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Review Article

Hyperthermia-induced infertility in women: an urgent narrative review of environmental and occupational risks: a literature review

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ABSTRACT

Female infertility is a global health challenge with multifactorial causes, yet the role of exogenous hyperthermia as a significant and growing risk factor remains underappreciated in clinical practice. This narrative review synthesizes current evidence on how environmental and occupational heat exposure impairs female reproductive function, focusing on physiological mechanisms, epidemiological data, and preventive strategies. Hyperthermia exerts its detrimental effects through multiple pathways, including increased oxidative stress, disruption of the hypothalamic-pituitary-ovarian axis, and direct damage to oocyte quality and endometrial receptivity. Rising global temperatures and more frequent heatwaves, particularly in low-resource settings and among women in high-heat occupations such as agriculture, manufacturing, and food services, create a double burden of environmental and occupational heat stress with limited protective infrastructure. Current occupational safety guidelines are largely based on male physiology and fail to adequately safeguard female reproductive health. Recognizing hyperthermia as a tangible threat to fertility is critical, and there is an urgent need for female-specific research, revised occupational health standards, and clinical guidance for at-risk patients. Addressing this challenge requires coordinated efforts from gynecologists, occupational physicians, policymakers, and climate scientists to protect reproductive health in a warming world.

Keywords: Hyperthermia, Female infertility, Heat stress, Environmental exposure, Occupational health, Reproductive health, Climate change

INTRODUCTION

Hyperthermia, defined as an elevation in core body temperature above the normal range, is a potent disruptor of physiological homeostasis. In the context of female reproduction, even a mild, sustained increase in core temperature can impair the delicate hormonal and cellular processes essential for ovulation, fertilization, and implantation.[1] The female reproductive system is highly thermosensitive, a fact long recognized in the context of febrile illness but now gaining critical importance due to exogenous heat exposure.[2]

Globally, infertility affects millions of couples, with a significant proportion of cases labeled "idiopathic".[3] Concurrently, our planet is experiencing unprecedented warming, with increasing frequencies of extreme heat events and expanding urban heat islands.[4] This convergence presents a new dimension to public health: the impact of a warming environment on human

reproduction. The rationale for this review is therefore twofold: first, to alert the clinical community to an emerging and modifiable risk factor for infertility, and second, to advocate for the integration of environmental and occupational history into our standard infertility workup. The multifactorial pathways through which exogenous heat impairs female reproduction are conceptualized in Figure 1.

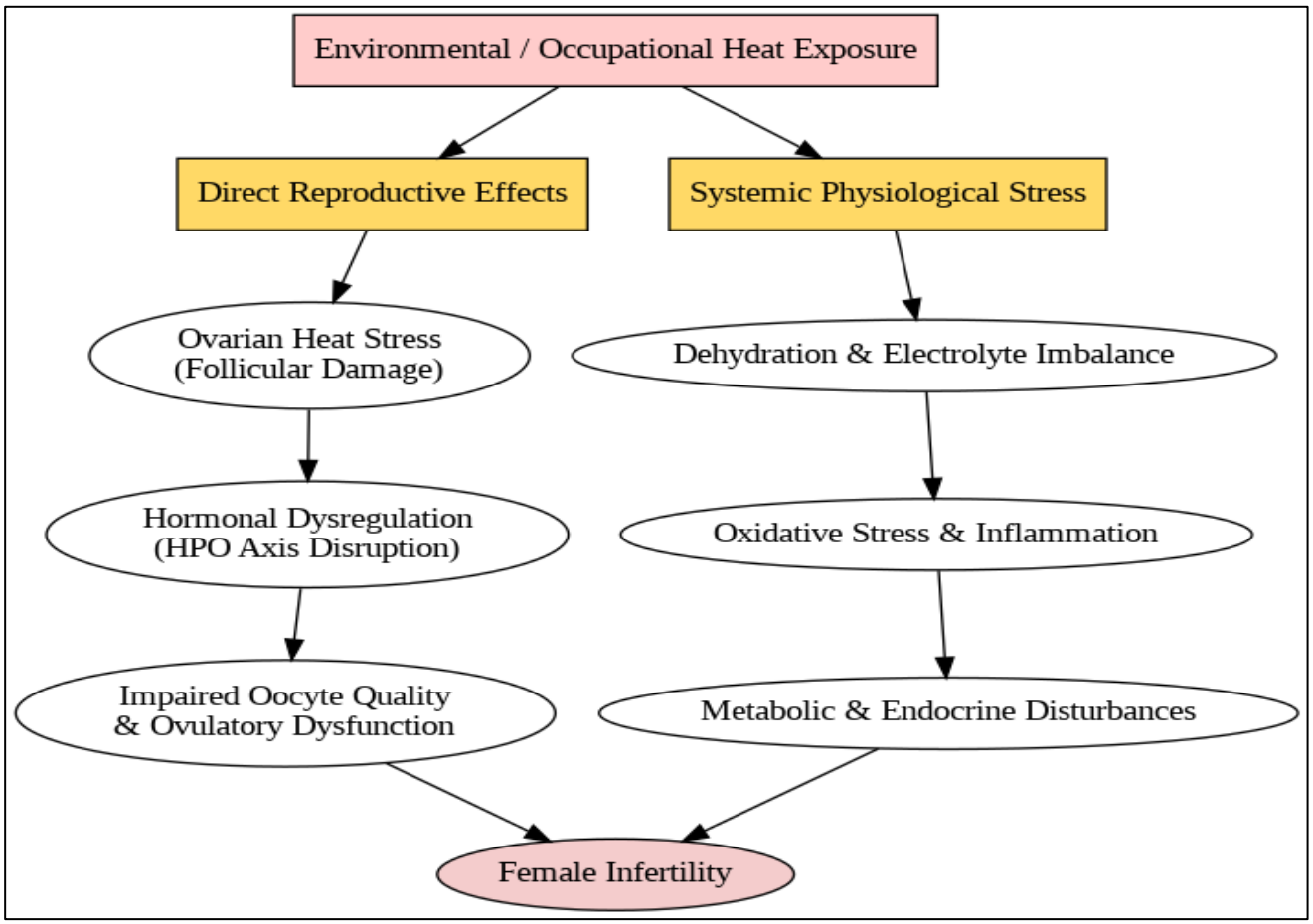

Figure 1: The dual pathway of heat stress to female infertility.

PHYSIOLOGICAL IMPACT OF HYPERTHERMIA ON FEMALE REPRODUCTION

The mechanisms by which hyperthermia impairs female fertility are robust, evidenced by both animal models and human studies. The primary pathways include: Heat stress generates reactive oxygen species, overwhelming the antioxidant defenses of the ovarian follicle and developing oocyte. This oxidative damage can lead to mitochondrial dysfunction, spindle abnormalities, and DNA fragmentation in the oocyte, compromising its developmental competence and increasing the risk of aneuploidy.[5,6] Thermoregulation and reproductive function are neurologically linked, and hyperthermia can suppress the pulsatile release of gonadotropin-releasing hormone from the hypothalamus, leading to downstream alterations in luteinizing hormone and follicle-stimulating hormone secretion. Such disruption may result in anovulation, luteal phase defects, and menstrual cycle irregularities.[7] The pre-ovulatory follicle and corpus luteum are particularly vulnerable to heat, with studies demonstrating reduced steroidogenesis, specifically progesterone production, which is critical for endometrial preparation and implantation.[8] Hyperthermia can also alter endometrial gene expression and reduce uterine blood flow, creating a suboptimal environment for embryo nidation.[9]

While much of the foundational evidence comes from livestock and rodent models, human data, including studies on febrile states and sauna use, corroborate these findings, confirming the vulnerability of human oocytes and reproductive function to elevated temperatures. [10]

ENVIRONMENTAL RISK FACTORS

Beyond personal behaviors, broader environment is source of chronic, low-grade heat stress. Climate change is no longer future threat but present-day determinant of health.

Rising global temperatures and prolonged heatwaves expose larger populations to sustained thermal stress, particularly affecting women in arid climates and tropical regions who may experience chronic, seasonal

hyperthermia coinciding with critical windows of reproductive function.[11] Phenomenon of urban heat islands, where urban areas are significantly hotter than surrounding rural zones, disproportionately impacts lower-income populations who often lack access to air conditioning/green spaces, turning their living environment into a constant thermal challenge.[12] In many low-resource settings, women are primarily responsible for strenuous domestic chores, such as cooking over open fires/fetching water in hot, unventilated conditions, which constitutes significant and largely unregulated occupational exposure.[13]

Case studies from agricultural communities in South Asia and sub-Saharan Africa highlight the compound effect of high ambient temperatures and intense physical labor, pointing to a potential silent contributor to regional infertility rates.[14]

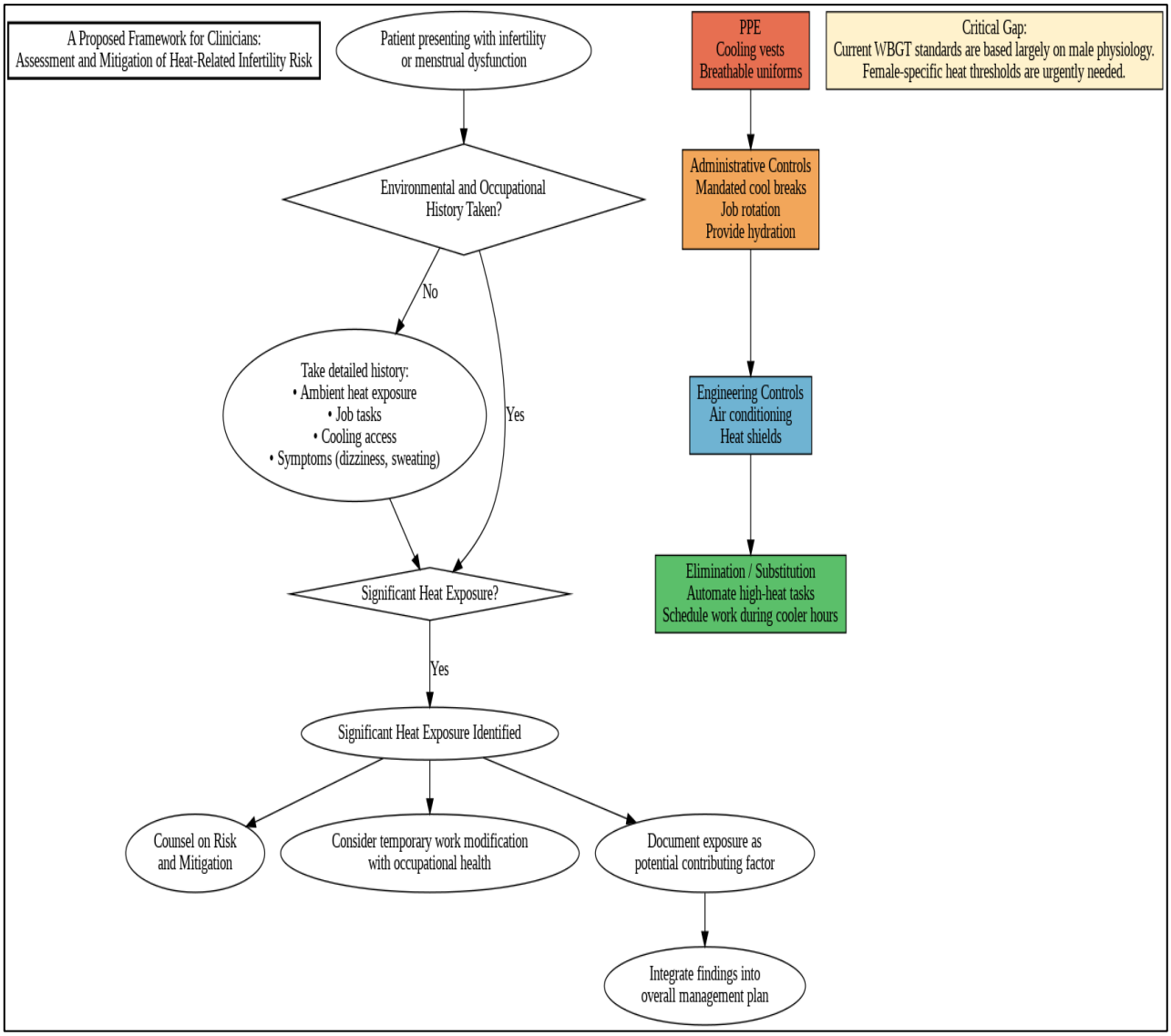

Figure 2: Clinical framework for assessing and mitigating heat-related female infertility risk.

OCCUPATIONAL EXPOSURE TO HEAT

A significant portion of the female workforce is employed in industries with high heat exposure. For reproductive-aged women, this constitutes a major, yet often unaddressed, occupational hazard. High-risk occupational sectors for women include agriculture, where outdoor work entails direct sun exposure; manufacturing industries such as textiles, glass, steel, and electronics, which involve high thermal loads from machinery; food services, including commercial kitchens with intense heat from ovens and stoves; and laundries or cleaning services, which often involve steam and humid environments. Pregnant workers face additional risks, as hyperthermia during early gestation is a recognized teratogen.[15] The risk is further exacerbated by prolonged durations of continuous exposure, insufficient breaks, inadequate hydration, and limited use of personal protective equipment due to cost or discomfort.[16]

EPIDEMIOLOGICAL EVIDENCE

Epidemiological data, while still emerging, consistently points towards an association. Systematic reviews have noted a correlation between high ambient temperature and adverse reproductive outcomes, including reduced fertility rates and increased risk of pregnancy loss.[17,18] Studies on specific occupational cohorts, such as greenhouse workers and pastry cooks, have reported increased menstrual disorders and longer time-to-pregnancy compared to control groups.[19,20]

A critical gap remains the significant underrepresentation of female workers in occupational heat stress research. Most existing thermal exposure limits (e.g., WBGT-Wet bulb globe temperature) were developed for a standard 70kg male performing industrial work and do not account for the physiological differences in thermoregulation, body size, and the specific vulnerability of the reproductive system in women.[21]

PREVENTIVE AND PROTECTIVE MEASURES

As clinicians, we must translate this evidence into actionable strategies for prevention. Effective workplace interventions to mitigate heat-related reproductive risks include engineering controls, such as improved ventilation, air conditioning, and heat shields, which are among the most effective strategies. Administrative measures, including providing adequate rest breaks in cool areas, shifting physically demanding tasks to cooler parts of the day, and implementing job rotation, further reduce exposure. Ensuring access to cool potable water is fundamental to protect female workers.[22] Additionally, there is a pressing need for policies that specifically safeguard reproductive-aged women from hazardous heat exposure, similar to protections established against chemical teratogens. Pre-conception and occupational health counseling should incorporate guidance on heat avoidance, empowering women with knowledge about their rights to a safe work environment. [23] Clinical Guidance: For our patients struggling with infertility, a thorough history should include an "environmental and occupational review of systems," specifically inquiring about heat exposure. In some cases, a temporary modification of work duties may be a prudent, low-cost intervention. To translate this evidence into clinical and occupational practice, we propose an integrated framework for assessment and intervention (Figure 2). This model underscores the dual responsibility of clinicians to screen for heat exposure and counsel patients, and of employers to implement a hierarchy of controls. Central to this framework is the recognition that current occupational safety standards, based on male physiology, are inadequate for protecting female reproductive health. Therefore, patient advocacy and demands for workplace adaptation become essential components of care

CURRENT GUIDELINES AND RESEARCH GAPS

Current guidelines from the WHO and ILO acknowledge heat as a general occupational hazard but lack female-specific recommendations for reproductive protection.[24,25] The U.S. CDC and OSHA offer guidance that is not legally enforceable in many contexts and is not gender-specific.[26]

The research agenda must be urgent and interdisciplinary. We need Future research priorities should focus on identifying female-specific thermal thresholds for reproductive safety, conducting longitudinal cohort studies of women in high-heat occupations, and implementing intervention studies to evaluate the efficacy of protective measures on fertility outcomes. Additionally, integrating data from climate science, ergonomics, and reproductive endocrinology is essential to model future risks and inform evidence-based guidelines for safeguarding women's reproductive health.

CONCLUSION

The evidence is clear: exogenous hyperthermia is a significant and growing threat to female reproductive health, driven by environmental degradation and occupational inequities. For the practicing gynecologist, this necessitates a paradigm shift to look beyond the pelvis and consider the environment in which our patients live and work.

We must become advocates on two fronts: in the clinic, by incorporating heat exposure into our diagnostic considerations, and in the public sphere, by calling for robust policies that protect women from this insidious risk. Safeguarding fertility in the 21st century requires us to confront the challenges posed by a warming planet. The right to reproduce is a fundamental human right, and it is our professional duty to protect it from environmental and occupational threats.

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