

# A Systematic Review of the Impacts of Active Military Service on Sexual and Reproductive Health Outcomes Among Servicewomen and Female Veterans of Armed Forces

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## Background

There are clear evidence gaps relating to health outcomes of servicewomen and female military veterans (here included as servicewomen). In addition to physical health, mental wellbeing and maternal health, there is limited literature regarding their sexual and reproductive health, particularly within an international context.<sup>1</sup> Internationally, a recent increased focus on the health of servicewomen and female veterans reflects both increased numbers of females in the military and removal of duty restrictions. Consequently, specific policies addressing pregnancy, breastfeeding and return to work have been developed, although research evidence to inform these is lacking. Identifying available evidence and mapping evidence gaps is critical to develop policies that will support the future female military workforce. Therefore, as a basis to address these emerging issues, an evidence mapping review was conducted to identify reproductive and sexual health issues faced by servicewomen, and establish the evidence gaps and target areas for future research.

## Method

A systematic literature search of library databases was undertaken in April 2015, including Embase, Medline, PubMed, Web of Science, Cumulative Index to Nursing and Allied Health Literature (CINAHL), and the Cochrane Database. The following Medical Subject Heading (MeSH) terms were searched in title, abstract and keyword fields: servicewomen; veterans; military; Defence; reproductive health; menstruation disturbances; menopause; premature; fertility; contraception; contraception behaviour;

pregnancy; female urogenital diseases; pregnancy complications; obstetric surgical procedures; hydatidiform and mole. To broaden the search, the reference lists of all included studies were examined to identify any other potentially relevant papers (Pearling). Results were limited to studies published in English, from the year 2000 to the present.

Exclusion criteria from the initial search included:

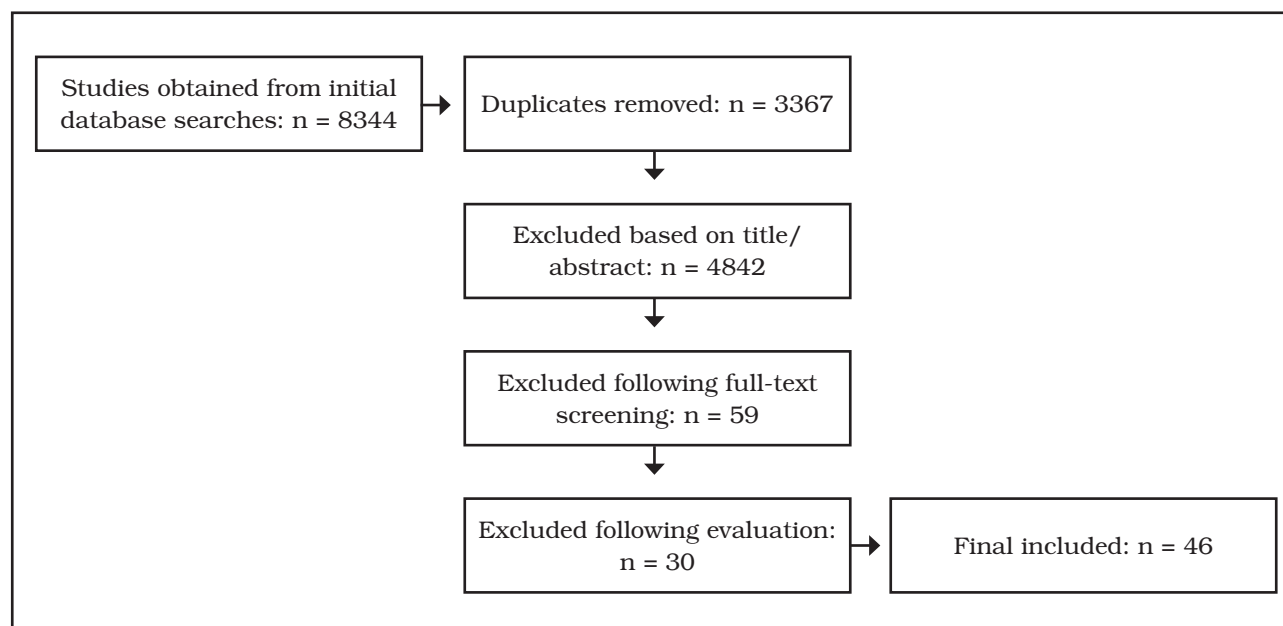
- Not published in English,
- Published prior to 2000,
- Not published in peer-reviewed journals,
- Editorials or correspondence,
- Did not involve servicewomen or female veterans,
- Did not report reproductive or sexual health issues.

Included studies were assessed on their level of evidence according to the Australian National Health and Medical Research Council (NHMRC) hierarchy of evidence,<sup>2</sup> and data regarding country of origin, study aim(s), population, sample size and key findings (Table 1), were initially extracted from ninety-six relevant studies. Inclusion criteria were further refined to focus on:

- Servicewomen and female veterans of the military forces (active service)
- Sexual and reproductive health impacts, effects of and associations with military service

Where possible a non-service comparison group was preferred, however broader criteria were utilised to provide the most comprehensive overview of available published research. Due to the limited research

Figure 1



in this area, studies of lower evidence addressing issues of interest were retained, though findings were interpreted with caution. A total of 76 papers were independently evaluated by the lead author and another reviewer, with 46 included in this review (see Figure 1).

## Results

The majority of published research in this area comes from the United States (US), which has the largest cohort of females in active military service. Initial assessment identified the following key areas where impacts of active military service could be examined: (1) general reproductive and sexual health; (2) menstrual regulation and menopause; (3) birth control; (4) pregnancy incidence and birth outcomes; and (5) post-pregnancy health and wellbeing. Papers were grouped accordingly, with active service and deployment-specific findings examined separately where appropriate. An assessment of the available evidence is summarised for each outcome, and conclusions regarding the state of evidence in the area as a whole is presented, including an overview of notable gaps. Key study information and findings, organised by topic, are summarised in Table 1.

### General reproductive and sexual health

There were only a small number of studies that addressed general reproductive and sexual health. This included two reviews, one small qualitative study, and two large administrative database studies. Evidence from these suggests higher healthcare use by females compared to males, of which a substantial

proportion relates to gynaecological, contraceptive and menstrual issues. Sexual assault, unintended pregnancy on deployment, pregnancy termination, and infertility among female veterans were also highlighted. However, in most studies there was insufficient evidence to determine whether these issues are specific to military service.

A small qualitative study from Doherty and Scannell-Desch<sup>3</sup> indicated gynaecological infections, suppression of menstruation, unintended pregnancy and other experiences (e.g., difficulties accessing bathroom and toilet facilities, hygiene and cleanliness issues, personal safety) as important issues in the deployed environment. While this study was limited in terms of size and scope, the findings are consistent with those from earlier work in this area.<sup>4</sup> These types of gynaecological issues may also persist post-deployment.<sup>5</sup> Menstrual disorders and endometriosis were the most frequent reproductive health diagnoses among US servicewomen aged 18–44 years.<sup>6,7</sup> Additionally, Katon et al.<sup>6</sup> reported a higher prevalence of mental health diagnoses among women with these conditions, possibly reflecting a greater need for attention.

Recent studies demonstrate an emerging problem of sexual assault in the military with 11–48% of female veterans reporting sexual trauma during their service.<sup>2,8,9</sup> Military sexual trauma can lead to deleterious physical and psychological comorbidities, including termination of pregnancy, delayed or avoidance of pregnancy as well as infertility, sexually transmitted infection, posttraumatic stress disorder and postpartum dysphoria.<sup>10,11</sup>

**Table 1. Summary of papers included in review, organised by key topics.**

| General reproductive and sexual health |         |   |                      |                |  |   |  |
|--|---------|---|----------------------|----------------|--|---|--|
| Author (Year)                          | Country | Measurement   | Design               | Level Evidence | Population                                   | Sample size   | Key Findings   |
| Doherty & Scannell-Desch (2012)        | USA     | Qualitative interviews  | Qualitative          | NA             | Women deployed to MEAO                       | 24  | Themes identified:<br>Bathroom and toilet facilities<br>Shower challenges<br>Menstrual suppression/regulation<br>Hygiene<br>Genitourinary infections<br>Unintended pregnancy<br>Personal safety  |
| Haskell et al. (2011)                  | USA     | Observational study of VA administrative and clinical databases | Retrospective cohort | III_2          | Veterans 1yr post-deployment MEAO            | 19520 female  | Among female veterans:<br>13% had a gynaecologic examination<br>7% sought assistance for menstrual disorders<br>10% sought contraceptive counselling   |
| Katon et al. (2015)                    | USA     | Cross-sectional analysis of VA administrative and clinical data | Cross-sectional      | III_2          | Women Veterans using VA health care in FY10. | Women aged 18–44 (n = 12492),<br>45–64 (n = 3437),<br>Age ≥65 (n = 38963) | Most frequent reproductive health diagnoses were:<br>Menstrual disorders and endometriosis among those aged 18–44 (n=16658, 13%)<br>Menopausal disorders among those aged 45–64 (n = 20707, 15%),<br>Osteoporosis among those aged ≥ 65 years (n = 8365, 22%).<br>Compared with women without reproductive health diagnoses, those with such diagnoses were more likely to have concomitant mental health (46% vs. 37%, P < 0.001) and medical conditions (75% vs. 63%, P < 0.001) |

|                            |     |                                       |  |    |  |      |  |
|----------------------------|-----|---------------------------------------|--|----|--|------|--|
| Rossiter and Smith. (2013) | USA | NA                                    | Case study/<br>review of<br>literature | NA | Service women  |      | <p>~26,000 women have experienced some form of sexual assault in the military</p> <p>Military Sexual Trauma (MST) can lead to multiple physical and psychological comorbidities including pregnancy issues, infertility, sexually transmitted infections, PTSD and postpartum dysphoria</p> <p>It is imperative that nurse practitioners ask women about military service and utilize the Military Health History Pocket Card for clinicians to ascertain service-connected health risks, primarily MST and PTSD</p> <p>Prompt identification and intervention is key to reducing physical and psychological comorbidities</p>   |
| Ryan et al. (2014)         | USA | Computer-assisted telephone interview | Cross-sectional observational study    | IV | Female veterans (aged 20–52 years) enrolled at two Midwestern VA medical centers or their outlying clinics (July 2005-August 2008) | 1004 | <p>62% reported at least one attempted or completed Lifetime Sexual Assault (LSA)</p> <p>Veterans with LSA more often self-reported history of pregnancy termination (31% vs. 19%), infertility (23% vs. 12%), STI (42% vs. 27%), PTSD (32% vs. 10%), and postpartum dysphoria (62% vs. 44%)</p> <p>LSA independently associated with termination and infertility in multivariate models; STI, PTSD, and postpartum dysphoria were not</p> <p>LSA by period of life: 41% in childhood, 15% in adulthood before military, 33% in military, 13% after military</p> <p>Among the 511 who experienced a completed LSA, 23% reported delaying or foregoing pregnancy owing to assault</p> |

| Zephyrin et al. (2014)      | USA     | Report  | Report based on program evaluation analysis conducted by Women's Health Services | NA             | Women veteran                                     | 297,392<br>Age 18-44<br>n= 124092<br>Age 45-64<br>n= 134337<br>Age ≥65 n= 38963 | 43% of women Veterans who used VA in fiscal year 2010 had at least one diagnosis of any Reproductive Health condition.<br>Top 5 diagnoses aged 18-44:menstrual disorders and endometriosis, STI and vaginitis, urinary conditions, pregnancy-related conditions<br>Top 5 diagnoses aged 45-64 Menopausal disorders , urinary condition,<br>Top 5 diagnoses age ≥65: Osteoporosis, urinary conditions, menopausal disorders, breast cancer, benign breast conditions |
|-----------------------------|---------|---|--|----------------|---|---|---|
| <b>Menstrual regulation</b> |         |   |  |                |   |   |   |
| Author (Year)               | Country | Measurement   | Design   | Level Evidence | Population  | Sample size   | Key Findings  |
| Christopher & Miller (2007) | USA     | NA  | Narrative review   | NA             | Military  | NA  | Unintended pregnancy can interfere with ability to deploy<br>Menstruation can negatively impact female deployment experience<br>Hormonal medications can be used to suppress menstruation<br>Hormonal medications for menstrual suppression should be routinely available during training/ deployment   |
| Deuster et al. (2011)       | USA     | Self-report questionnaires                            | Cross-sectional  | IV             | Women aged 18-45, 30 days or less post-deployment | 459   | Menstrual concern lower among African Americans compared to other ethnicities, with highest concern among Hispanic and Asian women<br>Less than 50% of women took oral contraceptives, and less than 50% of them took OCPs continuously despite menstrual burden  |
| Enewold et al. (2010)       | USA     | Demographic and clinical data from existing databases | Retrospect-ive cohort  | III_2          | Military Females aged 18-39                       | 83181 military, 360 general   | OCP use:<br>Significantly higher in military (35%) compared to general population (29%)<br>This difference increased with age<br>This difference was greater for Hispanic women (military 32.2% vs general 19.8%)<br>Use was highest in the Air Force (39%) and lowest in the Army (30%)  |

|                              |                       |                           |                        |    |                           |     |   |
|------------------------------|-----------------------|---------------------------|------------------------|----|---------------------------|-----|---|
| Grindlay & Grossman (2013a)  | USA                   | Online self-report survey | Cross-sectional cohort | IV | Servicewomen              | 281 | <p>Birth control used by 63% during their last deployment</p> <p>59% did not consult healthcare provider regarding contraceptives before last deployment</p> <p>One third of women unable to access preferred contraception method</p> <p>Intrauterine devices or sterilisation either not available or discouraged</p> <p>41% reported difficulty accessing prescription refills</p>   |
| Holt et al. (2011)           | USA and International | NA                        | Narrative review       | NA | Female servicewomen       | NA  | <p>Pregnancy and unintended pregnancy rates higher among servicewomen compared to general population</p> <p>Use of contraceptives decreases during deployment</p> <p>Interest in menstrual suppression using OCPs greater than actual use</p>   |
| Powell-Dunford et al. (2009) | USA                   | Self-report survey        | Cross-sectional        | IV | Deployed women using OCPs | 56  | <p>93% were aware that continuous OCP use could suppress menstruation</p> <p>81% had used OCPs</p> <p>During deployment:</p> <p>33% used OCPs</p> <p>15% of these used OCPs continuously</p> <p>Those who used OCPs continuously reported less menstrual burden and had greater compliance</p> <p>66% wanted menstrual suppression</p> <p>44% of OCP users reported difficulty remembering to take it</p> <p>35% reported insufficient knowledge about OCPs</p> |

| Powell-Dunford et al. (2011) | USA     | Self-report survey   | Cross-sectional      | IV             | Active duty, Reserve or national Guard, deployed in combat operation | 500         | Menstrual suppression wanted by 66%<br>78% had used OCPs<br>21% reported using OCPs continuously while deployed<br>40% used OCPs at some point during deployment<br>67% reported compliance problems<br>45% missed at least 1 pill per week<br>Compliance for continuous users better compared to conventional users<br>Menstrual burden significantly less among compliant users<br>85% wanted mandatory education for women regarding the use of OCPs for menstrual suppression |
|------------------------------|---------|--|----------------------|----------------|--|-------------|---|
| Trego (2007)                 | USA     | Semi-structured interviews   | Qualitative          | NA             | Army personnel deployed to military operations                       | 9           | Themes regarding menstruation identified:<br>Intensified during deployment<br>Hygiene and self-care difficulties<br>Deployment challenges<br>Inconvenience<br>Military challenges<br>More negatives than positives<br>Menstrual suppression   |
| <b>Menopause</b>             |         |  |                      |                |  |             |   |
| Author (Year)                | Country | Measurement  | Design               | Level Evidence | Population   | Sample size | Key Findings  |
| Haskell et al. (2008)        | USA     | Participants from existing database, evaluated on oestrogen status                                       | Retrospective cohort | III_2          | Veterans   | 36222       | By 2004 66% of sample had discontinued HT use<br>Younger women were less likely to discontinue use  |
| Haskell et al. (2009)        | USA     | Participants from existing database, compared to randomly selected sample on hormone replacement status. | Retrospective cohort | III_2          | Veterans   | 836         | 25% tapered use of HT<br>75% stopped HT abruptly<br>Tapering use associated with reduced recurrence of menopausal symptoms<br>Women were more likely to taper use if:<br>They had menopausal symptoms<br>Were younger<br>Had been using HT for longer<br>Had higher income  |

| Birth control                   |         |  |                 |                |  |             |  |
|---------------------------------|---------|--|-----------------|----------------|--|-------------|--|
| Author (Year)                   | Country | Measurement  | Design          | Level Evidence | Population   | Sample size | Key Findings   |
| Essien et al. (2010)            | USA     | Self-report validated questionnaire  | Cross-sectional | IV             | Female military personnel  | 346         | <p>Condom use in previous 3 months:</p> <p>63% always used<br/>26% sometimes used<br/>11% never used</p> <p>Condom use significantly associated with:</p> <p>Attitudes and behaviour<br/>HIV risk behaviours<br/>Social support</p> <p>Demographic factors including marital status, age, number of children, relationship types and employment status</p> <p>After adjusting for all factors, only attitudes and behaviours, relationship type and marital status significant</p>   |
| Manski et al. (2014)            | USA     | Qualitative in-depth phone interviews  | Qualitative     | IV             | Women who had served in the U.S. military between May 2011- Jan 2012 | 22          | <p>Range of barriers to accessing medical care in deployment settings</p> <p>Confidentiality concerns, lack of female providers, health-seeking stigma</p> <p>No option to access contraception off-base during deployment, citing logistical challenges, inability to travel, and safety concerns</p> <p>Challenges obtaining contraceptive refills and specific contraceptive methods during deployment</p> <p>Only a few participants received pre-deployment counseling on contraception, despite interest in both menstruation suppression and pregnancy prevention</p> |
| Thomas, Thomas & Garland (2001) | USA     | Self-report survey (containing questions about demographics, attitudes to family planning, ship-board stress, quality of job life, depression) | Cross-sectional | IV             | Navy Personnel   | 714 women   | <p>Birth control use:</p> <p>86% of responders<br/>27% OCP, 11.6% depo provera, 2.2% implant, 0.2% IUD, 0.7% diaphragm</p> <p>Most women were comfortable asking for advice</p> <p>13% reported that their birth control use would be influenced by their partner's wishes</p>   |



| Van Royen et al (2000)      | USA     | Self-report survey adapted from Henry J Keiser Foundation (1994) to incorporate military specific factors. | Cross-sectional       | IV             | Active duty military                  | 293                | Knowledge of emergency contraception and reproductive issues poor<br>85% of sample sexually active<br>62% used birth control<br>40% good awareness of reproductive cycle<br>While 64% aware of emergency contraception, only 15% understood how to use it<br>Younger unmarried women more likely to use emergency contraception<br>55% would use emergency contraception if needed |
|-----------------------------|---------|--|-----------------------|----------------|---------------------------------------|--------------------|--|
| Unintended pregnancy        |         |  |                       |                |                                       |                    |  |
| Author (Year)               | Country | Measurement  | Design                | Level Evidence | Population                            | Sample size        | Key Findings   |
| Buller et al. (2007)        | USA     | Retrospective chart review of visits of gynaecological clinic in Kuwait from Augusts 2003-April 2004.      | Retrospect-ive cohort | III_2          | Female soldiers                       | 1737 health visits | Average age for positive pregnancy test 27 years<br>Amenorrhea primary complaint<br>92% received ultrasound<br>77% of pregnant soldiers became pregnant in country<br>23% arrived in country already pregnant  |
| Custer et al. (2008)        | USA     | Self-report survey about pregnancy intentions and socio-demographic information.                           | Cross-sectional       | IV             | Army women                            | 212                | Of live births:<br>35% were intended<br>51% were unintended<br>14% ambivalent<br>These rates are consistent with the upper limits within civilian communities  |
| Goyal et al. (2012a)        | USA     | Review of existing literature on unintended pregnancy and contraception                                    | Narrative review      | NA             | Active duty servicewomen, veterans    | NA                 | High rates of unintended pregnancy<br>Low rates of contraceptive use<br>Barriers to contraceptive use:<br>Logistical access issues on deployment<br>Limited knowledge of patient and provider regarding options<br>Prohibition of sexual activity  |
| Grindlay & Grossman (2013b) | USA     | Self- report survey responses to DOD Survey of Health Related Behaviors                                    | Cross-sectional       | IV             | Active duty female military personnel | 7225               | Unintended pregnancies in previous 12 months:<br>11% of participants<br>Higher among less educated, non-white, younger, married or cohabiting<br>No impact of deployment   |
| Manski et al. (2014)        | USA     |  |                       |                |                                       |                    |  |

| Ponder & Nothnagle (2010)               | USA     | Review of literature   | Narrative review     | NA             | Military women                               | NA                                      | Recommendations regarding unintended pregnancy in the US military:<br>Improve access to full range of contraceptive options<br>Remove restrictions to abortion<br>Promote reproductive choice<br>Provide high quality reproductive healthcare   |
|---|---------|--|----------------------|----------------|--|---|---|
| Robbins et al. (2005)                   | USA     | Structured telephone interviews  | Cross-sectional      | IV             | Active duty Air Force women                  | 2348                                    | Pregnancies during 2001:<br>12% had at least one pregnancy<br>54% were unplanned<br>7% of sample had unplanned pregnancies within year<br>Unplanned pregnancies:<br>Approximately 50% due to contraceptive non-use<br>Other reasons include contraceptive misuse and failure  |
| <b>Pregnancy incidence and outcomes</b> |         |  |                      |                |  |   |   |
| Author (Year)                           | Country | Measurement  | Design               | Level Evidence | Population                                   | Sample size                             | Key Findings  |
| Araneta et al. (2004)                   | USA     | Deployment and inpatient records from military hospitals and self-report survey. | Retrospective cohort | III_2          | Servicewomen from units deployed to Gulf War | 1558                                    | Reproductive outcomes similar for deployed compared to non-deployed<br>Ectopic pregnancies and miscarriage elevated among post Gulf War conceptions   |
| Armed Forces Health Surveillance (2012) | USA     | Health Surveillance of military personnel deploying October 2001 - December 2010 | Retrospective cohort | III_2          | US Armed Forces                              | 194956 pregnancies                      | During the study period (2002-2011) 0.64% of pregnancies for women aged under 49 were ectopic<br>Rates of ectopic pregnancies not significantly different from civilian population.<br>Servicewomen more likely to be surgically than medically treated.<br>Ectopic pregnancies more common in women aged in their 30s and among black non-Hispanic women |
| Doyle et al. (2004)                     | UK      | Validated postal self-report questionnaire                                       | Retrospective cohort | IV             | Gulf war VS non-Gulf war veterans            | 484 veterans, 377 non-veterans (female) | Gulf war service:<br>No impact on miscarriage risk<br>Unknown impact on stillbirths and birth defects due to insufficient numbers of cases  |

|                        |     |  |                       |       |  |   |   |
|------------------------|-----|--|-----------------------|-------|--|---|---|
| Kang et al. 2001       | USA | Self-report survey   | Retrospective cohort  | III_2 | Army, Airforce, Marine, Navy Vietnam veterans                                | 8280                                    | Among Gulf War veterans compared with controls:<br>Significantly more birth defects among live births<br>No significant differences in stillbirths, infant mortality and pre-term delivery  |
| Katon et al. (2014)    | USA | Existing self- report data from DVA National Health Study for a New Generation of US Veterans (nationally representative survey)                       | Retrospective cohort  | III_2 | Male and female veterans deployed to Iraq and Afghanistan                    | 20,370 Veterans (16056 men; 4314 women) | Prevalence of lifetime history of infertility was 15.8% for women and 13.8% for men<br>After adjusting for age, ever married, education, ethnicity, component, branch of service, and deployment to OEF/OIF, compared with men, women Veterans had similar odds of lifetime history of infertility (OR =1.07), but increased odds of seeking medical help for infertility (OR =1.35)  |
| Mattocks et al. (2015) | USA | Data from the OEF/OIF/OND roster file from the DMDC Contingency Tracking System Deployment file of military discharges from October 2001–December 2010 | Retrospect-ive cohort | III_2 | Women Veterans ages 18-45 who utilized VA health care after military service | 68,442                                  | ~ 2% received an infertility diagnosis during the study period. Compared with women VA users without infertility diagnosis<br>Those with infertility diagnosis were younger, obese, black, or Hispanic, have a service connected disability rating, a positive screen for military sexual trauma, and a mental health diagnosis<br>22% of women with an infertility diagnosis received an infertility assessment or treatment<br>39% of women Veterans receiving infertility assessment or treatment received this care from non-VA providers |
| Rivera et al. (2014)   | USA | Literature review of publications from Vietnam War, Persian Gulf War, and OIF and OEF periods  | Literature review     | NA    | Service women  | NA                                      | Female veterans historically report more reproductive and gynecological problems than the general population<br>Experience higher incidences of PTSD and depression compared to male veterans, and overall exhibit a higher prevalence of several mental health disorders compared to the general population  |

| Wells et al. (2006)   | USA     | Self-reported postal survey  | Cross-sectional       | IV             | Gulf war veterans               | 8742  | Among deployed compared to non-deployed female veterans:<br>No sig. difference in rates of pregnancy, miscarriage and adverse birth outcomes<br>Less risk of any adverse outcome among white, non-Hispanic women<br>420 reproductive losses  |
|-----------------------|---------|--|-----------------------|----------------|---------------------------------|---|--|
| <b>Birth outcomes</b> |         |  |                       |                |                                 |   |  |
| Author (Year)         | Country | Measurement  | Design                | Level Evidence | Population                      | Sample size   | Key Findings   |
| Conlin et al. (2012)  | USA     | Electronic data from DOD Birth and Infant Health Registry and the Defense Manpower Data Center | Retrospect-ive cohort | III_2          | Active duty                     | 13129 women   | No consistent association between burn pit exposure on deployment and pre-term delivery or birth defects   |
| Conlin et al. (2013)  | USA     | Retrospective data from the DMDC   | Retrospect-ive cohort | II             | Active duty U.S. military women | H1N1 vaccine-exposed n=510376<br>Seasonal influenza vaccine-exposed pregnancies n=57560 | Vaccinated during pregnancy with either the H1N1 vaccine or seasonal influenza vaccine<br>No difference in rates of pregnancy loss, pre-eclampsia or eclampsia (5.8% vs. 5.2%) or preterm labor (6.5% vs. 6.2%)<br>No significant differences in rates of preterm birth (6.2% vs. 6.3%), birth defects (2.1% vs. 2.0%), fetal growth problems (2.6% vs. 2.4%), or male-to-female sex ratio (1.05 vs. 1.07)<br>Rates of all outcomes were lower or similar to overall general population rates<br>No adverse pregnancy or newborn health outcomes associated with pandemic H1N1 vaccination |
| Evans & Rosen (2000)  | USA     | Self-report survey   | Prospective cohort    | II             | Pregnant active duty            | 269   | Greater risk of pre-term delivery:<br>Separated or divorced<br>Single<br>These differences may be attributable to other demographic correlates:<br>Lower rank, ethnic minority, greater number of medical conditions, less educated  |

| Greer et al. (2012)                        | USA     | Self-report demographic /weight data 1 year pre-pregnancy, exercise during/after pregnancy | Prospective cohort    | II             | Marines and Navy women                      | 1409 (1163 Marines, 246 Navy) | Marines compared to Navy<br>Significantly greater likelihood of spontaneous vaginal delivery<br>Mean infant birth weight significantly lower   |
|--|---------|--|-----------------------|----------------|---|-------------------------------|--|
| Hourani & Hilton (2000)                    | USA     | Self-report Reproductive Health Survey   | Case control          | III_3          | US Navy active duty women                   | 336 cases, 696 controls       | Adverse live-birth outcomes associated with:<br>Self-reported exposure to heavy metals, petroleum products, pesticides, and other chemicals  |
| Kang et al. (2000)                         | USA     | Self-report survey conducted by telephone  | Retrospective cohort  | III_2          | Gulf War veterans and non Gulf War veterans | 3000                          | Among Vietnam veterans compared with controls:<br>Significantly more moderate to severe birth defects among live births<br>No significant differences in infant death, stillbirth, pre-term delivery or low birth weight   |
| Kang et al. (2001)                         | USA     |  |                       |                |   |                               |  |
| Ryan et al. (2011)                         | USA     | Electronic data from the DOD Birth and Infant Health Registry                              | Retrospect-ive cohort | III_2          | Military women                              | 63056                         | Deployment during first trimester of pregnancy, at any time during pregnancy compared to no deployment:<br>No greater odds of pre-term birth, malignancy diagnosis, or birth defects   |
| Wells et al. (2006)                        | USA     |  |                       |                |   |                               |  |
| <b>Post-pregnancy Health and Wellbeing</b> |         |  |                       |                |   |                               |  |
| Author (Year)                              | Country | Measurement  | Design                | Level Evidence | Population                                  | Sample size                   | Key Findings   |
| Appolonio & Fingerhut (2008)               | USA     | Self-report survey   | Cross-sectional       | IV             | Active Duty                                 | 526                           | 19.5% reported symptoms of postpartum depression<br>The following variables were associated with postpartum depression:<br>Low self-esteem, prenatal anxiety, prenatal depression, history of depression, poor social support, poor marital satisfaction, life stress, child care stress, difficult infant temperament |
| Armitage & Smart (2012)                    | USA     | Retrospective data from existing data bases  | Retrospect-ive cohort | III_2          | Active Duty Air Force                       | 107                           | 6 months postpartum compared with pre-pregnancy:<br>Larger abdominal circumference<br>Longer run time<br>Fewer pushup repetitions<br>No significant difference in situps<br>Fitness assessment pass rate significantly lower   |

|                      |      |  |                    |    |  |                               |  |
|----------------------|------|--|--------------------|----|--|-------------------------------|--|
| Greer et al. (2012)  | USA  | Self-reported survey including weight before/after pregnancy             | Prospective cohort | II | Marines and Navy women                                 | 1409 (1163 Marines, 246 Navy) | One year pre-pregnancy body weight:<br>79% of Navy within standards<br>97% of Marines within standards<br>First antenatal visit body weight:<br>69% of navy within standards<br>96% of marines within standards<br>3 and 6 months post-partum body weight:<br>Marines significantly more likely to be within standards compared to Navy  |
| Katon et al. (2015)  | USA  |  |                    |    |  |                               |  |
| Nguyen et al. (2013) | USA  | Self-report survey   | Prospective cohort | II | Active duty military                                   | 1660                          | Maternal depression more likely among women who deployed and were exposed to combat after having child<br>No differences in maternal depression among women who had deployed before having a child and those who had not deployed  |
| Stewart (2015)       | AUS. | Cross-sectional electronic survey. ADF women identified from PMKeyS data | Cross-sectional    | IV | ADF women took MATL during the Australian FY 2006/2007 | 152                           | 98% ADF women breastfed for ~8 months, returning to work when the mean age of the child was 8.4 months<br>66% returned to work full-time, with median breastfeeding duration of 7 months<br>Women who returned to work part-time had a longer median duration of 10 months<br>Breastfeeding rates among ADF women compare favorably with the general Australian population until 9 months, coinciding with returning to work after a period of maternity leave |
| Weina (2006)         | USA  | Self-report survey   | Cross-sectional    | IV | Army   | 52                            | Physical fitness test scores reduced significantly between pre-pregnancy and post-partum (6 months after birth)<br>Postpartum exercise was positively associated with physical fitness test scores postpartum<br>Pregnancy complications and weight gain negatively associated with physical fitness test scores postpartum  |

### Menstrual regulation and menopause

Research examining menstrual regulation among servicewomen is somewhat limited, predominantly comprising retrospective self-report data, however this does include a number of large administrative database studies, and supplementary qualitative findings. The issues arising most consistently in this area related to the use of Oral Contraceptive Pills (OCPs) to suppress menstruation, particularly within the deployed environment, the real or implied barriers to access and use of OCPs and the lack of understanding about OCPs, particularly in relation to menstrual suppression.

Overall, there appears to be a disconnect between desire to reduce menstrual burden and actual use of OCPs for this purpose.<sup>12</sup> Using OCPs to suppress menstruation may be beneficial in training and deployed environments<sup>13</sup> given that unplanned pregnancy can impede deployability and menstruation has potentially adverse impacts in the deployed environment. Although deployed women have reported positive attitudes toward menstrual suppression, these attitudes rarely translated to behaviour. For example, Powell-Dunford et al.<sup>14</sup> found that among a sample of US active duty servicewomen, 86% wanted to suppress menstruation, particularly during deployment and field training, but only 7% reported using OCPs to do so. Willingness to consider OCPs for this purpose was positively correlated with the self-reported burden of menses in this study, and in fact other research suggests lower reported burden of menstrual symptoms in women who do suppress menses.<sup>15,16</sup> Despite these attitudes, compliance with OCP use can be poor in deployed environments.<sup>15</sup>

Barriers to access and lack of knowledge about OCPs may account for their under-use in women reporting a desire to reduce the menstrual burden.<sup>16-19</sup> In a study of deployed US servicewomen,<sup>20</sup> one third reported being unable to access their desired contraception and 40% had difficulty obtaining prescribed contraception. More long-term methods of contraception including IUDs were unavailable or discouraged. Whether this issue translates to other international contexts is not clear. In addition to access difficulties, Enewold et al.<sup>18</sup> also found a lack of knowledge and understanding about effective OCP use among US servicewomen, particularly among younger women. Older women, in contrast, had greater knowledge about and were more likely to use OCPs. This study also reported inter-service differences in OCP use, with higher rates in the US Air Force compared to Army.

Despite the increasing population and age of female personnel,<sup>1</sup> the issue of menopause is largely unexamined. Of the two studies investigating menopause, while utilising large sample sizes, neither were able to draw conclusions regarding the impact of, or relationship with service. However, as menopause generally occurs before the regular retirement age of sixty five<sup>8</sup>, it is likely that many women in the armed forces will experience menopause during their career. Importantly, given the association between age and seniority, the potential for functional impact of menopause in senior levels of service should be acknowledged.

Hormone Replacement Therapy (HRT) can effectively reduce adverse impacts of menopause on everyday functioning.<sup>21</sup> Accordingly, Haskell et al.<sup>22</sup> examined both use and discontinued use of HRT among US servicewomen. Women experiencing menopause at a younger age, and those who had accessed Veterans Affairs clinics were significantly more likely to continue use than other women, although the reasons for these differences were unclear. In a follow-up study, Haskell, Bean-Mayberry and Gordon<sup>23</sup> found the majority of HRT users discontinued use abruptly, despite evidence that tapering use is associated with reduced recurrence of menopausal symptoms. Those who did taper their use (thus having less adverse outcomes) generally had higher income and were younger. Given apparent issues of access to hormonal contraceptives on deployment, similar barriers may apply to accessing HRT. Awareness of and access to OCPs and HRT is important in the deployment environment, given their potential functional benefits.

### Birth Control

#### Contraception

The majority of studies examining contraceptive use among servicewomen were cross-sectional, with some retrospective and qualitative studies. The level of evidence available and lack of comparison groups limit conclusions that can be drawn. However, as with menstrual regulation, a number of issues emerged around knowledge, use of and access to birth control measures. While there is evidence supporting use of OCPs as birth control, particularly while on deployment and training, the number of women actually using them is low. Women may also be less likely to use OCPs whilst deployed, despite understanding their potential benefits, again indicating real or perceived barriers to access and use. Together these findings have implications for unplanned pregnancy and gynaecological

presentations on deployment (as well as menstrual regulation).

More generally, US literature points to a gap in contraceptive understanding among military women. Van Royen, Calvin and Lightner<sup>24</sup> found that among active duty US military women, knowledge about emergency contraceptive methods was poor; 85% were sexually active but only 62% used contraception. Although 64% were aware of emergency contraception, only 15% knew how and when to take it, and younger, unmarried women were most likely to have this knowledge. Thomas, Thomas and Garland<sup>25</sup> explored contraceptive use and family planning among active service US Navy women, with only 40% of these using an oral or implant hormonal contraceptive, suggesting reliance on other methods (e.g., condoms). In some cases pre-deployment counselling on contraception may be inadequate, resulting in a lack of knowledge of available methods on deployment and consequent problems with access.<sup>26</sup>

Von Sadvosky et al.<sup>27</sup> found that among US Army women, condom use overall was low, and a number of factors including ease of use and access contributed to higher use. Use was predicted by relationship type, attitudes to condoms and marital status. In contrast, in a study of sexually active US servicewomen stationed in Nigeria,<sup>28</sup> the majority of women reported using condoms, possibly reflecting differences in perceived risk of sexually transmitted infections (STIs). Despite national policies precluding sexual relations on deployment, condom use has a role in reducing unplanned pregnancies and preventing STIs. Importantly, the availability of condoms (as well as other types of birth control) may be limited in the deployed environment. Therefore, improving access and availability is important.

### Unintended pregnancy

There is a general consensus that pregnancy is incompatible with deployment.<sup>26</sup> However, regulations regarding pregnancy testing prior to and during deployment vary across international militaries. In the Australian Defence Force (ADF), for example, pregnancy testing is mandated prior to land deployments and recommended (but optional) in the case of maritime deployments. This is not the case in many other militaries, with optional pregnancy testing prior to deployment. However, pregnancy can occur on deployment, and is not necessarily a rare occurrence. Combined with trends suggesting possible impacts of deployment and deployment exposures on conception and in early pregnancy (discussed below), this is an area requiring further research.

The prevalence of unintended pregnancy among servicewomen appears to be inversely associated with age, rank and seniority, and related to contraceptive non-use, misuse or failure.<sup>29-31</sup> Custer et al.<sup>32</sup> found approximately half of pregnancies among US soldiers were unintended. Although this figure is consistent with the civilian population, these rates significantly impact workforce capability because elements of active military service (e.g., deployment) are incompatible with pregnancy. Regarding deployment, Buller et al.<sup>33</sup> reported unintended pregnancies among approximately five percent of US females during deployment to Afghanistan, a number equivalent to those reported during the Persian Gulf War.

Grindlay et al.<sup>34</sup> explored the issue of abortion among deployed U.S. servicewomen. This qualitative study reported a lack of access to abortion while on deployment, which at times led to the unsafe practice of women attempting to terminate their own pregnancies. Similarly, Ponder and Nothnagle<sup>35</sup> reported a lack of access to education regarding contraception, reproductive choice and support for termination of pregnancy. While conclusions regarding pregnancy termination cannot be drawn on the basis of this research, the potential implications of these anecdotal findings are significant in view of known rates of unintended pregnancies on deployment.

### Pregnancy Incidence and Birth Outcomes

There is no definitive evidence that active service impacts on pregnancy likelihood, frequency of ectopic pregnancies or miscarriage. However, a small number of studies indicate a potential increased risk of miscarriage among previously deployed servicewomen, and the possibility of increased risk of birth defects. In relation to active service more generally, there could be adverse effects of occupational standing, or noise exposure, which may increase risk of pre-term labour and birth, and sedentary administrative positions, which may be associated with a greater risk of pregnancy complications (see Table 2 for a summary of evidence). Importantly, any conclusions from this research are limited by the small number of studies available.

There is limited research relating to pregnancy likelihood and pregnancy loss (including ectopic pregnancies and miscarriage) among servicewomen, however most studies do utilise large samples, and include control groups. The Armed Forces Health Surveillance Center<sup>36</sup> reported that among US servicewomen deployed to Afghanistan and Iraq, infertility rates increased with increasing



Table 2. Summary of evidence regarding pregnancy and birth outcomes

| Exposure type          | Evidence | Outcome          |                   |             |                |               |
|------------------------|----------|------------------|-------------------|-------------|----------------|---------------|
|                        |          | Fertility issues | Ectopic pregnancy | Miscarriage | Pre-term birth | Birth defects |
| Level of activity      | Yes      |                  |                   |             | X              |               |
|                        | Mixed    |                  |                   |             |                |               |
|                        | No       | X                | X                 | X           |                | X             |
| Deployment             | Yes      |                  | X                 |             |                |               |
|                        | Mixed    | X                |                   | X           |                | X             |
|                        | No       |                  |                   |             | X              |               |
| Occupational exposures | Yes      |                  |                   |             |                | X             |
|                        | Mixed    |                  |                   |             | X              |               |
|                        | No       | X                | X                 | X           |                |               |

deployment number and length. Menstrual disorders (potentially a precursor to fertility issues) were also more common among females deployed longer than nine months.

Although there is no conclusive evidence that active service impacts on the frequency of ectopic pregnancies or miscarriage, trends from a large administrative data study suggest a potentially increased miscarriage risk among US servicewomen deployed to the Gulf War.<sup>37</sup> Araneta et al.<sup>38</sup> and Wells et al.<sup>39</sup> reported no significant impact of Gulf War service on rates of conception, but Araneta et al. did find increased prevalence of post-deployment ectopic pregnancy and miscarriage. They argued that these higher rates of reproductive losses could be partially explained by demographic risk factors including socio-economic status, however.

A review by Rivera et al.<sup>40</sup> showed that female veterans historically report more reproductive and gynaecological problems than the general population. In addition they are more likely than their male counterparts to seek care for infertility. Increasing numbers of US female veterans are seeking reproductive health care through the Veterans Affairs, yet little is known about the delivery of infertility care for this population.<sup>41</sup> Two large studies utilising Department of Defence and Veterans Affairs data, examined infertility among US servicewomen. Katon et al.<sup>42</sup> found no significant difference in rates of infertility among veterans compared to civilians, however they did find that female veterans were more likely to seek infertility treatment. Mattocks et al.<sup>43</sup> reported that only 2% of US women veterans of Iraq and Afghanistan operations actually received infertility diagnoses, and less than a quarter of these women received infertility treatment.

Literature suggests that demographic factors may be more important predictors of birth outcomes than military service factors such as active duty, occupational exposures, vaccination and deployment; however, emerging evidence does indicate the possibility of service impacts. There is insufficient evidence from the studies to determine definite impacts of active service generally, or the specific impact of deployment on adverse pregnancy outcomes including pre-term birth and birth defects. There is limited evidence that active service may impact preterm birth. However, available evidence does indicate that deployment probably has an impact on pregnancy and birth outcomes more generally, while occupational exposures may have an effect on birth outcomes more specifically (see Table 2).

The limited research into the impact of service on birth outcomes has produced mixed findings. Compared to a control group of civilian dependents of military servicemen (thus subject to the same healthcare access and conditions), active duty servicewomen reported similar birth outcomes including infant weight and gestational age.<sup>44</sup> Of note, this prospective study found that active duty servicewomen had significantly less social support and worked longer into their pregnancy compared to civilian women – further suggesting these factors did not impact on birth outcomes. However, women who engaged in higher levels of occupational activity can have increased risks of pre-term delivery, even after accounting for age, socioeconomic status, marital status and education.<sup>44</sup> Consistent with this, Greer et al.<sup>45</sup> reported that female US Marines were significantly more likely to have a spontaneous

vaginal birth, with babies of lower birth weight, compared to Navy women; inter-service differences in activity levels may explain this finding.

The effect of occupational exposures is also unclear. Hourani and Hilton<sup>46</sup> reported no significant association between occupational 'burn pit' exposures and pre-term birth among deployed US active duty servicewomen. However, odd ratios for adverse birth outcomes appeared consistently higher for women who had been deployed and exposed to burn pits during their pregnancy. This trend is inconclusive but suggests the need for further monitoring. Interestingly, in this same study a significant association was observed between paternal burn pit exposure and risk of birth defects for the subsequent pregnancy. However, the authors noted these findings were inconsistent with others and had no biological explanation. Therefore, this finding should be interpreted with caution. In examining the impact of active duty-related exposures among US navy women, Hourani and Hilton<sup>46</sup> and Conlin et al.<sup>47</sup> found self-reported exposure to heavy metals, petroleum products, pesticides, and other chemicals, were associated with adverse birth outcomes, although these effects were largely accounted for by maternal health variables. Consistent with findings reported by Hourani and Hilton,<sup>46</sup> after controlling for health and pregnancy related variables, the only significant exposure effect on birth outcomes in this study was paternal exposure to pesticides – which was associated with increased risk for pre-term birth. Conlin et al.<sup>48</sup> also reported no adverse pregnancy or newborn health outcomes among active duty US military women who received pandemic H1N1 vaccine during pregnancy.

Likewise, the impact of deployment on pregnancy and birth outcomes is also unclear. Conlin et al.<sup>47</sup> and Ryan et al.<sup>49</sup> reported no differences in rates of pre-term birth, infant malignancies or major birth defects among infants of women who deployed during their first trimester of pregnancy, compared with those who did not deploy. Wells et al.<sup>39</sup> found no significant difference in the rates of adverse birth outcomes for Gulf War deployed female veterans, compared to a non-deployed comparison group. Doyle et al.<sup>50</sup> were unable to determine any association between Gulf War deployment and stillbirths and malformations among the offspring of British servicewomen, due to limited sample size. However, Kang et al.<sup>37</sup> did report a significantly greater risk of birth defects among Gulf War veterans compared to a control group, and in earlier research they found increased risk of birth defects among female Vietnam veterans.<sup>51</sup> Together these findings highlight the need for future research regarding birth outcomes in servicewomen.

### Post-pregnancy health and wellbeing

There is a dearth of research focussed on post-pregnancy health and wellbeing among servicewomen. There is little information on breastfeeding rates, workforce retention and post-partum return to work in this population, although recent data is emerging from Australia. This significant research gap has important policy and workforce implications regarding the appropriate supports for and needs of new mothers in the military. The lack of research in this area limits the assessment of evidence, however, it appears that military weight requirements may be unrealistic for new mothers, postnatal mental health issues require further research in this population, and support for breastfeeding may need to extend into the return-to-work period.

Some studies have examined post-partum physical fitness in servicewomen. Armitage and Smart<sup>52</sup> reported poorer performance and lower fitness pass rates for US active duty Air Force women 6 months post-childbirth, compared with participants' pre-pregnancy fitness test results. Further, Armitage and Smart<sup>52</sup> and Weina<sup>53</sup> found that post-partum fitness scores were significantly associated with post-pregnancy complications and weight gain. Overall, the physical fitness of women in the US military services reduces significantly between the pre-pregnancy and post-partum testing. Interestingly, Greer et al.<sup>45</sup> compared weight standards pre- and post-pregnancy among US Marines and Navy servicewomen. Approximately one year pre-pregnancy, almost 80% of Navy women and 97% of female Marines were within accepted body weight standards. At the first prenatal visit, the proportion of Navy women within accepted standards fell to near 70%, while for Marines it remained largely unchanged (96%). Consistent with this, at 3 and 6 months post-partum, Marines were significantly more likely than Navy women to meet body weight standards, again suggesting an inter-service difference.

Appolonio and Fingerhut<sup>54</sup> examined post-partum depression (PPD) among active duty US servicewomen and found almost twenty percent had PPD symptoms. A number of psychosocial variables were associated with PPD diagnosis, including poor social support, life stress and childcare stress. While rates of PPD in the military sample were elevated compared to those observed in the community, no military specific factors were found to significantly predict PPD. However, given the higher rates of PPD in the military sample, further research is warranted. In studying the impact of previous childbirth on the psychological health on deployment, Nguyen et al.<sup>55</sup> found maternal depression was increased among mothers subject to combat exposure while deployed.

This finding suggests that deployment could be associated with increased adverse outcomes for mothers versus non-mothers, though the underlying mechanisms are not clear.

While few studies have examined the impacts of breastfeeding in military environments, Appolonio and Fingerhut<sup>54</sup> reviewed evidence regarding service-related risks to breastfeeding mothers in the British Army. There was limited evidence that lead and pesticide exposure posed a risk to the offspring of breastfeeding mothers, with a recommendation that breastfeeding servicewomen be excluded from duties where these exposures are likely, including environmental duties and working in firing ranges. A recent Australian military study investigated breastfeeding initiation, prevalence, and duration in a cohort of working mothers.<sup>56</sup> Breastfeeding rates among this cohort compared favourably with women in the general population until 9 months, coinciding with returning to work post-leave. Australian servicewomen are entitled to maternity leave as a condition of service, which may have affected initial breastfeeding rates in this study and the proportion of women continuing to breastfeed until maternity leave had elapsed.

### Summary and conclusions

In summary, despite limited extant knowledge regarding sexual and reproductive health impacts of military service among women, a number of key issues were identified. There appear to be issues with knowledge of, access to and compliance with oral contraceptives among servicewomen, with two associated implications being rates of unplanned pregnancies on deployment and relief of menstrual burden through contraceptive suppression of menses. While the evidence regarding menstrual burden was mostly anecdotal, there are indications that this could be problematic in austere environments such as the Middle East. By addressing poor contraceptive knowledge and access among female personnel, menstrual burden and unplanned pregnancy could be reduced. There is some evidence indicating deployment may impact on pregnancy and birth outcomes, however it is unclear whether this is due to deployment exposures or other factors that persist post-deployment. Data trends suggest an association between active service and miscarriage, however this is statistically inconclusive. In relation to birth outcomes, evidence suggests a trend towards higher rates of birth defects among offspring of previously deployed women, although this is less the case for contemporary Middle East deployments. Again, this evidence is inconclusive, however it suggests the need for further research in this area.

There were a number of notable gaps in research and evidence. The area of menopause and post-menopause health in the female military workforce was a clear omission. These issues are important given the increasing numbers and age of the female military workforce, and the likelihood that menopausal and post-menopausal women will remain in the workforce longer. More striking, fertility was only examined in two studies, and only then as a secondary outcome. The dearth of research examining impacts on fertility is surprising, although both gaps could be attributable to the age of the cohort. Most deploying females in the US are relatively young and may not yet have encountered fertility issues or menopause, but these areas will become more significant as increased numbers (and ages) of women deploy in operational roles, and their roles expand. Furthermore, with insufficient data from other countries and differing demographic profiles of servicewomen, it is not possible to determine whether fertility issues exist. Growing evidence of the potential burden of menopause, and the various environmental exposures that may adversely impact fertility, indicates these topics will be extremely relevant into the future. Finally, while post-childbirth health and wellbeing was addressed in the context of mental health, and briefly in relation to physical fitness, there was a distinct absence of research regarding breastfeeding among servicewomen. Given the extent of research focussed on pregnancy outcomes, the lack of studies in the area of post-childbirth health and wellbeing is conspicuous. With an increased drive to retain mothers in the workforce, more research in this area is required.

In addition to examining active service impacts more generally, the studies in this review examined the effects of deployment to the Persian Gulf, Iraq and Afghanistan. It is important to note that, except where otherwise specified, findings related to deployment impacts from one area are not necessarily applicable to other areas. Similarly, where findings are specified for Army, Navy, Air Force or Marines, these may not be transferable to other services. Indeed, a number of studies showed significant service specific differences in health outcomes for servicewomen.

Taken together, this review highlights the limited available research relating to the impacts of military service on the sexual and reproductive health of servicewomen. The majority of reviewed studies fell into NHMRC evidence category III-2 or below including a considerable body of qualitative research. Only four included papers were of evidence category II or above (Controlled trials, with and without randomisation). With the exception of one Australian

study, the remainder were from the United States. This disparity reflects the higher numbers of females in the US already in combat and deployed roles, and their increased focus on health surveillance. However, it also highlights issues in terms of generalisability and current gaps in research and understanding relevant to the experience of other countries, including Australia.

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# Malaria Outbreak Aboard an Australian Navy Ship in the Indian Ocean

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## Abstract:

Four sailors aboard HMAS *Newcastle* were infected with falciparum malaria during a port visit to Dar-es-Salaam in Tanzania. All four were successfully treated at sea with oral atovaquone/proguanil. Besides their apparent non-adherence with the usual antimalarial precautions, the key aspects of this outbreak include a lack of on-board definitive diagnostic capability and treatment, both of which have since been addressed for other Fleet units. Although some Royal Australian Navy (RAN) deployments have lower malaria risk, this is not true for East Africa. All Australian Defence Force (ADF) medical officers need to be aware of falciparum malaria, as one of the few infections that can rapidly kill adults.

**Key words:** malaria, falciparum, Royal Australian Navy, Indian Ocean

## Introduction:

Febrile persons returning from Africa have a very long list of differential diagnoses including common (e.g. influenza) and uncommon (e.g. Yellow Fever) viral, rickettsial (e.g. African tick typhus), bacterial (e.g. typhoid fever) and parasitic (e.g. falciparum malaria) infections. Although all of the examples listed are potentially lethal, falciparum malaria is the only common infection that can rapidly (1-3 days) kill non-immune travellers such as military personnel.

For this reason, early consideration should always be given to malaria in the management of any febrile patient from a malaria endemic area. Although many of the more recent Australian Defence Force (ADF) overseas deployments ashore have been to areas with no (Iraq) or limited (Afghanistan) malaria risk, the risk varies far more widely in the Australasian region from very low in Vanuatu to very high on the north coast of Papua New Guinea (PNG). Furthermore, most ADF malaria cases ashore in recent years have been caused by relapsing (*Plasmodium vivax*) malaria weeks to months after they return to Australia, rather than the more lethal and acute onset *Plasmodium falciparum*.<sup>1</sup>

The risks associated with maritime operations in malarious areas depend on the type of operation being undertaken. The Royal Australian Navy (RAN) often conducts extended littoral maritime operations very close inshore (within mosquito range, typically less than 1-2 nautical miles). Examples include RAN personnel conducting hydrographic surveys off northern PNG, and clearance divers conducting explosive ordnance disposal tasks in Bougainville

and the Solomon Islands (although the latter tend to be shore, rather than sea-based).

Ships conducting offshore maritime operations are only exposed to malaria risk during port visits in malarious areas which are typically of short duration (four days or less), and usually involve ports where the risk is low. Although ships undertaking these visits require the same antimalarial precautions as for extended littoral operations close inshore, they are usually only required for the duration of each visit, rather than the whole deployment. All personnel undertaking maritime deployments are briefed on the relevant health hazards in accordance with Australian Fleet standard operations, usually with additional deployment-specific guidance and reinforced by port-specific health briefs prior to each visit.

RAN units undertaking Operation MANITOU conduct counter-piracy and interception of narcotic-running dhows along the eastern coast of Africa. When not engaged in operations, these Fleet units will visit a variety of ports, most of which have no or minimal malaria risk. (Figure 1) See Malaria Atlas Project (<http://www.map.ox.ac.uk/>) for global malaria estimates. However, malaria chemoprophylaxis is required for port visits to endemic malarial countries on the East African coast. Although preventive measures sometimes fail, most ADF malaria cases result from individual non-adherence. Four such failures recently occurred aboard HMAS *Newcastle* following a port visit to Dar-es-Salaam, Tanzania. (Figure 2) This highly unusual event highlighted several issues for future ADF deployments.