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Editorial

Sustainable IVF: The Next Revolution in ART

The birth of the first IVF baby in 1978 was a landmark in medical history and the catalyst for a revolution in reproductive medicine. In its early years, the field remained in its infancy, costly, and highly inefficient; poor and inconsistent clinical results frustrated both physicians and society, reflecting considerable skepticism. Over time, driven by scientific advances, more than 12 million babies have been born worldwide through assisted reproductive technology (ART). Today, IVF encompasses well-established diagnostic and therapeutic protocols, standing as one of the most commercially and scientifically robust areas of women's health. This trajectory demonstrates how the simultaneous convergence of research and development (R&D), societal demand, and strategic execution can drive industrial scale-up. As this growth continues, the next wave of market expansion will stem from innovative technologies and subsequent globalization of IVF services. These forces will generate new demand, improve success rates, and enhance patient satisfaction, thereby securing the field's long-term expansion (1).

However, as ART spreads globally across diverse economic contexts, concerns are mounting regarding the environmental consequences of these services. IVF procedures rely heavily on disposable medical supplies; in fact, clinical outcomes remain highly dependent on the quality and sterility of these single-use plastics. While the overall environmental footprint of IVF may seem relatively small compared to broader healthcare sectors, its intensive per-patient reliance on high-grade consumables makes it a critical area for targeted sustainability efforts. Consequently, there is a growing imperative to make reproductive care more environmentally sustainable without compromising patient safety or clinical outcomes (2).

The broader global implications of plastic reliance underscore the urgency of this transition. If current trends in plastic production and usage persist, the annual global health impact is projected to more than double, escalating from 2.1 million disability-adjusted life years (DALYs) lost in 2016 to 4.5 million DALYs by 2040 (3). This health burden is primarily driven by greenhouse gas emissions (accounting for approximately 40% of the burden), air pollution from manufacturing (~32%), and the release of toxic chemicals during the plastic life cycle (~27%) (3). Notably, isolated measures to increase the collection and recycling of plastic waste have shown limited efficacy in reducing this global health burden. Instead, comprehensive, systems-level interventions are required which could potentially reduce the global health impact of plastics by 43% by 2040 (3). Within this context, medical sub-specialties, particularly those highly dependent on plastics, must urgently re-evaluate their supply chains and operational practices.

Because gametes, embryos, and reproductive tissues are exquisitely sensitive to environmental contaminants, chemical substances, and genotoxic agents, strict quality standards are mandated for materials used in ART. Furthermore, emerging evidence suggests that environmental and laboratory exposures during IVF may influence embryo development and potentially the long-term health of offspring, though definitive conclusions remain under investigation. Consequently, IVF consumables are manufactured under stringent quality assurance and biocompatibility requirements that often exceed those of standard medical applications. These rigorous processes demand greater energy consumption, high-purity raw materials, and extensive quality control, all of which generate significant waste and amplify the sector's carbon footprint (2).

Practical recommendations for reducing carbon footprint in IVF laboratories focus on improving sustainability without compromising laboratory performance. Key measures include reducing energy consumption by transitioning to renewable electricity, optimizing heating, ventilation, and air conditioning (HVAC) systems, and powering down non-essential equipment when not in use. Laboratories are also encouraged to improve building energy efficiency, optimize liquid nitrogen cryostorage management, and minimize waste by reducing single-use consumables whenever these can be performed without compromising safety. Sustainable procurement from environmentally responsible suppliers is recommended, utilizing life-cycle assessments to guide purchasing decisions. Recent evidence demonstrates that targeted sustainability interventions during oocyte retrieval and embryo transfer can substantially reduce material waste, by approximately 60% and 8%, respectively, without increasing clinical or laboratory infection rates. This highlights the feasibility of integrating sustainable practices into routine ART procedures. Finally, fostering a culture of sustainability through staff education, environmental monitoring, and the promotion of virtual meetings can further decrease a clinic's carbon footprint (2, 4).

Despite these practical solutions, the implementation of sustainable practices in IVF laboratories faces several technical, economic, and organizational barriers. Major obstacles include the high initial cost of sustainable technologies, the absolute reliance on single-use plastics to meet strict sterility requirements, and the substantial energy demands of cryostorage systems. Organizational barriers such as limited staff awareness, a lack of cohesive environmental regulations, insufficient leadership commitment, fragmented supply chains for sustainable products, and a lack of data on the long-term cost-effectiveness of these initiatives, further hinder widespread adoption (5).

The transition toward "Green IVF" represents a critical evolution in reproductive medicine. Green IVF should not be viewed as a compromise between environmental responsibility and clinical excellence. As the field strives to innovate and improve clinical outcomes, equivalent focus must be directed toward mitigating the environmental impact of these interventions. Adopting sustainable practices is no longer merely an operational choice, but a clinical and ethical imperative for the next decade of reproductive care. Such a paradigm shift will not only optimize operational costs, potentially facilitating broader global access to infertility treatments, but will also ensure the long-term ecological and economic viability of ART services worldwide.

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