-death codes, medical encounter data, and medical records indicating a cause related to or aggravated by pregnancy



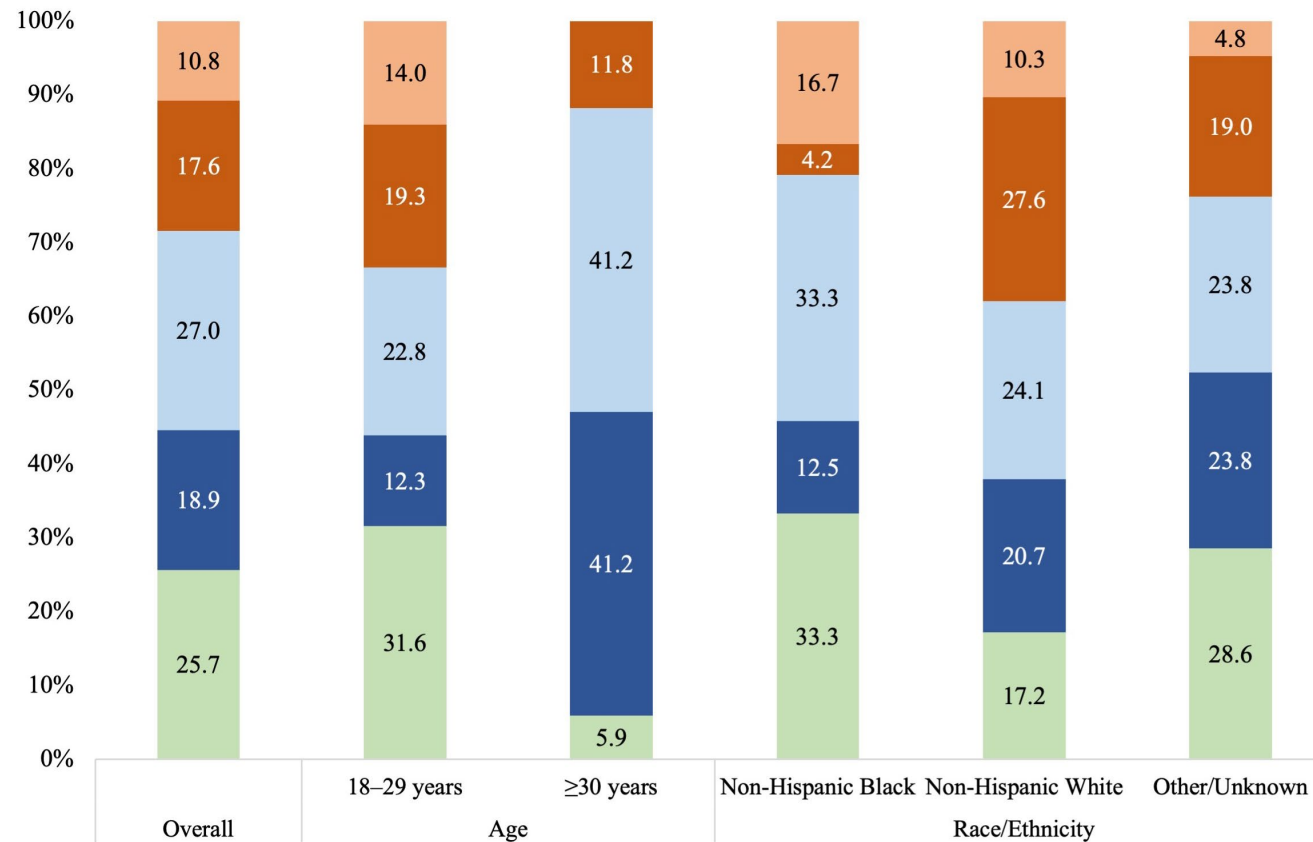
# Pregnancy Associated and Pregnancy-Related Maternal Deaths



\*Pregnancy-related mortality ratios with a relative standard error of 30-50%, indicating they might be unreliable.



# Pregnancy Associated and Pregnancy-Related Maternal Deaths



Causes of pregnancy-associated mortality, overall and by age and race/ethnicity, 2003-2014

- Assault and undetermined intent
- Suicide and unintentional overdose
- Other pregnancy-related mortality (excluding suicide and unintentional overdose)
- Other pregnancy-associated mortality (e.g., neoplasms, injuries)
- Transport accident





# Deployment-Specific Projects

- Health outcomes among offspring of US Coast Guard responders to the Deepwater Horizon oil spill, 2010–2011
  - Male sponsor exposure window was the 3 months before conception
  - Female sponsor exposure window spanned 3 months before date of last menstrual period through the infant's date of birth
  - Adverse health outcomes were generally comparable between infants born to male oil spill responders and non-responders; there was a suggestive risk for any poor live birth outcome among infants born to female spill responders



# Deployment-Specific Projects

- Birth defects in infants born in 1998–2004 to men and women serving in the US military during the 1990–1991 Gulf War era
  - Infants born to Gulf War I veterans 7–14 years after deployment were not at higher risk for having birth defects. Assessed parental in-theater exposures were not associated with a long-term higher prevalence of birth defects in this population of infants
- Birth outcomes among military personnel following exposure to documented open-air burn pits before and during pregnancy
  - Burn pit exposure at various times in relation to pregnancy and for differing durations was not consistently associated with an increase in birth defects or preterm birth in infants of AD military personnel



# Deployment-Specific Projects

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- Outcomes among pregnant women included in the Operation TOMODACHI Registry
- Health outcomes among infants born to women deployed to US military operations during pregnancy
- Maternal and infant safety of vaccines received during pregnancy
  - Military unique – anthrax, smallpox, yellow fever, Japanese encephalitis, typhoid\*
  - Others – influenza, Tdap, COVID-19
- Malaria prophylaxis (e.g., malarone, doxycycline)\*

\*These projects have proposals and/or collaborators, but lack funding



# Future Directions/Potential Collaborations

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- Long-term follow-up assessments of previous deployment-specific work, focused on women who went on to seek VA care
- Long-term outcomes following specific diagnoses in pregnancy (e.g., hypertension, gestational diabetes)
- Birth outcomes among retiree veterans
- Intergenerational study of BIHR infants who have now given birth to second generation BIHR infants



# Intergenerational Health Outcomes

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- More than 3,000 second generation infants born to women who are included in BIHR as infants (1998–2000)
  - ~ 400 born to AD women
  - ~ 1,100 born to dependent spouses
  - Remainder to dependent daughters without continued care



# Conclusions

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- Finding an appropriate balance between maintaining optimal operational readiness, while minimizing adverse exposures, among AD women is a difficult yet necessary task
- The BIHR program has the capability to:
  - Evaluate a broad range of reproductive health outcomes among service members and their families
  - Link with relevant military exposure data
  - Provide findings to help inform and direct policy development
- Future collaborative efforts have the potential to expand assessments through the military/veteran lifespan





# Acknowledgments

## ➤ The DoD Birth and Infant Health Research Team

Anna Bukowinski, MPH

Monica Burrell, MPH

Ava Marie Conlin, DO, MPH

Gia Gumbs, MPH

Clinton Hall, PhD

Zeina Khodr, PhD

Jackielyn Lanning, MPH

Sandra Magallon

Celeste Romano, MS

## ➤ Many DoD and civilian collaborators

## ➤ Funding sources

- US Navy Bureau of Medicine and Surgery (core funding ended with FY22)
- Defense Health Agency Immunization Healthcare Division
- MHS Research Collaborations with Dartmouth



Photo courtesy of U.S. Department of Defense from Defense.gov/Released



# Questions?

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**The DoD Birth and Infant Health Research Program**

**Naval Health Research Center**

**Military Population Health Directorate**

**Deployment Health Research Department**

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**Phone 619-553-9255**

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*This biennial report summarizes state-specific birth defects surveillance data, and includes complementary information from US military families for infants born 2014-2018.*

*The BIHR program began contributing to these reports for the NBDPN in 2003, with the first complete five-year increment of data (1998-2002) appearing in the 2005 publication. This sheet omits subsequent citations.*

Lutgendorf MA, Abramovitz LM, Bukowinski AT, Gumbs GR, Conlin AMS, Hall C. **Pregnancy and posttraumatic stress disorder: associations with infant outcomes and prenatal care utilization.** J Matern Fetal Neonatal Med. 2022;35(25):9053-9060. Epub 2021DEC09

*For pregnant Servicewomen with current posttraumatic stress disorder (PTSD), no associations with adverse infant outcomes were observed, and these women initiated prenatal care (PNC) earlier and had higher PNC utilization compared to pregnant Servicewomen without PTSD. Universal health care and utilization of PNC in this population may mitigate adverse pregnancy outcomes observed in other populations with PTSD.*

Hall C, Abramovitz LM, Bukowinski AT, Khodr ZG, Gumbs GR, Conlin AS. **Receipt of the tetanus, diphtheria, and acellular pertussis vaccine during pregnancy and risk for maternal acute respiratory infection within 6 months postpartum.** San Diego, CA: Naval Health Research Center, Technical Report 20-28.

*Tdap vaccine exposure during pregnancy was associated with a small, reduced risk for maternal acute respiratory infections (ARI) within 6 months postpartum. Results must be interpreted with caution because the Tdap vaccine does not confer immunity against all ARIs.*

Hall C, Romano CJ, Bukowinski AT, Gumbs GR, Dempsey KN, Poole AT, Conlin AMS, Lamb SV. **Severe maternal morbidity among women in the U.S. military, 2003-2015.** Am J Perinatol. 2021. (Online ahead of print)

*Active duty US military women experienced an increase in severe maternal morbidity from 2003 to 2015 that followed national trends, despite protective factors such as stable employment and universal health care. Similar to other populations, military women of color were at higher risk for severe maternal morbidity relative to non-Hispanic White military women.*

Romano CJ, Hall C, Khodr ZG, Bukowinski AT, Gumbs GR, Conlin AMS. **History of pandemic H1N1-containing influenza vaccination and risk for spontaneous abortion and birth defects.** Vaccine. 2021;39(44):6553-6562.

*Analyses did not find evidence to suggest differential risk for spontaneous abortion or birth defects by receipt of a boosting versus priming dose of pandemic H1N1-containing vaccine in pregnancy.*

Abramovitz LM, Lutgendorf MA, Bukowinski AT, Gumbs GR, Conlin AMS, Hall C. **Posttraumatic Stress Disorder in a Cohort of Pregnant Active Duty U.S. Military Servicewomen.** J Traumatic Stress. 2021;34(3):586-595.

*This descriptive study examined characteristics of US active duty military women associated with a PTSD diagnosis during pregnancy, 2007-2014. Compared with noncases, PTSD cases were more likely to be White non-Hispanic, unmarried, in the Army or Marine Corps, and to have previously deployed. Other demographic and occupational characteristics, comorbidities, and receipt of psychotropic medication differed substantially among PTSD cases and noncases in this large records-based study.*

Hall C, Khodr ZG, Chang RN, Bukowinski AT, Gumbs GR, Conlin AMS. **Safety of yellow fever vaccination in pregnancy: findings from a cohort of active duty US military women.** J Travel Med. 2020;27(6):1-8.

*Yellow fever vaccine exposure during preconception/pregnancy was generally not associated with any adverse outcomes in this study, though a tenuous association between preconception vaccine exposure and birth defects was observed in one sensitivity analysis.*

Bukowinski AT, Hall C, Chang RN, Gumbs GR, Conlin AMS. **Maternal and infant outcomes following exposure to quadrivalent human papillomavirus vaccine during pregnancy.** Vaccine. 2020;38(37):5933-5939.

*After adjustments, no positive associations were detected between inadvertent exposure to quadrivalent human papillomavirus (4vHPV) during pregnancy and any adverse pregnancy or infant outcomes. This further supports the literature demonstrating the safety of 4vHPV when inadvertently administered during pregnancy.*

Khodr ZG, Hall C, Chang RB, Bukowinski AT, Gumbs GR, Conlin AMS. **Japanese encephalitis vaccination in pregnancy among U.S. active duty military women.** Vaccine. 2020;38(29):4529-4535.

*Overall results provide reassuring findings for the safety of Japanese encephalitis (JE) vaccination in pregnancy. Higher counts of JE vaccine received in pregnancy yielded large yet non-statistically significant risk estimates for all outcomes, though likely driven by lack of pregnancy awareness.*

Hall C, Bukowinski AT, Jewell JA, Conlin AMS. **Infant health outcomes among offspring of male U.S. military divers.** Arch Environ Occup Health. 2020;75(7):431-434.

*In analyses including records from over 1 million live born infants, paternal occupational diving was not positively associated with any adverse infant outcome under study, suggesting that male divers in the US military are not occupationally exposed to reproductive hazards that adversely influence offspring infant health outcomes.*



Hall C, Bukowinski AT, McGill AL, You WB, Gumbs GR, Wells NY, Conlin AMS. **Racial Disparities in Prenatal Care Utilization and Infant Small for Gestational Age Among Active Duty US Military Women.** Maternal and Child Health Journal. 2020;24(7):885-893.

*Non-Hispanic Black military women had consistently worse prenatal care utilization and infant small for gestational age outcomes compared to their non-Hispanic White counterparts, suggesting that equal access to care does not eliminate racial disparities among active duty women. Research elucidating the etiology of these disparities is needed.*

Hall C, Abramovitz LM, Bukowinski AT, Ricker AA, Khodr ZG, Gumbs GR, Wells NY, Conlin AMS. **Safety of tetanus, diphtheria, and acellular pertussis vaccination among pregnant active duty U.S. military women.** Vaccine. 2020;38(8):1982-1988.

*Women who received the tetanus, diphtheria, and acellular pertussis (Tdap) vaccine during pregnancy did not demonstrate increased risks for adverse maternal, fetal, or infant outcomes, corroborating existing literature on safety of Tdap vaccine in pregnancy.*

Gutman JR, Hall C, Khodr ZG, Bukowinski AT, Gumbs GR, Conlin AMS, Wells NY, Tan KR. **Atovaquone-proguanil (AP) exposure in pregnancy and risk for adverse fetal and infant outcomes: A retrospective analysis.** Travel Medicine and Infectious Disease. 2019. Epub ahead of print.

*While definitive conclusions are not possible due to the small number of AP exposed pregnancies in this study, these data suggest further research of AP exposure in pregnancy and fetal loss is warranted.*

Rogers AE, Khodr ZG, Bukowinski AT, Conlin AMS, Faix DJ, Garcia SMS. **Postpartum Fitness and Body Mass Index Changes in Active Duty Navy Women.** Military Medicine. 2020;185(1-2):e227-e234.

*Among active duty Navy women, there was an increased odds of Physical Readiness Test (PRT) failures and lower PRT scores up to 2.5 years postpartum. Additional interventions may be needed to assist women in returning to pre-pregnancy fitness up to 1 year postpartum.*

Hall C, Bukowinski AT, Kramer KE, Conlin AMS. **Offspring Sex Ratio of Male Active Duty U.S. Navy Submariners, 2001–2015.** MSMR. 2019;26(6):2-5.

*This record-based analysis did not find an atypical offspring sex ratio among male submariners. Furthermore, no meaningful variation in offspring sex ratio by length of submarine or military service, nor by rating, was detected.*

Khodr ZG, Bukowinski AT, Hall C, Gumbs GR, Wells NY, Conlin AMS. **The Department of Defense Birth and Infant Health Research Program: Assessing the Reproductive Health of U.S. Active Duty Women.** Seminars in Reproductive Medicine. 2018;36(6):351-360. Epub 19APR19.

*This invited review article summarizes research findings of the BIHR program and outlines future directions. Topics discussed include potential reproductive health risk factors that may occur through military readiness, exposure to military-unique environments and occupations, and deployments.*

Conlin AMS, Bukowinski AT, Levine JA, Khodr ZG, Kaur N, Farrish SC, Sevick CJ. **A Follow-Up Comparative Safety Analysis of Pandemic H1N1 Vaccination During Pregnancy and Risk of Infant Birth Defects Among U.S. Military Mothers.** Vaccine. 2018;36(20):2855-2860.

*Comparable to our previous analyses assessing birth defects diagnosed at birth, these analyses, using a more refined definition and diagnoses through the first year of life, did not find a significant association between the pandemic H1N1 vaccination during pregnancy and birth defects, versus the seasonal influenza vaccine.*

Kaur N, Gumbs GR, Fontecha ML, Khodr ZG, Bukowinski AT, Snell KJ, Farrish SC, Conlin AMS. **Validating Obstructive Genitourinary Defects in an Environment of Potential Over-Diagnosing.** J Registry Manag. 2018;45(1):4-7.

*Findings show that updated methods for identifying obstructive genitourinary defects (OGD) by the NBDPN were needed to reduce capture of spontaneously-resolving cases. Using both diagnostic and procedure medical codes to identify OGD may create a more conservative definition for use in research versus surveillance efforts.*



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. 2017;24(11):39-49.

*This report includes data from 2003–2014 on infants among military families and pregnancies among active duty women. Rates of common adverse infant and pregnancy outcomes were comparable to or lower than those in the general US population.*

Khodr ZG, Bukowinski AT, Gumbs GR, Conlin AMS. **Tetanus, Diphtheria, and Acellular Pertussis Vaccination During Pregnancy and Reduced Risk of Infant Acute Respiratory Infections.** Vaccine. 2017;35(42):5603-5610.

*Maternal Tdap vaccination between 27-36 weeks of pregnancy was consistently protective against infant respiratory infection in the first 2 months of life, regardless of Tdap vaccination prior to pregnancy. These findings support current ACIP guidelines recommending Tdap vaccination in late pregnancy for every pregnancy.*

Conlin AMS, Sevick CJ, Gumbs GR, Khodr ZG, Bukowinski AT. **Safety of inadvertent anthrax vaccination during pregnancy: An analysis of birth defects in the U.S. military population, 2003-2010.** Vaccine. 2017;35(34):4414-4420.

*No strong associations between inadvertent Anthrax Vaccine Absorbed (AVA) vaccination during pregnancy and birth defects risk were observed.*

Ippolito AC, Seelig AD, Powell TM, Conlin AMS, Crum-Cianflone NF, Lemus H, Sevick CJ, LeardMann CA. **Risk Factors Associated with Miscarriage and Impaired Fecundity among United States Servicewomen during the Recent Conflicts in Iraq and Afghanistan.** Women's Health Issues 2017;27(3):356-365.  
epub: [http://www.whijournal.com/article/S1049-3867\(16\)30407-8/fulltext](http://www.whijournal.com/article/S1049-3867(16)30407-8/fulltext)

*Military deployments do not appear to increase risk for miscarriage and impaired fecundity among US servicewomen. More research is needed to better understand the potential risks associated with environmental exposures and specific types of combat exposures.*

Conlin AMS, Bukowinski AT, Gumbs GR. **Analysis of pregnancy and infant health outcomes among women in the National Smallpox Vaccine in Pregnancy Registry who received Anthrax Vaccine Absorbed.** Vaccine. 2015;33(36):4387-4390. Epub: <http://dx.doi.org/10.1016/j.vaccine.2015.05.054>.

*Rates of adverse pregnancy and infant health outcomes (including birth defects) among the AVA-exposed group were similar to or lower than expected when compared with reference rates and the AVA-unexposed population.*

Levine JA, Bukowinski AT, Sevick CJ, Mehlhaff KM, Conlin AMS. **Postpartum Depression and Timing of Spousal Military Deployment Relative to Pregnancy and Delivery.** Arch Gynecol Obstet. 2015;292(3):549-558.

*Military wives whose husbands were deployed at their child's delivery were more likely to develop postpartum depression than wives whose husbands were not deployed at this time. Those whose husbands returned from deployment before delivery, as well as those whose husbands left for deployment after delivery, were not more likely to develop postpartum depression.*

Gumbs GR, Keenan HT, Sevick CJ, Conlin AS, Lloyd DW, Runyan DK, Ryan MAK, Smith TC. **Infant Abusive Head Trauma in a Military Cohort.** Pediatrics. 2013;132(4):668-76.

*Risk factors and rates of abusive head trauma among military families are similar to civilian populations when applying a similar definition. Infants born preterm or with birth defects may have higher abuse risk.*

Conlin AS, Sevick CJ, Bukowinski AT, Crum-Cianflone NF. **Outcomes Among Pregnant Women Included in the Operation TOMODACHI Registry.** San Diego, CA: Naval Health Research Center, Technical Report 13-3C.

*Although analyses to date are reassuring and the radiation exposure levels have not approached levels associated with possible health effects to a developing fetus, additional efforts are planned.*

Conlin AS, Bukowinski AT, Sevick CJ, DeScisciolo C, Crum-Cianflone NF. **Safety of the Pandemic H1N1 Influenza Vaccine Among Pregnant U.S. Military Women and Their Newborns.** *Obstetrics & Gynecology.* 2013;121(3):511-518.

*This study did not identify adverse pregnancy or infant health outcomes associated with pandemic H1N1 vaccination during pregnancy, which should encourage increased use of these vaccines among pregnant women.*

Nguyen S, LeardMann CA, Smith B, Conlin AMS, Slymen DJ, Hooper TI, Ryan MAK, Smith TC, for the Millennium Cohort Study Team. **Is Military Deployment a Risk Factor for Maternal Depression?** *J Women's Health.* 2013;22(1):9-18.

*Military women who deployed with combat-like experiences after childbirth were at increased risk for maternal depression. The risk appeared primarily related to combat rather than childbirth-related experiences.*

Barrett JP, Sevick CJ, Conlin AS, Gumbs GR, Lee S, Martin DP, Smith TC. **Validating the Use of ICD-9-CM Codes to Evaluate Gestational Age and Birth Weight.** *J Registry Manag.* 2012;39(2):69-75.

*Electronically derived ICD-9-CM codes provide an accurate assessment of the gestational age and low birthweight recorded in birth medical records.*

Bukowinski AT, DeScisciolo C, Conlin AMS, Ryan MAK, Sevick CJ, Heller JM, Smith TC. **Birth defects in infants born in 1998-2004 to men and women serving in the US military during the 1990-1991 Gulf War era.** *Birth Defects Res A Clin Mol Teratol.* 2012;94(9):721-728.

*Infants born to Gulf War I Veterans 7-14 years after deployment were not at higher risk for having birth defects. Assessed parental in-theatre exposures were not associated with a long-term higher prevalence of birth defects in this population of infants.*

Conlin AS, DeScisciolo C, Sevick CJ, Bukowinski AT, Phillips CJ, Smith TC. **Birth Outcomes Among Military Personnel Following Exposure to Documented Open-Air Burn Pits Before and During Pregnancy.** *JOEM.* 2012;54(6):689-697.

*Burn pit exposure at various times in relation to pregnancy and for differing durations was not consistently associated with an increase in birth defects or preterm birth in infants of active-duty military personnel.*

Ryan MAK, Jacobson IG, Sevick CJ, Smith TC, Gumbs GR, Conlin AMS. **Health outcomes among infants born to women deployed to US military operations during pregnancy.** *Birth Defects Res A Clin Mol Teratol.* 2011;91(2):117-124.

*Findings indicate that infants born to women who inadvertently deployed to military operations during pregnancy were not at increased risk of adverse birth or infant health outcomes and highlight the need to study outcomes related to specific maternal exposures during deployment.*

Cranston MM, Ryan MAK, Smith TC, Sevick CJ, Brodine SK. **Hypothyroidism among military infants born in countries of varied iodine nutrition status.** *BMC Endocr Disord.* 2010;10:2.

*Findings indicate that hypothyroidism in military-dependent infants does not vary by birth location, but is associated with other risk factors, including preterm birth, civilian maternal status, and advanced maternal age.*

Endara SM, Ryan MAK, Sevick CJ, Conlin AMS, Macera CA, Smith TC. **Does acute maternal stress in pregnancy affect infant health outcomes? Examination of a large cohort of infants born after the terrorist attacks of September 11, 2001.** *BMC Public Health.* 2009;9:252.

*The findings from this large population-based study suggest that women who were pregnant during the terrorist attacks of September 11, 2001 had no increased risk of adverse infant health outcomes.*

Ryan MAK, Smith TC, Sevick C, Honner WK, Loach RA, Moore CA, Erickson DJ. **Birth defects among infants born to women who received anthrax vaccine in pregnancy.** *Am J Epidemiol.* 2008;168(4):434-42.

*This DoD/CDC collaboration investigated more than 115,000 infants born to military women of which 3000 were born to women who were inadvertently vaccinated against anthrax in early pregnancy. Birth defects were slightly*

*more prevalent among first trimester-exposed infants, but the association was neither strong nor consistently statistically significant.*

Bukowinski AT, Ryan MAK, Slymen DJ, Sevick CJ, Alcaraz JE, Smith TC. **Hemangiomas and associated congenital malformation in infants born to a large population-based sample.** Paediatr Perinat Epidemiol. 2008;22(6):520-9.

*Consistent with other literature, infants diagnosed with hemangiomas were more likely to be diagnosed with spina bifida, hydrocephalus, or anomalies of the female genitalia.*

Jacobson IG, Gumbs GR, Sevick C, Smith TC, Ryan MAK. **Smallpox Vaccination Is Not Associated With Infertility in a Healthy Young Adult Population.** Hum Vaccin. 2008;4(3):224-8.

*This study evaluated infertility diagnoses in a large population of healthy young adults in relation to prior smallpox vaccination. There was no association between smallpox vaccination and subsequent infertility diagnoses in either men or women.*

Ryan MAK, Gumbs GR, Conlin AS, Sevick CJ, Jacobson IG, Snell KJ, Spooner CN, Smith TC. **Evaluation of Preterm Births and Birth Defects in Liveborn Infants of US Military Women Who Received Smallpox Vaccine.** Birth Defects Res A Clin Mol Teratol. 2008;82(7):533-539.

*Findings indicate smallpox vaccine, when inadvertently administered to pregnant women, is not associated with preterm delivery or birth defects in liveborn infants.*

Ryan MAK, Lloyd DW, Conlin AMS, Gumbs GR, Keenan HT. **Evaluating the epidemiology of inflicted traumatic brain injury in infants of US military families.** Am J Prev Med. 2008;34(4S):S143–S147.

*This report describes a research protocol designed to assess the epidemiology of inflicted traumatic brain injury among infants born to US military families.*

Ryan MAK, Seward JF, for the National Smallpox Vaccine in Pregnancy Registry Team. **Pregnancy, birth, and infant health outcomes from the National Smallpox Vaccine in Pregnancy Registry, 2003–2006.** Clin Infect Dis. 2008;46:S221-S226.

*Women inadvertently exposed to the smallpox vaccine in pregnancy are not at higher risk for pregnancy loss, preterm birth, or having an infant with birth defects. To date, no cases of fetal vaccinia have been identified.*

Centers for Disease Control and Prevention. **Surveillance guidelines for smallpox vaccine (vaccinia) adverse reactions.** MMWR Recomm Rep. 2006;55(RR-1):1-16.

*DoD Birth and Infant Health Research (previously Registry) professionals contributed to these national surveillance guidelines.*

Napolitano PG, Ryan MAK, Grabenstein JD. **Pregnancy discovered after smallpox vaccination: is vaccinia immune globulin appropriate?** Am J Obstet Gynecol. 2004;191(6):1863-1867.

*Reviews of existing information and clinical guidelines are provided for healthcare practitioners and policymakers considering response to inadvertent smallpox vaccine exposure in pregnancy.*

Ryan MAK, Grabenstein JD, Broder K. **Women with smallpox vaccine exposure during pregnancy reported to the National Smallpox Vaccine in Pregnancy Registry - United States, 2003.** MMWR Morb Mortal Wkly Rep. 2003;52(17):386-8. Reprinted in Infectious Diseases in Children 2003;16(6):16.

*An early summary of findings from women inadvertently vaccinated against smallpox in pregnancy.*

Ryan MAK, Pershyn-Kisor MA, Honner WK, Smith TC, Reed RJ, Gray GC. **The Department of Defense Birth Defects Registry: overview of a new surveillance system.** Teratology. 2001;64(S1):S26-9.

*Describes the origins and methodology of the DoD Birth and Infant Health Registry.*

Bush RA, Smith TC, Honner WK, Gray GC. **Active surveillance of birth defects among US Department of Defense beneficiaries: a feasibility study.** Mil Med. 2001;166:179-83.

*There is good concurrence between passively and actively collected data used for birth defects surveillance.*

### **Significant Reports**

U.S. House and Senate Committees on Armed Services. **Second Report on Millennium Cohort Study Relating to Women of the Armed Forces** (in response to Section 748 of the National Defense Authorization Act for Fiscal Year 2020 [Public Law 116-92], Page 278). September 2021.

*This report meets a requirement for the Secretary of Defense to submit a report on "Millennium Cohort Study Relating to Women Members of the Armed Forces" to the U.S. Congressional Armed Services Committees. This second report describes findings of the Millennium Cohort Study (MCS) relating to the gynecological and perinatal health of female members of the Armed Forces enrolled in the MCS. The BIHR program contributed to the report providing frequencies for maternal, pregnancy, and infant health outcomes among women enrolled in the MCS between 2001 and 2013 with a pregnancy (n=14,363), as well as outcomes in the larger BIHR population (n=150,021) of active duty women with a pregnancy captured in BIHR (2003-2105). In this report, the BIHR program addressed severe maternal morbidity, birth defects, low birth weight, preterm birth, miscarriage, gestational diabetes, and preeclampsia.*

U.S. House and Senate Committees on Armed Services. **Initial Report on Millennium Cohort Study Relating to Women of the Armed Forces** (in response to Section 748 of the National Defense Authorization Act for Fiscal Year 2020 [Public Law 116-92], Page 278). July 2020.

*This report meets a requirement for the Secretary of Defense to submit a report on "Millennium Cohort Study Relating to Women Members of the Armed Forces" to the U.S. Congressional Armed Services Committees. This initial report describes findings of the MCS relating to the gynecological and perinatal health of female members of the Armed Forces enrolled in the MCS. In this initial report, previously published findings from the BIHR program were reviewed to provide context on work already completed on assessments of the reproductive health of military women and their offspring.*

### **RESEARCH TEAM:**

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