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Deployment, Post-Traumatic Stress Disorder and Hypertensive Disorders of Pregnancy among U.S. Active-Duty Military Women

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Deployment, Post-Traumatic Stress Disorder and Hypertensive Disorders of Pregnancy among U.S. Active-Duty Military Women

by

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TABLE OF CONTENTS

List of Tables iii

List of Figures vi

Abstract vii

Chapter 1: Introduction 1

Chapter 2: Literature Review 4
- Hypertensive Disorders of Pregnancy 4
- Deployment and Adverse Birth Outcomes 6
- Deployment Characteristics and Perinatal Health 8
- Post-Traumatic Stress Disorder (PTSD) 10

Chapter 3: Methods 18
- Overview of Study Population 18
- Outcome Definition 20
- Analysis Dataset Merge 21
- Potential Confounders and Covariates 22
- Specific Aim 1 Deployment Measures 23
  - Deployment Definition 23
  - Previous Research 24
  - Deployment Measures 24
  - Statistical Modeling 25
    - Sub-Analysis: Stratification by Race 26
    - Sub-Analysis: HDP Types 26
    - Sub-Analysis: Timing of Conception 26
    - Sub-Analysis: Military Entry Timing 27
- Specific Aim 2 Deployment Exposures 27
  - Deployment Measures 27
  - Statistical Methods 28
- Specific Aim 3 PTSD Exposures 29
  - Exposure Definition 29
    - Mini-Sensitivity Analysis 31
  - Statistical Modeling 32
    - Analysis 1: Overall Cohort 32
      - Sub-Analysis: Effect Modification by Deployment 32
      - Sub-Analysis: Stratification by Race 32
      - Sub-Analysis: HDP Types 32
    - Analysis 2: PDHA Mothers 33
      - Sub-Analysis: Stratification by Race 33
      - Sub-Analysis: HDP Types 33
      - Sub-Analysis: Timing of Conception 33

Sub-Analysis: Pre-Post Comparison 33
Sub-Analysis: PDHRA Mothers Only 34

Chapter 4: Results 35
Overall Cohort 35
Specific Aim 1 Deployment 36
Descriptive Characteristics 36
Overall Findings 37
Racial/Ethnic Findings 38
Other Sub-Analysis Findings 39
Specific Aim 2 Classification Trees 40
Descriptive Characteristics 40
Classification Tree Findings 40
Specific Aim 3 PTSD 41
Descriptive Characteristics: PTSD among the Entire Cohort 41
Descriptive Characteristics: PDHA Mothers 41
Descriptive Characteristics: PTSD among PDHA Mothers 42
Overall Findings 43
Overall Sub-Analysis Findings 44
Overall Findings: PDHA Mothers 44
Racial/Ethnic Findings: PDHA Mothers 45
HDP Sub-Type Findings: PDHA Mothers 46
PDHRA Agreement Sub-Analysis Findings: PDHA Mothers 46
Timing of Conception Sub-Analysis Findings: Entire Cohort and PDHA Mothers 47

Chapter 5: Discussion, Conclusions, and Recommendations 72
Deployment and HDP 72
PTSD and HDP 75
Overall Strengths and Weaknesses 79
Conclusions and Future Research 80

Chapter 6: References 81

Appendix 1: ICD-9-CM Codes Used to Define Variables in the Methods Section 88

Appendix 2: Main Terms and Variable Definitions Used in the Methods Section 90

Appendix 3: Supplemental Tables for Results Section 95

Appendix 4: USF IRB Letter for the Current Study 108

About the Author End Page

LIST OF TABLES

Table 1. PTSD-Specific Question on the PDHA/PDHRA according to DSM Criteria. 16

Table 2. Frequency of Main Exposures and Covariates for the Entire Cohort, n=36,6575. 48

Table 3. Frequency of Main Exposures and Covariates by HDP Status for the Entire Cohort, n=36,675. 49

Table 4. Frequency of HDP Sub-types Overall and by Race, Entire Cohort. 50

Table 5. Frequency of Main Exposures and Covariates, Specific Aim 1. 51

Table 6. Frequency of Main Deployment Exposures and Covariates by HDP Status, Specific Aim 1. 53

Table 7. Odds-ratios and 95% Confidence Intervals for Overall Deployment Measures and HDP, Specific Aim 1. 55

Table 8. Odds-ratios and 95% Confidence Intervals for Overall Deployment Measures and HDP by Racial Category, Specific Aim 1. 56

Table 9. Frequency of Main Exposures and Covariates by HDP Status for Deployed Women Only, Specific Aim 2. 57

Table 10. Odds-ratio and 95% Confidence Intervals for Categorized Cumulative Weeks of Deployment among Deployed Women Only, Specific Aim 2, n=11,685. 59

Table 11. Frequency of PTSD Exposures for the Entire Cohort, Specific Aim 3, n=36,675. 60

Table 12. Frequency of PTSD Exposures by HDP Status for the Entire Cohort, Specific Aim 3, n=36,675. 61

Table 13. Frequency of Main Exposures and Covariates for PDHA Mothers Only, Specific Aim 3, n=8,801. 62

Table 14. Frequency of Main Exposures and Covariates by HDP Status for PDHA Mothers Only, Specific Aim 3, n=8,801. 64

Table 15. Frequency of HDP Sub-types Overall and by Race, PDHA Mothers Only, Specific Aim 3. 66

Table 16. Frequency of PTSD for PDHA Mothers Only, Specific Aim 3, n=8,801. 67

Table 17. Frequency of PTSD by HDP Status for PDHA Mothers Only, Specific Aim 3, n=8,801. 68

Table 18. Odds-ratio and 95% Confidence Intervals for PTSD, Entire Cohort, Specific Aim 3, n=35,897. 69

Table 19. Odds-ratio and 95% Confidence Intervals for PTSD and HDP, Case-Definition Based on Screening among PDHA Mothers Only, Specific Aim 3. 70

Table 20. Odds-ratio and 95% Confidence Intervals for PTSD Diagnosis Relative to Timing of Conception and HDP, Specific Aim 3. 71

Table A1.1. ICD-9-CM Procedure Codes for Live-Born Singleton Infants. 88

Table A1.2. ICD-9-CM Diagnosis Codes for HDP. 88

Table A1.3. ICD-9-CM Diagnosis Codes for Pre-Gestational Diabetes. 88

Table A1.4. ICD-9-CM Diagnosis Codes for Gestational Age. 89

Table A2.1. Outcome Definition for Study. 90

Table A2.2. Aim 1: Main Terms and Variable Definitions. 90

Table A2.3. Aim 2: Main Terms and Variable Definitions. 91

Table A2.4. Aim 3: Main Terms and Variable Definitions. 92

Table A2.5. Additional Covariates: Main Terms and Variable Definitions. 93

Table A3.1. Odds-ratio and 95% Confidence Intervals for Deployed vs. Non-Deployed, HDP Sub-Types. 95

Table A3.2. Odds-ratio and 95% Confidence Intervals for Timing of Deployment End Relative to Birth, HDP Sub-Types. 96

Table A3.3. Odds-ratio and 95% Confidence Intervals for Cumulative Weeks of Deployment among Deployed Women Only, HDP Sub-Types. 98

Table A3.4. Frequency of Main Exposures and Covariates by HDP Status for PDHA Moms Missing PTSD/Probable Responses Only. 100

Table A3.5. Odds-ratio and 95% Confidence Intervals for Any PTSD vs. None, Racial Groups. 103

Table A3.6. Odds-ratio and 95% Confidence Intervals for Any PTSD and HDP Sub-Types, Entire Cohort. 104

Table A3.7. Odds-ratio and 95% Confidence Intervals for PTSD and HDP, Case-Definition Based on Screening among PDHRA Moms Only. 105

Table A3.8. Odds-ratio and 95% Confidence Intervals for PTSD and HDP Sub-types, Case-Definition Based on Screening among PDHA Moms Only. 106

Table A3.9. Odds-ratio and 95% Confidence Intervals for Pre-Post Agreement Between PDHA and PDHRA PTSD Screening and HDP. 107

LIST OF FIGURES

Figure 1. DSM-V Criteria and Symptoms for PTSD. 11

Figure 2. Classification Tree for Cumulative Weeks of Deployment by Maternal Age. 58

ABSTRACT

Introduction. Today women comprise 15% of the U.S. active-duty military, but are often overlooked in research of the Armed Forces. While some of the challenges faced by women are similar to men, they encounter unique stressors related to childcare while deployed, sexual harassment and assault, and gynecological needs. Women are also more likely than men to develop post-traumatic stress disorder (PTSD). Both stress and PTSD have been linked to the development of chronic hypertension and some adverse birth outcomes. We hypothesized that post-9/11/2001 era military women who deployed or who had indicators of PTSD would be at greater risk of developing a hypertensive disorder of pregnancy (HDP) than non-deployed or non-PTSD military women.

Methods. We conducted a retrospective cohort study using a U.S. Department of Defense database comprised of all active-duty women who gave birth to their first, live-born singleton infant using Tricare from January 1, 2004 to December 31, 2008. The database included maternal and infant birth hospitalization records, maternal mental health visits, and post-9/11/2001 deployment information which included Post-Deployment Health Assessment (PDHA) and Reassessment (PDHRA) screening responses. HDP was defined with ICD-9-CM codes in the maternal birth hospitalization record. We evaluated the risk of HDP associated with overall deployment and timing of deployment ending compared to non-deployed women, in addition to cumulative months of deployment. We also conducted Classification Tree Analysis (CART) to determine appropriate cut-points for categorization of deployment variables among mothers who deployed: cumulative weeks of deployment, percent of study time spent deployed, and dwell time between two most recent pre-birth deployments. We explored effect modification by covariates postulated to potentially modify the relationship between deployment history and

risk of HDP. New variables were defined and used in multivariable logistic regression models for each deployment measure. Women fit into four PTSD case-definition categories: confirmed (ICD-9-CM diagnosis), probable (possible plus endorsement of "high risk" items on the PDHA), possible (endorsement of ≥3 PTSD items on the PDHA), or none (no PTSD indicators). We compared mothers with PTSD to non-cases using multivariable logistic regression to quantify the risk of HDP, and repeated the analyses using a ≥2 PTSD item endorsement case-definition criteria. All logistic regression models were adjusted for known confounders and important covariates.

Results. There were a total of 36,675 births, 13.4% of mothers experienced at least one HDP, and 35% of mothers deployed. No increased risk of HDP was observed for deployment overall (OR=1.02, 95% CI: 0.95-1.09), but black mothers who deployed were 13% more likely to develop an HDP (OR=1.13, 95% CI: 1.00-1.27). CART revealed an important cut-point for cumulative deployment length of ≥1 year, which was statistically significant among mothers <35 years old. Mothers with ≥1 year cumulative deployment were 17% more likely to have an HDP than mothers deployed <1 year (OR=1.17, 95% CI: 1.01-1.36). The prevalence of confirmed PTSD was 1.6% in the overall cohort. The prevalence of any PTSD among deployed mothers who completed a PDHA was 6.2%. Overall, PTSD was not significantly associated with HDP except among probable PTSD cases using the ≥2 item criteria (OR=1.30, 95% CI: 1.01-1.67) and among confirmed PTSD mothers identifying as "other" race (OR=6.62, 95% CI: 1.72-25.47).

Conclusion. Results are suggestive of an elevated risk of HDP among the military population among women who deployed for a year or longer and for black mothers. Although PTSD did not clearly confer additional risk in the overall cohort, there is evidence to support further research using more thorough screening especially across racial/ethnic groups. Our study likely underestimated PTSD and possibly attenuated results since individuals may purposely report inaccurately on the PDHA in order to go home sooner after deployment. Future studies should

include information related to deployment-specific experiences and screen all participants for evidence of PTSD.

CHAPTER 1
Introduction

Today women comprise 15% of the United States (U.S.) active-duty military,[1] and the responsibilities of female military personnel are expected to shift since the Department of Defense (DOD) opened all military positions to women in 2016.[2] It is possible that the burden of women developing long-term health consequences similar to men after combat will increase, including PTSD. PTSD is a condition that develops in certain individuals after experiencing or witnessing a traumatic event.[3] Symptoms can include intense flashbacks and social/emotional distancing that dramatically interferes with an individual's daily activities.[3] While the incidence is estimated to be approximately nine cases per 1,000 veterans (both sexes),[4] a 2011 survey revealed that 42% of women and 35% of male veterans believed they experienced some symptoms of PTSD after military service.[5] Psychological trauma can dysregulate stress response systems,[6] and has been linked to chronic conditions such as cardiovascular disease[7,8] in addition to certain adverse birth outcomes.[9] Women are more likely to develop PTSD after a traumatic event than men.[10] With the growing proportion of females in the Armed Forces, their increasing likelihood of exposure to intense acts of war, and their unique medical and physical needs, PTSD has the potential to place an economic burden on both the U.S. military and civilian health care systems.

Hypertensive disorders of pregnancy (HDP) are an increasingly important cause of maternal morbidity and mortality in the U.S., accounting for 16% of all perinatal-related deaths.[11] Research in the general population suggests women experience greater risk of HDP following

chronic stress,[12] but the relationship has not been thoroughly explored among the military. Civilian epidemiologic studies of psychosocial stress reveal a higher chance of developing HDP among mothers reporting the most life strain prior to or during pregnancy.[13-15] Other research examining birth outcomes following traumatic events (i.e. 9/11/2001, Hurricane Katrina) experienced by civilian mothers indicate an increased risk of low birth weight (LBW), preterm birth (PTB), and other adverse outcomes among the mothers with positive screening indicators of PTSD.[16-18] However, few of these studies included HDP. No analytical epidemiologic studies have been conducted examining the impact of PTSD on HDP risk among active-duty military mothers, but it has been shown that female service member veterans encounter a greater prevalence of HDP despite lower obesity rates than the general population.[19,20] Overall the findings remain inconsistent due to differing methodologies. Since active-duty women face a higher likelihood of encountering extremely distressing experiences and HDP can result in excess maternal mortality, it is imperative to understand the role of trauma in the development of HDP among the growing female military population.

The overall objective of this project was to determine HDP risk among female military personnel who gave birth between 2004 and 2008. We hypothesized that the likelihood of HDP would be higher among active-duty women with certain deployment characteristics or PTSD compared to active-duty women without these experiences. To test our central hypothesis, we pursued these *specific aims*:

1. ***Identify the effect of deployment to the Middle East between 2001 and 2008 on HDP incidence among active-duty women who gave birth, adjusted for known confounders.***

   Hypothesis: Deployment, timing of its ending relative to birth, and cumulative deployment length will impact HDP incidence compared to non-deployed women or women with the shortest cumulative deployment length.

2. ***Explore which pre-birth dwell times (months off between deployments) and deployment durations are associated with the greatest risk of HDP among women deployed between 2001 and 2008 and who subsequently gave birth.***

   Approach: We will identify 1) the cumulative number of deployed months, 2) the percent of study time spent deployed, 3) the number of weeks dwell time between the last two pre-birth deployments, and, 4) the ratio between the duration of the earlier two most recent deployments and dwell time afterwards that are associated with the greatest risk of HDP.

3. ***Evaluate the association between PTSD and HDP among active-duty women deployed to the Middle East between 2003 and 2008, who subsequently gave birth adjusted for known confounders.***

   Hypothesis: Women diagnosed with confirmed PTSD or who screen positive on post-deployment health assessments prior to birth will experience a greater risk of HDP compared to women with no PTSD indicators.

CHAPTER 2
Literature Review

Hypertensive Disorders of Pregnancy

Between 5-10% of pregnancies are impacted by HDP yearly, and the condition is responsible for 16% of maternal deaths in developed countries. This figure reaches nearly 25% in some less developed areas of the world where ability to treat the condition is lacking. The incidence of all HDP has increased in the U.S. over recent years, likely due to the increase in obesity and older maternal age at birth. The biological pathways associated with HDP are not well understood, but are necessary to understand since mothers who experience HDP are at increased risk of cardiovascular disease later in life.[21] Four different conditions comprise HDP: 1) chronic hypertension (systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg diagnosed before 20 weeks gestation or diagnosed after 20 weeks gestation and persisting >12 weeks postpartum), 2) gestational hypertension (systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg diagnosed before 20 weeks gestation that resolves ≤12 weeks postpartum), 3) preeclampsia (systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg diagnosed after 20 weeks gestation with proteinuria) and, 4) preeclampsia superimposed on chronic hypertension.[22] Preeclampsia is the most severe manifestation, effecting about 3% of pregnancies in the U.S. each year. With improved early identification through screening, the rates of eclampsia decreased substantially in the U.S. during the 20th century. Established HDP risk factors include family history of preeclampsia, primiparity, preeclampsia in a previous pregnancy, multiple gestation, maternal obesity, older

maternal age, maternal race, and pre-gestational diabetes.[21,23] Maternal stress has also been hypothesized to contribute to HDP development.

When the brain perceives a stimulus as potentially threatening, the hypothalamic-pituitary-adrenal (HPA) axis is activated by releasing corticotropin-releasing hormone and arginine-vasopressin by the hypothalamus. These signal the pituitary gland to release cortisol and vasopressin (ADH) while the adrenal glands are signaled to release epinephrine. ADH controls the amount of water that the kidneys retain in addition to having a role in blood pressure regulation. When it is released as part of the normal physiological response to stress, it constricts the blood vessels to increase blood pressure. The response is beneficial in acute situations; however, chronic health complications arise in the presence of ongoing stressors when the HPA axis remains activated.[24,25] Continued exposure to stress has been shown to increase the risk of cardiovascular diseases,[26] gastrointestinal conditions, and Type II diabetes,[27] and a growing body of epidemiologic literature also reveals increased risk of LBW, PTB, and HDP following exposure to traumatic events or chronic stressors prior to or during pregnancy.[9]

A multitude of situations and events encountered in daily life can act as stressful stimuli that activate the HPA axis. For example, Walker et al.[28] reported that pregnant women who later developed HDP had higher mean increase in blood pressure on days that they worked compared to working mothers who did not develop an HDP, but they did not explore perceived job strain. Loss of a close relative between six months prior to conception to 12 weeks gestation resulted in a statistically significant increased risk of pre-eclampsia among Swedish mothers,[13] while an Amsterdam study found a statistically non-significant elevated risk of HDP among mothers self-reporting the highest levels of work stress before 24 weeks gestation.[15] Non-response bias might explain their findings, as the most stressed mothers may have failed

to return their surveys. Other single studies reported positive associations with HDP,[14,29-31] with one being statistically non-significant.[32] Each study used a different method of defining stress, in addition to differing exposure windows. Two authors completed pooled analyses using some of these studies. Katz et al.[33] included 161,000 pregnant women and found that physically stressful work was associated with a 60% increased risk of HDP (95% CI: 1.3-1.96). A larger pooled analysis also revealed a positive association between mental stress (OR=1.26, 95% CI: 1.0-1.59) and work stress (OR=1.40, 95% CI: 1.09-1.80) and HDP.[12] The latter analysis included more heterogeneous studies than the former which could explain the differing magnitudes of association.

Deployment and Adverse Birth Outcomes

Deployment of active-duty military personnel to war zones poses unique medical and social challenges. Both the service member and their families encounter emotional hurdles at each stage of deployment: preparing for separation prior to, worrying about the others' safety during, and facing possible reintegration issues post-deployment.[34] Many of these issues are gender neutral, but women experience specific difficulties surrounding their reproductive needs during and after deployment that must be addressed. For example, the reality of sexual assault faced by women in conjunction with military service is beginning to be recognized publicly. Individuals serving in active war zones are barred from having sexual relations due to the possibility of pregnancy and threats to morale; however, women are commonly subjected to sexual harassment and sexual abuse while deployed despite this rule. In a 2014 DOD survey conducted by the RAND Corporation of the military workforce, just under 5% of active-duty women reported sexual assault in the preceding year.[35] In a more recent 2017 survey of 1,339 women who were in the military during Operation Enduring Freedom (OEF)/Operation Iraqi Freedom (OIF), 16% of participants reported being the victim of attempted or completed sexual assault during their service time. Interestingly, sexual assault in a non-deployment setting was

associated with unethical behaviors demonstrated by leadership, and it is expected that similar patterns exist to facilitate assaults in deployed situations.[36] Unintended pregnancies do result from this type of abuse, in addition to serious emotional disturbances requiring mental health services post-deployment. Although the number of women conceiving during deployment is estimated to be 10%,[37] the female active-duty population has a birth rate comparable to civilians.[38] Unfortunately, war zones encompass an endless variety of mild to severe stressors with the potential to effect a service woman's future health. It is therefore necessary to understand their impact on pregnancy outcomes in this population.

Few studies on the impact of stress and adverse birth outcomes have included the military population directly, and only one has examined HDP as an outcome. Endara et al.[39] examined PTB, LBW, and birth defects among military infants who were in utero during the 9/11/2001 terrorist attacks compared to infants in utero during the same time in 2000. The authors reported null findings, but the results included births to both active-duty women and spouses of active-duty men. A study of births to enlisted U.S. Navy mothers between 1987 and 1989 reported no significant difference in incidence of HDP across jobs regardless of the position's ranked risk, but deployment status was not assessed.[40] It is unknown if this trend is consistent across military branches or with current wartime conditions experienced by active-duty women. In a recent exploratory analysis of post-9/11/2001 veterans who used Veteran's Health Administration (VHA) maternity benefits, Katon et al.[19] found that compared to general population births in the Nationwide Inpatient Sample, veterans were more likely to develop HDP (SIR=1.32, 95% CI: 1.15-1.51).

Araneta et al.[41] investigated the risk of miscarriage, ectopic pregnancy, and stillbirth among 3,825 women who were active-duty in the U.S. military in 1991. They compared women who conceived during deployment or after returning home from the Gulf War to women who never

deployed. Their only statistically significant findings showed that women conceiving post-deployment were more likely to have a miscarriage (OR=2.90, 95% CI: 1.86-4.53) or ectopic pregnancy (OR=7.35, 95% CI: 2.97-18.2) than non-deployers. Individual-level deployment data was not available and self-reported dates of deployment were obtained through survey in 1998, potentially leading to misclassification of the conception period. Two other studies by the same author investigated the risk of birth defects among active-duty Gulf War veterans in several U.S. states. Overall, they only reported one significant finding among female veterans for hypospadias (OR=6.3, 95% CI: 1.5-26.3), but used non-deployed veterans as the comparison group and did not adjust for multiple comparisons.[42,43] In a study examining births to military mothers deployed during the first trimester post-9/11/2001, Ryan et al.[44] did not find any statistically significant association between deployment and adverse birth outcomes, but they did report that women in the Navy (OR=1.32, 95% CI: 1.10-1.58) and Reserves (OR=1.71, 95% CI: 1.23-2.37) were at increased risk of having infants with birth defects compared to mothers in other branches. Four additional studies have explored the risk of birth defects among women deployed in the Gulf War or post-9/11 OEF/OIF, and none reported a significant association.[45-48] However, two limited exposure to burn pits only, which does not fully define the full range of stressors someone faces in theater. Additional analytical epidemiologic studies are needed to clarify the risks associated with deployment overall, and especially in the etiology of HDP.

Deployment Characteristics and Perinatal Health

While stressful experiences during deployment necessitate investigation, so do certain deployment characteristics hypothesized to impact health. Dwell time is defined as the interval military personnel spend at their home assignment between the end of one deployment and the beginning of the next. For example, the Army's goal is to have service personnel spend twice as much time at home than their deployment lasted, for a dwell time ratio between deployment and home time of 1:2. This means that an individual who deployed for one year should spend

two years at home before deploying again.[49] Although some policy exists regarding suggested dwell times, the epidemiologic literature is incomplete and contradictory on what is considered a healthy dwell time.[50] While it seems intuitive that longer dwell times are preferred for optimal health, some have purported that military personnel with longer breaks between deployments have more time to adjust to their normal lives and can experience increased stress transitioning back to deployed status compared to individuals with shorter breaks.

In an analysis of 1.3 million U.S. military personnel deployed between October 1, 2001 and December, 31, 2010, the percent of men and women diagnosed with PTSD increased as dwell times increased compared to breaks of less than six months; however, the trend was not linear. For individuals completing their second deployment, the riskiest dwell time was 12-18 months (RR=1.81), with a slightly lower risk for 18 or more months (RR=1.75) compared to <6 months. The trend held for each deployment through the fifth. The authors did not examine deployment to dwell time ratios.[51] Macgregor et al. conducted two analyses of U.S. Marines who deployed between January 2003 and December 2007 (n=65,704),[52] and between January 2005 and December 2008 (n=3,512).[53] In the larger study, the authors reported that individuals with the longest dwell time relative to deployment were protected against provider-diagnosed PTSD, and the result was statistically significant (dwell-to-deployment ratio 2:1 vs. <1:1, OR=0.47, 95% CI: 0.32-0.70). They reported similar results in the smaller study, but they did not reach statistical significance. A July 2012 U.S. Military Medical Surveillance Monthly Report of post-deployment women's health reported no association between dwell times and any medical complaint; however, no data was shown. They further showed that PTSD was associated with deployments lasting more than nine months compared to shorter ones ending by month four (OR=1.73, 95% CI: 1.50-2.00 for 9-12 months duration and OR=2.24, 95% CI: 1.95-2.57 for >12 months duration).[54] Bleier et al. reported similar findings among the Australian military, with individuals deployed 8-10 months during the previous three years at greatest risk of PTSD

(OR=1.6, 95% CI: 1.1-2.2) or any self-reported condition (OR=1.3, 95% CI: 1.0-1.8). They also found that deploying once (OR=1.4, 95% CI: 1.1-1.9) or at least twice (OR=2.1, 95% CI: 1.5-2.8) resulted in greater risk of screening positive for PTSD or any self-reported health condition. However, this study suffered from severe limitations with a response rate of approximately 45%, and deployment data unavailable for >50% of respondents.[55] No studies examining the impact of dwell times and/or deployment duration on perinatal health were located, leaving an important gap in our current understanding of military reproductive health.

Post-Traumatic Stress Disorder (PTSD)

Most individuals demonstrate resiliency to acute stressors and return to a normal state after processing the traumatic event; however, some individuals exposed to particularly traumatic events progress to develop PTSD. This disorder is characterized by four major symptom criteria that last one month or more: 1) Intrusion; 2) Avoidance; 3) Negative Cognition/Mood; and, 4) Hyperarousal. Intrusion symptoms can include persistent negative memories, nightmares or repeated negative dreams, flashbacks, and upset after exposure to stimuli representative of or directly related to the event. Avoidance is characterized by withdrawal from people or situations that might trigger memories, even if they are activities the individual once enjoyed. On-going negative emotions related to the event, including self-blame, distrust, and ability only to feel negative emotions are indicative of the Negative Cognition/Mood criteria. Hyperarousal behaviors tend to manifest as excitability, the inability to sleep or concentrate, and aggressive outbursts. Figure 1 illustrates the criteria groups.

Symptoms typically appear within three months of the traumatic event, and about 50% of cases recover three months after onset. However, chronic PTSD can develop with symptoms reappearing multiple times across the lifespan in response to reminders of the traumatic event or other intense life stressors. Not all stressors are serious enough to cause this disorder.[56]

Experiencing or witnessing potentially life-threatening events such as sexual assault, natural disasters, motor vehicle accidents, violent death, or combat increases the risk of subsequent

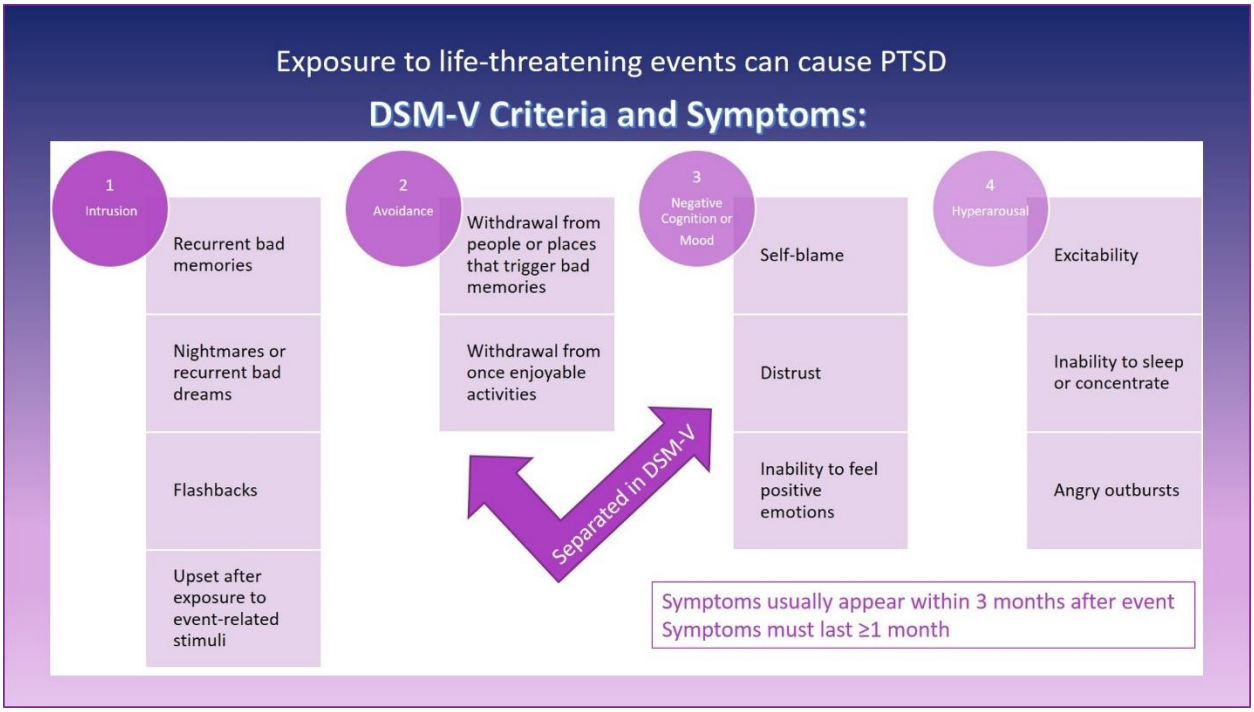

Figure 1. DSM-V Criteria and Symptoms for PTSD.

PTSD.[57] The scenarios encountered by the military population are all included as part of the diagnostic criteria in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), and being a perpetrator, witnessing atrocities, and killing enemies are specifically mentioned as risk factors for military personnel.[56]

The lifetime prevalence of PTSD in the general population is approximately 8% based on results from the U.S. National Comorbidity Survey, but women reported PTSD twice as often as men (10.4% vs. 5.0%).[58] The prevalence of PTSD among service personnel from OEF and OIF is slightly higher than the general population at 14%.[58] Overall, exposure to life-threatening

events while deployed is most likely to lead to PTSD, while sexual assault, being threatened with a weapon,[59] and working in the health care field[51] results in the most cases among women.

Only 11 epidemiologic studies exploring the impact of PTSD on adverse birth outcomes were located; however, 10 were among the general population and none included HDP. The most common conditions studied were PTB, LBW, intrauterine growth restriction (IUGR), and birth defects. Overall, six studies reported a statistically significant association between PTSD and certain adverse birth outcomes (head circumference, PTB, LBW, ectopic pregnancy, miscarriage and hyperemesis).[16,60-64] Small sample size with few PTSD cases in the non-significant studies substantially reduced their power, in addition to methodologic differences that limit the validity and comparability of their findings.[65-69] There was also inconsistent timing of exposure across the studies ranging from pre-conception to any trimester of pregnancy. It is important to understand how the timing of exposure impacts birth outcomes, and we lack this information with the state of the current literature. Some studies may even suffer from reverse causality. All studies intended to capture pre-birth PTSD as an exposure leading to an adverse birth outcome; however, a few conducted PTSD interviews related to the event after birth. If a mother experienced a particularly difficult pregnancy related to HDP, her PTSD symptoms may have been related to the birth instead of the exposure despite being directed to frame her symptoms around the traumatic pre-birth event.

For example, three studies conducted in New York City following the World Trade Center attacks on 9/11/2001,[16,60,65] and one in Louisiana following Hurricane Katrina[68] all potentially failed to establish temporality of PTSD among some participants. All included women who were pregnant at the time of the disaster, but assessed presence of PTSD at the time of interview months to years later. Berkowitz et al.[65] did not specify when interviews occurred relative to September 11, but Engel et al.[60] indicated exposure ascertainment took place on average 6.5

months after the attack and that 57% of the cohort was interviewed after giving birth. Similarly, Lipkind et al.[16] assessed PTSD up to 30 days prior to interview, but they were administered up to three years post-9/11/2001. It is possible that the detected maternal PTSD resulted from birth complications or a post-birth traumatic event and was not related to 9/11/2001. Each study used the same PTSD checklist to measure exposure, but applied different cut-points to the score to dichotomize their variable. The Lipkind study relied on the lowest cut-point (score >44) and was the only study to find a statistically significant association between PTSD and both PTB (OR=2.49, 95% CI: 1.05-5.84) and LBW (OR=2.49, 95% CI: 1.02-6.08), but this study also contained the largest sample size of the three studies (n=599). The number of PTSD cases might have been larger in these studies if exposure ascertainment occurred more proximal to the disaster since 50% of cases resolve within three months of onset.

The remaining six general population studies were not focused on a particular traumatizing event, thus they included only the background rate of PTSD. Participants comprised women at varying trimesters of pregnancy seeking OB care from physicians in Hawaii,[66] New England,[67,69] or Michigan,[61-63] and two studies limited their population to Healthy Start[67] or Medicaid recipients.[61] Varying instruments were utilized to categorize PTSD, which likely impacted the number of PTSD cases and comparability of exposure across studies. In a cross-sectional analysis of Medicaid women, Seng et al.[61] used the strictest definition of PTSD (ICD-9-CM diagnosis code 309.81) and found a statistically significant increased risk of PTB (OR=1.4, 95% CI: 1.1-1.9) in addition to other adverse outcomes; however, it is unknown if PTSD resulted from pregnancy and birth complications. Using the Life Stressor Checklist and National Women's Study PTSD Module among a general population of pregnant women, Seng et al.[63] later reported that PTSD did not increase the risk of PTB (p=0.202) but current PTSD was associated with decreasing birth weight (p=0.001). In the largest study to date among the general population (n=2,654 women), PTSD was assessed using the Modified PTSD Symptom Scale

and was not associated with PTB (OR=1.22, 95% CI: 0.57-2.61) but taking an SSRI antidepressant was (OR=1.55, 95% CI: 1.02-2.36).[69]

In the only study among a military population, Shaw et al.[64] investigated the risk of spontaneous PTB after PTSD diagnosis among 16,477 deliveries to women utilizing VHA maternity benefits from 2000 to 2012. Each woman was screened for PTSD prior to birth, and PTSD was determined using ICD-9-CM code 309.81. After controlling for demographics, military sexual trauma, recent deployment, and certain health conditions, they reported that women diagnosed with PTSD within the year prior to birth were 1.35 times more likely to experience PTB compared to women with no PTSD (95% CI: 1.14.-1.61). They reported no almost association for PTSD diagnosed before this time period. While this is a vital initial study among the military population, it excluded a large proportion of potentially effected women. Only about one third of eligible female veterans take advantage of VHA health benefits.[70] It is possible that women with PTSD sought VHA benefits more frequently than those without the condition, especially if they were unable to secure civilian employment with health insurance. This could introduce bias in the direction of the results observed in the current study.

PTSD has been linked to cardiovascular disease and hypertension among individuals with trauma or military history.[7,8,71] In a cross-sectional study of OEF/OIF veterans, those with PTSD or other mental health conditions were more likely to have hypertension (OR=2.88, 95% CI: 2.79-2.97), and also had higher resting heart rates than healthy veterans.[72] Granado et al.[73] also reported that individuals deployed to OEF/OIF with combat experience were 33% more likely to develop incident hypertension compared to deployed personnel with no combat experience (95% CI: 1.07-1.65). The underlying mechanism is hypothesized to be dysregulation of the HPA axis and neurochemical processes. Individuals with PTSD have overactive norepinephrine (NE), which has roles in regulating arousal and blood flow to organs

in response to a stressor. When NE is not downregulated and this part of the nervous system remains "on", hyperarousal PTSD symptoms result, including sustained increased heart rate and increased blood pressure.[6]

The DOD currently administers two health assessments to members of the U.S. Armed Forces at the conclusion of each deployment in order to screen for medical and mental health concerns. The Health Assessment Program was initiated in 2003 to detect mental health issues among troops deployed post-9/11/2001 to Afghanistan and Iraq during OEF and OIF. Only deployed individuals sent outside the U.S. for >30 days to support a military operation located in an area without a medical facility capable of providing long-term care complete health assessment forms. Form 2796 Post-Deployment Health Assessment (PDHA) is given within 30 days of deployment end and is often completed during in-theater out-processing before the individual returns home. Form 2900 Post-Deployment Health Reassessment (PDHRA) is then completed 90-180 days later. A health care professional reviews all forms and suggests referrals for more rigorous assessment when indicated by the responses. The PDHA has been administered since the program began in 2003, while the PDHRA was instituted in 2005. Both forms were expanded in 2008 to include additional questions on traumatic brain injury and alcohol consumption.[74]

There are specific questions on both the PDHA and PDHRA that attempt to screen for mental health disturbance, including PTSD. Questions ask if the individual encountered dead bodies, discharged their weapon, felt in danger of being killed, has been recently depressed, disinterested, on guard, avoiding situations, detached, or having nightmares/unwanted thoughts. The last four questions are specifically designed to screen for PTSD, with each question representative of a symptom category. Table 1 illustrates the text of each question in relation to

its symptom category. Two or more positive responses indicates referral for more rigorous PTSD assessment.[75]

A few validation studies/exploratory analyses exist pertaining to certain PTSD-related questions on the PDHA and/or PDHRA.[76-80] The largest study utilized records from 58,242 active-duty

Table 1. PTSD-Specific Question on the PDHA/PDHRA according to DSM Criteria.

Have you ever had any experience that was so frightening, horrible, or upsetting that, IN THE PAST MONTH, you… (Yes/No Responses)

Intrusion (Re-Experiencing)	Avoidance and Negative Cognition/Mood		Hyper-Arousal
1. Have had nightmares about it or thought about it when you did not want to?	2. Tried hard not to think about it or went out of your way to avoid situations that remind you of it?	3. Felt numb or detached from others, activities, or your surroundings?	4. Were constantly on guard, watchful, or easily startled?

U.S. Air Force personnel between January 1, 2008 and December 31, 2008.[76] The authors considered individuals with an ICD-9-CM code for PTSD, and assessed how well positive responses on PTSD screening questions predicted a true PTSD diagnosis. Compared to Airmen with negative PTSD screenings, individuals who screened positive for PTSD on the PDHRA (according to the criteria discussed above) were more likely to have medically confirmed PTSD also. The sensitivity for positive PDHRAs was 0.65 and specificity was 0.74. The authors further assessed the individual utility of multiple PDHRA questions in predicting PTSD through structural equation modeling, and reported that conflict in important relationships, nightmares, and avoidance were most associated with a confirmed PTSD diagnosis. However, currently being on guard or being shot, involved in a motor vehicle accident, or exposure to a blast all during deployment were also predictive of true PTSD to a lesser but statistically significant degree. Three of the remaining studies were conducted by Bliese et al. among small samples (n<1,600) of the U.S. Army.[78-80] They compared the four PDHA questions to clinician

diagnoses, and reported conflicting results. In one study, the best sensitivity and specificity was associated with two (sensitivity=0.85, specificity=0.71) and three positive responses (sensitivity=0.76, specificity=0.88),[78] while one (sensitivity=0.86, specificity=0.73) and two (sensitivity=0.73, specificity=0.88) responses maximized the measures in another study.[79,80]

Since PTSD and deployment have been shown to increase the risk of cardiovascular disease among veterans, and linked to certain adverse birth outcomes, it is imperative to quantify the risk of HDP among active-duty women who are deployed, diagnosed with PTSD or exhibit hallmark symptoms of the disorder.

CHAPTER 3
Methods

We conducted a retrospective cohort study using a U.S. DOD database comprised of all active-duty women who gave birth using Tricare from January 1, 2004 to December 31, 2008. Tricare health insurance was available to all current and retired military personnel and their families, and most active-duty personnel subscribed.[81] The database included: 1) maternal and infant birth hospitalization records, 2) maternal inpatient and outpatient mental health visits for the study period, and 3) deployment records that included post-deployment health assessments and re-assessments completed during the study period. Each data file contained a unique identifier created randomly by the DOD. Names and social security numbers were removed by DOD, and maternal date of birth was masked. The only patient demographic identifiers that remained were mother's age and month/year of delivery. All dates for events such as diagnoses and deployments were calculated in days from the mother's first birth during the study period to the event. For example, a deployment that ended 12 months prior to birth had a recorded end date of -365. All data were collected prior to the October 15, 2015 implementation of ICD-10-CM; therefore, all medical diagnoses and procedures were coded using ICD-9-CM.[82]

Overview of Study Population

Our study population consisted of active-duty military women who delivered their first, live-born singleton infant between January 1, 2004 and December 31, 2008 as identified in the infant birth database using the ICD-9-CM codes listed in Appendix 1, Table 1. There were 69,575 total births during the study period. After excluding multiple/unknown plurality births (n=3,808),

secondary or higher births (n=29,048), and births outside our study period (n=13), there were 36,706 births that met our eligibility criteria. We merged this dataset with the mother's inpatient hospitalization file using the unique identifier and year of birth to create a master study population file.

Tricare assigned each dependent on a woman's health care plan a specific family member code. Any children on a mother's plan were counted in order of age, so that the oldest child was classified as child #1, the next child as #2, and so on. If a mother joined Tricare with existing children and then gave birth, that first child born on Tricare would be assigned the appropriate family member code based on its birth order. Thus, we first restricted to first births within the study period, and then to births with a family member code of one. There is a chance we misclassified some birth orders based on this methodology. If a mother adopted children prior to giving birth to her first biological child on Tricare, that infant would not receive a family member code of one and would be ineligible for our study despite being the mother's first birth. Also, the possibility of error exists if a woman's partner was also on Tricare. For example, if previous biological children were dependents on the father's Tricare and the mother gave birth for the first time on Tricare during our study period, then that infant would be coded as the mother's first child and included in our study population.

Women who became pregnant while on active-duty but left the service prior to birth were not included in the data. However, if the pregnancy was known at the time of discharge, the woman was offered Tricare coverage for her healthcare through labor and delivery. Lastly, any active-duty woman giving birth off Tricare was also missed, but few active-duty women utilize alternative insurance coverage.[81]

Outcome Definition

We ascertained the presence of HDP conditions using ICD-9-CM diagnosis codes from the mothers' records in the merged birth file previously discussed. Table 2 in Appendix 1 denotes the specific codes used to define the outcome. According to a validation study conducted in Australia that compared hospital coding using ICD-10-CM codes to medical record review, Roberts et al. reported that the sensitivity of hospital discharge coding for all HDPs together was 68.2% and the specificity was 99.6%. Sensitivity was lowest for chronic hypertension (44.4%), but increased for gestational hypertension (47.8%) and preeclampsia (71.0%) while specificity remained similar. Interestingly, sensitivity and specificity were very high for first time mothers when examining all HDPs together (sensitivity=80.1%, specificity=100%).[83] Some misclassification may have occurred by using diagnosis codes in our study; however, it is reasonable to assume that it was likely non-differential if it occurred.

Any woman who had at least one type of coded HDP in any of her birth hospitalization(s) was considered to have our study-defined outcome of interest. We created an overall HDP variable, and also classified the subtypes as shown in Appendix 2, Table 1. We used a hierarchical approach for women with multiple diagnoses, assigning them to the most severe category. For example, a mother diagnosed with both gestational hypertension and preeclampsia was assigned to the preeclampsia group. Women were only classified in the unspecified group if they lacked a more specific HDP code. Very few women developed eclampsia, and no cases received this code without first being diagnosed with preeclampsia. Therefore, we did not examine eclampsia cases as a separate group. Women with pre-existing chronic hypertension were treated as chronic hypertension complicating pregnancy cases (n=8) since it is customary in obstetric care to treat these women as cases in this category (H. Rawji, MD, personal communication, January 30, 2017).

Analysis Dataset Merge

The master deployment database contained deployment records for all mothers beginning January 1, 2001, which included variables related to deployment beginning and end dates, occupation, deployment location, and service branch. We combined this dataset with our birth dataset described above to keep deployment records for mothers meeting our eligibility criteria. We included only deployments that were completed before birth, and that lasted ≥30 days. Mothers in the deployment database were coded as deployed and mothers in the birth dataset who did not appear in the master deployment file were categorized as non-deployed. We discovered that 103 deployment records were missing deployment end dates. We matched these records to the mother's PDHA and imputed the date if the start dates were within 16 days of each other. We were able to impute 44 records, and excluded the remaining 59. Additionally, if two records for the same mother had a start or end date within five days of each other the earlier record was kept (23 records excluded). The final merged deployment file contained 36,675 mothers.

We next added the military demographic, PDHA and PDHRA files to the deployment file. We found that 491 mothers who completed a PDHA and 55 mothers who completed a PDHRA without a PDHA were missing from the master deployment file. We flagged those women and updated the deployment variable to reflect their deployment. We also identified and flagged 21 women who deployed >1 with overlapping deployment start and end dates, 1,784 women with missing military entry dates, and 86 women who either spent >100% of the study period deployed or whose military entry date was later than her first deployment. These represented DOD data entry errors.

There were 387 PDHAs missing deployment start dates, 854 missing end dates, and 270 missing both. We imputed 46 start dates and 359 end dates from the master deployment dates,

and excluded the remaining records. We also excluded records if the start or end dates were within five days of each other (n=2,055 records). After all exclusions, 8,801 deployed mothers had at least one PDHA, for a total of 10,201 completed PDHAs. Missing was quantified across the variables needed to define our PTSD exposure, and a total of 1,285 records were flagged. There were 3,564 PDHRAs meeting our eligibility criteria. We matched these to the PDHA records by deployment start and end dates to assess agreement between PTSD screenings. Some PDHRA records also had some missing on the PTSD-related variables (n=99), and these records were flagged. A total of 2,419 PDHRAs were matched to a PDHA. There were 722 mothers who completed a PDHA that did not match to a PDHRA. Finally, we combined the maternal inpatient and outpatient mental health visit records to identify eligible women who had any physician-diagnosed PTSD before birth and added the earliest diagnosis to the analysis dataset. Mothers in the dataset with no confirmed PTSD were coded as non-cases.

Potential Confounders and Covariates

Several important covariates were explored in all our aims. Variables available for the entire cohort: maternal age at the time of birth (18 to 24 years, 25 to 29, 30 to 24, 35+), race (white, black, Hispanic, other), marital status at birth (married, single/never married, other), pay grade (enlisted or officer), and maternal medical conditions including the presence of pre-gestational diabetes (identified using ICD-9-CM diagnosis codes shown in Appendix 1, Table 3 in the maternal birth hospitalization record). Certain variables were only present for mothers who deployed: military branch (Army, Air Force, Navy), deployment location (Iraq/Afghanistan, Southwest Asia, Kosovo), and occupation (combat, healthcare, other). Women serving in the Coast Guard and Marines were included with the Navy due to small sample size in these two branches. The Marines are a subset of the Navy, and while the Coast Guard operates under the Department of Homeland Security, they deploy with the Navy when activated. The military is also subject to immunizations at boot camp, prior to deployment, and at recommended

intervals for boosters. While our data did not capture specific vaccines administered, we explored the use of deployment location as a proxy to create a vaccine variable indicating deployment-specific vaccines in excess of baseline in order to adjust for vaccination history. Since 99% of our deployed mothers were deployed to OEF/OIF, we did not use this variable in our models. Variables that were available for deployed mothers only were not added to any regression models that included non-deployed mothers. All variable definitions are presented in Appendix 2, Table 5.

Although obesity and smoking modify the risk of HDP,[22] this information was not collected and was unavailable for analysis. However, since our study population was comprised of active-duty military who were required to meet fitness standards as a condition of service, chronic medical conditions, and overweight/obesity likely did not impact a large number of participants. According to the most recent DOD Health Behaviors Survey conducted in 2011,[84] about 60% of active-duty women were at a healthy weight as measured by body mass index (BMI), and 83% were former or non-smokers. Among women that did currently smoke, 12% reported moderate to heavy use. Younger women and those who were enlisted were more likely to smoke than older women and officers. Smoking prevalence also differed according to service branch, with the Marines most likely to smoke (23%) and Air Force least likely (15%). We were able to somewhat control for these health behaviors by including age and pay grade in statistical models for the entire cohort, and by including branch in models including deployed women only.

Specific Aim 1 Deployment Exposures

Deployment Definition. Pre-birth deployment in the post-9/11/2001 era (beginning January 1, 2001 or after) was the main exposure of interest. Deployments are distinguished from other types of military travel. Individuals are considered deployed when assigned to a location that lacks a permanent U.S. military medical treatment facility outside the U.S. for >30 days.[85] For

example, a service person given temporary duty at a base in Japan with a U.S. military clinic is not considered deployed despite the amount of travel involved or length of stay; however, assignment to Afghanistan for >30 days does constitute a deployment since there is no permanent hospital or medical clinic there. All specialty terms and main variable definitions are presented in Appendix 2, Table 2.

Previous Research. This data was obtained and analyzed previously under a 2008 grant by Kathleen O'Rourke, PhD, Faculty Advisor (USF IRB# 106906). One unpublished research paper exists examining the effect of deployment on the incidence of LBW and PTB. Four categories of deployment before birth were used: <12 months, breaks between the most recent two deployments of <6 months, deployments lasting >15 months, and cumulative deployment ≥12 months prior to birth. The only statistically significant finding showed an increased risk of both LBW (OR=1.27, 95% CI: 1.10-1.46) and PTB (OR=1.31, 95% CI: 1.11-1.53) among mothers whose last deployment ended <12 months prior to birth compared to those with a longer deployment interval after adjusting for maternal age, race, marital status, educational attainment, military branch, pay grade, and infant gender. These findings informed the hypothesis in the current aim.

Deployment Measures. The following describes the specific measures of deployment we analyzed.

1. Deployed vs. Non-deployed: Any woman who had at least one deployment during our study period that ended prior to birth was considered deployed. We compared this group to women who gave birth during the same time period (January 1, 2004 to December 31, 2008) but who had no deployment record prior to birth.

Women we flagged who were missing from the DOD master deployment file but completed a PDHA or a PDHRA were not included in the following analyses since complete deployment history was not available.

2. Deployment ending <12 months or ≥12 months before birth vs. Non-deployed: Women whose most recent deployment ended <365 days before birth or ≥365 days before birth were compared to non-deployed women as the reference group. We also explored the association with the flagged women as an additional "missing" category.
3. Cumulative Weeks of Deployment (continuous). We quantified the total weeks each woman spent deployed prior to birth to explore dose-response trends restricted to deployed women only.

***Statistical Modeling*.** All statistical analyses were performed using SAS version 9.4 (Cary, NC). We first explored descriptive statistics for our main deployment exposures and important covariates in association with our overall HDP outcome. Chi-square tests of homogeneity (Fisher's Exact test when any cell was ≤5) were performed for all categorical variables and t-tests for continuous variables using a 5% level of significance, and missing was quantified for each variable. We built one logistic regression model for each of our three main deployment exposures and HDP. Based on public health and biological significance, we decided to leave all covariates in the models whether or not they confounded the observed association, and records with missing values were excluded prior to entering a variable into the model. The cumulative weeks of deployment model only included deployed women so we could examine the effect of service branch and occupation. We reported odds-ratios (ORs) and 95% confidence intervals (CIs). Mothers with missing data on any variables included in a specific model were excluded from that analysis.

Sub-Analysis: Stratification by Race. Racial disparities in general population epidemiologic studies on various health outcomes are well documented,[86-88] and certain research indicates that black mothers experience greater risk of HDP compared to whites.[89,90] Our study population provided a unique opportunity to investigate racial disparity in HDP incidence since socioeconomic status was more standardized than in the general population. For example, all of our mothers possessed the same access to health care, were required to maintain certain physical fitness standards, were subjected to the same medical screenings, and were paid equally by rank. We therefore re-ran the analyses described above stratified by race (white, black, Hispanic, other) without race included in the model. Women with pre-gestational diabetes were excluded from these analyses due to small numbers with the additional stratifications.

Sub-Analysis: HDP Types. To explore the association between our deployment exposures and specific HDPs, we repeated the main logistic regression described above for the three deployment exposures using each of the four HDP types as discrete outcomes. Only women without any HDP were included as the comparison group.

Sub-Analysis: Timing of Conception. We approximated the timing of conception for everyone in the cohort based on gestational age, prematurity, and respiratory distress syndrome (RDS) ICD-9-CM codes in the infant's hospitalization record (Appendix 1, Table 4). Approximately 88% of the population was missing a gestational age code. We explored whether or not any of these records had an indication of prematurity or RDS, a condition highly correlated with prematurity. For the remaining records still missing a code, we assumed that they were somewhere between ≥37 and 40 weeks gestation since they lacked a specific code available for other gestational lengths. Records with unspecified or non-specific gestational ages were excluded (i.e. <24

weeks gestation, premature with no gestational age), and infants with gestational age >42 weeks were included in the 40-42 weeks category. We calculated the approximate conception date in days before birth by multiplying the midpoint of the gestational age range by seven. We then determined whether or not the pregnancy was conceived during the most recent pre-birth deployment and categorized women as conceiving before, during, or after deployment as compared to non-deployed women. We examined this as a fourth deployment exposure using the entire cohort.

Sub-Analysis: Military Entry Timing. We also examined whether or not pre-2001 entry to the military confounded the observed associations for the three deployment measures. In these analyses, women flagged with military entry date errors were excluded (n=1,842).

Specific Aim 2 Deployment Exposures

Deployment Measures. We explored cut-points for categorization of the following continuous deployment characteristics among deployed women only:

1. Cumulative weeks of deployment: defined as the cumulative weeks of pre-birth deployment in the study period.
2. Percent of time in study period spent deployed: calculated as the total number of days spent deployed prior to birth divided by the total number of days spent in the military during the study period prior to birth. Women missing a military entry date and those with entry date errors were excluded.
3. Dwell time: calculated as the cumulative number of weeks between the ending and beginning of the two most recent pre-birth deployments. Only women with >1 deployment were included when examining dwell time measures.

4. Dwell time ratio: calculated as the duration in days of the second most recent pre-birth deployment divided by the dwell time in days between it and the most recent pre-birth deployment.

Mothers flagged as completing a PDHA or PDHRA but not included in the original master deployment file or with overlapping dwell times were not included in these analyses. These terms are also found in Appendix 2, Table 3.

Statistical Methods. We used non-parametric classification tree analysis (CART) using PROC HPSPLIT in SAS to identify meaningful cut-points for our four deployment measures related to our HDP outcome. CART uses recursive partitioning that begins by aggregating the entire sample into one group, and then splits the data into successive sub-groups by determining which cut-points of a particular exposure variable (or variables) result in the most homogenous groups according to outcome. Output is illustrated as a tree. The top of the tree is represented by the root node that contains the entire data set. The tree is split into branches leading to child nodes. When a particular branch cannot be split any further, it ends in a terminal node. The cut-points and proportion of the outcome in each node are shown on the output tree. Trees can grow quite large and be difficult to interpret practically without specifying a pruning method. To select the most parsimonious tree, the data is fitted on a subset of the sample (training) and then fit to the remaining data (validation). We used the cost-complexity pruning method, which outputs the least complex tree that has the lowest error rate among the validation sample. We specified that 80% of our sample be used for training and 20% for validation. Further, we used gini as our splitting criteria to maximize homogeneity in each child node.[91-93] In order to make interpretation meaningful in public health practice, we limited our trees to eight branches for each of the four exposure variables in this aim.

First, we produced one tree for each of the four deployment measures alone versus HDP. Then, we examined the added importance of age, race, marital status, pay grade, branch, and occupation by producing one tree for each variable plus the deployment measure versus HDP. A full tree with all variables versus HDP was also examined for each of the four deployment measures. Relative importance was judged for the deployment measures alone and then by the additional covariates. Once cut-points were determined for the most important measures, we categorized them and fit logistic regression models as previously described to report ORs and 95% CIs for the association with HDP.

Specific Aim 3 PTSD Exposures

Exposure Definition. We identified women with PTSD from the entire cohort and then among women who completed a PDHA. All the main terms and variable definitions used in this Aim are located in Appendix 2, Table 4.

1. *Confirmed Cases*. Women diagnosed with PTSD identified from inpatient and outpatient records using ICD-9-CM code 309.81 prior to birth were considered a confirmed case. Also, women with a new PTSD diagnosis in the birth hospitalization record were also considered confirmed cases.
2. *Probable Cases*. Women who fit the possible case definition and who endorsed at least one other "high-risk" or depression screening question as shown in Appendix 2, Table 4 were considered a probable case.
3. *Possible Cases*. Women endorsing ≥3 of the PTSD screening questions (Appendix 2, Table 4) on a PDHA prior to birth were considered a possible case.
4. *None*. Women with negative screenings across all pre-birth PDHAs and who lacked a medical diagnosis were considered unexposed and comprised our comparison group.

We selected the possible cut point based on how PTSD diagnosis is made using the PTSD Checklist – Military Version (PCL-M). The PCL-M is a 17-item questionnaire aligning with DSM-IV diagnosis criteria, and the number and clustering of statements that are endorsed are used to screen for PTSD. Moderate PTSD is diagnosed based on ≥1 intrusion, ≥3 detached or avoidance, and ≥2 hyperarousal endorsements. The four PTSD screening questions on the PDHA represent these symptom categories, and by requiring endorsement of ≥3 we minimized the false-positive rate of PTSD in our sample.[94]

In a large meta-analysis, Rytwinski et al. examined the correlation between clinical depression and PTSD using 57 civilian and military studies.[95] They reported coexistence of the two conditions in 52% of PTSD cases, but when restricted to military studies, the prevalence increased to approximately 65%. Similarly, the correlation between the two among PTSD women in a general population survey was about 50%, and women with PTSD were four times more likely to experience depression than women without PTSD (OR=4.07, 95% CI: 3.08-5.29).[96] There is likely considerable overlap between the conditions in our study population, making it probable that an individual meeting the possible case definition who also endorsed the depression question(s) did have PTSD. Likewise, engaging in combat, being threatened by a weapon, or comparable traumas have been associated with development of PTSD and further strengthens our case definition.[3,96] Rape and sexual assault are highly predictive of PTSD among women; and, unfortunately does occur among the military population. We possess no data to account for its occurrence in our study population.[96] In a 2014 DOD survey conducted by the RAND Corporation of the military workforce, just under 5% of active-duty women reported sexual assault in the preceding year.[35] In an analysis using data from the Millennium Cohort Study, a prospective study of health among current military and veterans, LeardMann et al. reported that 10% of women participants had experienced unwanted sexual attention in the

three years since baseline. Most attention was in the form of sexual harassment, but 8.9% of the unwanted attention was sexual assault. When restricting to women who deployed during the study period, there was a high correlation between combat and sexual assault. Specifically, women endorsing similar questions to our "high risk" assessment reported the most sexual harassment (19.9%) and sexual assault (4.0%) compared to women who did not experience combat or who did not deploy.[97] The relationship is likely due to women in the highest combat zones being most at risk of sexual assault for unknown reasons, and they therefore are also commonly exposed to the situations described in the "high risk" questions. Regardless, there is some overlap of unwanted sexual attention and endorsement of these items, further strengthening our probable case definition.

A hierarchical approach was used to categorize women into the most stringent category they met. For example, if a woman met both the probable and confirmed case-definitions, she was categorized as confirmed. For women with multiple PDHAs, the earliest record where they met the most stringent case definition was kept, including women categorized as missing. A woman was only captured as missing if none of her other PDHA records or medical records fit her into a higher category.

Mini-Sensitivity Analysis. The possible case-definition using ≥3 endorsements on the PTSD screening portion of the PDHA limited the false-positive rate by employing strict parameters for defining a case. However, we re-ran the analyses that included PTSD case-definition categories after an expansion of the possible definition to include women endorsing ≥2 questions on the PTSD screening questions. The probable category parameters remained the same.

***Statistical Modeling*.** We first examined descriptive bivariate analyses between PTSD, the covariates/potential confounders discussed in Specific Aim 1 Methods, and our overall HDP outcome. We compared frequencies using chi-square tests of homogeneity with a 5% level of significance and Fisher's Exact test when any cell was ≤5. Logistic regression was performed and the OR and 95% CI for the association between PTSD and HDP overall controlling for the important covariates were reported. Women with missing values for any variables included in the models were excluded. The specific models are described below.

Analysis 1: Overall Cohort. We assessed the association between confirmed PTSD and overall HDP among deployed and non-deployed women, with women lacking any ICD-9-CM diagnosis serving as the reference group. The analysis was repeated comparing women with any indication of PTSD (confirmed or screening) to women without any PTSD indication.

Sub-Analysis: Effect Modification by Deployment. Using the entire analysis dataset, we explored the impact of effect modification between confirmed PTSD and deployment on HDP. The analysis was repeated comparing women with any indication of PTSD (confirmed or screening) to women without any PTSD indication.

Sub-Analysis: Stratification by Race. As in Specific Aim 1, we conducted our any PTSD and HDP analysis stratified by race (white, black, Hispanic, other) without race included in the model. Again, women with pre-gestational diabetes were excluded due to small sample size.

Sub-Analysis: HDP Types. We repeated the any PTSD analysis using the four sub-types of HDP as individual outcomes. Only women without any HDP were included as the comparison group.

Analysis 2: PDHA Mothers. We assessed the association between PTSD and HDP among all women completing a PDHA using the case-definition described above. We repeated the analysis using the relaxed ≥2 case-definition for PTSD among PDHA mothers. For both, we also examined the association by adding the missing women into an additional variable category. The following sub-analyses were also performed for both case-definitions.

Sub-Analysis: Stratification by Race. We also repeated the overall PDHA/HDP analyses stratified by race (white, black, Hispanic, other) without race included in the model. Again, women with pre-gestational diabetes were excluded due to small sample size.

Sub-Analysis: HDP Types. We repeated the main logistic regression analyses using the four sub-types of HDP as individual outcomes. Only women without any HDP were included as the comparison group.

Sub-Analysis: Timing of Conception. We used the estimated conception dates calculated in Aim 1 to quantify how long prior to conception PTSD was diagnosed or reported. The date of earliest confirmed ICD-9-CM diagnosis or deployment end date for the earliest PDHA screening was used as the reference date. We created "shorter" and "longer" categories by classifying women as first positive between conception and birth, <1 year before conception, or ≥1 year before conception vs. women without any positive PTSD indicator as the reference group.

Sub-Analysis: Pre-Post Comparison: Among women who had matching PDHRA, we assessed the relationship between agreement categories and overall HDP to explore whether or not women with "chronic" PTSD screenings were at increased risk. Women without any PTSD served as the comparison group.

Sub-Analysis: PDHRA Mothers Only. We conducted the main analysis using our PTSD screening case-definition among only women who completed a PDHRA. We examined the association between PTSD and HDP using both the ≥3 and ≥2 case-definitions with the same reference group.

CHAPTER 4
Results

Overall Cohort

Our study population included women giving birth to their first infant, and as expected, differed slightly from the overall female military population. Table 2 illustrates the overall demographic characteristics of our population with a column for female military estimates. Our mothers were younger (65.4% under 25), predominantly white (50.3%) or black (25.9%), and either married (65.1%) or single and never married at birth (32.1%). By way of comparison, about 40% of women in the military in 2013 were under 26 years old,[38] and in 2008, 53% were white, 31% black, and 13% Hispanic. Also, fewer women in the military were married (46%).[5,98] The majority of mothers were enlisted at the time of birth (89%) compared to 83% in the entire military, and just under 30% entered military service prior to 2001.[98] Very few of our mothers had pre-gestational diabetes (<1%) or confirmed PTSD (1.6%), and about a third deployed during the study period (35%). Just over 4,900 mothers (13.4%) experienced at least one HDP, with mothers over 35 years old experiencing a significantly higher HDP incidence than younger mothers (19.1% vs. 13.1-13.7%, $p<0.0001$) as shown in Table 3. Black women were most likely to experience an HDP (15.7%), and Hispanic women were the least likely (9.9%, $p<0.0001$). We also observed a significantly higher incidence of HDP among enlisted women compared to officers (13.5% vs. 12.3%, $p=0.03$) and among women who had pre-gestational diabetes (30.0% vs. 13.4%, $p=0.002$). No other significant differences were observed.

The most common type of diagnosed HDP overall was preeclampsia (55% of HDP cases), followed by gestational hypertension (32.8%), chronic hypertension (9.5%), and unknown

hypertension (2.7%) as presented in Table 4. A similar distribution was seen by race/ethnicity, but a larger proportion of Hispanic mothers had preeclampsia than the overall cohort (63.8%). Whites had a slightly lower proportion of preeclampsia compared to the overall cohort (51.3%), while blacks and other race mothers were closer to the overall percentage (57.9 and 56.8%, respectively). We examined the frequencies of our main covariates and exposures by racial/ethnic category (data not shown). The majority of mothers in each category were under 30 years old, but Hispanic mothers were the youngest (93.0% under 30) and white mothers oldest (86.9% under 30). Whites were also most likely to be married at birth (71.6%) and blacks least likely (51.3%). Whites and mothers of other race had the highest proportion of officers (15% and 11.8%, respectively), with only about 5% of black and Hispanic mothers in the officer pay grade.

Specific Aim 1 Deployment

Descriptive Characteristics. Descriptive statistics for the three main deployment exposures and covariates for deployed women only are presented in Tables 5 and 6. Overall, 35.0% of mothers deployed and 98.8% of them were deployed in service of OEF/OIF (Table 5). The majority of mothers were in the Army (37.8%) or Navy (39.2%). Compared to the female military force overall (deployed and non-deployed), fewer women in our study held combat positions (10.6% vs. 15%). In the general military, more women served in the Air Force than in our study (31% vs. 23%), the same proportion in the Army (37% vs. 38%), and fewer in the Navy (32% vs. 39%).[5] However, since Coast Guard and Marines were combined with our Navy category, we expected the proportion of women in this group to be slightly higher. As of 2009, about 50% of all active-duty women had been deployed to Iraq and/or Afghanistan compared to 35% of our population.[70]

There was no significant difference in HDP incidence between deployed and non-deployed mothers (13.6% vs. 13.3%, p=0.47) as shown in Table 6, and no difference by timing of deployment end prior to birth. Although slightly more mothers whose last deployment ended ≥12 months before birth developed an HDP (14.0%) compared to deployments ending <12 months before birth (13.0%) and the non-deployed (13.3%), the difference was insignificant (p=0.21). Similarly, no significant difference was found for timing of deployment relative to conception, deployment location, or cumulative weeks of pre-birth deployment. However, HDP incidence did differ by service branch and occupation. Mothers in the Air Force experienced the highest incidence of HDP (15.4%) compared to the Army (13.5%) and Navy (12.6%, p<0.0001), and mothers in combat roles had a much lower incidence of HDP compared to mothers in healthcare occupations (11.5% vs. 15.5%, p=0.01).

When stratifying by race in our cohort (data not shown), the most common branch for all races except blacks was the Navy, with blacks most likely to serve in the Army. Women in the Air Force were more likely to develop an HDP across all races, but the observed differences were not statistically significant. Similar to the overall cohort, whites, blacks, and Hispanic women in combat roles had slightly lower HDP rates, but the incidence was similar across all occupational roles for women identifying as other race. HDP incidence was only higher for whites in a healthcare occupation compared to the other roles. When examining differences across the deployment exposures, black women were the only racial/ethnic group to experience a statistically different HDP rate if deployed (16.8% vs, 15.0%, p=0.02), and if deployment ended ≥12 months prior to birth (17.7%, p=0.02).

Overall Findings. Table 7 shows the ORs and 95% CIs for the main deployment exposures explored in this Aim. There was no association between overall deployment and HDP

(OR=1.03, 95% CI: 0.96-1.09), and the OR remained unchanged after adjustment for covariates. Similarly, we observed a very weak association between deployment ending ≥12 months before birth and HDP that approached statistical significance (OR=1.06, 95% CI: 0.99-1.15), but it moved away from this when adjusting for our covariates. There was no association for deployments ending <12 months before birth, with the crude and adjusted ORs being equal (OR=0.97, 95% CI: 0.88-1.07). For each one month increase in cumulative pre-birth deployment duration, there was an estimated 1% increased risk of any HDP, and this finding almost reached statistical significance even after adjusting for all covariates (OR=1.01, 95% CI: 0.99-1.02). We did not observe any association between timing of conception relative to deployment and HDP.

Racial/Ethnic Findings. Examination of the three main deployment exposures by racial/ethnic group produced similar results as the overall cohort, and crude ORs and 95% CIs remained unchanged when adjusting for covariates (Table 8). The notable exception was among deployed black mothers, who experienced a 13% increased risk of HDP compared to blacks who did not deploy (OR=1.13, 95% CI: 1.00-1.27). Mothers of other race had a similar risk, but it was not significant (OR=1.09, 95% CI: 0.87-1.36). The observed risk between deployment and HDP among whites trended towards protective, but it was also statistically non-significant (OR=0.94, 95% CI: 0.86-1.03).

When examining the timing of deployment end date relative to birth, the only statistically significant finding was among black mothers whose last deployment ended ≥12 months before birth. Those women experienced an 18% increased risk of HDP compared to non-deployed black women (OR=1.18, 95% CI: 1.03-1.36). The risk dropped to 8% among black mothers who gave birth within a year of their last deployment ending, and less than a 10% increased risk

was also observed for Hispanic and other race mothers for either deployment end date. Again, although the relationship was not statistically significant, white mothers with either deployment end date were slightly protected against HDP compared to non-deployed white mothers. There was very little increased risk of HDP for each additional month of cumulative deployment among each racial/ethnic group. There was no association among whites (OR=1.00, 95% CI: 0.99-1.01).

Other Sub-Analysis Findings. We observed statistically significant independent associations between certain covariates and HDP in the adjusted models examined in this Aim (data not shown). Specifically, maternal age ≥35 years conferred a consistent 75% increased risk of HDP compared to the youngest mothers, and mothers with pre-gestational diabetes were 2.5 times more likely to develop an HDP than mothers without this condition. When we explored confounding by military date, we did not observe any change in the odds-ratios for any of the three deployment exposures. However, we noticed that women who entered the military prior to 2001 were about 10% less likely to develop an HDP compared to mothers who entered in 2001 and after. Further, single mothers who were never married at the time of birth experienced a similar lower risk compared to married mothers. Enlisted mothers experienced a 30% greater risk of HDP than officers, and the association strengthened to 40% when restricting to deployed mothers only. Finally, women in the Army and Navy were about 20% less likely to develop any HDP compared to Air Force mothers.

The relationship between deployment (yes vs. no) and the four individual HDPs was very similar to the previously discussed findings for HDP overall (Appendix 3, Table 1). When examining timing of deployment ending relative to birth, we observed the risk of chronic and gestational hypertension was about 15% greater for women whose deployments ended ≥12 months prior to

birth compared to non-deployed women, but the results were not significant as shown in Appendix 3, Table 2. While this was slightly higher than for HDP overall, there was no association between women with deployments ending at this time and either preeclampsia or unknown hypertension. Women whose last deployment ended within a year before birth were seemingly protected against each HDP except for preeclampsia, where there was an estimated 7% increased risk. However, none of the findings were statistically significant. The findings for cumulative months of deployment and each HDP sub-type were also consistent with the overall cohort previously discussed (Appendix 3, Table 3).

Specific Aim 2 Classification Trees

Descriptive Characteristics. Women were deployed for a cumulative average of 33.3 weeks (±20.7) or just over 7.5 months during their military service before giving birth, with an average of 16.5% (±9.7) of the study period spent deployed as shown in Table 9. No differences were observed between mothers with HDP and those without. The average dwell time between the last two pre-birth deployments was 59.6 weeks (±40.3), or just under 14 months. The average dwell time ratio was 0.77 (±1.3), indicating that most deployers had a longer dwell time than the previous deployment lasted. Again, no significant difference was observed between HDP and non-HDP mothers.

Classification Tree Findings. The only meaningful classification trees were observed for cumulative weeks of deployment as it related to maternal age at birth and maternal race/ethnicity. Figure 2 illustrates the tree created for maternal age, with the first cut occurring at 52 weeks of cumulative deployment, and then at maternal age 34 years. We categorized the deployment variable into <1 year and ≥1 year of cumulative deployment, maternal age into <35 years old and ≥35 years old, and race into black vs. all others. The results of multivariable logistic regression are shown in Table 10. Women who had a year or more of cumulative

deployment during the study period before birth were 17% more likely to develop an HDP than women with less deployment time (OR=1.17, 95% CI: 1.01-1.36). This relationship remained among women under 35 years old (OR=1.16, 95% CI: 1.00-1.36), and it strengthened to 35% among women 35 years and older but the result was not statistically significant, perhaps due to low power of this small subgroup (OR=1.35, 95% CI: 0.74-2.47). Black women with ≥1 year of cumulative deployment had a 19% increased likelihood of an HDP that approached statistical significance (OR=1.19, 95% CI: 0.98-1.42), but the risk among other races was only slightly lower (OR=1.14, 95% CI: 0.90-1.45).

Specific Aim 3 PTSD

Descriptive Characteristics: PTSD among the Entire Cohort. The overall prevalence of confirmed PTSD was 1.6% (Table 11). Table 12 shows there was no significant difference in HDP incidence between women with confirmed PTSD and non-cases in the complete cohort (14.4% vs. 13.4%, p=0.47). Although women with both PTSD and deployment history had the highest incidence of HDP (14.9% vs. 13.3% for neither), the rates did not differ significantly (p=0.70). There were also no notable racial/ethnic differences in the overall prevalence of confirmed PTSD (data not shown), but confirmed PTSD cases among women identifying as other race had over twice the incidence of HDP as non-PTSD cases (25.5% vs. 11.7%, p=0.0004).

Descriptive Characteristics: PDHA Mothers. We explored demographic characteristics among the 8,801 women who completed a PDHA in Table 13. Compared to the overall cohort, a similar proportion of PDHA mothers were under 30 years old (86.3% vs. 88.6%), and the distribution was similar across racial/ethnic groups. We noted that more mothers who completed a PDHA entered the military prior to 2001 (37.3% vs. 28.5%), more mothers were in

the Army (46.9% vs. 37.8%), and the proportion of mothers with confirmed PTSD was slightly higher (2.1% vs. 1.6%).

A similar proportion of PDHA mothers had an HDP as compared to the overall cohort (13.7% vs. 13.4%), and PDHA mothers older than 35 years old had the highest incidence of HDP (19.5%, p=0.004) as shown in Table 14. Among women who completed a PDHA, black mothers had the highest incidence of HDP (17.2%, p<0.0001). This was slightly higher than for black mothers in the overall cohort (15.7%). We observed no other statistically significant differences in HDP incidence for other covariates among PDHA mothers. Overall, there was consistency between the entire cohort and PDHA mothers when examining the proportion of HDP sub-types overall and by race/ethnicity, with the exception of Hispanic mothers experiencing less preeclampsia than overall (Table 15).

We also studied demographics for the 808 mothers missing PDHA responses (Appendix 3, Table 4). Among mothers with missing data, we discovered that a slightly higher proportion were older than those without missing data (22.5% vs. 13.8%), the proportion of Hispanics was slightly lower (11.7% vs. 15.7%), and the proportion of whites slightly greater (55.4% vs. 47.7%). More women with missing data were married (75.7% vs. 64.7%), were officers (15.4% vs. 11.9%), in the Air Force (68.7% vs. 24.9%), and entered military service after 2001 (82.6% vs. 62.7%). Mothers with missing data had no confirmed PTSD cases and were more likely to have deployed to Kosovo (4.7% vs. 0.4%).

Descriptive Characteristics: PTSD among PDHA Mothers. Tables 16 and 17 quantify the distribution of our PTSD variables for PDHA mothers. Using the ≥3 case-definition, the overall prevalence of any PTSD was 6.2%. Very few women had possible PTSD (n=33, 0.4%), while 3.5% were classified as probable (n=279), and 2.3% were confirmed (n=187). When relaxing

the case-definition to the ≥2 criteria, an additional 25 mothers were added to the possible category (n=58, 0.7%) and 257 added to the probable category (n=536, 6.7%), bringing the overall prevalence to 9.7%. Women in the ≥3 probable category had the highest incidence of HDP (16.1%), followed by possible (15.2%), confirmed (14.4%), and none (13.7%), and the difference was significant (p<0.0001). The overall pattern was the same using the ≥2 criteria, but the differences were not statistically significant (p=0.38). Patterns across racial/ethnic groups were similar (data not shown). A total of 2,419 (77%) PDHRAs were matched to a PDHA using the ≥3 case-definition, and the result was almost identical using the ≥2 method (n=2,428, 77.3%). Only 103 (4.3%) of women were positive on a PDHA (defined as possible or probable) but were negative on a PDHRA. The number increased only slightly to 163 (6.7%) using the ≥2 definition.

Overall Findings. Out of the entire cohort, mothers with confirmed PTSD experienced a 9% increased risk of HDP compared to non-PTSD mothers (OR=1.09, 95% CI: 0.86-1.39) as Table 18 shows, and the relationship strengthened slightly to a 15% increased risk for mothers with any PTSD (OR=1.15, 95% CI: 0.95-1.39). The latter finding also approached statistical significance. When exploring effect modification by deployment, the risk was virtually the same among deployed (OR=1.10, 95% CI: 0.77-1.57) and non-deployed (OR=1.08, 95% CI: 0.78-1.49) women with confirmed PTSD vs. women without PTSD. However, when using the expanded PTSD definition (any PTSD), the association among deployed women with PTSD strengthened slightly, so that deployed women with any PTSD were at 18% greater risk of HDP than women who did not have PTSD (OR=1.18, 95% CI: 0.93-1.50). Increased risk among non-deployed mothers with any PTSD remained at 8% (OR=1.08, 95% CI: 0.78-1.49). This represented an approximate 9% increase in HDP risk for deployed mothers with PTSD vs. those without PTSD compared to non-deployed PTSD mothers.

Overall Sub-Analysis Findings. Overall, women with any PTSD across racial categories experienced a higher risk of HDP compared to women without PTSD (Appendix 3, Table 5). White (OR=1.08, 95% CI: 0.84-1.41) and black (OR=1.08, 95% CI: 0.74-1.59) mothers had the same and smallest elevated risk (both 8%), followed by a 16% higher risk among Hispanics (OR=1.16, 95% CI: 0.65-2.10), and nearly 90% higher risk of HDP among PTSD mothers identifying as other race (OR=1.87, 95% CI: 1.05-3.34). The latter group is the only one that achieved statistical significance. When examining the relationship between any PTSD and specific HDP sub-types as shown in Appendix 3, Table 6, we noted the risk of chronic hypertension and preeclampsia was approximately 10%, followed by a 24% increased risk of gestational hypertension, and a 72% increased risk of unknown hypertension compared to non-PTSD mothers. No category was statistically significant.

Overall Findings: PDHA Mothers. Table 19 illustrates the relationship between case-definition levels of PTSD and HDP overall and by racial/ethnic group among mothers who completed a PDHA. Interestingly, women in the possible and probable categories experienced the same magnitude of risk of HDP (OR=1.21, 95% CI: 0.46-3.16 and OR=1.22, 95% CI: 0.87-1.72, respectively), and it was higher than the risk experienced by women with confirmed PTSD (OR=1.05, 95% CI: 0.68-1.62) in the fully adjusted models. When relaxing the case-definition to the ≥2 criteria, risk among women in the possible category was attenuated to match mothers in the confirmed category (OR=1.03, 95% CI: 0.46-2.29 and OR=1.06, 95% CI: 0.69-1.64, respectively), while HDP risk among women in the probable group was higher at 30% compared to mothers without any PTSD (OR=1.30, 95% CI: 1.01-1.67).

The analysis assessing the relationship among PTSD levels and HDP from the PDHRA only was not more informative, and no findings were statistically significant (Appendix 3, Table 7). Using the ≥3 case-definition, confirmed mothers were 1.45 times more likely to develop HDP

(OR=1.45, 95% CI: 0.77-2.272) vs. 1.05 times more likely on the PDHA, probable mothers were 1.23 times more likely (OR=1.23, 95% CI: 0.79-1.92) vs. 1.22 times more likely on the PDHA, and possible mothers 0.91 were times less likely to develop HDP (OR=0.91, 95% CI: 0.27-3.11) vs. 1.21 times more likely on the PDHA compared to mothers without PTSD. The ORs for the confirmed (OR=1.32, 95% CI: 0.67-2.59) and probable (OR=1.14, 95% CI: 0.79-1.63) groups were attenuated when relaxing the case-definition, but the OR among the possible group changed direction and became a risk factor (OR=1.41, 95% CI: 0.74-2.69).

Racial/Ethnic Findings: PDHA Mothers. The observed findings were not consistent across racial/ethnic groups, and the only significant finding was among other race women (Table 19). The pattern among white mothers was closest to the overall but differed slightly. Mothers with confirmed PTSD experienced the lowest risk of HDP which was also seemingly protective (OR=0.84, 95% CI: 0.47-1.53), with probable mothers experiencing the highest risk (OR=1.30, 95% CI: 0.77-2.20). Relaxing the case-definition strengthened the probable PTSD association but attenuated the OR among the possible PTSD group. Among black women, we observed a 24% reduced risk of HDP in the confirmed PTSD group (OR=0.76, 95% CI: 0.29-1.99), with probable PTSD mothers 8% (OR=1.08, 95% CI: 0.61-1.89) more likely to develop HDP and possible PTSD mothers 32% (OR=1.32, 95% CI: 0.28-6.29) more likely to develop HDP. Similar to whites, using the ≥2 case-definition strengthened the association for probable PTSD mothers, but actually caused the possible OR to change direction and become protective. Confirmed PTSD (OR=1.79, 95% CI: 0.50-6.41) and probable PTSD (OR=1.95, 95% CI: 0.79-4.86) Hispanic mothers were both at higher risk of HDP with more extreme associations than whites or blacks, but the OR among probable PTSD women instead weakened using the relaxed case-definition. There were no Hispanics who met the case-definition for possible PTSD. Among other race mothers, those with confirmed PTSD experienced 6.62 times the risk of HDP compared to mothers without PTSD (OR=6.62, 95% CI: 1.72-25.47), but probable

PTSD mothers experienced nearly 30% lower risk of HDP (OR=0.71, 95% CI: 0.15-3.31). The confirmed relationship remained when exploring the ≥2 criteria while the probable was attenuated.

HDP Sub-Type Findings: PDHA Mothers. We were not able to assess the relationship between PTSD using the case-definition method and either chronic hypertension or unknown hypertension. There were too few cases across some strata to fit the logistic model. However, we noted increasing risk as the case-definition became more stringent using the ≥3 criteria for our gestational hypertension outcome as shown in Appendix 3, Table 8. There was no association between confirmed PTSD and gestational hypertension (OR=1.01, 95% CI: 0.51-2.01), but women with probable PTSD experienced 1.69 times the risk of gestational hypertension compared to non-PTSD women (OR=1.69, 95% CI: 1.04-2.76), increasing to 2.18 times the risk of HDP among possible mothers (OR=2.18, 95% CI: 0.65-2.76). Both the probable and possible associations were attenuated when relaxing the case-definition, with probable PTSD mothers experiencing the greatest risk out of the categories (OR=1.58, 95% CI: 1.08-2.32). The pattern was less clear for our preeclampsia group, and there were no significant findings.

PDHRA Agreement Sub-Analysis Findings: PDHA Mothers. Overall, women with positive agreement between their PDHA and PDHRA (OR=1.31, 95% CI: 0.56-3.06) or who became positive on their PDHRA (OR=1.19, 95% CI: 0.65-2.17) were at increased risk of HDP using the ≥3 case-definition whereas there was essentially no association among women who were initially positive on their PDHA and negative on their PDHRA (OR=0.96, 95% CI: 0.54-1.71) as illustrated in Appendix 3, Table 9. However, none of the observed associations were statistically significant. Associations for the positive-positive and negative-positive groups were

attenuated when examining the ≥2 case-definition criteria, with an association remaining only for positive-positive mothers (OR=1.18, 95% CI: 0.63-2.20).

Timing of Conception Sub-Analysis Findings: Entire Cohort & PDHA Mothers. Table 20 shows that mothers across the entire cohort with confirmed PTSD diagnosed between conception and birth (OR=0.87, 95% CI: 0.49-1.56) or diagnosed within a year before conception (OR=0.72, 95% CI: 0.46-1.11) were seemingly protected against HDP compared to mothers without PTSD. However, mothers who were diagnosed with confirmed PTSD a year or more prior to conception were 55% more likely to develop HDP (OR=1.55, 95% CI: 1.09-2.20). When restricting to PDHA mothers using the ≥3 PTSD screening definition, only mothers diagnosed within a year before conception were protected (OR=0.38, 95% CI: 0.12-1.21), while the other two categories increased risk by approximately 20% compared to non-PTSD mothers. None of the findings among PDHA-only mothers were statistically significant.

Table 2. Frequency of Main Exposures and Covariates for the Entire Cohort, n=36,675.[1]			
	Total		Military
	n	%	%
Maternal Age at Birth			
18 to 24 years	23,969	65.4	40%
25 to 29 years	8,524	23.2	60%
30 to 34 years	3,017	8.2	
≥35 years	1,165	3.2	
Maternal Race			
White	18,071	50.3	53.0
Black	9,291	25.9	31.0
Hispanic	5,229	14.6	13.0
Other[2,3]	3,343	9.3	11.0
Missing	741	2.0	
Marital Status at Birth			
Married	23,861	65.1	46.0
Single, never married	11,773	32.1	Unk
Other	1,002	2.7	Unk
Missing	39	0.1	
Pay Grade at Birth			
Officer	4,037	11.0	17.0
Enlisted	32,638	89.0	83.0
Pre-Gestational Diabetes			
Yes	40	0.1	
No	36,635	99.9	
Entry to Military Before 2001			
Yes	9,936	28.5	
No	24,983	71.6	
Missing	1,756	4.8	
Confirmed PTSD			
Yes	569	1.6	
No	36,106	96.5	
Deployed			
Yes	12,828	35.0	50.0
No	23,847	65.0	50.0

[1]Missing values were not included in calculated percents or p-values.
[2]Other race included Asian, American Indian, and DOD "Other" category.
[3]Military totals do not add to 100 because estimates separated race from Hispanic ethnicity.

Table 3. Frequency of Main Exposures and Covariates by HDP Status for the Entire Cohort, n=36,675.[1]			
	HDP		*p*-value[2]
	n=4,907		
	13.4%		
	n	%	
Maternal Age at Birth			
18 to 24 years	3,135	13.1	<0.0001
25 to 29 years	1,135	13.3	
30 to 34 years	414	13.7	
≥35 years	223	19.1	
Maternal Race			
White	2,435	13.5	<0.0001
Black	1,457	15.7	
Hispanic	520	9.9	
Other[3]	396	11.9	
Missing	99	13.4	
Marital Status at Birth			
Married	3,238	13.6	0.29
Single, never married	1,527	13.0	
Other	134	13.4	
Missing	8	20.5	
Pay Grade at Birth			
Officer	497	12.3	0.03
Enlisted	4,410	13.5	
Pre-Gestational Diabetes			
Yes	12	30.0	0.002
No	4,895	13.4	
Entry to Military Before 2001			
Yes	1,358	13.7	0.43
No	3,334	13.4	
Missing	215	12.2	
Confirmed PTSD			
Yes	82	14.4	0.47
No	4,825	13.4	
Deployed			
Yes	1,739	13.6	0.47
No	3,168	13.3	

[1]Missing values were not included in calculated percents or p-values.
[2]P-values are for Chi-square tests of homogeneity (or Fisher exact tests if a cell <5) using a 5% significance level.
[3]Other race included Asian, American Indian, and DOD "Other" category.

Table 4. Frequency of HDP Sub-types Overall and by Race, Entire Cohort.										
	Total		Whites		Blacks		Hispanic		Other	
	n=36,675		n=18,071		n=9,291		n=5,229		n=3,343	
	n	%	n	%	n	%	n	%	n	%
Any HDP	4,907	13.4	2,435	13.5	1,457	15.7	520	9.9	396	11.9
Chronic Hypertension[1]	465	9.5	214	8.8	176	12.1	35	6.7	29	7.3
Gestational Hypertension	1,610	32.8	903	37.1	401	27.5	144	27.7	128	32.3
Preeclampsia	2,700	55.0	1,249	51.3	844	57.9	332	63.8	225	56.8
Unknown Hypertension	132	2.7	69	2.8	36	2.5	9	1.7	14	3.5

[1]Chronic hypertension included 8 women coded as having pre-gestational chronic hypertension without any diagnosed HDP.

Table 5. Frequency of Main Deployment Exposures and Covariates, Specific Aim 1.[1]			
	Total		Military
	n	%	%
Deployed (n=36,675)			
Yes	12,828	35.0	50.0
No	23,847	65.0	50.0
Number of Deployments (n=36,108)[2]			
0	23,847	66.0	
1	9,740	27.0	
2	2,109	5.8	
≥3	412	1.1	
Timing of Deployment End Relative to Birth (n=36,108)[2]			
Non-deployed	23,847	66.0	
Ended ≥12 months before birth	7,740	21.4	
Ended <12 months before birth	4,521	12.5	
Timing of Deployment Relative to Estimated Conception Date (n=35,843)[2]			
Non-deployed	23,847	66.5	
Before Deployment Started	399	1.1	
During Deployment	1,957	5.5	
After Deployment Ended	9,640	26.9	
Missing Gestational Age	265	0.7	
Branch (n=12,261)[2,3]			
Air Force	2,824	23.0	31.0
Army	4,631	37.8	37.0
Navy[4]	4,806	39.2	32.0
Occupation (n=11,939)[2,3]			
Combat	1,264	10.6	15.0
Healthcare	1,275	10.7	15.0
Other	9,400	78.7	70.0
Missing	322	2.6	
Deployment Location (n=12,261)[2,3]			
Kosovo Only	40	0.3	
Southwest Asia Only	26	0.2	
OEF/OIF Only	12,116	98.8	
Other[5]	79	0.6	

Table 5. Frequency of Main Deployment Exposures and Covariates, Specific Aim 1 (Continued).[1]	
Cumulative Weeks of Deployment (n=12,261)[2,3]	
Mean±Std. dev.	33.3±20.7

[1]Missing values are not included in calculated percents.
[2]Women missing from the original deployment database but who completed a PDHA or PDHRA and women with overlapping deployment dates were excluded (n=567).
[3]Included deployed mothers only.
[4]Navy included the Marines and Coast Guard.
[5]Other included Kosovo and OEF/OIF, Southwest Asia and OEF/OIF.

Table 6. Frequency of Main Deployment Exposures and Covariates by HDP Status, Specific Aim 1.[1]			
	HDP		*p*-value[2]
	n	%	
Deployed (n=36,675)			
Yes	1,739	13.6	0.47
No	3,168	13.3	
Number of Deployments (n=36,108)[3]			
0	3,168	13.3	0.93
1	1,311	13.5	
2	299	14.2	
≥3	57	13.8	
Timing of Deployment End Relative to Birth (n=36,108)[3]			
Non-deployed	3,168	13.3	0.21
Ended ≥12 months before birth	1,081	14.0	
Ended <12 months before birth	586	13.0	
Timing of Deployment Relative to Estimated Conception Date (n=35,843)[3]			
Non-deployed	3,168	13.3	0.50
Before Deployment Started	53	13.3	
During Deployment	241	12.3	
After Deployment Ended	1,310	13.6	
Missing Gestational Age	63	23.8	
Branch (n=12,261)[3,4]			
Air Force	435	15.4	<0.0001
Army	627	13.5	
Navy[5]	605	12.6	
Occupation (n=11,939)[3,4]			
Combat	145	11.5	0.01
Healthcare	198	15.5	
Other	1,279	13.6	
Missing	45	14.0	
Deployment Location (n=12,261)[3,4]			
Kosovo Only	4	10.0	0.77
Southwest Asia Only	5	19.2	
OEF/OIF Only	1,648	13.6	
Other[6]	10	12.7	

Table 6. Frequency of Main Deployment Exposures and Covariates by HDP Status, Specific Aim 1 (Continued).[1]

Cumulative Weeks of Deployment (n=12,261)[3,4]

		***p*-value[2]**
Mean±Std. dev.	33.9±20.9	0.24

[1]Missing values are not included in calculated percents.
[2]P-values are for Chi-square tests of homogeneity (or Fisher exact tests if a cell <5) for categorical variables and t-tests for continuous variables using a 5% significance level.
[3]Women missing from the original deployment database but who completed a PDHA or PDHRA and women with overlapping deployment dates were excluded (n=567).
[4]Included deployed mothers only.
[5]Navy included the Marines and Coast Guard.
[6]Other included Kosovo and OEF/OIF, Southwest Asia and OEF/OIF.

Table 7. Odds-ratios and 95% Confidence Intervals for Overall Deployment Measures and HDP, Specific Aim 1.[1]

	Crude OR	95% CI	Adjusted OR	95% CI
Deployed vs. Non-Deployed (n=35,897)[2]				
No	1.00		1.00	
Yes	1.03	0.96-1.09	1.02	0.95-1.09
Timing of Deployment Ending Relative to Birth (n=35,337)[2,3]				
Non-Deployed	1.00		1.00	
Ended ≥12 months before birth	1.06	0.99-1.15	1.05	0.97-1.13
Ended <12 months before birth	0.97	0.88-1.07	0.97	0.88-1.07
Cumulative Weeks of Deployment (n=11,685)[3,4]				
For each 1 month increase	1.01	0.99-1.02	1.01	0.99-1.02
Timing of Conception (n=35,617)[2,3,5]				
Non-Deployed	1.00		1.00	
Before Deployment Started	1.01	0.75-1.35	1.01	0.75-1.36
During Deployment	0.92	0.80-1.06	0.92	0.80-1.06
After Deployment Ended	1.02	0.96-1.10	1.01	0.92-1.09

[1]Women with missing values for any covariates were not included in regression models.
[2]Adjusted logistic models include maternal age at birth, maternal race, marital status at birth, pay grade at birth, and pre-gestational diabetes.
[3]Women missing from the original deployment database but who completed a PDHA or PDHRA and women with overlapping deployment dates were excluded (n=567).
[4]Logistic models included deployed women only and adjusted models include covariates used in previous models in addition to branch and occupation.
[5]Records missing gestational age were excluded.

Table 8. Odds-ratios and 95% Confidence Intervals for Overall Deployment Measures and HDP by Racial Category, Specific Aim 1.[1]

	White		Black		Hispanic		Other[2]	
	Adjusted OR	**95% CI**	**Adjusted OR**	**95% CI**	**Adjusted OR**	**95% CI**	**Adjusted OR**	**95% CI**
Deployed vs. Non-Deployed[3]	**n=18,039**		**n=9,264**		**n=5,220**		**n=3,334**	
No	1.00		1.00		1.00		1.00	
Yes	0.94	0.86-1.03	**1.13**	**1.00-1.27**	1.04	0.86-1.26	1.09	0.87-1.36
Timing of Deployment Ending Relative to Birth[3,4]	**n=17,766**		**n=9,129**		**n=5,123**		**n=3,279**	
Non-Deployed	1.00		1.00		1.00		1.00	
Ended ≥12 months before birth	0.98	0.87-1.09	**1.18**	**1.03-1.36**	1.06	0.84-1.33	1.07	0.82-1.39
Ended <12 months before birth	0.88	0.76-1.02	1.08	0.91-1.27	1.04	0.80-1.36	1.06	0.75-1.48
Cumulative Weeks of Deployment[4,5]	**n=5,462**		**n=3,321**		**n=1,823**		**n=1,069**	
For each 1 month increase	1.00	0.99-1.01	1.003	0.99-1.01	1.003	0.99-1.01	1.004	0.99-1.01

[1]Women with missing values for any covariates were not included in regression models.
[2]Other race included Asian, American Indian, and DOD "Other" category.
[3]Adjusted logistic models include maternal age at birth, marital status at birth, and pay grade at birth.
[4]Women missing from the original deployment database but who completed a PDHA or PDHRA and women with overlapping deployment dates were excluded (n=567).
[5]Logistic models included deployed women only and adjusted models include covariates used in previous models in addition to branch and occupation.

Table 9. Frequency of Main Exposures and Covariates by HDP Status for Deployed Women Only, Specific Aim 2.[1]			
	Total	**HDP**	***p*-value[2]**
Cumulative Weeks of Deployment (n=12,261)			
Mean±Std. dev.	33.3±20.7	33.9±20.9	0.24
Percent of Time Spent Deployed in Study Period Before Birth (n=11,589)[3]			
Mean±Std. dev.	16.5±9.7	16.4±10.0	0.89
Dwell Time (in weeks) (n=2,521)[4]			
Mean±Std. dev.	59.6±40.3	60.2±38.7	0.74
Dwell Time Ratio (n=2,521)[4,5]			
Mean±Std. dev.	0.77±1.3	0.70±1.0	0.37

[1]Women missing from the original deployment database but who completed a PDHA or PDHRA and women with overlapping deployment dates were excluded (n=567).
[2]P-values are for t-tests using a 5% significance level.
[3]Excludes women missing military entry time or with entry time errors.
[4]Includes women who completed >1 deployment.
[5]Dwell time ratio is calculated as the length of the second most recent pre-birth deployment divided by the length of break time between the two most recent pre-birth deployments.

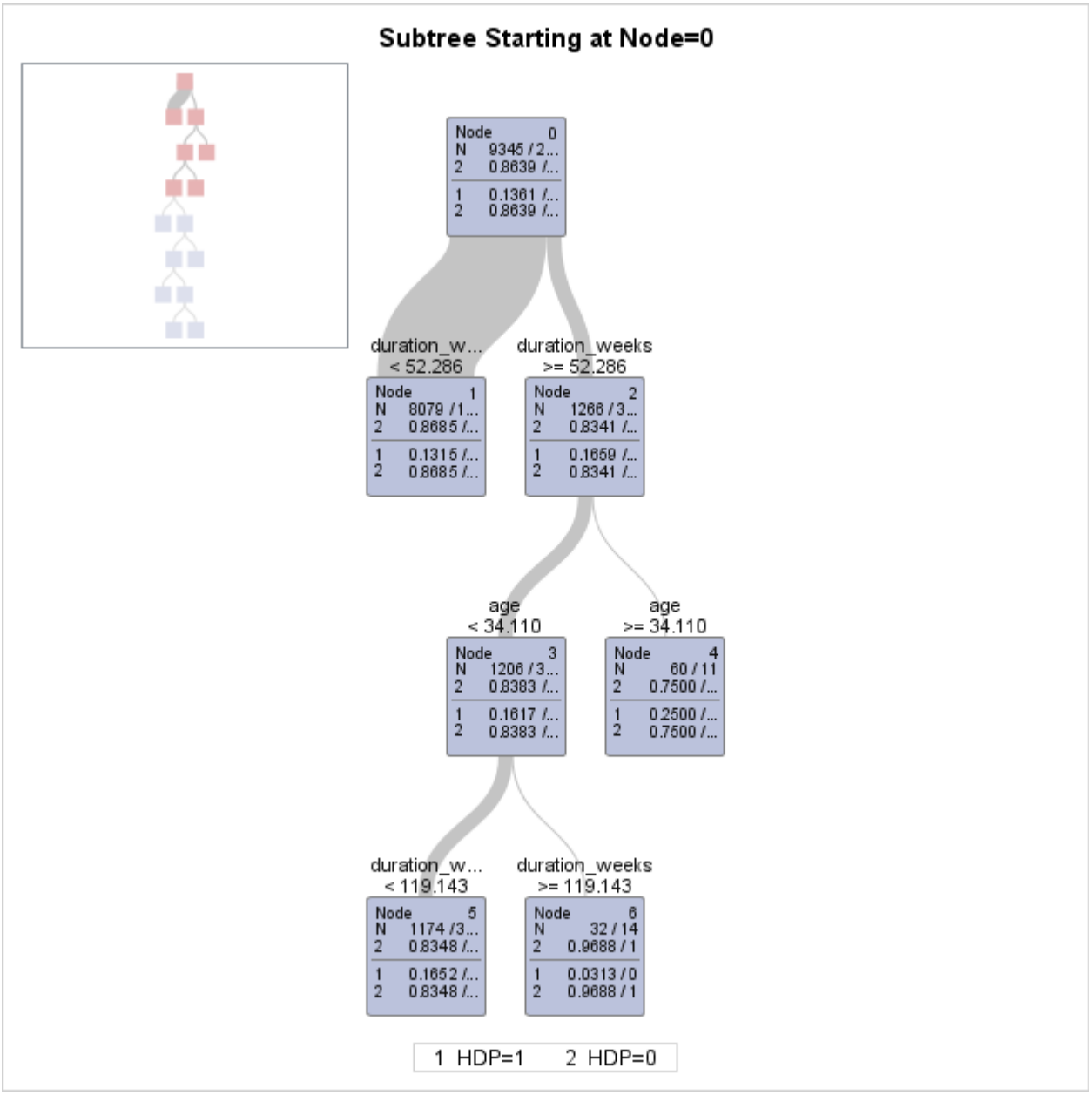

Figure 2. Classification Tree for Cumulative Weeks of Deployment by Maternal Age.

Table 10. Odds-ratio and 95% Confidence Intervals for Categorized Cumulative Weeks of Deployment among Deployed Women Only, Specific Aim 2, n=11,685.[1,2,3]		
	OR	**95% CI**
Cumulative Weeks of Deployment		
<1 year	1.00	
≥1 year	**1.17**	**1.01-1.36**
Interaction with Age		
<35 Years Old		
≥1 year vs. <1 year cumulative deployment	**1.16**	**1.00-1.36**
≥35 Years Old		
≥1 year vs. <1 year cumulative deployment	1.35	0.74-2.47
Interaction with Race		
Black		
≥1 year vs. <1 year cumulative deployment	1.19	0.98-1.42
All Other Races[4]		
≥1 year vs. <1 year cumulative deployment	1.14	0.90-1.45

[1]Women missing from the original deployment database but who completed a PDHA or PDHRA and women with overlapping deployment dates were excluded (n=567).
[2]ORs are adjusted for maternal age at birth, maternal race, marital status at birth, pay grade, branch, and occupation.
[3]Women with missing values for any covariates were not included in regression models.
[4]Other race includes White, Hispanic, Asian, American Indian, and DOD "Other" category.

Table 11. Frequency of PTSD Exposures for the Entire Cohort, Specific Aim 3, n=36,675.		
	Total	
	n	%
Confirmed PTSD		
Yes	569	1.6
No	36,106	96.5
Confirmed PTSD by Deployment Status		
No PTSD/No Deployment	23,526	64.1
PTSD/No Deployment	321	0.9
No PTSD/Deployment	12,580	34.3
PTSD/Deployment	248	0.7

Table 12. Frequency of PTSD Exposures by HDP Status for the Entire Cohort, Specific Aim 3, n=36,675.			
	HDP		*p*-value[1]
	n=4,907		
	13.4%		
	n	%	
Confirmed PTSD			
Yes	82	14.4	0.47
No	4,825	13.4	
Confirmed PTSD by Deployment Status			
No PTSD/No Deployment	3,123	13.3	0.70
PTSD/No Deployment	45	14.0	
No PTSD/Deployment	1,702	13.5	
PTSD/Deployment	37	14.9	

[1]P-values are for Chi-square tests of homogeneity (or Fisher exact tests if a cell <5) for categorical variables and t-tests for continuous variables using a 5% significance level.

Table 13. Frequency of Main Exposures and Covariates for PDHA Mothers Only, Specific Aim 3, n=8,801.[1]		
	Total	
	n	%
Maternal Age at Birth		
18 to 24 years	4,919	55.9
25 to 29 years	2,673	30.4
30 to 34 years	902	10.3
≥35 years	307	3.5
Maternal Race		
White	4,108	47.7
Black	2,398	27.8
Hispanic	1,350	15.7
Other[2]	758	8.8
Missing	187	2.1
Marital Status at Birth		
Married	5,684	64.7
Single, never married	2,724	31.0
Other	377	4.3
Missing	16	0.2
Pay Grade at Birth		
Officer	1,046	11.9
Enlisted	7,755	88.1
Pre-Gestational Diabetes		
Yes	7	0.1
No	8,794	99.9
Entry to Military Before 2001		
Yes	3,101	37.3
No	5,220	62.7
Missing	480	5.5
Branch		
Air Force	2,191	24.9
Army	4,129	46.9
Navy[3]	2,481	28.2
Occupation		
Combat	769	9.5
Healthcare	973	12.0
Other	6,337	78.4
Missing	722	8.2

Table 13. Frequency of Main Exposures and Covariates for PDHA Mothers Only, Specific Aim 3, n=8,801 (Continued).[1]

	Total	
	n	%
Deployment Location		
Kosovo Only	32	0.4
Southwest Asia Only	7	0.1
OEF/OIF Only	8,185	98.5
Other[4]	86	1.0
Missing	491	5.6
Confirmed PTSD		
Yes	187	2.1
No	8,614	97.9

[1]Missing values are not included in calculated percents.
[2]Other race includes Asian, American Indian, and DOD "Other" category.
[3]Navy included the Marines and Coast Guard.
[4]Other included Kosovo and OEF/OIF, Southwest Asia and OEF/OIF.

Table 14. Frequency of Main Exposures and Covariates by HDP Status for PDHA Mothers Only, Specific Aim 3, n=8,801.[1]			
	HDP n=1,201 13.7%		*p*-value[2]
	n	%	
Maternal Age at Birth			
18 to 24 years	646	13.1	0.004
25 to 29 years	355	13.3	
30 to 34 years	140	15.5	
≥35 years	60	19.5	
Maternal Race			
White	539	13.1	<0.0001
Black	413	17.2	
Hispanic	134	9.9	
Other[3]	88	11.6	
Missing	27	14.4	
Marital Status at Birth			
Married	802	14.1	0.18
Single, never married	344	12.6	
Other	52	13.8	
Missing	3	18.8	
Pay Grade at Birth			
Officer	126	12.1	0.11
Enlisted	1,075	13.9	
Pre-Gestational Diabetes			
Yes	2	28.6	0.25
No	1,199	13.6	
Entry to Military Before 2001			
Yes	430	13.9	0.61
No	703	13.5	
Missing	68	14.2	
Branch			
Air Force	321	14.7	0.06
Army	574	13.9	
Navy[4]	306	12.3	
Occupation			
Combat	862	12.1	0.14
Healthcare	93	12.1	
Other	149	15.3	
Missing	97	13.4	

Table 14. Frequency of Main Exposures and Covariates by HDP Status for PDHA Mothers Only, Specific Aim 3, n=8,801 (Continued).[1]

	HDP		*p*-value[2]
	n=1,201		
	13.7%		
	n	%	
Deployment Location			
Kosovo Only	4	12.5	1.00
Southwest Asia Only	1	14.3	
OEF/OIF Only	1,122	13.7	
Other[5]	12	14.0	
Missing	62	12.6	
Confirmed PTSD			
Yes	27	14.4	0.75
No	1,174	13.6	

[1]Missing values are not included in calculated percents.
[2]P-values are for Chi-square tests of homogeneity (or Fisher exact tests if a cell <5) for categorical variables and t-tests for continuous variables using a 5% significance level.
[3]Other race includes Asian, American Indian, and DOD "Other" category.
[4]Navy included the Marines and Coast Guard.
[5]Other included Kosovo and OEF/OIF, Southwest Asia and OEF/OIF.

Table 15. Frequency of HDP Sub-types Overall and by Race, PDHA Mothers Only, Specific Aim 3.										
	Total		Whites		Blacks		Hispanic		Other	
	n=8,801		n=4,108		n=2,398		n=1,350		n=758	
	n	%	n	%	n	%	n	%	n	%
Any HDP	1,201	13.7	539	13.1	413	17.2	134	9.9	88	11.6
Chronic Hypertension	122	10.2	51	9.5	49	11.9	12	9.0	8	9.1
Gestational Hypertension	411	34.2	226	41.9	113	27.4	40	29.9	23	26.1
Preeclampsia	638	53.1	252	46.8	242	58.6	78	58.2	52	59.1
Unknown Hypertension	30	2.5	10	1.9	9	2.2	4	3.0	5	5.7

Table 16. Frequency of PTSD for PDHA Mothers Only, Specific Aim 3, n=8,801.[1]		
	n	**%**
PTSD (≥3 Case-Definition)		
None	7,494	93.8
Possible	33	0.4
Probable	279	3.5
Confirmed	187	2.3
Missing	808	9.2
PTSD (≥2 Case-Definition)		
None	7,212	90.2
Possible	58	0.7
Probable	536	6.7
Confirmed	187	2.3
Missing	808	9.2
PTSD Diagnosis Relative to Estimated Conception Date (≥3 Case-Definition)		
No PTSD	7,494	93.9
Diagnosis between conception and birth	51	0.6
Diagnosis <1 year prior to conception	61	0.8
Diagnosis ≥1 year prior to conception	374	4.7
Missing Gestational Age	821	9.3
PTSD Screening Agreement Between PDHA and PDHRA (≥3 Case-Definition)		
Both Negative	2,140	88.5
Both Positive	37	1.5
Negative to Positive	87	3.6
Positive to Negative	103	4.3
One or Both Missing	52	2.2
PDHRA Did Not Match a PDHA	722	23
PTSD Screening Agreement Between PDHA and PDHRA (≥2 Case-Definition)		
Both Negative	1,989	81.9
Both Positive	77	3.2
Negative to Positive	148	6.1
Positive to Negative	163	6.7
One or Both Missing	51	2.1
PDHRA Did Not Match a PDHA	713	22.7

[1]Missing values are not included in calculated percents.

Table 17. Frequency of PTSD by HDP Status for PDHA Mothers Only, Specific Aim 3, n=8,801.[1]			
	HDP n=1,201 13.7%		*p*-value[2]
	n	%	
PTSD (≥3 Case-Definition)			
None	1,026	13.7	<0.0001
Possible	5	15.2	
Probable	45	16.1	
Confirmed	27	14.4	
Missing	98	12.1	
PTSD (≥2 Case-Definition)			
None	982	13.6	0.38
Possible	7	12.1	
Probable	87	16.2	
Confirmed	27	14.4	
Missing	98	12.1	
PTSD Diagnosis Relative to Estimated Conception Date (≥3 Case-Definition)			
No PTSD	1,026	13.7	0.07
Diagnosis between conception and birth	8	15.7	
Diagnosis <1 year prior to conception	3	4.9	
Diagnosis ≥1 year prior to conception	62	16.7	
Missing Gestational Age	102	12.4	
PTSD Screening Agreement Between PDHA and PDHRA (≥3 Case-Definition)			
Both Negative	338	15.8	0.53
Both Positive	7	18.9	
Negative to Positive	15	17.2	
Positive to Negative	16	15.5	
One or Both Missing	4	1.1	
PDHRA Did Not Match a PDHA	104	14.4	
PTSD Screening Agreement Between PDHA and PDHRA (≥2 Case-Definition)			
Both Negative	315	15.8	0.64
Both Positive	13	16.9	
Negative to Positive	22	14.9	
Positive to Negative	25	15.3	
One or Both Missing	4	7.8	
PDHRA Did Not Match a PDHA	105	14.7	

[1]Missing values are not included in calculated percents.
[2]P-values are for Chi-square tests of homogeneity (or Fisher exact tests if a cell <5) for categorical variables and t-tests for continuous variables using a 5% significance level.

Table 18. Odds-ratio and 95% Confidence Intervals for PTSD, Entire Cohort, Specific Aim 3, n=35,897.[1]				
	Confirmed PTSD		Any PTSD	
	OR	95% CI	OR	95% CI
PTSD[2,3]				
No	1.00		1.00	
Yes	1.09	0.86-1.39	1.15	0.95-1.39
Interaction with Deployment				
Deployed				
PTSD vs. none	1.10	0.77-1.57	1.18	0.93-1.50
Non-Deployed				
PTSD vs. none	1.08	0.78-1.49	1.08	0.78-1.49

[1]Women with missing values for any covariates were not included in regression models.
[2]Adjusted logistic models include maternal age at birth, maternal race, marital status at birth, pay grade at birth, and pre-gestational diabetes.
[3]Crude OR did not change after adjustment for listed covariates.

Table 19. Odds-ratio and 95% Confidence Intervals for PTSD and HDP, Case-Definition Based on Screening among PDHA Mothers Only, Specific Aim 3.[1]

	Overall[2]		White[3]		Black		Hispanic		Other[4]	
	n=7,261		n= 3,353		n=2,083		n=1,173		n=646	
	Adjusted OR	95% CI	Adjusted OR	95% CI	Adjusted OR	95% CI	Adjusted OR	95% CI	Adjusted OR	95% CI
PTSD (≥3 Case Definition)										
No PTSD	1.00		1.00		1.00		1.00		1.00	
Confirmed	1.05	0.68-1.62	0.84	0.47-1.53	0.76	0.29-1.99	1.79	0.50-6.41	**6.62**	**1.72-25.47**
Probable	1.22	0.87-1.72	1.30	0.77-2.20	1.08	0.61-1.89	1.95	0.79-4.86	0.71	0.15-3.31
Possible	1.21	0.46-3.16	1.19	0.26-5.53	1.32	0.28-6.29	No cases		8.90	0.53-150.28
PTSD (≥2 Case Definition)										
No PTSD	1.00		1.00		1.00		1.00		1.00	
Confirmed	1.06	0.69-1.64	0.86	0.47-1.56	0.77	0.30-2.01	1.79	0.50-6.41	**6.69**	**1.74-25.76**
Probable	**1.30**	**1.01-1.67**	1.41	0.97-2.07	1.21	0.80-1.84	1.40	0.69-2.83	0.95	0.32-2.88
Possible	1.03	0.46-2.29	1.07	0.31-3.68	0.79	0.18-3.56	0.77	0.10-6.05	4.38	0.38-50.37

[1]Women with missing values for covariates are not included in regression models.
[2]Logistic model adjusted for maternal age at birth, maternal race, marital status at birth, pay grade at birth, pre-gestational diabetes, branch, and occupation.
[3]Race-specific logistic models are adjusted for the same covariates as the overall model except for maternal race and pre-gestational diabetes. Women with pre-gestational diabetes were excluded.
[4]Other race includes Asian, American Indian, and DOD "Other" category.

Table 20. Odds-ratio and 95% Confidence Intervals for PTSD Diagnosis Relative to Timing of Conception and HDP, Specific Aim 3.[1]						
	Confirmed PTSD[2]		**PTSD ≥3[3]**		**PTSD ≥2[3]**	
	Entire Cohort		**PDHA Moms Only**			
	n=35,875		**n=7,261**			
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Timing of PTSD Diagnosis						
No PTSD	1.00		1.00		1.00	
PTSD diagnosed between conception and birth	0.87	0.49-1.56	1.19	0.55-2.55	1.01	0.60-1.70
PTSD diagnosed <1 year before conception	0.72	0.46-1.11	0.38	0.12-1.21	1.20	0.87-1.65
PTSD diagnosed ≥1 year before conception	**1.55**	**1.09-2.20**	1.23	0.91-1.65	1.24	0.88-1.73

[1]Women with missing values for covariates are not included in regression models.
[2]Logistic model adjusted for maternal age at birth, maternal race, marital status at birth, pay grade at birth, and pre-gestational diabetes.
[3]Logistic models are adjusted for the same covariates as the entire cohort model in addition to branch and occupation.

CHAPTER 5
Discussion, Conclusions, and Recommendations

Deployment and HDP

Our study was the first to quantify the incidence of HDP among active-duty military women giving birth to their first child. At just over 13%, the incidence was higher than among the general population where 5-10% of pregnancies are affected.[21] This was an unexpected finding since active-duty military personnel are younger and healthier due to strict fitness standards, but supports the exploratory findings of Katon et al. who reported female veterans utilizing VA maternity benefits were 32% more likely to develop an HDP compared to the general population (SIR=1.32 95% CI: 1.15.-1.51).[19] However, we found no association between overall deployment history and HDP. Our results are supported by a study among U.S. Gulf War veterans that examined deployment during pregnancy compared to deployment at other times and its relationship with preterm birth and birth defects. The authors reported no statistically significant associations with deployment in general, but they did find increased risk associated with maternal age greater than 35 years old (OR=1.45, 95% CI: 1.09-1.94).[44] We also consistently observed elevated risk among our oldest mothers across our multivariable analyses, providing further evidence of older maternal age acting as a consistent risk factor for HDP. The American College of Obstetricians and Gynecologists (ACOG) Task Force on Hypertension in Pregnancy cite maternal age over 35 or 40 years old as an independent risk factor for HDP.[99] Overall, neither the timing of deployment ending relative to birth nor timing of deployment relative to conception contributed to the risk of HDP.

Black women in our study who had any deployment history and whose last deployment ended a year or more prior to birth did appear to experience a modest risk of HDP. In a 2010 study of all North Carolina births between 1994 and 2003, Miranda et al. showed that black mothers had about twice the incidence of HDP compared to white mothers (20% vs. 11%), and the risk of HDP was greater for blacks across every age group.[100] A comprehensive look at births in New York City from 1993 to 2002 revealed overall lower HDP incidence rates, but black mothers still carried the highest burden.[101] If racial/ethnic disparities result from differential access to care, similar rates among racial/ethnic groups among the military population are expected. Despite this theory, we identified a gap that could be explained by unmeasured sociodemograpic differences in our study that persisted even with presumably equal accessibility to health care. Such factors may include lower levels of social support, more sexual harassment during deployment, or specific stressful occupations. Since there are about 2.5 times more black women in the U.S. military than in the U.S. general population (31% vs. 13%),[5,102] it is imperative to understand and mitigate any extenuating circumstances that adversely impacts the health of black military women.

We noticed a few other notable patterns. We consistently observed that women who entered the military prior to 2001, those in the Navy or Marines, and single, never married women were seemingly protected against HDP. The first two groups support the healthy warrior or healthy deployer effect that purports individuals who deploy are mentally and physically healthier than military personnel who do not.[103,104] Our findings expand this concept to a healthy military effect where women who remain in the military for a long period of time tend to be healthier because they did not experience health problems expediting their discharge. Further, individuals in the Army and Marine service branches are required to meet more rigorous physical training (PT) requirements due to the nature of their roles compared to the Air Force, likely decreasing the overall incidence of many health problems. We hypothesize that single mothers experienced

less stress than married women in our cohort. About 50% of married military women are married to another service member.[5] Not only do married women in the general population experience poorer cardiovascular outcomes, the married women in our cohort may have felt particularly worried about a deployed partner in addition to their own military and normal life stresses.[105]

Interestingly, we discovered that for each month of increasing cumulative deployment, the risk of HDP rose by 1% for the entire cohort, and our classification tree exploratory analysis helped us identify that cumulative deployment longer than one year increased the risk of HDP by 17% compared to deployed mothers with less than a year of cumulative deployment, especially among older mothers. Exploring cut-points supported a critical dose-response relationship that we would have been missed by only looking at overall deployment status. On average, deployed women had less than a year of cumulative deployment (about 7.5 months), thus the overall association among the entire cohort might have been attenuated because the adverse effect of deployment was not observed until the one year mark. More likely, though, it was attenuated due to the healthy warrior effect when comparing deployed women to a non-deployed reference group.

Our findings somewhat support those of previous authors investigating the relationship between deployment duration and adverse health outcomes. Bleier et al. reported a general trend of worsening health outcomes associated with increasing months of deployment in the previous three years among troops, with the greatest risk occurring among individuals deployed 8 to 10 months. Individuals deployed 4 to 7 and >10 months experienced similar increased risk, but less than the 8 to 10 month group.[55] This study was conducted among the Australian military, who may encounter different situations and care than the U.S. military. Our findings for the exploration of etiologically relevant dwell times and dwell time ratios were not statistically

significant; however, our sample size was reduced considerably to about 2,500 women with >1 deployment which may have reduced power significantly in that sub-analysis. Since we could not locate any studies assessing the impact of these specific deployment measures on perinatal outcomes, further analytical research is warranted to more definitively elucidate whether or not a relationship exists.

PTSD and HDP

Our study filled an important gap by estimating the prevalence of PTSD among a large cohort of deployed military women in the post-9/11/2001 era. The proportion of confirmed PTSD among our entire study population was 1.6%. When integrating our screening case-definition among mothers who completed a PDHA, the proportion increased to 6.2% using the ≥3 criteria and to 9.7% using the ≥2 criteria. We noted a modest increase to 7.5% (≥3) and 11.7% (≥2) when examining only PDHRAs. While our estimates are similar to existing studies assessing PTSD on the PDHA or PDHRA, they tended to be slightly different, perhaps due to different methodologies employed.

Hoge et al. assessed the prevalence of PTSD using PDHAs among both men and women returning from OEF/OIF between 2003 and 2004, and reported 9.8% of OIF respondents endorsed two or more of the PTSD questions on the PDHA while only 4.7% of OEF respondents did.[106] Our estimates were combined for returning OEF/OIF service personnel, and the overall prevalence using the ≥2 criteria was slightly higher than an average of the Hoge result (9.7% vs. 7.3%). However, we also integrated additional "high risk" questions into our criteria that Hoge et al. did not use. A later 2007 assessment revealed a similar level of PTSD as ours on the PDHA using both ≥3 and ≥2 criteria, but a higher prevalence of PTSD than we reported on the PDHRAs alone (9.1% using ≥3 and 16.7% using ≥2). Their study population

was very different than our female cohort, with 90% being male, all in the Army, and most returning from combat-related positions.[107] A DOD analysis of deployed personnel returning in 2005 revealed a 10% PTSD prevalence using the ≥2 criteria on the PDHA among women which was similar to ours (9.7%).[108]

We did not find any statistically significant findings when assessing the relationship between confirmed or any PTSD and HDP among the entire cohort. However, relying on ICD-9-CM confirmed PTSD in the medical record likely misclassified positive mothers as negative and attenuated the association, as most mothers likely were not clinically diagnosed with PTSD even if they may have screened positive. When expanding the definition to any PTSD, the OR for the overall relationship and the OR among deployed women strengthened and the lower bound of the confidence interval moved closer to statistical significance. This indicates that mothers with PTSD may be at risk of having a pregnancy complicated by HDP, especially if they also deployed. When restricting to mothers who deployed and completed a PDHA, we did find a 30% increased risk of HDP among probable PTSD cases using the ≥2 case-definition. The probable PTSD group using the ≥3 case-definition followed a similar pattern, but did not achieve statistical significance likely due to a smaller sample size.

We were surprised that we did not observe a strengthening dose-response trend when moving from probable to confirmed PTSD case status. In fact, among all mothers who completed a PDHA overall, confirmed PTSD conferred a lower HDP risk than probable PTSD (≥3). While this may have resulted from under detection of confirmed cases as previously discussed, differing diagnosis criteria could also explain the inconsistency. We included additional PDHA screening questions related to depression and specific wartime experiences (firing a weapon, seeing dead bodies, etc.) to define our probable category. Positive endorsement of these items

may indicate mental health conditions other than PTSD, such as anxiety disorders and depression. It is possible that we detected an association between another type of mental health condition and HDP, or an interaction between PTSD and these conditions.

We also noted that despite the very small sample size, mothers with confirmed PTSD and identifying as "other race" experienced a large, significant increased HDP risk. It is difficult to interpret this result, as no clear patterns emerged among the other racial/ethnic groups. Our original data from the DOD included an "other race" category to which Asian/Pacific Islander and American Indian women were added. We can only speculate that the other category included women identifying as bi-racial, those of Middle Eastern descent, women who did not want to self-identify race, and women with another combination of race/ethnicity. Also, inconsistent patterns across the other races may have resulted from unmeasured sociodemographic differences and/or differential medical follow-up. A more specific racial/ethnic analysis should be conducted with detailed data.

Women who conceived a year or more before their PTSD diagnosis (or positive screening) were at risk of HDP, which is opposite of the Shaw et al. study that found an increased risk of PTB among military women when diagnosis was made within a year before birth.[64] We are unsure if our findings indicated a true association or was due to unmeasured confounding by an underlying fertility condition linked to HDP. For example, polycystic ovarian syndrome effects approximately 8% of women in the general population, can cause infertility or delayed fertility, and is associated with a greater risk of later development of Type II diabetes and cardiovascular disease.[109] Additionally, since we observed a protective association between diagnosis within a year of conception and HDP, there may have been under-diagnosis or attrition among this group. Caution should be used interpreting this result.

Our study population included PTSD screenings for women who remained in the service post-deployment long enough to have their first child, thus our data does not include women lost to attrition post-deployment who gave birth outside the military. It is likely that some proportion of women with PTSD who would have been included in our study if they had remained in the military were missed, potentially underestimating the true number of PTSD cases. Since it appears a relationship may exist between PTSD and HDP, our results may underestimate the true risk by missing these women. Hoge et al. reported a slightly higher rate of military attrition within a year after completing a PDHA among individuals documenting mental health concerns compared to those not reporting any concerns (21% vs. 16%),[106] demonstrating that less healthy individuals are likely to leave the military sooner.

We may have also underestimated PTSD using the screening method because some service personnel provide false information on the PDHA to return home without additional medical referral.[108] It is impossible to quantify the impact, but it is generally accepted that responses on the PDHRAs are more truthful. The prevalence of PTSD did not increase substantially among the PDHRAs in our study population, therefore our findings using the PDHAs are likely only marginally underestimated due to this practice. However, it may have impacted particular racial/ethnic groups differentially if extenuating socioeconomic or cultural drivers existed that influenced either how quickly an individual needed to return home after deployment, or which were acceptable responses. Additionally, 808 (9.2%) of women completing a PDHA had missing responses for all of the variables we used to create our case-definition. These women seemed more affluent, as they were slightly older, white, married officers, and more likely to be in the Air Force. With a slightly lower rate of HDP and no confirmed PTSD cases among this group, the data was likely missing at random and did not impact our findings.

Overall Strengths and Weaknesses

In addition to limitations previously discussed, we recognize that data on tobacco use was lacking; thus, we were unable to adjust for it as a potential confounder. Previous studies have shown a reduced risk of HDP among smokers, a counterintuitive finding that is postulated to occur due to higher rates of early spontaneous miscarriage among smokers or due to a link between the genetic predisposition to smoke and HDP.[110,111] Our observed results may be close to the null or even protective due to uncontrolled confounding by smoking in our cohort, especially since smoking is highly prevalent in the military. About a quarter of the U.S. military were classified as current smokers in 2011 compared to 19% in the general population.[84,112]

Additionally, we chose not to adjust for multiple comparisons in our study, and instead reported 95% CIs with our OR estimates to let the reader make their own conclusions. It is possible that some of our statistically significant findings were due to chance. However, we carefully planned our hypotheses a priori and are confident they are based in scientific plausibility. We did not wish to be too conservative and discourage further study among this often neglected portion of the U.S. Armed Forces. Similarly, as Rothman purports, new scientific discoveries have been born of seemingly random findings that would have otherwise been missed if adjusting for multiple comparisons.[113]

Our research did possess several strengths. It was the first to include such a large number of military women in a study examining HDP as an outcome. Our data included approximately 36,000 first births, allowing us to explore two important exposures among this population, deployment and PTSD, with high statistical power. Existing studies on deployment and adverse birth outcomes have lacked this level of power, which is likely responsible, at least in part, for the inconclusive findings. Our study also included longitudinally collected records for our entire

study population, which eliminated the temporality issues some previous studies have encountered.

Conclusions and Future Research

We reported increasing risk of HDP among deployed black mothers and for cumulative deployment time longer than one year, in addition to increased risk associated with some levels of PTSD. Future research is needed that includes more detailed demographic information for the entire cohort (i.e. smoking, race, occupation and branch), more specifics related to deployment experience, and PTSD screening information for all mothers. If possible, quantifying deployment, PTSD and HDP among women who leave the military before having children should also be attempted to compare differences to those who remain in service. Based on our results, the military should explore the possibility of limiting cumulative deployment length to a year or less among women who wish to become pregnant, and may also wish to treat pregnant women who ever had signs or a diagnosis of PTSD as high risk maternity patients. Also, drivers for the racial/ethnic disparities we observed should also be further explored and corrected.

CHAPTER 6
References

1. By the numbers: Women in the U.S. military. CNN, 2013. (Accessed January 5, 2016, at http://www.cnn.com/2013/01/24/us/military-women-glance/).
2. Brook TV. Military will open all combat jobs to women, Defense secretary announces. USA Today, December 3, 2015.
3. American Psychiatric Association. Diagnostic and statistical manual of mental disorders. 5th ed. Washington, D.C.2013.
4. Otto JL, Ford SA, Ritschard, HV. Selected mental health disorders among active component members, U.S. Armed Forces, 2007-2010. Medical Surveillance Monthly Report 2010;17:2-5.
5. Patten, E and Parker, K. Women in the U.S. military: Growing share, distinctive profile. Pew Research Center, Washington, D.C., 2011.
6. Sherin JE and Nemeroff CB. Post-traumatic stress disorder: The neurobiological impact of psychological trauma. Dialogues in Clinical Neuroscience 2011;13:263-78.
7. Boscarino JA. A prospective study of PTSD and early-age heart disease mortality among Vietnam veterans: implications for surveillance and prevention. Psychosomatic Medicine 2008;70:668-76.
8. Sumner JA, Kubzansky LD, Elkind MS, et al. Trauma exposure and posttraumatic stress disorder symptoms predict onset of cardiovascular events in women. Circulation 2015;132:251-9.
9. Harville E, Xu X, Buekens P. Disaster and perinatal health: A systematic review. Obstetrical and Gynecological Survey 2011;65:713-28.
10. Lamprecht F and Sack M. Posttraumatic stress disorder revisited. Psychosomatic Medicine 2002;64:222-37.
11. Lo JO, Mission JF, Caughley AB. Hypertensive disease of pregnancy and maternal mortality. Maternal-Fetal Medicine 2013;25:124-32.
12. Zhang S, Ding Z, Liu H, et al. Association between mental stress and gestional hypertension/preeclampsia: A meta-analysis. Obstetrical and Gynecological Survey 2013;68:825-34.
13. Laszlo KD, Liu XQ, Svensson T, et al. Psychosocial stress related to the loss of a close relative the year before or during pregnancy and risk of preeclampsia. Hypertension 2013;62:183-9.
14. Bertozzi S, Londero AP, Salvador S, et al. Influence of the couple on hypertensive disorders during pregnancy: A retrospective cohort study. Pregnancy Hypertension 2011;1:156-63.
15. Vollebregt KC, van der Wal MF, Wolf H, et al. Is psychosocial stress in first ongoing pregnancies associated with pre-eclampsia and gestational hypertension? British Journal of Obstetrics and Gynecology 2008;115:607-15.
16. Lipkind HS, Curry AE, Huynh M, et al. Birth outcomes among offspring of women exposed to the September 11, 2001, terrorist attacks. Obstetrics and Gynecology 2010;116:917-25.
17. Lederman SA, Rauh V, Weiss L, et al. The effects of the World Trade Center event on birth outcomes among term deliveries at three lower Manhattan hospitals. Environmental Health Perspectives 2004;112:1772-8.

18. Zotti ME, Williams AM, Robertson M, et al. Post-disaster reproductive health outcomes. Maternal and Child Health Journal 2013;17:783-96.
19. Katon J, Mattocks K, Zephyrin L, et al. Gestational diabetes and hypertensive disorders of pregnancy among women veterans deployed in service of operations in Afghanistan and Iraq. Journal of Women's Health (2002) 2014;23:792-800.
20. Mattocks KM, Skanderson M, Goulet JL, et al. Pregnancy and mental health among women veterans returning from Iraq and Afghanistan. Journal of Women's Health (2002) 2010;19:2159-66.
21. Hutcheon JA, Lisonkova S, Joseph KS. Epidemiology of pre-eclampsia and the other hypertensive disorders of pregnancy. Best Practice & Research Clinical Obstetrics & Gynaecology 2011;25:391-403.
22. Leeman L and Fontaine P. Hypertensive disorders of pregnancy. American Family Physician 2008;78:93-100.
23. Trogstad L, Magnus P, Stoltenberg C. Pre-eclampsia: Risk factors and causal models. Best Practice & Research Clinical Obstetrics & Gynaecology 2011;25:329-42.
24. Hobel CJ, Goldstein A, Barrett ES. Psychosocial stress and pregnancy outcome. Clinical Obstetrics and Gynecology 2008;51:333-48.
25. Purves WK, Sadava D, Orians GH, et al. Life: The science of biology. 6th ed. Sunderland, Massachusetts: Sinauer Associates, Inc.; 2001.
26. Kivimaki M and Kawachi I. Work stress as a risk factor for cardiovascular disease. Current Cardiology Reports 2015;17:630.
27. Salleh MR. Life event, stress and illness. The Malaysian Journal of Medical Sciences 2008;15:9-18.
28. Walker SP, Permezel M, Brennecke SP, et al. Blood pressure in late pregnancy and work outside the home. Obstetrics and Gynecology 2001;97:361-5.
29. Leeners B, Neumaier-Wagner P, Kuse S, et al. Emotional stress and the risk to develop hypertensive diseases in pregnancy. Hypertension in Pregnancy 2007;26:211-26.
30. Yu Y, Zhang S, Wang G, et al. The combined association of psychosocial stress and chronic hypertension with preeclampsia. American Journal of Obstetrics and Gynecology 2013;209:438.e1-.e12.
31. Klonoff-Cohen HS, Cross JL, Pieper CF. Job stress and preeclampsia. Epidemiology 1996;7:245-9.
32. Landsbergis PA and Hatch MC. Psychosocial work stress and pregnancy-induced hypertension. Epidemiology 1996;7:346-51.
33. Katz VL. Work and work-related stress in pregnancy. Clinical Obstetrics and Gynecology 2012;55:765-73.
34. American Psychological Association Presidential Task Force on Military Deployment Services for Youth. The psychological needs of U.S. military service members and their families: A preliminary report, 2007.
35. Morral AR, Gore KL, Schell TL. Sexual assault and sexual harrassment in the U.S. military: Volume 2. Estimates from Department of Defense service members from the 2014 RAND workplace study. Santa Monica, California: RAND Corporation; 2014.
36. Sadler AG, Mengeling MA, Booth BM, et al. The relationship between U.S. military officer leadership behaviors and risk of sexual assault of Reserve, National Guard, and Active component servicewomen in nondeployed locations. American Journal of Public Health 2017;107:147-55.
37. Braun LA, Kennedy HP, Womack JA, et al. Integrative literature review: U.S. military women's genitourinary and reproductive health. Military Medicine 2016;181:35-49.
38. Military Fertility: It's Complicated. U.S. News and World Reports. 2016. (Accessed February 18, 2016, 2016, at http://health.usnews.com/health-news/health-wellness/articles/2016-01-28/military-fertility-its-complicated).

39. Endara SM, Ryan MA, Sevick CJ, et al. 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.
40. Irwin DE, Savitz DA, St Andre KA, et al. Study of occupational risk factors for pregnancy-induced hypertension among active duty enlisted Navy personnel. American Journal of Industrial Medicine 1994;25:349-59.
41. Araneta MR, Kamens DR, Zau AC, et al. Conception and pregnancy during the Persian Gulf War: The risk to women veterans. Annals of Epidemiology 2004;14:109-16.
42. Araneta MR, Destiche DA, Schlangen KM, et al. Birth defects prevalence among infants of Persian Gulf War veterans born in Hawaii, 1989-1993. Teratology 2000;62:195-204.
43. Araneta MR, Schlangen KM, Edmonds LD, et al. Prevalence of birth defects among infants of Gulf War veterans in Arkansas, Arizona, California, Georgia, Hawaii, and Iowa, 1989-1993. Birth defects research Part A, Clinical and Molecular Teratology 2003;67:246-60.
44. Ryan MA, Jacobson IG, Sevick CJ, et al. Health outcomes among infants born to women deployed to United States military operations during pregnancy. Birth Defects Research Part A, Clinical and Molecular Teratology 2011;91:117-24.
45. Bukowinski AT, DeScisciolo C, Conlin AM, et al. Birth defects in infants born in 1998-2004 to men and women serving in the U.S. military during the 1990-1991 Gulf War era. Birth Defects Research Part A, Clinical and Molecular Teratology 2012;94:721-8.
46. Conlin AM, DeScisciolo C, Sevick CJ, et al. Birth outcomes among military personnel after exposure to documented open-air burn pits before and during pregnancy. Journal of Occupational and Environmental Medicine 2012;54:689-97.
47. Kang H, Magee C, Mahan C, et al. Pregnancy outcomes among U.S. Gulf War veterans: A population-based survey of 30,000 veterans. Annals of Epidemiology 2001;11:504-11.
48. Armed Forces Health Surveillance Center. 2010. Epidemiological studies of health outcomes among troops deployed to burn pit sites.
49. Leuschner KJ. Can the Army deploy more soldiers to Iraq and Afghanistan? Santa Monica, CA: RAND Corporation; 2010.
50. Losey S. Air Force deployment tempo brings new kinds of strains. Air Force Times. March 29, 2016.
51. Associations between repeated deployments to Iraq (OIF/OND) and Afghanistan (OEF) and post-deployment illnesses and injuries, Active component, U.S. Armed Forces, 2003-2010. Part II. Mental disorders, by gender, age group, military occupation, and dwell times" prior to repeat (second through fifth) deployments. Medical Surveillance Monthly Report 2011 September 18:2-11.
52. MacGregor AJ, Han PP, Dougherty AL, et al. Effect of dwell time on the mental health of US military personnel with multiple combat tours. American Journal of Public Health 2012;102 Suppl 1:S55-9.
53. MacGregor AJ, Heltemes KJ, Clouser MC, et al. Dwell time and psychological screening outcomes among military service members with multiple combat deployments. Military Medicine 2014;179:381-7.
54. Health of women after wartime deployments: Correlates of risk for selected medical conditions among females after initial and repeat deployments to Afghanistan and Iraq, Active component, U.S. Armed Forces. Medical Surveillance Monthly Report 2012 July 19:2-10.
55. Bleier J, McFarlane A, McGuire A, et al. Risk of adverse health outcomes associated with frequency and duration of deployment with the Australian Defence Force. Military Medicine 2011;176:139-46.

56. American Psychiatric Association. Posttraumatic Stress Disorder. Diagnostic and Statistical Manual of Mental Disorders. 5th ed. Arlington, VA: American Psychiatric Association; 2013:271-80.
57. Post Traumatic Stress Disorder (PTSD). National Institute of Mental Health. 2015. (Accessed June 16, 2015, 2015, at http://www.nimh.nih.gov/health/topics/post-traumatic-stress-disorder-ptsd/index.shtml).
58. Epidemiology of PTSD. U.S. Department of Veteran's Affairs. 2016. (Accessed February 29, 2016, 2016, at http://www.ptsd.va.gov/professional/PTSD-overview/epidemiological-facts-ptsd.asp).
59. Benedek DM. Posttraumatic stress disorder from Vietnam to today: The evolution of understanding during Eugene Brody's tenure at the Journal of Nervous and Mental Disease. The Journal of Nervous and Mental Disease 2011;199:544-52.
60. Engel SM, Berkowitz GS, Wolff MS, et al. Psychological trauma associated with the World Trade Center attacks and its effect on pregnancy outcome. Paediatric and Perinatal Epidemiology 2005;19:334-41.
61. Seng JS, Oakley DJ, Sampselle CM, et al. Posttraumatic stress disorder and pregnancy complications. Obstetrics and Gynecology 2001;97:17-22.
62. Seng JS, Low LK, Ben-Ami D, et al. Cortisol level and perinatal outcome in pregnant women with posttraumatic stress disorder: a pilot study. Journal of Midwifery & Women's Health 2005;50:392-8.
63. Seng JS, Low LK, Sperlich M, et al. Post-traumatic stress disorder, child abuse history, birthweight and gestational age: A prospective cohort study. British Journal of Obstetrics and Gynecology 2011;118:1329-39.
64. Shaw JG, Asch SM, Kimerling R, et al. Posttraumatic stress disorder and risk of spontaneous preterm birth. Obstetrics and Gynecology 2014;124:1111-9.
65. Berkowitz GS, Wolff MS, Janevic TM, et al. The World Trade Center disaster and intrauterine growth restriction. Journal of the American Medical Association 2003;290:595-6.
66. Morland L, Goebert D, Onoye J, et al. Posttraumatic stress disorder and pregnancy health: Preliminary update and implications. Psychosomatics 2007;48:304-8.
67. Rogal SS, Poschman K, Belanger K, et al. Effects of posttraumatic stress disorder on pregnancy outcomes. Journal of Affective Disorders 2007;102:137-43.
68. Xiong X, Harville EW, Mattison DR, et al. Exposure to Hurricane Katrina, post-traumatic stress disorder and birth outcomes. The American Journal of the Medical Sciences 2008;336:111-5.
69. Yonkers KA, Smith MV, Forray A, et al. Pregnant women with posttraumatic stress disorder and risk of preterm birth. JAMA Psychiatry 2014;71:897-904.
70. National Center for Veterans Analysis and Statistics. America's women veterans: Military service history and VA benefit utilization statistics. Department of Veterans Affairs, Washington, DC, November 2011.
71. Sumner JA, Kubzansky LD, Roberts AL, et al. Post-traumatic stress disorder symptoms and risk of hypertension over 22 years in a large cohort of younger and middle-aged women. Psychological Medicine 2016:1-12.
72. Coughlin SS. Post-traumatic stress disorder and cardiovascular disease. Open Cardiovascular Medicine Journal 2011;5:164-70.
73. Granado NS, Smith TC, Swanson GM, et al. Newly reported hypertension after military combat deployment in a large population-based study. Hypertension 2009;54:966-73.
74. Deployment Health Assessment Program. U.S. Army Reserve. 2016. (Accessed June 23, 2016, at http://www.usar.army.mil/Featured/Resources/DHAP.aspx).

75. Committee on the Assessment of the Readjustment Needs of Military Personnel, Veterans, and Their Families; Board on the Health of Select Populations; Institute of Medicine. Returning Home from Iraq and Afghanistan: Assessment of readjustment needs of veterans, service members, and their families. Washington, D.C.: National Academies Press; 2013.
76. McCarthy MD, Thompson SJ, Knox KL. Use of the Air Force post-deployment health reassessment for the identification of depression and posttraumatic stress disorder: Public health implications for suicide prevention. American Journal of Public Health 2012;102 Suppl 1:S60-5.
77. Skopp NA, Swanson R, Luxton DD, et al. An examination of the diagnostic efficiency of post-deployment mental health screens. Journal of Clinical Psychology 2012;68:1253-65.
78. Bliese PD, Wright KM, Adler AB, et al. Validating the primary care posttraumatic stress disorder screen and the posttraumatic stress disorder checklist with soldiers returning from combat. Journal of Consulting and Clinical Psychology 2008;76:272-81.
79. Bliese P, Wright KM, Thomas JL, et al. Post-deployment mental health screening instruments: How good are they? Army Science Conference (24th). Orlando, FL, 2005.
80. Bliese PD, Wright KM, Adler AB, et al. Post-deployment psychological screening: Interpreting and scoring DD Form 2900. U.S. Army Medical Research Unit - Europe, Walter Reed Army Institute of Research, 2005.
81. Tricare Patients by Beneficiary Category. 2016. (Accessed January 7, 2016, at http://health.mil/I-Am-A/Media/Media-Center/Patient-Population-Statistics/Patients-by-Beneficiary-Category).
82. ICD-10. Centers for Medicare and Medicaid Services. 2016. (Accessed June 29, 2016, at https://www.cms.gov/medicare/coding/icd10/index.html).
83. Roberts CL, Bell JC, Ford JB, et al. The accuracy of reporting of the hypertensive disorders of pregnancy in population health data. Hypertension in Pregnancy 2008;27:285-97.
84. Barlas FM, Higgins WB, Pflieger JC, et al. Department of Defense health related behaviors survey of Active Duty military personnel. Fairfax, VA, February 2013.
85. Deployment Health Assessment Program builds ready, resilient Soldiers. U.S. Army. 2013. (Accessed June 29, 2016, at https://www.army.mil/article/105757).
86. Lu MC and Halfon N. Racial and ethnic disparities in birth outcomes: A life-course perspective. Maternal and Child Health Journal 2003;7:13-30.
87. Cheng TC and Lo CC. Racial disparities in children's health: A longitudinal analysis of mothers based on the multiple disadvantage model. Journal of Community Health 2016;41:753-60.
88. Egan KJ, Knutson KL, Pereira AC, et al. The role of race and ethnicity in sleep, circadian rhythms and cardiovascular health. Sleep Medicine Reviews 2016.
89. Tanaka M, Jaamaa G, Kaiser M, et al. Racial disparity in hypertensive disorders of pregnancy in New York state: A 10-year longitudinal population-based study. American Journal of Public Health 2007;97:163-70.
90. Breathett K, Muhlestein D, Foraker R, et al. Differences in preeclampsia rates between African American and Caucasian women: Trends from the National Hospital Discharge Survey. Journal of Women's Health (2002) 2014;23:886-93.
91. Lemon SC, Roy J, Clark MA, et al. Classification and regression tree analysis in public health: Methodological review and comparison with logistic regression. Annals of Behavioral Medicine 2003;26:172-81.
92. Zhang H and Bonney G. Use of classification trees for association studies. Genetic Epidemiology 2000;19:323-32.
93. SAS 9.4 Help and Documentation: The HPSPLIT Procedure. Cary, NC, 2002-2015.

94. Weathers FW, Litz BT, Herman DS, et al. The PTSD Checklist (PCL): Reliability, validity, and diagnostic utility. 9th Annual Conference of the ISTSS. San Antonio, TX, 1993.
95. Rytwinski NK, Scur MD, Feeny NC, et al. The co-occurrence of major depressive disorder among individuals with posttraumatic stress disorder: A meta-analysis. Journal of Traumatic Stress 2013;26:299-309.
96. Kessler RC, Sonnega A, Bromet E, et al. Posttraumatic stress disorder in the National Comorbidity Survey. Archives of General Psychiatry 1995;52:1048-60.
97. Leardmann CA, Pietrucha A, Magruder KM, et al. Combat deployment is associated with sexual harassment or sexual assault in a large, female military cohort. Women's Health Issues 2013;23:e215-23.
98. U.S. Department of Defense. Population representation in the military services: Fiscal year 2008, Table B-15: FY2008 Active component enlisted members by age group, service, and gender with civilian comparison group. 2008.
99. The American College of Obstetricians and Gynecologists. Hypertension in pregnancy. Washington, D.C.: American College of Obstetricians and Gynecologists; 2013.
100. Miranda ML, Swamy GK, Edwards S, et al. Disparities in maternal hypertension and pregnancy outcomes: Evidence from North Carolina, 1994-2003. Public Health Reports 2010;125:579-87.
101. Tanaka M, Jaamaa G, Kaiser M, et al. Racial disparity in hypertensive disorders of pregnancy in New York State: A 10-year longitudinal population-based study. American Journal of Public Health 2007;97:163-70.
102. U.S. Census Bureau. Current population survey, annual social and economic supplement, 2013. Washington, D.C., 2016.
103. Hoge CW. Re: "Psychiatric diagnoses in historic and contemporary military cohorts: combat deployment and the healthy warrior effect. American Journal of Epidemiology 2008;168:1095-6; author reply 6-8.
104. Wilson J, Jones M, Fear NT, et al. Is previous psychological health associated with the likelihood of Iraq War deployment? An investigation of the "healthy warrior effect". American Journal of Epidemiology 2009;169:1362-9.
105. Eaker ED, Sullivan LM, Kelly-Hayes M, et al. Marital status, marital strain, and risk of coronary heart disease or total mortality: The Framingham Offspring Study. Psychosomatic Medicine 2007;69:509-13.
106. Hoge CW, Auchterlonie JL, Milliken CS. Mental health problems, use of mental health services, and attrition from military service after returning from deployment to Iraq or Afghanistan. Journal of the American Medical Association 2006;295:1023-32.
107. Milliken CS, Auchterlonie JL, Hoge CW. Longitudinal assessment of mental health problems among active and reserve component soldiers returning from the Iraq war. Journal of the American Medical Association 2007;298:2141-8.
108. Martin C. Routine screening and referrals for post-traumatic stress disorder (PTSD) after returning from Operation Iraqi Freedom in 2005, U.S. Armed Forces. Morbidity and Surveillance Monthly Report 2007 November;14:2-7.
109. Park K, Wei J, Minissian M, et al. Adverse pregnancy conditions, infertility, and future cardiovascular risk: Implications for mother and child. Cardiovascular Drugs and Therapy 2015;29:391-401.
110. Gudnadóttir TA, Bateman BT, Hernádez-Díaz S, et al. Body mass index, smoking and hypertensive disorders during pregnancy: A population based case-control study. PLoS ONE 2016;11:e0152187.
111. Engel SM, Scher E, Wallenstein S, et al. Maternal active and passive smoking and hypertensive disorders of pregnancy: Risk with trimester-specific exposures. Epidemiology 2013;24:379-86.

112. Centers for Disease Control and Prevention. Current cigarette smoking among adults: United States. Morbidity and Mortality Weekly Report 2012;61:889-890.
113. Rothman KJ. No adjustments are needed for multiple comparisons. Epidemiology 1990;1:43-6.

APPENDIX 1:
ICD-9-CM Codes Used to Define Variables in Methods Section

Table 1. ICD-9-CM Procedure Codes for Live-Born Singleton Infants.					
Live, Singleton Birth	V30.0	V30.00	V30.01	V30.1	V30.2
Multiple Births and Unknown Plurality					
Twin, mate live-born	V31.0	V31.00	V31.01	V31.1	V31.2
Twin, mate stillborn	V32.0	V32.00	V32.01	V32.1	V32.2
Twin, unspecified	V33.0	V33.00	V33.01	V33.1	V33.2
Other multiple, all mates live-born	V34.0	V34.00	V34.01	V34.1	V34.2
Other multiple, all mates stillborn	V35.0	V35.00	V35.01	V35.1	V35.2
Other multiple, mates live and stillborn	V36.0	V36.00	V36.01	V36.1	V36.2
Other multiple, unspecified	V37.0	V37.00	V37.01	V37.1	V37.2
Unspecified	V39.0	V39.00	V39.01	V39.1	V39.2

Table 2. ICD-9-CM Diagnosis Codes for HDP.					
Chronic Hypertension	642.00	642.01	642.02	642.03	642.04
	642.10	642.11	642.12	642.13	642.14
	642.20	642.21	642.22	642.23	642.24
Gestational Hypertension	642.30	642.31	642.32	642.33	642.34
Preeclampsia	642.40	642.41	642.42	641.43	641.44
	642.50	642.51	642.52	641.53	641.54
	642.70	642.71	642.72	642.73	642.74
Eclampsia	642.80	642.81	642.82	642.83	642.84
Unspecified	642.90	642.91	642.92	642.93	642.94

Table 3. ICD-9-CM Diagnosis Codes for Pre-Gestational Diabetes.			
250.00	250.01	250.02	250.03
250.10	250.11	250.12	250.13
250.20	250.21	250.22	250.23
250.30	250.31	150.32	250.33
250.40	250.41	250.42	250.43
250.50	250.51	250.52	250.53
250.60	250.61	250.62	250.63
250.70	250.71	250.72	250.73
250.80	250.81	250.82	250.83
250.90	250.91	250.92	250.93

Table 4. ICD-9-CM Diagnosis Codes for Gestational Age.				
Unspecified weeks	765.20			
<24 weeks	765.21			
24 weeks	765.22			
25-26 weeks	765.23			
27-28 weeks	765.24			
29-30 weeks	765.25			
31-32 weeks	765.26			
33-34 weeks	765.27			
35-36 weeks	765.28			
≥37 weeks	765.29			
>40 to 42 weeks	766.21			
>42 weeks	766.22			
Extreme Immaturity	765.00	765.01	765.02	765.03
	765.04	765.05	765.06	765.07
	765.08	765.09		
Other preterm infants	765.10	765.11	765.12	765.13
	765.14	765.15	765.16	765.17
	765.18	765.19		
RDS	769			

APPENDIX 2:
Main Terms and Variable Definitions Used in Methods Section

Table 1. Outcome Definition for Study.	
Hypertensive Disorders of Pregnancy (HDP)	
Definition:	Any woman with ≥1 ICD-9-CM diagnoses in her birth hospitalization(s) records
Variable Categories:	0=None 1=Yes
Four sub-types of HDP defined and coded the same way: Chronic hypertension, Gestational hypertension, Preeclampsia, Unknown hypertension	

Table 2. Aim 1: Main Terms and Variable Definitions.	
Main Terms:	
Deployment. Assignment to a location that lacks a permanent U.S. military medical treatment facility outside the U.S. for >30 days, with current study examining post-9/11 era deployments.	
Main Variables:	**Categories:**
Deployed vs. Non-Deployed	0=Non-Deployed 1=Deployed
Deployment Ending <12 months or ≥12 months before birth	0=Non-Deployed 1=Deployment ended ≥12 months before birth 2=Deployment ended <12 months before birth
Cumulative Weeks of Deployment	Continuous

Table 2. Aim 1: Main Terms and Variable Definitions (Continued).	
Main Variables:	**Categories:**
Timing of Conception Relative to Deployment	0=Non-Deployed 1=Conception Before Deployment Started 2=Conception During Deployment 3=Conception After Deployment Ended

Table 3. Aim 2: Main Terms and Variable Definitions.	
Main Variables:	**Definitions** (all continuous)**:**
Cumulative Weeks of Deployment	Total number of weeks each woman spent deployed within study period prior to birth
Percent of Study Period Deployed	Cumulative weeks of deployment divided by the total number of days spent in the military during the study period prior to birth
Dwell Time (in weeks)	Total number of weeks between the ending and beginning of the two most recent pre-birth deployments for women with >1 deployment
Dwell Time Ratio	Duration in days of the second most recent pre-birth deployment divided by the dwell time in days between it and the most recent pre-birth deployment

Table 4. Aim 3: Main Terms and Variable Definitions.

Main Terms:

Post-Deployment Health Assessment (PDHA, Form DD2796). Administered within 30 days of deployment end to screen for potential mental health problems among troops returning home from deployment. Used in the current study to define possible and probable PTSD.

Post-Deployment Health Re-Assessment (PDHRA, Form DD2900). Administered 90-180 days after the PDHA to screen for continuing or new mental health problems related to deployment.

Health Assessment Screening Questions Used in PTSD Possible Case-Definition: (Yes / No)

Have you ever had any experience that was so frightening, horrible, or upsetting that, IN THE PAST MONTH, you…

1. Have had nightmares about it or thought about it when you did not want to?
2. Tried hard not to think about it or went out of your way to avoid situations that remind you of it?
3. Felt numb or detached from others, activities, or your surroundings?
4. Were constantly on guard, watchful, or easily startled?

Health Assessment Screening Questions Used in PTSD Probable Case-Definition:

"High-Risk" (Yes / No)

1. Did you see anyone wounded, killed, or dead during this deployment?
2. Were you engaged in direct combat where you discharged your weapon?
3. During this deployment, did you ever feel that you were in great danger of being killed?

Depression (None, Some, A lot)

1. Over the last 2 weeks (version 2003) or last month (version 2008), how often have you been bothered by any of the following problems?
   a. Little interest or pleasure in doing things
   b. Feeling down, depressed, or hopeless

Table 4. Aim 3: Main Terms and Variable Definitions (Continued).	
Main Variables:	**Categories:**
Confirmed PTSD	0=No ICD-9-CM diagnoses for PTSD 1=≥1 ICD-9-CM diagnoses for PTSD
Any PTSD	0= No ICD-9-CM diagnoses for PTSD 1=≥1 ICD-9-CM diagnoses for PTSD or Possible/Probable screening on PDHA
PTSD Case-Definition (≥3 and ≥2)	0=No indication of PTSD 1=Confirmed 2=Probable 3=Possible
Timing of PTSD Diagnosis Relative to Conception	0=No indication of PTSD 1=PTSD diagnosed between conception and birth 2=PTSD diagnosed <1 before conception 3=PTSD diagnosed ≥1 year before conception
Pre-Post Comparison	0=Both Negative 1=Both Positive 2=Negative to Positive 3=Positive to Negative 4=One or Both Missing

Table 5. Additional Covariates: Main Terms and Variable Definitions.	
Variables:	**Categories:**
Maternal Age	0=18 to 24 years 1=25 to 29 years 2=30 to 34 years 3=≥35 years
Maternal Race	0=White 1=Black 2=Hispanic 3=Other

Table 5. Additional Covariates: Main Terms and Variable Definitions (Continued).	
Variables:	**Categories:**
Marital Status at Birth	0=Married 1=Single, never married 2=Other
Pay Grade at Birth	0=Officer 1=Enlisted
Pre-Gestational Diabetes	0=No ICD-9-CM diagnoses in birth hospitalization record(s) 1=≥1 ICD-9-CM diagnosis in birth hospitalization record(s)
Entry to Military Before 2001	0=No 1= Yes
Military Branch	0=Air Force 1=Army 2=Navy (includes Marines and Coast Guard)
Occupation	0=Other 1=Combat 2=Healthcare

APPENDIX 3:
Supplementary Tables for the Results Section

Table 1. Odds-ratio and 95% Confidence Intervals for Deployed vs. Non-Deployed Women, HDP Sub-Types.[1,2]

	Chronic Hypertension		Gestational Hypertension		Preeclampsia		Unknown Hypertension	
	n=31,549		n=32,670		n=33,742		n=31,224	
	453 cases		1,574 cases		2,646 cases		128 cases	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Deployed								
Yes vs. No	1.03	0.85-1.25	1.04	0.93-1.16	1.01	0.93-1.10	0.91	0.62-1.32
Maternal Age at Birth								
18 to 24 years	1.00		1.00		1.00		1.00	
25 to 29 years	1.54	1.23-1.94	1.05	0.92-1.19	0.97	0.88-1.08	0.92	0.58-1.47
30 to 34 years	1.70	1.21-2.40	1.02	0.83-1.25	1.14	0.97-1.34	1.55	0.84-2.86
≥35 years	4.88	3.40-7.00	1.05	0.77-1.45	1.72	1.38-2.14	2.33	1.07-5.11
Maternal Race								
White	1.00		1.00		1.00		1.00	
Black	1.75	1.42-2.16	0.91	0.80-1.02	1.31	1.20-1.44	1.10	0.73-1.67
Hispanic	0.59	0.41-0.85	0.53	0.44-0.63	0.87	0.77-0.99	0.46	0.23-0.93
Other[3]	0.74	0.50-1.09	0.76	0.62-0.91	0.95	0.82-1.10	1.10	0.62-1.97
Marital Status at Birth								
Married	1.00		1.00		1.00		1.00	
Single, never married	0.74	0.59-0.92	0.83	0.74-0.93	1.01	0.93-1.11	0.92	0.61-1.38
Other	0.89	0.52-1.53	1.12	0.84-1.50	0.81	0.61-1.05	1.41	0.57-3.50
Pay Grade at Birth								
Officer	1.00		1.00		1.00		1.00	
Enlisted	1.40	1.02-1.93	1.2	0.99-1.45	1.39	1.18-1.63	0.93	0.52-1.66
Pre-Gestational Diabetes								
Yes vs. No	3.36	0.78-14.57	2.03	0.61-6.70	2.71	1.18-6.23	No cases	

[1]Women with missing values are not included in regression models.
[2]Logistic models are adjusted for all covariates in the table.
[3]Other race includes Asian, American Indian, and DOD "Other" category.

Table 2. Odds-ratio and 95% Confidence Intervals for Timing of Deployment End Relative to Birth, HDP Sub-Types.[1,2]								
	Chronic Hypertension		Gestational Hypertension		Preeclampsia		Unknown Hypertension	
	n=31,056		n=32,154		n=33,220		n=30,731	
	448 cases		1,546 cases		2,612 cases		123 cases	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Timing of Deployment Ending Relative to Birth								
Non-deployed	1.00		1.00		1.00		1.00	
Ended ≥12 months before birth	1.15	0.92-1.43	1.13	0.99-1.28	0.99	0.89-1.10	0.96	0.62-1.48
Ended <12 months before birth	0.86	0.63-1.18	0.87	0.74-1.03	1.07	0.95-1.20	0.62	0.32-1.20
Maternal Age at Birth								
18 to 24 years	1.00		1.00		1.00		1.00	
25 to 29 years	1.52	1.21-1.91	1.04	0.91-1.18	0.97	0.88-1.08	0.91	0.56-1.46
30 to 34 years	1.67	1.18-2.36	0.99	0.81-1.23	1.12	0.95-1.32	1.46	0.77-2.76
≥35 years	4.77	3.32-6.87	1.01	0.73-1.40	1.71	1.38-2.14	2.07	0.91-4.72
Maternal Race								
White	1.00		1.00		1.00		1.00	
Black	1.76	1.43-2.16	0.91	0.80-1.03	1.32	1.20-1.45	1.12	0.74-1.71
Hispanic	0.58	0.40-0.84	0.54	0.45-0.65	0.86	0.76-0.98	0.49	0.24-0.98
Other[3]	0.72	0.48-1.07	0.75	0.62-0.91	0.94	0.81-1.09	1.07	0.59-1.95
Marital Status at Birth								
Married	1.00		1.00		1.00		1.00	
Single, never married	0.74	0.59-0.92	0.84	0.74-0.94	1.002	0.92-1.09	0.94	0.62-1.41
Other	0.84	0.48-1.48	1.07	0.79-1.44	0.82	0.63-1.07	1.52	0.61-3.79
Pay Grade at Birth								
Officer	1.00		1.00		1.00		1.00	
Enlisted	1.43	1.03-1.97	1.18	0.98-1.43	1.39	1.28-1.63	0.89	0.50-1.62

Table 2. Odds-ratio and 95% Confidence Intervals for Timing of Deployment End Relative to Birth, HDP Sub-Types (Continued).[1,2]

	Chronic Hypertension		Gestational Hypertension		Preeclampsia		Unknown Hypertension	
	n=31,056		n=32,154		n=33,220		n=30,731	
	448 cases		1,546 cases		2,612 cases		123 cases	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Pre-Gestational Diabetes								
Yes vs. No	3.31	0.76-14.32	2.01	0.61-6.64	2.73	1.18-6.28	No cases	

[1]Women with missing values for any variable included in a model and those missing from original DOD deployment database or with overlapping deployment dates are not included in the regression models.
[2]Logistic models are adjusted for all covariates in the table.
[3]Other race includes Asian, American Indian, and DOD "Other" category.

Table 3. Odds-ratio and 95% Confidence Intervals for Cumulative Weeks of Deployment among Deployed Women Only, HDP Sub-Types.[1,2]								
	Chronic Hypertension		Gestational Hypertension		Preeclampsia		Unknown Hypertension	
	n=10,255		n=10,612		n=10,975		n=10,134	
	158 cases		515 cases		878 cases		37 cases	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Cumulative Weeks of Deployment								
Each 1 month increase	1.02	0.99-1.06	1.01	0.99-1.03	1.01	0.99-1.02	0.97	0.90-1.05
Maternal Age at Birth								
18 to 24 years	1.00		1.00		1.00		1.00	
25 to 29 years	1.01	0.68-1.49	1.08	0.88-1.33	0.91	0.76-1.07	0.44	0.17-1.16
30 to 34 years	1.53	0.88-2.66	1.04	0.74-1.45	1.12	0.86-1.46	1.21	0.40-3.62
≥35 years	3.85	2.05-7.22	1.12	0.66-1.88	1.85	1.29-2.64	1.22	0.28-5.33
Maternal Race								
White	1.00		1.00		1.00		1.00	
Black	2.01	1.40-2.89	0.94	0.76-1.17	1.56	1.33-1.84	2.42	1.12-5.24
Hispanic	0.74	0.42-1.31	0.61	0.45-0.81	0.91	0.73-1.14	1.17	0.37-3.68
Other[3]	1.02	0.55-1.90	0.65	0.45-0.93	1.12	0.86-1.44	1.75	0.56-5.41
Marital Status at Birth								
Married	1.00		1.00		1.00		1.00	
Single, never married	0.77	0.54-1.11	0.74	0.60-0.92	0.97	0.83-1.13	1.74	0.83-3.65
Other	0.68	0.27-1.70	0.82	0.51-1.33	0.79	0.52-1.19	2.71	0.77-9.56
Pay Grade at Birth								
Officer	1.00		1.00		1.00		1.00	
Enlisted	1.62	0.88-2.96	1.49	1.05-2.11	1.42	1.07-1.90	0.37	0.13-1.11

Table 3. Odds-ratio and 95% Confidence Intervals for Cumulative Weeks of Deployment among Deployed Women Only, HDP Sub-Types (Continued).[1,2]

	Chronic Hypertension		Gestational Hypertension		Preeclampsia		Unknown Hypertension	
	n=10,255		n=10,612		n=10,975		n=10,134	
	158 cases		515 cases		878 cases		37 cases	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Branch								
Air Force	1.00		1.00		1.00		1.00	
Army	0.83	0.54-1.28	0.86	0.68-1.10	0.85	0.70-1.03	0.52	0.23-1.15
Navy[4]	0.80	0.53-1.22	0.74	0.59-0.94	0.90	0.75-1.08	0.31	0.13-0.78
Occupation								
Combat	0.94	0.54-1.64	0.75	0.53-1.05	0.93	0.73-1.18	0.22	0.03-1.68
Healthcare	1.03	0.61-1.73	1.48	1.14-1.91	0.98	0.77-1.24	1.64	0.69-3.85
Other	1.00		1.00		1.00		1.00	
Pre-Gestational Diabetes								
Yes vs. No	10.9	1.33-89.72	2.41	0.29-19.79	No cases		No cases	

[1]Women with missing values for any variable included in a model and those missing from original DOD deployment database or with overlapping deployment dates are not included in the regression models.
[2]Logistic models are adjusted for all covariates in the table.
[3]Other race includes Asian, American Indian, and DOD "Other" category.
[4]Navy includes the Marines and Coast Guard.

Table 4. Frequency of Main Exposures and Covariates by HDP Status for PDHA Moms Missing PTSD/Probable Responses Only.[1]							
	Total n=808		HDP n=98 12.1%		No HDP n=710 87.9%		*p*-value[2]
	n	%	n	%	n	%	
Maternal Age at Birth							
18 to 24 years	286	35.4	25	8.8	261	91.3	0.65
25 to 29 years	340	42.1	43	12.7	297	87.4	
30 to 34 years	135	16.7	24	17.8	111	82.2	
≥35 years	47	5.8	6	12.8	41	87.2	
Maternal Race							
White	436	55.4	53	12.2	383	87.8	<0.0001
Black	194	24.7	31	16.0	163	84.0	
Hispanic	92	11.7	4	4.4	88	95.7	
Other[3]	65	8.3	7	10.8	58	89.2	
Missing	21	2.6	3	14.3	18	85.7	
Marital Status at Birth							
Married	609	75.7	76	12.5	533	87.5	0.02
Single, never married	163	20.3	17	10.4	146	90.0	
Other	33	4.1	4	12.1	29	87.9	
Missing	3	0.4	1	33.3	2	66.7	
Pay Grade at Birth							
Officer	124	15.4	21	16.9	103	83.1	0.07
Enlisted	684	84.7	77	11.3	607	88.8	
Pre-Gestational Diabetes							
Yes	0	0.0					
No	808	100					

Table 4. Frequency of Main Exposures and Covariates by HDP Status for PDHA Moms Missing PTSD/Probable Responses Only (Continued).[1]

	Total n=808		HDP n=98 12.1%		No HDP n=710 87.9%		*p*-value[2]
	n	%	n	%	n	%	
Entry to Military Before 2001							
Yes	129	17.4	83	13.6	529	94.6	0.01
No	612	82.6	7	5.4	122	86.4	
Missing	67	8.3	8	11.9	59	88.1	
Confirmed PTSD							
Yes	0	0.0					
No	808	100					
Branch							
Air Force	555	68.7	70	12.6	485	87.4	0.01
Army	205	25.4	24	11.7	181	88.3	
Navy[4]	48	5.9	4	8.3	44	91.7	
Occupation							
Combat	82	12.6	6	7.3	76	92.7	0.11
Healthcare	102	15.7	18	17.7	84	82.4	
Other	466	71.7	59	12.7	407	87.3	
Missing	158	19.6	15	9.5	143	90.5	

Table 4. Frequency of Main Exposures and Covariates by HDP Status for PDHA Moms Missing PTSD/Probable Responses Only (Continued).[1]

	Total n=808		HDP n=98 12.1%		No HDP n=710 87.9%		*p*-value[2]
	n	%	n	%	n	%	
Deployment Location							
Kosovo Only	31	4.7	3	9.7	28	90.3	0.01
Southwest Asia Only	1	0.2	0	0	1	100	
OEF/OIF Only	613	92.0	74	12.1	539	87.9	
Other[5]	21	3.2	6	28.6	15	71.4	
Missing	142	17.6	15	10.6	127	89.4	

[1]Missing values are not included in calculated percents.
[2]P-values are for Chi-square tests of homogeneity (or Fisher exact tests if a cell <5) for categorical variables and t-tests for continuous variables using a 5% significance level.
[3]Other race includes Asian, American Indian, and DOD "Other" category.
[4]Navy included the Marines and Coast Guard.
[5]Other included Kosovo and OEF/OIF, Southwest Asia and OEF/OIF.

Table 5. Odds-ratio and 95% Confidence Intervals for Any PTSD vs. None, Racial Groups.[1,2]								
	White		Black		Hispanic		Other[3]	
	n=18,039		n=9,264		n=5,220		n=3,334	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Any PTSD[4]								
Yes vs. No	1.08	0.84-1.41	1.08	0.74-1.59	1.16	0.65-2.10	1.87	1.05-3.34
Maternal Age at Birth								
18 to 24 years	1.00		1.00		1.00		1.00	
25 to 29 years	1.00	0.90-1.11	1.12	0.97-1.29	1.07	0.85-1.35	1.05	0.81-1.36
30 to 34 years	1.05	0.89-1.24	1.43	1.15-1.78	1.01	0.65-1.55	1.21	0.79-1.85
≥35 years	1.60	1.28-1.99	2.00	1.47-2.72	1.42	0.73-2.78	2.19	1.24-3.84
Marital Status at Birth								
Married	1.00		1.00		1.00		1.00	
Single, never married	0.90	0.81-0.99	0.99	0.88-1.11	0.99	0.81-1.21	0.74	0.58-0.95
Other	0.97	0.75-1.26	0.98	0.68-1.41	0.91	0.53-1.58	0.60	0.26-1.42
Pay Grade at Birth								
Officer	1.00		1.00		1.00		1.00	
Enlisted	1.27	1.09-1.47	1.34	1.02-1.75	1.08	0.67-1.72	1.35	0.91-2.01

[1]Women with missing values for covariates are not included in regression models.
[2]Logistic models are adjusted for all covariates in the table.
[3]Other race includes Asian, American Indian, and DOD "Other" category.
[4]Crude OR did not change after adjustment for listed covariates.

Table 6. Odds-ratio and 95% Confidence Intervals for Any PTSD and HDP Sub-Types, Entire Cohort.[1,2]								
	Chronic Hypertension		**Gestational Hypertension**		**Preeclampsia**		**Unknown Hypertension**	
	n=31,549		**n=32,670**		**n=33,742**		**n=31,224**	
	453 cases		**1,574 cases**		**2,646 cases**		**128 cases**	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Any PTSD[3]								
No	1.00		1.00		1.00		1.00	
Yes	1.13	0.63-2.01	1.24	0.92-1.68	1.06	0.82-1.38	1.72	0.70-4.22

[1]Women with missing values for covariates are not included in regression models.
[2]Logistic models are adjusted for maternal age at birth, maternal race, marital status at birth, pay grade, and pre-gestational diabetes.
[3]Crude OR did not change after adjustment for listed covariates.

Table 7. Odds-ratio and 95% Confidence Intervals for PTSD and HDP, Case-Definition Based on Screening among PDHRA Moms Only.[1,2] n=3,021				
	Crude OR	**95% CI**	**Adjusted OR**	**95% CI**
PTSD (≥3 Case Definition)				
No PTSD	1.00		1.00	
Confirmed	1.50	0.81-2.80	1.45	0.77-2.72
Probable	1.22	0.79-1.89	1.23	0.79-1.92
Possible	0.88	0.26-2.97	0.91	0.27-3.11
PTSD (≥2 Case Definition)				
No PTSD	1.00		1.00	
Confirmed	1.36	0.70-2.65	1.32	0.67-2.59
Probable	1.12	0.78-1.60	1.14	0.79-1.63
Possible	1.39	0.73-2.64	1.41	0.74-2.69

[1]Women with missing values for covariates are not included in regression models.
[2]Logistic model adjusted for maternal age at birth, maternal race, marital status at birth, pay grade at birth, pre-gestational diabetes, branch, and occupation.

Table 8. Odds-ratio and 95% Confidence Intervals for PTSD and HDP Sub-types, Case-Definition Based on Screening among PDHA Moms Only.[1,2]								
	Chronic Hypertension		**Gestational Hypertension**		**Preeclampsia**		**Unknown Hypertension**	
	n=6,369		**n= 6,606**		**n=6,794**		**n=6,287**	
	104 cases		**341 cases**		**529 cases**		**22 cases**	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
PTSD (≥3 Case Definition)								
	No convergence						**No convergence**	
No PTSD	1.00		1.00		1.00		1.00	
Confirmed	1.20	1.16-1.23	1.01	0.51-2.01	1.09	0.61-1.95	No cases	
Probable	0.46	0.45-0.48	1.69	1.04-2.76	1.13	0.71-1.79	1.05	0.14-8.21
Possible	0.33	0.29-0.37	2.18	0.65-7.31	0.88	0.21-3.74	No cases	
PTSD (≥2 Case Definition)								
							No convergence	
No PTSD	1.00		1.00		1.00		1.00	
Confirmed	1.23	0.38-3.97	1.03	0.51-2.04	1.10	0.62-1.97	No cases	
Probable	0.88	0.38-2.02	1.58	1.08-2.32	1.18	0.83-1.66	1.94	0.55-6.89
Possible	No cases		1.33	0.41-4.34	1.08	0.38-3.02	No cases	

[1]Women with missing values for covariates are not included in regression models.
[2]Logistic model adjusted for maternal age at birth, maternal race, marital status at birth, pay grade at birth, pre-gestational diabetes, branch, and occupation.

Table 9. Odds-ratio and 95% Confidence Intervals for Pre-Post Agreement Between PDHA and PDHRA PTSD Screening and HDP.[1,2]

	PTSD ≥3 Case Definition		PTSD ≥2 Case Definition	
	n=2,216		n=2,223	
	OR	95% CI	OR	95% CI
PTSD Agreement				
Both Negative	1.00		1.00	
Positive Agreement	1.31	0.56-3.06	1.18	0.63-2.20
Negative to Positive	1.19	0.65-2.17	1.00	0.61-1.62
Positive to Negative	0.96	0.54-1.71	0.97	0.61-1.57
Missing on PDHA and/or PDHRA	0.52	0.15-1.81	0.53	0.15-1.83

[1]Women with missing values for covariates are not included in regression models.
[2]Logistic model adjusted for maternal age at birth, maternal race, marital status at birth, pay grade at birth, pre-gestational diabetes, branch, and occupation.

APPENDIX 4:
USF IRB Letter for the Current Study

USF
UNIVERSITY OF
SOUTH FLORIDA

RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX (813) 974-7091

5/3/2016

Michelle Nash
Epidemiology and Biostatistics
Tampa, FL 33612

RE: **Not Human Subjects Research Determination**

IRB#: Pro00024855

Title: Evaluating the Effect of Deployment and Post-Traumatic Stress Disorder on Hypertensive Disorders of Pregnancy among U.S. Active-Duty Females Deployed to the Middle East, 2001-2008

Dear Ms. Nash:

The Institutional Review Board (IRB) has reviewed your application and determined the activities do not meet the definition of human subjects research. Therefore, this project is not under the purview of the USF IRB and approval is not required. If the scope of your project changes in the future, please contact the IRB for further guidance.

All research activities, regardless of the level of IRB oversight, must be conducted in a manner that is consistent with the ethical principles of your profession. Please note that there may be requirements under the HIPAA Privacy Rule that apply to the information/data you will utilize. For further information, please contact a HIPAA Program administrator at 813-974-5638.

We appreciate your dedication to the ethical conduct of research at the University of South Florida. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

V Jorgensen MD

E. Verena Jorgensen, M.D., Chairperson
USF Institutional Review Board

ABOUT THE AUTHOR

Michelle C. Nash received a BS in Biology from Stetson University in 2006, a Master of Public Health with a concentration in Epidemiology from the University of South Florida in 2008, and will receive a PhD with a concentration in Epidemiology from the University of South Florida in 2017. She has worked as a communicable disease Epidemiologist at the Volusia County Health Department in Daytona Beach, Florida and an undergraduate instructor at the University of Central Florida. Other interests include curriculum development in higher education, and cardiovascular disease outcomes and maternal and child health research.