Navigating Pregnancy for Employees in Civilian Rotary-Wing Aeromedicine

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INTRODUCTION: Women of child-bearing age make up an ever-increasing element of the aeromedical workforce in Australia and the UK. However, policy relating to the management of risk for pregnant employees in this sector is often missing or inadequate, with many women facing detrimental impacts on their career progression and financial well-being. For women who choose to continue flying, there is a lack of transparent guidance about the risks of flying within a helicopter in an aeromedical role. While grounding pregnant employees removes some risks, it is at the cost of autonomy and brings other adverse effects for the employee and employer. Updated reflections on this important topic will empower the audience to make informed discussions around pregnancy in aeromedical roles.

TOPIC: Applying principles from literature surrounding commercial, military, and medical aviation, the risks to pregnant employees and the fetus are reviewed. These risks are complex and dynamic depending on gestation and underlying medical problems; thus, individualization of risk management is of key importance. In low-risk pregnancies, incapacitation risk is below the usual threshold adopted for safety-sensitive aviation activities. Based on available evidence we have quantified risks where possible and provide guidance on the relevant factors to consider in creating a holistic risk-management framework. The greatest unknown surrounds the risk from vibration, noise, and winching. These are reviewed and suggestions given for discussing this risk. We also highlight the need for policy providing acceptable nonflying options to remove the pressure to continue flying in pregnancy.

APPLICATION: Based on a literature review we have generated a framework for understanding and assessing risk relating to pregnant employees in the aeromedical sector. This is intended for use by aeromedical organizations, pregnant employees, and their treating medical practitioners to provide rational and sensible policy and guidance.

KEYWORDS: pregnancy, aeromedicine, risk assessment, rotary-wing aircrew, occupational health.

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Women have been members of the aviation team since the early 1900s, but have had limited access to many roles. The current generation are now able to do all jobs in aviation, but inequity remains about normal lifestyle choices, including pregnancy. As the number of women working within the aeromedical sector increases, a pregnancy occurring is becoming a 'normal phenomenon' within the working environment. However, within the United Kingdom and Australian civilian aeromedical services, there is a widespread lack of policy to lay out a logical and standardized approach to assessing the risk of pregnant employees flying. This leaves employees unequipped to assess the risks and make an informed decision about flying duties, and leaves employers at risk of not providing an equitable working environment.

This paper aims to challenge current practice in the aeromedical sector in Australia and the UK, and question the decision-making around women working while pregnant. The fact that women are continuing to fly with any additional pregnancy

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risk implies the existence of factors, including delayed career progression, financial penalties, or cultural norms, together with inadequate policies and no structured approach to discussing the risks, motivating this decision. It is of paramount importance that a decision to cease flying duties is supported by employers, unions, and workplace culture in such a way that women are truly empowered to make a decision without experiencing negative career or financial outcomes.

This paper seeks to outline a sensible and structured approach to an occupational risk assessment, to frame the discussion, and enable a process akin to informed consent regarding the potential risks that could occur. We break the considerations around flight risk and pregnancy into four main areas: operating environment, operational role, physical pregnancy changes, and fetal influence, and discuss how these change during the pregnancy. This is a novel categorization separating aviation factors that are modifiable (relating to platform and operations) from nonmodifiable (relating to working at altitude), and pregnancy factors related to physical changes from physiological and pathological changes.

Discussion points have been drawn from several countries to highlight the disparity in approaches and to demonstrate differences between aeromedical retrieval services. Anecdotal examples from Australia and the United Kingdom represent the authors' own experience while other evidence is drawn from the United Kingdom, Australia, and the U.S. military. The authors intend this review to support discussions between employees and employers, help current and future policymaking, and highlight gaps in the evidence, with emphasis on the pressing need for research in this area. Given the limitations of the literature, this paper is not intended to provide blanket conclusions about the safety of flying while pregnant, but to provide a structured way of discussing risk between the organization and the employee to inform and support decision making.

The authors acknowledge that the role of aeromedical services and their aviation platforms varies worldwide. The scope of this paper is limited to civilian services, specifically rotary-wing platforms, delivering emergency medical care to prehospital scenes and unscheduled interfacility retrieval of patients. Although many aeromedical retrievals are done by fixed wing aircraft, the paper will not deal with these platforms. The risks discussed are those relevant to the flying crew: paramedics, doctors, nurses, winch operators, and pilots. When we discuss a pregnancy, we are including the embryonic and fetal stage up until birth. We acknowledge that there are also considerations for the employee postpartum, e.g., return to work and breastfeeding; we are focusing this paper on the pregnancy period. We also wish to acknowledge those women who choose not to fly, or continue, and suffer a complication and the psychological and emotional sequalae. The crux of informed consent is that the decision to expose oneself and a pregnancy to any risk must be made with the best available evidence, including knowledge of uncertainty, and without any form of pressure to accept flying duties.

We hope our paper is useful in three ways. Firstly, in providing information to allow occupational health practitioners to make risk assessments for pregnant employees and provide informed consent in decisions about flight duties. Secondly, in creating a framework for employers to begin writing policies for approaching the management of pregnancy for their employees. Finally, as a call for research directed at better understanding the risks to a pregnancy of rotary wing operations.

BACKGROUND

It is a decade since a literature review first explored the complex issues surrounding women flying while pregnant in the aeromedical world.[53] Since this review, despite great advances in medical work provided by such services, there remains a lack of evidence-based policy to support decision making about pregnancy within UK and Australian aeromedical services. Furthermore, civil cases like Plaintiffs v. Frontier Airlines show women face restrictions and difficulties even after giving birth.[55]

Given a lack of clear information around the risks associated with pregnant women flying in civilian helicopters, and in an era of increasing litigation, it is tempting for employers to simply remove pregnant employees from flying roles. While doctors and paramedics may have their jobs transferred to ground-based roles, these rules can severely delay career progression for those dependent on their number of flying hours or mission numbers. Often deciding to have a family coincides with a critical point in their career as they transition into highly skilled and valued members of the workforce. No pregnancy or journey is identical and, medically, it may be appropriate for a woman to stop flying duties. In the context of a long flying career this may be a brief period; however, the decision must be made with a thorough consideration of the associated risks. Pregnancy occurring needs to be normalized and a progressive approach to pregnancy should become the norm, with input from the employee, employer, rota coordinator, aircrew medical examiner, and obstetric care team. A lack of support for choice relating to pregnancy and flying could deter women entering these jobs and risks perpetuating bias toward and stigma surrounding pregnancy for aeromedical employees.

Historical concerns within rotary wing civilian aeromedical work have been based on evidence that has come from the commercial sector. Current culture in many UK and Australian services results in women ceasing flying once they declare their pregnancy. This is either because there is a policy at the service that grounds pregnant employees, or because the policy is so gray and uninformative that the women feel there is not enough information or evidence to make an informed choice. There are also no national guidelines specific to aeromedical operations. This approach is fast becoming outdated and unacceptable. With female employees now representing a considerable proportion of the sector, they need to be involved in decisions around their life and career choices. There are also widely documented benefits to maintaining a diverse workforce and a key method to achieve this is to support women when making career and life choices associated with their pregnancy. No pregnancy is the same, including subsequent pregnancies, so a clear understanding of the risks is needed to enable both employee and employer to make informed, considered, and mutually beneficial decisions.

Current Regulations

Aviation authorities around the world have different regulations covering pregnant pilots which employers must follow, together with further risk control policies as appropriate. The U.S. Federal Aviation Administration permits flying throughout a low-risk pregnancy, in accordance with FAR 61.53, unless medical requirements cannot be met. Realistically, many are transitioned to desk roles within permissive organizations around the 30th week.[45] The UK Civil Aviation Authority permits a pilot to fly as part of a multicrew operation up to 26 wk, providing it has been deemed a low-risk pregnancy by a medical examiner.

The Australian Civil Aviation Safety Authority (CASA) requires a license holder to ground herself as soon as pregnancy is confirmed and seek advice before returning. She can resume flying duties provided the pregnancy is uncomplicated and the Designated Aviation Medical Examiners (DAME) and obstetrician agree, but only until the end of the 30th week of gestation. Reinstatement requires the DAME to certify a full recovery following delivery or termination.[1] This guidance is less specific than the United States and United Kingdom but does allow more consideration of the individual. A risk assessment is made along with surveillance checks every 2 wk.

International Civil Aviation Organization Class 1 Medical Standards recommend pregnant applicants be assessed as unfit unless obstetric evaluation and continued medical supervision indicates a low-risk pregnancy.[50] For applicants with low-risk uncomplicated pregnancies, suitably evaluated and supervised, flying should be limited to from the end of the 12th week (a stage at which the pregnancy can be confirmed as low-risk) until the end of the 26th week of gestation (second trimester only).

The U.S. Air Force has adopted a permissive stance, stating that "aircrew may voluntarily request to fly during pregnancy and no waiver is required to fly in the second trimester with an uncomplicated pregnancy." While military flying introduces different risks to aeromedical work, there is clearly scope to update policy and lift historical restrictions on women flying during their pregnancy.[10]

Pilots are governed by strict rules depending on the country; however, there is not clear guidance for the rest of the crew. The rest of the paper will discuss how to consider risk and apply these principles to each crewmember. It is reasonable to consider multiple factors relevant to each individual case, with regular reassessment at check-up appointments, such as the 2-weekly review approach used by the CASA, but this level of care may not be available as part of routine antenatal monitoring.

Calculating Risk

Within aviation, the level of acceptable risk is set by the regulator and any condition that affects fitness to fly may incur a safety limitation; like any major medical condition, pregnancy is approached as a risk that must be assessed. This contrasts to most nonaviation scenarios, where a pregnant woman decides on the risks she is willing to take for herself and her pregnancy. The established principle of the 'risk triad' should be applied to assessing risk: what is the risk to the pregnancy? What is the risk to the woman—physically and psychologically? What is the risk to the operation? Clearly, there will be circumstances where not all of these align, and, therefore, a discussion of the balance of risk and the principle of 'as low as reasonably practicable' should be employed. However, where previously employers have made these decisions on behalf of women, this paternalistic approach should change and these discussions should be transparent and allow women to be involved in shared decision making.

Aeromedical work involves a reliance of each team member on the other for the safety of the group, operation, and the patient. There is a complex ethical argument about individual team members having responsibility for assessing each other's fitness to fly, although this debate is beyond the scope of the paper.

Incapacitation risk describes the sudden inability to perform tasks relevant to the mission and will, therefore, impact mission success. There are clear examples of pathological pregnancy occurrences which can cause complete incapacitation, e.g., ruptured ectopic pregnancy and placental abruption. These must be considered in the risk management process, together with the probability of occurrence at each stage of gestation and potential mitigation strategies. These events are singular; however, cumulative risks also exist such as incapacitation from sudden severe nausea and vomiting, which can happen more than once.

Quantifying risk in pregnancy is an evolving process; different physical, physiological, and psychological factors influence risk at each stage of pregnancy. The '1% rule', derived from cardiac event risk stratification,[51] is often used in aviation to provide a line of unacceptable risk of complete incapacitation.[36] This approach can be difficult to apply, especially when considering partial incapacitation, though tools such as operation risk matrices clarify the process.[12] The unquantifiable risks within aeromedical work, including large unknowns, make it difficult to provide evidence-based discussion about continuing to fly.

It is also important to consider the psychological risk to pregnant women. There are conflicting pressures on them, both internally and externally. These women are often at the height of their careers and will be acutely aware of the impact of time away from flying. However, they may equally feel peer pressure to continue flying in the face of more liberal policy for pregnant women. There is also great potential for guilt if they do decide to continue flying and a pregnancy complication occurs. This must be thoroughly explored in the risk assessment process, as the sequelae of a complication following a choice to accept a risk are potentially severe.

FACTORS AFFECTING RISK FOR PREGNANT EMPLOYEES IN THE AEROMEDICAL SECTOR

Much emphasis in the assessment of risk for pregnant aviators is placed on differentiating "low-risk" pregnancies from those that are not low risk. While wording differs by jurisdiction, anything other than "low-risk" pregnancies will likely prompt suspension of flying duties. This differs from "complicated," which is medical terminology. For example, CASA states if the pregnancy is complicated, the woman should be grounded until assessed and have regular assessments if flying duties are permitted to resume.[1] In addition, discussion should consider the context of the pregnancy, for example, the difficulty of conception, as this can be highly relevant to any discussion of risk of pregnancy complications.

While previous literature has categorized risk into 'impact of pregnancy on flying' vs. 'impact of flying on pregnancy', we present a novel approach to considering this interaction in the inherently complex aeromedical environment by breaking the considerations into four key domains: operating environment, operating role, pregnancy changes, and fetal influence—but clearly there can be some overlap between the sections. **Fig. 1** provides an overview of this categorization.

Operating Environment

These factors are risks of where the mission is undertaken, are nonmodifiable, and all crew are exposed to the same risk.

Hypoxia. The percentage of oxygen in inspired air is constant, but the partial pressure falls with increasing altitude from 20.9 kPa at sea level to 13.3 kPa at 9843 ft (3000 m), reducing the oxygen content of blood in the woman and fetus. Altitude is a cause of preplacental hypoxia and acts as an independent risk factor for low birth weight.[8] Even acute and brief exposure to hypoxia has been shown to reduce birth weight and interfere with organogenesis.[18] Pregnant women, particularly in the later stages of pregnancy, are more at risk of hypoxia due to reduced residual lung volume (due to increases in lung water and compression from the developing fetus) and increased oxygen demands. However, aeromedical missions rarely fly to significant altitude and the degree of hypoxia encountered during travel at commercial aircraft cabin altitudes [up to 4921–7874 ft (1500–2400 m)] is not considered to pose a hazard in this setting to the woman,[13] although if there a pre-existing placental disorder then the pregnancy may not tolerate hypoxia. Oxygen is available if that height is transiently exceeded; furthermore, there is dialogue among the crew as to an appropriate height to fly as this is relevant to the medical component of the mission.

Cosmic and occupational radiation. Historically there has been significant anxiety within the aviation community about the risks of cosmic radiation to the developing fetus (particularly during organogenesis at 3–8 wk), raising concerns about congenital abnormalities, growth restriction, developmental disorders, and higher miscarriage rates than the general population.[7] Other studies suggest it could interfere with a woman's menstrual cycle, causing higher rates of subfertility,[24] although this may be confounded by shift work and stress.[2] Data from survivors of nuclear weapons suggests single doses greater than 300 mSv induce deformities, with doses below 100 mSv unlikely to cause demonstrable harm.[15,38] The International Commission of Radiation Protections recommends occupational radiation exposure be limited to 1 mSv[38] and assessment of radiation exposure and methods to reduce or avoid it are legal requirements.

The U.S. National Institute for Occupational Safety and Health suggests "Try to reduce your working on long flights, flights at high latitudes, or flights which fly over the poles."[38] Exposure to electromagnetic radiation, from sources such as radar and aircraft radios, is below legal requirements for civilian jurisdictions. While noting the original studies are based on data following acute rather than cumulative exposure, the literature suggests aeromedical operations would expose

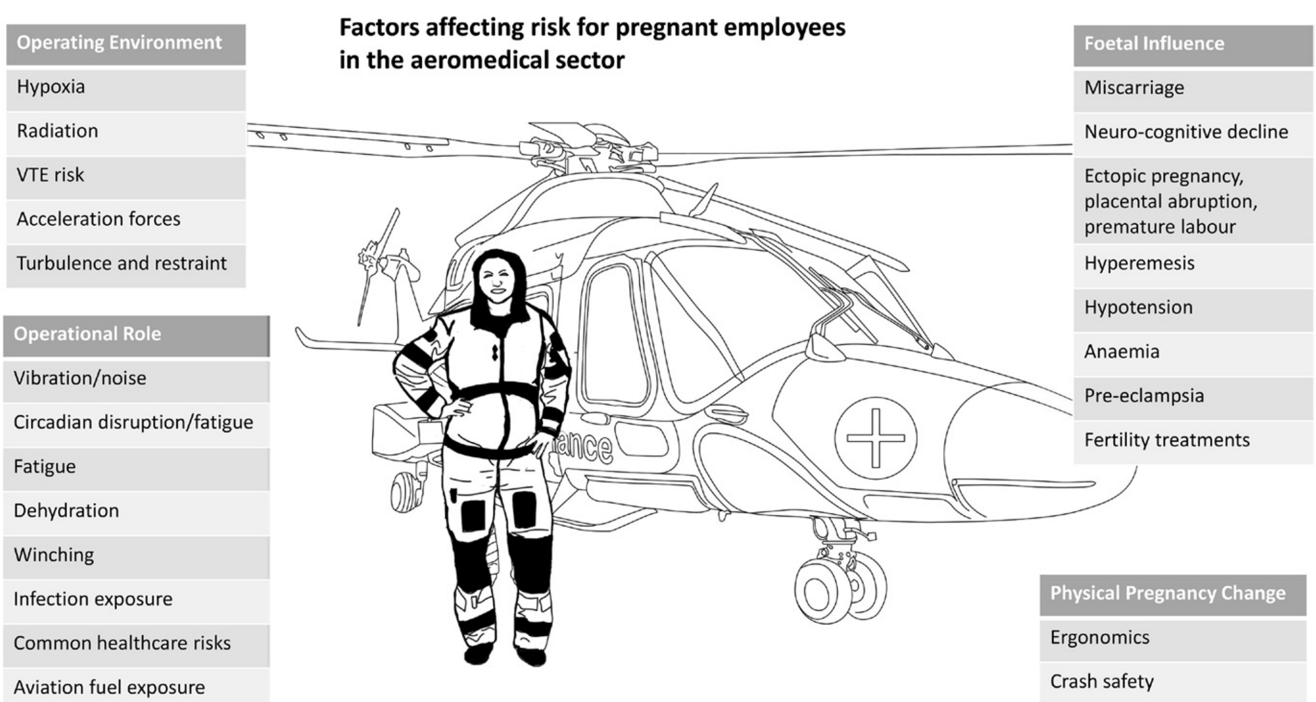

Fig. 1. Factors affecting risk for pregnant employees in the aeromedical sector.

pregnant employees to less radiation than commercial long-haul work due to the typical time spent flying and altitude. Future research could include measuring radiation exposure of aeromedical crew to increase understanding of actual radiation exposure for the aeromedical employee. In aeromedical rotary wing platforms, the nonionizing radiation risk from radio equipment is negligible due to certification requirements.

Thromboembolism. Pregnant women are at higher risk of thrombosis for several reasons, including reduced venous return and mobility, and increased estrogen levels, and this increases with gestation, with the highest risk during delivery and postpartum. There is wide variation in estimated incidence rates for deep vein thrombosis and pulmonary embolism, and although it is rare, it is the major cause of preventable maternal death.[32] The aeromedical operating environment may add risk if dehydration and prolonged periods sitting in a cramped seat occur, with risk known to double in flights over 4 h.[54] CASA address this risk through regulation requiring all pilots to have a medical investigation if they develop symptoms of thromboembolic disease such as pain in the calf or sudden shortness of breath.[30]

Acceleration forces. The body is affected by acceleration forces in different planes. An avoidance maneuver within the scope of aeromedical retrieval may expose the crew to up to 3 G sustained (4 G peak), although a standard 60° turn will not exceed 2 G (double perceived weight). Human tolerance of acceleration forces depends on factors including magnitude, time applied, direction of action, and posture of the body.[46] High acceleration is not recommended in pregnancy as the uterus will move under proportionally increased acceleration force and can result in placental abruption (as seen in high-speed trauma).

Turbulence and restraint. Aeromedical operations are time-critical and often occur in marginal weather conditions. The flight environment is hazardous to unrestrained occupants and, since pregnant employees are at higher risk of trauma from blunt force, unrestrained time should be minimized or avoided altogether. Furthermore, the pregnant abdomen places extra pressure on a 5-point harness, which may compromise the employee's comfort. In the event of exposure to significant force from turbulence or emergency procedures such as a hard landing, or even more innocuous trauma like slipping on hard ground, pregnant women should be encouraged to seek attention and appropriate monitoring for risk of placental abruption.

Operational Role

These factors are dependent on how the mission is undertaken, are potentially modifiable, but affect different members of the crew.

Vibration. Vibration and its impact on humans within a helicopter are well understood, but assessing the risk for a pregnant woman and fetus is more complex. Vibrations from a helicopter are transferred as mechanical energy to a human body, some of which is lost as heat within tissues, but internal organs are most at risk due to differences in resonant frequency. If vibrations are insufficiently dampened by other tissues or fluids, then damage can occur. In a sitting position, vibrations are dampened to a significant degree by the buttocks and the vertebral column, although this pathway is affected by body position.[22] As pregnancy progresses so does the woman's biodynamics, changing the normal pathway. Any additional injury would compound the musculoskeletal pain in the lower back experienced during pregnancy.[20] Vibration studies on female truck drivers suggests the mechanical effects on body segments is dependent on the location, frequency of vibration, and stage of pregnancy.[47] Animal studies trying to quantify the natural frequency of a pregnant abdomen and the fetus are inconclusive, although significant levels of 'whole body vibration' have been linked to fetal abnormalities and early miscarriage.[43] A recent cohort study from Sweden suggests pregnant women experiencing moderate-high exposure to vibration within acceptable 'safe' limits have an increased risk of preterm birth. Methods of reducing vibration within the helicopter include dynamic vibration absorbers, selective seat isolation, and maintenance of mechanical parts. However, beyond attempts to reduce vibration to an individual's seat, not much can be done by individual services to reduce the pregnant employee's exposure. Uncertainty surrounding this issue makes it difficult to produce meaningful policy/guidance for pregnant employees. This is clearly an area requiring more research given the significant magnitude of the risk.

Noise. Fetal hearing is considered sensitive to external sound by 27–29 wk gestation.[9] Noise exposure above 85 dB (the level of exposure requiring UK employers to provide hearing protection) may cause fetal harm, increasing the risk of low birth weight, fetal malformations, preterm deliveries,[5,9] and high frequency hearing loss in children with an increasing risk of gestational hypertension.[5,9] These levels are frequently encountered in rotary-wing operations, with significant potential morbidity for affected children.[5,39] Maternal hearing protection provides no fetal protection and consideration should be given to avoiding noise exposure from the later stages of the second trimester to minimize these risks.

Circadian disruption. Aeromedical work never stops. Shift work can have long-term health effects, including reduced immune function, increased risk of cardiovascular disease and mental health issues, and decreased cognitive performance.[28] During pregnancy a woman requires more sleep at different stages and hormones like progesterone and cortisol can worsen sleep quality, while circadian disruption has been linked to a higher incidence of miscarriage.[25] Notably, this has been recognized in legislation such as the German Maternity Protection Act, which provides relief for women from working disruptive shift patterns during pregnancy.[35]

Fatigue. "Fatigue during pregnancy is a physiological, psychological, and potentially pathological condition of decreased energy."[3] Fatigue appears inevitable during pregnancy, often worse during the first trimester due to hormonal changes and in the third trimester because of the burden of weight gain and increasing fetal metabolic demands. Around 40% of U.S. women report poor sleep quality at 14 wk gestation and this worsens with gestation. Circadian pattern disruption occurs as a result—over 40% of pregnant U.S. and New Zealand women report daytime sleepiness requiring a nap.[32] This disruption decreases cognitive performance in pilots,[28] and the same theory can be applied to other aircrew. The compound effects of fatigue and stress have been linked to various maternal and fetal complications.[25] Given the fluctuating nature of stress and sleep within aeromedicine, it would be wise for the pregnant crewmember and her service to consider the impact on rostering.

Dehydration. Heat stress in the operating environment leads to increased insensible losses. The operational environment can impede ability to maintain hydration with reduced chance for breaks. Hydrating may be avoided to mitigate limited access to private toilet facilities, increased effort with one-piece flying suits, and additional aircrew equipment. This is before pregnancy potentially increases losses from hyperemesis and frequency of urination through bladder pressure from the gravid uterus. Relative dehydration can increase the frequency of hypotension (and thus syncope),[21] mood lability,[1] and cognitive effects,[26] potentially affecting flight performance, and pregnant women should be encouraged to ensure adequate hydration.[27]

Winching. Winch rescue is a high-risk operation with safety dependent on a complex system and team members in safety-critical roles. While the actual operation differs between services, there are several noteworthy risks. The pilot holds the responsibility of ensuring the helicopter hover stays steady, the winch operator controls the exit and descent of the doctor/paramedic, and the latter need to carry the equipment down, stabilize the patient, and communicate with the onboard crew for extraction. While on the wire the crew are potentially exposed to direct trauma from striking ground objects even in normal operations, together with abnormal conditions associated with emergencies. A key safety feature is a correctly fitting harness, but this still exposes a pregnant employee to an undetermined force on their abdomen. Then there are the strains of maneuvering a patient, often with relatively austere ground support teams. A less dangerous but more frequent risk exposure is the potential for crew to be left in a remote place for hours or even days in the event of a change in weather conditions; even in low-risk pregnancies this could prove a significant concern. It may not always be operationally feasible to avoid these risks so it should be considered in discussions between employees and employers.

Exposure to infections. Pregnant aeromedical crew, as in all healthcare settings, may be exposed to infections that could be dangerous to both the mother and the pregnancy—either from the respiratory route or needle stick injuries. Any pregnant employee should have her vaccination status checked and be advised of scenarios to avoid.

Common healthcare risks. Other risks that are common to other healthcare settings which may affect the medical crew come from direct interaction with the patient and their family. All crew should be aware of handling and moving protocols to reduce the likelihood of musculoskeletal injuries. However, ligament laxity and altered biomechanics in a pregnant woman will increase the chance of these occurring, which could be a risk if the aeromedical service requires the employee to carry heavy loads. Trauma from patients and family members could also occur—a risk assessment of the mental status of any accompanying helicopter passengers should be undertaken prior to boarding.

Exposure to aviation fuels. The turbine-engine helicopters generally used in aeromedical operations burn kerosene-based fuels, commonly JP8 (U.S. military) or Jet A1. Exposure to aviation fuel has been linked to negative health effects depending on length of exposure, whether the fuel is in fume or liquid form, and how the exposure occurred (ingested, inhaled, or absorbed via the skin). Postulated negative health effects range widely across the body systems along with potential impacts on DNA and metabolism.[34,49] A study by the U.S. Air Force exploring the effect of jet fuel on pregnancy showed pregnant mice exposed to similar levels as flight line personnel demonstrated a long-term detrimental effect on the immune system of newborn (particularly male) mice. Further studies have suggested that while exposure to JP8 prior to and during pregnancy does not impact pregnancy rates, gestational length, or viability, the offspring had significantly reduced body weight compared to controls.[40] The Australian military allows female employees to exclude themselves from working with fuel due to concern regarding fertility. Finally, there is the potential for exposure to other aviation fuels containing lead and exposure to combustion products from aircraft engines.

Pregnant Crew

These factors include the physical changes of pregnancy and the effect on the ability to undertake safety procedures.

Ergonomics. Men and women can change anthropometrically throughout their career, irrespective of pregnancy, impacting functionality inside the helicopter and the ease of exit in an emergency. Harnesses have a variety of adjustments according to size and pressure point requirements, and the seats can move forward and back, allowing for changes in abdominal size when accessing the cyclic control. Adjustments aside, if an abdomen prevents full access to the controls or a comfortable restraint, there is a safety issue. Additionally, there are requirements to carry and lift heavy equipment, often at speed, which may be affected by pregnancy. This is also applicable to the fixed wing or road environment. Fixed wing aircraft may have bigger, more comfortable seats, but are usually undertaking longer missions. Road ambulances provide greater flexibility as the cabin space is bigger and stops are possible.

Crash safety: emergency egress and restraints. Catastrophic crashes in aeromedical helicopters are incredibly rare due to the safety systems required by regulators. As such, the additional risk for a pregnant crewmember is inconsequential compared to the rest of the crew. Some safety features are affected during pregnancy. Diving is not recommended during pregnancy due to the unknown risks of microscopic gas emboli[48] and, thus, any Helicopter Underwater Escape Training (HUET) requirements and/or training would also be of increased risk to pregnant women, especially with use of emergency breathing systems (EBS, compressed-air bottles for underwater escape). As a flow-on effect, any overwater operations would also be at increased risk due to regulatory requirements for HUET training and use of EBS in a maritime environment. Ensuring appropriate fit of personal protective equipment including restraints is essential for reducing risk in the event of a crash. Studies based on motor vehicle crashes show that the shoulder harness and correctly fitting lap belts are the key factors in reducing the risk of placental abruption.[6,23,42] Both restraints are already incorporated into the helicopter aeromedical restraint design, as well as training for correct fit and emergency egress procedures held annually. The risk of accidents while working in road ambulances must also be considered in minimizing risk for pregnant employees, as it does come with an increased risk of obstetric complications such as placental abruption and uterine rupture caused by seatbelts in the event of a crash,[37] although that is reduced using modern 3-point seatbelts.[17]

Fetal Influence (Physiological/Psychological Changes)

These can cause an acute incapacitation and the presence of any of these will mean the pregnancy is no longer uncomplicated.

Miscarriage. On average, 1 in 4 pregnancies result in miscarriage by the fourth week, with rising risk with maternal age.[31] There is anecdotal evidence of increased miscarriage rates within aeromedicine,[53] but this is open to significant confounding. There are often minimal warning signs, but commonly spontaneous miscarriage is preceded by abdominal cramping and bleeding. Possible causation has been linked to cosmic radiation,[7,11] sleep deprivation,[25] and physical work strain.[28] Symptomatic women should seek medical help immediately and cease flying until resolved. If there is a threatened miscarriage, then there should be a discussion with the obstetrician about what level of duties the woman should undertake.

Neuro-cognitive decline. Increased forgetfulness and poor memory are difficulties frequently experienced by pregnant women.[4] Studies on memory function in pregnant aviators are limited and very small-scale,[44] making it difficult to draw broad conclusions.

Ectopic pregnancy. Occurring in 1–2% of pregnancies, this remains the most common cause of maternal death in the first trimester in the western world. Risk factors for developing an ectopic pregnancy include previous ectopic pregnancies, fallopian tube surgery, sexually transmitted infections, pelvic inflammatory disease, fertility treatment, indwelling intrauterine device, smoking, and increasing age.[19] Early symptoms often occur as the ectopic fetus grows, which would require further investigation, but rupture can cause life-threatening bleeding, which would create an aviation emergency. Any pregnant crewmember with a history of ectopic pregnancies should be aware of the increased risk and discuss possible amended duties until ectopic pregnancy is excluded.

Hyperemesis. Nausea and vomiting occur in approximately 80% of pregnancies during the first trimester. For the majority it is mild and self-limiting, but can persist to 22 wk in 10% of cases and, in severe cases (2%), can necessitate hospitalization for intravenous rehydration. It is reasonable to assume this ‘incapacitation risk’ is individual and should be assessed on a case-by-case basis. Even without vomiting, nausea can still affect attentiveness at work, with up to 65% of pregnant women reporting inattention when suffering morning sickness.[32] The CASA specifies that the presence of morning sickness represents an ‘unstable symptom’ and would need risk assessment. The onset is unlikely to be sudden or without warning, but places responsibility on aircrew to withdraw from flying if unable to carry out duties safely. If a woman is unwell enough to require ongoing medication or hospital admission, this would be incompatible with flying duties.[52]

Hypotension. Blood pressure begins to fall during the first trimester and reaches a nadir during the second due to dilation of blood vessels and diversion of blood to the uterus. Transient symptoms such as dizziness may not hinder a pregnant woman working, but syncope causes sudden incapacitation and is an aviation emergency for a pilot. Hypotension has also been linked to a pilot’s reduced tolerance for acceleration forces,[16] which can be further exacerbated by dehydration.[41] Symptoms on the ground necessitate a blood pressure check before recommencing duties.

Anemia. As the blood volume rises during pregnancy, the concentration of hemoglobin drops and, as a result, a dilutional anemia develops. This may go unnoticed or can present with dyspnea, fatigue, and arrythmias. If a pregnant team member develops these symptoms, further investigations are required. Often, simple oral iron supplementation will be sufficient to continue working, but refractory anemia may prompt a restriction to flying duties.

Pre-eclampsia. The current definition is hypertension developing after the 20th week in pregnancy accompanied by one or more signs of organ dysfunction.[29] The pathogenesis of pre-eclampsia is complex and poorly understood, although stress, which is unavoidable in the aeromedical sector, has been implicated. Pre-eclampsia can become a sudden incapacitation risk if it develops into eclampsia, albeit rare without diagnosed pre-eclampsia. Women with pre-eclampsia or pregnancy-induced hypertension no longer have ‘low-risk’ pregnancies.

Controlled pre-existing hypertension will require monitoring throughout pregnancy but should not preclude flying.

Placental abruption. Minimal trauma or sudden accelerating forces can cause placental abruption, which is an obstetric emergency. G force applied in flight during an emergency egress is a risk for abruption,[11] and is associated with turbulence, windshear, vortex ring states, engine loss recovery, or aborted takeoff. Although most aeromedical work does not require sudden accelerating/decelerating forces, there may be unpredictable sudden descent. Any woman with a 'high risk' pregnancy should discuss this potential complication with their obstetrician.

Premature labor. There are many causes of premature labor, but if the woman experiences bleeding or cramping then she should seek immediate medical advice and not fly.

Fertility treatment. In 2018, 54,000 women underwent assisted fertility procedures in the United Kingdom.[14] Fertility decreases with age and female physicians often delay childbearing due to the burden of their careers.[33] Increased use of IVF treatments should be recognized and normalized in policy. As IVF automatically classifies a resulting pregnancy as complicated, additional psychological factors may reduce the desire to continue flying. There exists no literature regarding IVF treatments and flight safety, thus all crew should be aware of requirements within their local jurisdiction for discussing changes in medications with their aviation medical examiner.

DISCUSSION

Pregnancy is a normal physiological process, but for women working within the aeromedical sector the risks to the pregnant employee, unborn child, and the operation must all be considered when deciding whether and how long to continue flying. As more women enter aeromedical roles, it is vital that the regulations and policy surrounding pregnancy and aviation provide support for this increasing proportion of the workforce during a normal part of their lives.

Given the additional risk of rotary-wing aeromedical work compared to not flying, the creation of a work environment where there are no costs to pregnant employees who stop flying should be the aim of both employers and unions alike. The language of policy needs to make clear that while flying in pregnancy will be supported where it meets appropriate safety criteria and the employee wishes to take the additional risk, it will never be expected, and the employer will do everything possible to mitigate the effects of not flying. Pregnant employees should be provided with the available evidence and give informed consent if they choose to continue flying. In the event of an adverse pregnancy outcome when flying duties continue, employers should be prepared to help support their employee, who faces a heavy psychological and social burden.

An important consideration is the complex issue of ownership of risk within aviation. The question of who owns risk in pregnancy is vexed, with significant crossover between the responsibilities of the aircraft operator, pilot, and individual members of the crew. Imposing flight restrictions should occur only where a demonstrable risk to safety exists that cannot be managed in less invasive ways, and unilateral decisions by employers should only consider incapacitation risk and ability to physically perform duties. While joint decision-making during a woman's pregnancy is a wider ethical discussion than this paper, the authors advocate a collaborative approach to decision-making involving the employee. The fluctuating course of pregnancy might mean that, for example, remote area operations are not safe in a particular week, where the next week they are acceptably safe. Access to an informed obstetrician and flight doctor allows an ongoing discussion which can adapt to the dynamic process of pregnancy. Clearly, stretched resources and scheduling may mean that this flexibility is not universally available, though it should be aspired to and at least some flexibility should be built into a pregnant employee's roster. Offering a more individualized work plan than dichotomized flying or nonflying roles should be seen as the optimal model for empowering pregnant employees.

Undertaking any role in the aeromedical sector usually requires 10–15 yr of experience in a career path as it requires high levels of experience and expertise. For example, pilots need appropriate qualifications and flight experience to meet the demands of the job. Most pilots have a military pedigree flying complex helicopters and considerable experience of winching, night vision goggles flight, and dynamic operations relative to total time. Similarly, paramedics will have completed further postgraduate qualifications in intensive care and spent considerable time on the road before being considered for a flight role. Doctors are often toward the end of their specialty training or practicing at a specialist level. This means most women are not entering the industry until their thirties, so, if choosing to start a family, are more likely to experience subfertility. For women, at this critical moment in their career paths, if they choose to have children, it is imperative their career progression is actively supported by the sector so that they can continue to progress in the future and use their high-value skill set. Furthermore, when applying for jobs, pregnancy-supportive approaches from employers will likely be considered by applicants.

Clearly defined policy for managing pregnancy in aeromedical operations is important not just to individual employees; it is vital for the industry as it shows commitment to investing in this high-value skill set for the long-term. Services should adopt clear policies outlining how risk will be assessed, criteria for allowing continued flying, and how nonflying duties will be handled (both by choice and medical disqualification). Consideration should also be given to preconception restrictions, if medically necessary, and return to work after delivery. This is important to allow employees to make major life decisions that balance a multitude of factors. Ultimately it will pay dividends for an employer to retain a high value asset, thereby achieving a return on their initial investment. If a woman is given a choice to fly or not through pregnancy, disruption to the workforce is minimized, as is disruption to her training and currency. However, given the significant unknowns, there is an urgent need for better evidence to guide risk assessment and decision-making. We urge employers, unions, and occupational health providers to normalize pregnancy in the aeromedical workplace, with focus on research to better understand the risks of this work while pregnant.

If a woman does not continue flying during pregnancy, there are still benefits to be gained from proactive management. When engaging in discussions with pregnant employees, an employer should encourage roles that supplement their operational knowledge. This could include management roles, further education, or application of their skills in a checking and training capacity. Such lateral thinking creates opportunities for the individual and enhances the employer's workforce diversity.

Aeromedical work differs depending on service and role and, therefore, the issues raised by this paper need to be applied on an individual basis. For example, a different approach is required by services with water- and winch-rescue elements than services performing only "land on" operations. Similarly, where longer transfers are common, the risk of fatigue and dehydration may be of greater significance. We would urge caution if allowing flying duties with tasking restrictions, as mission momentum can lead to "mission creep" and pressure to bend vague restrictions; where restrictions are established, they should be clear and known to the crew and tasking agency.

Many of the risks discussed above are applicable to any role, but it is important to closely understand the specific risks associated with each role. The aim of this paper is to highlight the current evidence base and provide a framework for understanding risk of flying while pregnant to assist aeromedical services around the world in creating their own policies.

Conclusion

This review has summarized current literature surrounding the risks of pregnancy and aeromedical work with a view to providing guidance for creating policy in this area. To summarize, we suggest the following conclusions:

1. The risks to pregnant women and the fetus are complex and dynamic, affected by gestation and underlying medical conditions. As a result, defining a generic policy to fit all circumstances is difficult. Efforts should be made to provide broadly inclusive policy with specific advice tailored to the risks of specific aeromedical roles and the individual pregnancy.
2. Work needs to be done to urgently address the career, financial, and social pressures motivating pregnant employees to continue flying during pregnancy.
3. The literature suggests women with low-risk pregnancies do not have a significantly increased incapacitation risk provided they seek medical attention if new symptoms occur.
4. Historical concerns surrounding aviation risks such as cosmic radiation and hypoxia are not relevant in low-risk pregnancies within civilian rotary-wing aeromedical work.
5. The greatest unknown risks are vibration, noise, acceleration, and winching. These must be considered in any decision to continue flying during pregnancy.
6. Policy implementation should recognize the higher need for rest during pregnancy and risks posed by circadian disruption, especially in relation to night shifts.
7. To mitigate the unknown and potential risks, a partnership between aerospace medical and antenatal care providers and the employing organization is essential. Frequent and regular antenatal checks that consider the occupational context are a sensible approach.
8. There is a pressing need for research to quantify the risks of vibration and noise on pregnancies in rotary-wing aeromedical work.

We recommend aeromedical organizations introduce a policy with a structure as outlined in this paper to allow the pertinent risks to be highlighted and facilitate discussions and individualized considerations. The holistic risk-management framework suggested within this paper will allow tailored decisions made as a team for individual pregnancies. Based on available evidence, we have quantified risks where possible and provided guidance on the relevant factors to consider in creating a holistic risk-management framework. There is limited evidence in some key areas that require further study, which we have highlighted.

It is inexcusable in 2022 for aeromedical organizations to not have policies covering operations involving pregnant employees. Introduction of policies based on the best available knowledge will encourage more women to enter aeromedical work in the first instance, support women having a family while continuing with their career, and maximize retention of highly skilled and expertly trained employees.

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