Investigating challenges and health concerns of female firefighters: A Review

1. Introduction

Firefighting is a physically demanding and high-risk profession characterized by unpredictable environments, extreme temperatures, and exposure to hazardous materials. Traditionally, it has also been a male-dominated field, shaped by a culture and infrastructure that has historically marginalized women. Despite growing efforts toward gender inclusivity and policy reforms aimed at equal opportunity, female firefighters remain significantly underrepresented worldwide. Recent statistics reveal that women account for only 9% of the firefighting workforce in the United States and approximately 2% in Australia (Fahy et al., 2022; Fire Recruitment Australia, 2022). The above figures reflect deeper structural and systemic barriers that continue to impede women's full participation and integration into the profession.

The challenges female firefighters face extends beyond representation. Literature across disciplines, including occupational health and gender studies, highlights a range of barriers that compromise both the safety and career longevity of women in this field. One persistent issue is the lack of access to well-fitted and ergonomically appropriate personal protective equipment (PPE) (Krause et al., 2023; McQuerry et al., 2023). Most firefighting gear is traditionally designed with male body dimensions in mind, resulting in ill-fitting equipment that can impede mobility, increase injury risk, and reduce thermal protection for women. Additionally, the gendered culture of many firefighting organizations often manifests in limited support structures, implicit bias, and fewer leadership opportunities for women (Hulett et al., 2008).

Female firefighters face specific health challenges related to reproductive and hormonal factors, including menstruation, pregnancy, and menopause. According to published studies female firefighters face elevated cancer risks due to occupational exposures, though more targeted research is needed to confirm associations (Kehler et al., 2022; Solle et al., 2021). Physiological factors such as hormonal fluctuations during menstruation, pregnancy, and menopause can influence thermoregulation and cardiovascular responses. When combined with occupational exposures like extreme heat, physical exertion, and heavy PPE use, these factors may contribute to increased physiological strain. For example, elevated core temperatures during late pregnancy or the luteal phase of the menstrual cycle can impair heat dissipation (Jacobsson et al., 2020). However, current firefighting protocols and health assessments rarely account for these gender-specific variables, highlighting a need for more inclusive and evidence-based occupational health practices.

This paper explores the unique challenges female firefighters face, focusing on health and safety concerns exacerbated by heat exposure during menstruation, pregnancy, and menopause across their careers. Literature highlights the importance of a human-centered design approach in understanding needs and lived experiences of female firefighters (Harte et al., 2017; Holeman & Kane, 2020). Technological advancements, guided by a human-centred design approach, can offer potential solutions to address challenges faced by female firefighters. Literature highlights that Wearable Sensor

Technology (WST) can be used to monitor health indicators vitals such as skin temperature, core temperature, heart rate, and support menstruation and maternal health by understanding the patterns (Buller et al., 2015; Morrissey et al., 2021; Saidi & Gauvin, 2023; Wibowo et al., 2024). Such innovations may enhance safety, job performance, and overall well-being while promoting a more inclusive and responsive firefighting environment.

2. Significance

This study contributes to ongoing conversations on health equity in firefighting by exploring challenges that may uniquely affect female firefighters. While there is increasing recognition of the need for inclusivity, a deeper understanding of how gender influences occupational health remains understudied. By reviewing literature on reproductive health, PPE, and workplace conditions, this study identifies areas where women may face specific concerns. This study highlights the importance of applying a Human-Centered Design (HCD) approach as it prioritizes the lived experiences, needs, and contexts of end users. Incorporating HCD into future research and design efforts may lead to more effective, inclusive, and sustainable solutions that support the well-being and performance of all firefighters.

3. Methodology

This study is based on a literature review exploring the challenges and health concerns faced by female firefighters. It also incorporates selected findings from a systematic review conducted that examine safety needs and lived experiences of firefighter trainees. Specific insights related to female firefighters are highlighted to inform inclusive safety considerations.

4. Findings & Discussion

4.1 Gender inequality

Underrepresentation of women in firefighting remains a persistent issue, with figures as low as 2–9% in countries like Australia and the U.S. This limited presence can exacerbate feelings of isolation and invisibility. According to published reports, female firefighters indicate experiences of gender-based discrimination and workplace harassment, including exclusion from certain roles and inappropriate behaviour. These issues not only affect job satisfaction and mental well-being but also create barriers to progression and retention within the profession (Krause et al., 2023).

Findings from published reports highlight the importance of fostering a workplace culture grounded in inclusion, safety, and respect. Such an environment is essential to ensure that female firefighters are afforded equal opportunities and support. Creating equitable conditions not only enhances their ability to perform effectively but also contributes to long-term retention and well-being within the service. These improvements are key to addressing systemic barriers and promoting a more diverse and resilient firefighting workforce (Hulett et al., 2008).

4.2 Inadequate options for female PPE

Findings from the reviewed literature consistently indicate that personal protective equipment (PPE) is often inadequately designed for female firefighters, presenting significant safety and comfort challenges. Most standard PPE is based on male body dimensions, resulting in poor fit for many women.

Issues such as oversized gloves, improperly fitting jackets, and restrictive trousers can hinder mobility and increase the risk of injury. Female-specific anatomical features including differing body contours, narrower shoulders, wider hips, and protruding structures like breasts are rarely accounted for in current PPE design. As a result, women may experience discomfort, thermal burden, and compromised protection during operations (Fahy et al., 2022; McQuerry et al., 2023).

4.3 Miscarriages

Evidence from female firefighter reports and occupational health studies highlights miscarriage as a significant concern. Repeated exposure to heat stress, physical exertion, and toxicants during early pregnancy may elevate the risk of spontaneous pregnancy loss. In several cases, women continued shift duties without awareness of early pregnancy or without accommodations, potentially increasing vulnerability. Limited access to reproductive health assessments and absence of workplace policies addressing early pregnancy considerations further compound the risk. Addressing these gaps by incorporating routine reproductive health screenings and creating early disclosure support mechanisms may help mitigate miscarriage risk in firefighting roles (Jung et al., 2021).

4.4 Pregnancy Complications

The physical and thermal demands associated with firefighting may contribute to challenges during pregnancy, such as increased physiological strain. Factors including the use of heavy personal protective equipment (PPE), prolonged exposure to elevated temperatures, and physically demanding tasks can place additional stress on the body. Some literature highlights around potential pregnancy-related outcomes like hypertension or early labor, although direct causal relationships require further investigation (Richardson et al., 2019, 2020).

Despite the physically intense nature of the role, formal workplace policies for modified duties during pregnancy appear limited or inconsistently applied. While some fire services offer reassignment options, these are not always standardized or well-communicated. Anecdotal reports from female firefighters suggest a hesitation to disclose pregnancy early, often due to perceived stigma or concerns over being reassigned to less valued roles. This may delay access to necessary support or adjustments during a critical time.

Establishing clearer guidance, routine health monitoring, and supportive frameworks that acknowledge the physical realities of firefighting during pregnancy could help mitigate risks and promote safer outcomes for both firefighter and child (Richardson et al., 2019). Additional research into occupational accommodations and health implications is recommended to inform evidence-based practices.

4.5 Menstruation-related Challenges

Menstruation presents a range of practical and physiological considerations that can affect the experiences of female firefighters during training and operational duties. While the subject has traditionally received limited attention in fire service planning, emerging literature suggest that standard facilities and work environments are not always conducive to managing menstrual health comfortably or effectively (Richardson et al., 2019).

While further research is needed, current findings suggest that gender-sensitive infrastructure, access to sanitary products, and inclusive workplace practices can help support the well-being and operational readiness of female firefighters. Literature suggests a Human-Centered Design (HCD) approach offers valuable insights into their needs and lived experiences, informing more effective and inclusive solutions (Höök et al., 2021). Creating space for open conversation around menstrual health within fire services may also help reduce stigma and promote more equitable working conditions for all personnel.

4.6 Health concerns

4.6.1 Cancer risk

Emerging research suggests that female firefighters may face an elevated risk of certain cancers due to prolonged exposure to occupational hazards such as smoke, diesel exhaust, and fireground contaminants. These exposures, which can also occur during training, are believed to contribute cumulatively over time. Some studies indicate potential associations with cancers such as breast and reproductive cancers, although evidence remains limited. Differences in physiological and hormonal factors between male and female firefighters may influence how such exposures affect health outcomes. Current literature highlights the importance of further investigation into gender-specific exposure pathways. There is also growing recognition of the need to improve decontamination procedures and protective strategies for female firefighters (Solle et al., 2021).

4.6.2 Heat Risk

Heat risk in firefighting refers to the physical and physiological strain that results from working in high-temperature environments, especially when combined with heavy personal protective equipment (PPE) that limits the body's ability to cool itself. For female firefighters, this risk can intersect with reproductive life stages such as menstruation, pregnancy, and menopause in ways that may introduce additional challenges, though the degree of impact can vary among individuals.

Research indicates that hormonal fluctuations during the menstrual cycle may influence thermoregulation. For example, during the luteal phase, increased progesterone levels can lead to a higher baseline core temperature and a delayed onset of sweating (Baker et al., 2020). When combined with physically demanding tasks and PPE-related heat retention, some female firefighters report greater physical discomfort, fatigue, and heat sensitivity during menstruation (Kehler et al., 2022; Krause et al., 2023). However, findings in this area are still developing, and individual responses to heat can vary widely.

The identification of heat stress among firefighters, has been studied by focusing on key physiological parameters, such as skin temperature, heart rate, sweat loss and core body temperature (CBT) (Buller et al., 2015; Morrissey et al., 2021; Saidi & Gauvin, 2023; Wibowo et al., 2024). Of these, CBT is widely regarded as the most accurate indicator of a firefighter's heat risk level during operational activities compared to the skin temperature. However, current methods for measuring CBT such as sensors placed in the ear, ingestible capsules, and rectal probes are often deemed impractical for firefighters due to discomfort and logistical challenges. Emerging research suggests alternative

approaches, including the estimation of CBT from heart rate data, enabling a more feasible and real-time assessment of thermal stress in first responders (Holm et al., 2016; Zheng et al., 2020). Existing literature highlights that using a human-centered design considering insights from actual end-user can support current limitations in existing methods for detecting core body temperature in firefighters (Bourlai et al., 2012; Mcentire et al., 2013; Yao et al., 2023).

The findings emphasize the value of applying a Human-Centered Design approach to address the specific challenges and health risks faced by female firefighters. By guiding the development of inclusive equipment, gender-sensitive infrastructure, and wearable technologies, this approach can play a key role in enhancing safety, inclusion, and respect within firefighting environments [Figure 1].

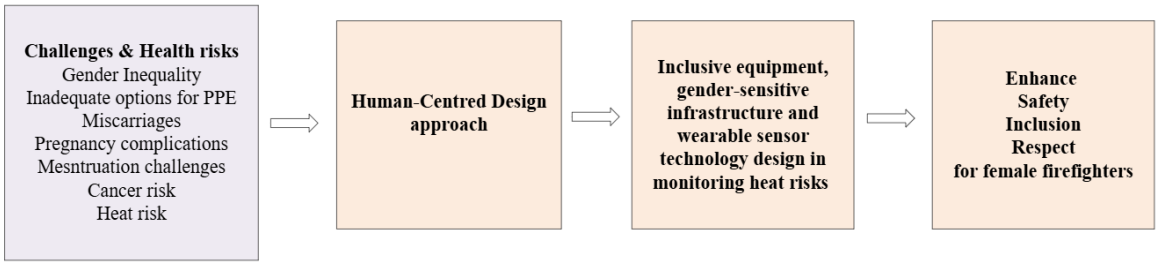

Figure 1: Suggestion of using a HCD to enhance female firefighter safety, inclusion and respect

5. Conclusion

This study has examined the key challenges and health concerns experienced by female firefighters, including gender inequality, ill-fitting PPE, reproductive health risks such as miscarriages and pregnancy complications, menstruation-related challenges, and heightened exposure to cancer and heat-related stress. These concerns are often under-recognized in current firefighting practices and policies. Addressing these concerns using a human-centered design approach understanding needs and lived experiences of female firefighters can support design inclusive equipment, gender-sensitive infrastructure and user wearable sensor technology in monitoring health risks such as heat risk as shown in above Figure 1. Authors suggest incorporating a HCD approach that explores the needs of end-users may enhance safety, inclusion, and respect for female firefighters.