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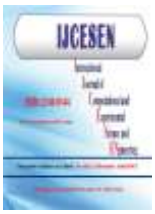

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Research Article

Safe Nursing Care and Sterilization Practices for Infection Prevention in Midwifery

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Abstract:

Safe nursing care and effective sterilization practices are crucial components in preventing infections during midwifery. Midwives play an essential role in providing care to pregnant individuals and newborns, necessitating a deep understanding of infection control protocols. Key strategies include hand hygiene, using gloves, and maintaining a sterile environment during procedures such as prenatal examinations, labor, and postpartum care. Midwives must also be educated on the appropriate use of personal protective equipment (PPE) to minimize the risk of transmitting pathogens. By implementing rigorous infection control practices, midwives can significantly reduce the incidence of healthcare-associated infections and ensure the safety of both mother and child. Sterilization of instruments and equipment is another vital aspect of midwifery that cannot be overlooked. Reusable instruments such as forceps and scissors must be thoroughly sterilized using methods like autoclaving or chemical disinfection to eliminate any microbial contaminants. Single-use items should be prioritized to prevent cross-contamination. In addition, midwives must understand the importance of proper cleaning and maintenance of the birthing environment, ensuring that all surfaces and equipment are regularly disinfected. Training programs focused on both theoretical knowledge and practical skills in sterilization techniques play a critical role in empowering midwives to uphold the highest standards of safe nursing care and infection prevention, fostering a healthier environment for mothers and newborns.

1. Introduction

The art and science of midwifery reside at a profound and unparalleled crossroads of human experience, where biological imperative, intimate vulnerability, profound empowerment, and clinical science converge. It is a discipline that does not merely oversee a medical event but facilitates a transformative passage—a rite of entry for the newborn and a re-birth of identity for the mother. Within this sacred space, the midwife operates as guardian, clinician, advocate, and witness, bearing a trust that is as weighty as it is honorable [1]. This trust is fundamentally rooted in the principle of non-maleficence: to do no harm. And in no domain is this principle more critically operationalized than in the rigorous, unwavering practice of infection prevention. The prevention of infection in midwifery care transcends the realm of clinical protocol; it is a foundational ethical covenant, a tangible expression of respect for the dignity and safety of the woman and the neonate whose systems are exquisitely susceptible. It is the bedrock upon which the very possibility of a positive birth experience is built, for even the most empowering, physiologically-supported labor can be irrevocably shattered by the incursion of a preventable pathogen [2].

The global statistics underscore a sobering reality that frames this ethical imperative with urgent, numerical clarity. Maternal sepsis, alongside hypertensive disorders and hemorrhage, remains a leading direct cause of maternal mortality worldwide. The World Health Organization (WHO) estimates that infections account for approximately 10% of the over 287,000 maternal deaths that occur annually, with the burden disproportionately crushing in low-resource settings [1]. Beyond mortality, the morbidity is vast—endometritis, wound infections, mastitis, and urinary tract infections can lead to chronic pain, infertility, psychological trauma, and societal ostracization, derailing a woman's recovery and her capacity to nurture her newborn. For the infant, the peril is even more acute. Neonatal infections, including sepsis, pneumonia, and tetanus, are responsible for nearly a quarter of the approximately 2.4 million neonatal deaths each year, with many of these deaths traceable to unhygienic practices during childbirth and the immediate postnatal period [2]. These are not abstract numbers; they represent individual tragedies, families shattered, and potential extinguished. They represent a failure of the systems and practices designed to protect life at its most fragile inception. This stark global backdrop renders infection prevention not a passive element of care, but an active, relentless campaign for health equity and justice [3].

The landscape in which midwives wage this campaign is remarkably diverse, presenting a complex tapestry of challenges that demand adaptability without compromising core principles. The controlled, resource-rich environment of a modern hospital labor and delivery suite, with its centralized sterilization departments and engineered controls, presents one set of operational parameters. Here, the challenge often lies in navigating systemic pressures, ensuring compliance amidst high acuity and staffing fluctuations, and personalizing aseptic care within sometimes impersonal protocols. In contrast, the free-standing birth center offers a middle ground, blending a homelike environment with clinical readiness, requiring midwives to maintain hospital-grade

standards of asepsis without the immediate institutional infrastructure. Perhaps the most demanding arena is the home birth setting. Here, the midwife is a guest in the family's sacred space, tasked with transporting the entire apparatus of safety into a domestic environment. Every action, from establishing a clean field on a kitchen table to managing biohazard waste in a residential bin, requires forethought, meticulous preparation, and improvised rigor. In each of these settings—hospital, center, or home—the constants must be the midwife's knowledge, vigilance, and unwavering commitment to the principles of asepsis. The environment dictates the method, but never the standard [2, 4].

This commitment finds its roots in a philosophical tension that is unique to midwifery: the integration of technical, even surgical, precision with the art of holistic, woman-centered support. The midwifery model of care rightly champions physiology, patience, and the empowerment of the woman as the primary actor in her birth. Yet, this philosophy can never be misconstrued as a laissez-faire approach to safety. The skillful midwife understands that true empowerment is impossible within a context of preventable risk. Therefore, the application of a sterile glove for a vaginal examination after rupture of membranes, the meticulous cleaning of a birth pool, the sterile draping for a perineal repair—these are not interruptions of the physiological process but its essential guardians. They are the means by which the natural process is protected from the unnatural threat of infection. This seamless blending is the hallmark of expert practice; the midwife who can maintain a continuous, calming dialogue while simultaneously executing flawless aseptic technique embodies the full spectrum of the profession's mandate [5].

2. From Puerperal Fever to Modern Asepsis

The understanding of infection prevention in childbirth is deeply rooted in a history marked by tragedy and scientific triumph. For centuries, puerperal or childbed fever was a terrifying and common killer of postpartum women, often sweeping through maternity wards in devastating epidemics. The pivotal work of figures like Ignaz Semmelweis in the 19th century, who demonstrated the drastic reduction in mortality when clinicians washed their hands with chlorinated lime solution, laid the foundational stone [2]. Although his theories were rejected by many contemporaries, his observations provided crucial evidence for the germ theory of disease later championed by Louis Pasteur and Robert Koch. The subsequent development of antiseptic techniques by Joseph Lister, using carbolic acid, and the eventual adoption of sterile surgical techniques, revolutionized all fields of medicine, including obstetrics [3]. In midwifery, this historical journey transitioned practice from often-communal, non-sterile attendance to a professional discipline grounded in microbiological science. Early midwifery texts began to incorporate directives on cleanliness, isolation of infected cases, and the disinfection of tools. This historical context is essential, as it underscores that modern infection control protocols are born from hard-earned knowledge paid for with countless lives. It instills a profound professional respect for these practices, framing them not as arbitrary rules but as the accumulated wisdom of medical history dedicated to protecting life at its most vulnerable beginning.

3. Chain of Infection and Breaking the Links

Effective infection prevention requires a systematic understanding of how infections spread. The classic model of the "Chain of Infection" provides a vital framework for midwifery practice. This chain consists of six interconnected links: (1) the infectious agent (e.g., bacteria like Group B *Streptococcus*, viruses like Hepatitis B, fungi), (2) a reservoir where the pathogen lives and multiplies (e.g., human skin, gastrointestinal tract, contaminated surfaces), (3) a portal of exit from the reservoir (e.g., blood, vaginal secretions, respiratory droplets), (4) a mode of transmission, (5) a portal of entry into a new host, and (6) a susceptible host [4]. The pregnant woman, particularly during labor and after birth, and the newborn are highly susceptible hosts due to physiological changes, potential tissue trauma, and an immature immune system in the neonate. The core objective of all sterilization and safe care practices is to break this chain at one or more links. Hand hygiene primarily breaks the chain at the mode of transmission (contact). Sterilization of instruments breaks it at the portal of entry by ensuring a sterile device contacts susceptible tissue. The use of personal protective equipment (PPE) breaks it at both the portal of exit and entry. Vaccination of the mother (e.g., against influenza, pertussis) reduces host susceptibility [5]. By internalizing this model, the midwife can critically assess every clinical scenario, from a routine prenatal visit to an emergency perineal repair, and identify targeted actions to interrupt potential transmission pathways, making infection control a dynamic and thoughtful process rather than a rote checklist.

4. Comprehensive Hand Hygiene

Without reservation, hand hygiene is the single most effective, cost-efficient, and fundamental practice for preventing healthcare-associated infections in any setting, and its importance in midwifery cannot be overstated. Hands are the primary vectors for transmitting microorganisms between the environment, the caregiver, and the woman or newborn. The WHO defines two primary methods: handwashing with soap and water, and hand rubbing with an alcohol-based hand rub (ABHR) [6]. The choice between methods depends on the clinical situation. Soap and water are mandatory when hands are visibly soiled, after caring for a woman with known or suspected *Clostridium difficile* (due to spore resistance to alcohol), and after using the restroom. In all other clinical situations, including before and after touching a patient, before clean/aseptic procedures, after exposure to body fluids, and after touching patient surroundings, ABHR is the preferred method due to its superior microbiological efficacy, speed, and better skin tolerance with emollients [7]. For midwives, specific "moments" are critical: before donning sterile gloves for vaginal examinations, cervical ripening balloon insertion, or perineal repair; after handling contaminated linens or instruments; before handling medications or preparing sterile fields; and before and after direct contact with the newborn, especially for breastfeeding support. Proper technique, covering all surfaces of the hands and rubbing until dry, is paramount. The cultural of safety in a midwifery practice must champion hand hygiene as an unassailable professional value, supported by accessible sinks and ABHR dispensers at the point of care.

5. Standard and Transmission-Based Precautions in Midwifery Care

Building upon universal precautions, the concept of Standard Precautions forms the first tier of infection control, applied to all patients regardless of diagnosis or presumed infection status. In midwifery, this assumes that all blood, body fluids, secretions, excretions (except sweat), non-intact skin, and mucous membranes may harbor transmissible pathogens [8]. Key elements include hand hygiene, use of appropriate PPE (gloves, gowns, masks, eye protection), safe injection practices, safe handling of potentially contaminated equipment and surfaces, and respiratory hygiene/cough etiquette. Transmission-Based Precautions (Contact, Droplet, Airborne) are added for women with known or suspected infections spread by specific routes. For example, a woman with active herpes simplex virus lesions would require Contact Precautions, including gloves and gown for any direct contact with the lesions or potentially contaminated surfaces [9]. A woman with influenza would necessitate Droplet Precautions, requiring a surgical mask for the caregiver during close contact. Although rare in pregnancy, a suspected case of pulmonary tuberculosis would require Airborne Precautions and an N95 respirator. The midwife must be adept at risk assessment, applying these precautions judiciously to prevent cross-transmission without creating unnecessary barriers to the intimate, supportive care that characterizes midwifery. This balance requires skill, clear communication with the woman and family about the reasons for precautions, and a commitment to providing compassionate care within a safe framework.

6. The Spectrum of Reprocessing: Cleaning, Disinfection, and Sterilization

A critical domain of infection prevention is the management of reusable medical devices, ranging from speculums and umbilical cord clamps to scissors and suture instruments. Reprocessing is a multi-step continuum, and a failure at any stage compromises safety. The first and most crucial step is thorough **cleaning**, the physical removal of organic material (blood, tissue, secretions) and microbial load. If debris remains, it can shield microorganisms from subsequent disinfection or sterilization and can interfere with the efficacy of chemical agents [10]. Cleaning should be done promptly after use, using enzymatic detergents and appropriate brushes, preferably in a dedicated utility area to prevent environmental contamination. Following cleaning, the required level of reprocessing is determined by the intended use of the item, categorized by the Spaulding Classification: **critical** items (enter sterile tissue or the vascular system, e.g., surgical instruments, suture needles) require **sterilization**; **semi-critical** items (contact mucous membranes or non-intact skin, e.g., vaginal speculums, ultrasound probes) require at least high-level disinfection; **non-critical** items (contact only intact skin, e.g., blood pressure cuffs, stethoscopes) require low-level disinfection [11]. In midwifery, common critical items include instruments for perineal repair and episiotomy. These must undergo validated sterilization processes, most commonly steam autoclaving, which uses pressurized saturated steam to achieve the destruction of all microbial life, including bacterial spores [12]. Chemical sterilants (e.g., hydrogen peroxide gas plasma,

ethylene oxide) are used for heat-sensitive items. High-level disinfection for semi-critical items can be achieved using chemical germicides registered as sterilants but used for shorter contact times (e.g., glutaraldehyde, ortho-phthalaldehyde) or automated pasteurization systems. The midwife must be fully trained in the protocols of their practice setting, understanding the operational parameters, monitoring (e.g., biological and chemical indicators for autoclaves), and storage requirements for processed items to ensure sterility is maintained until the point of use.

7. Aseptic Technique for Midwifery Procedures

Aseptic technique refers to the practices that minimize the contamination of sterile materials and sites by pathogenic microorganisms during clinical procedures. It is the practical application of the principles of asepsis. In midwifery, several common procedures demand strict aseptic technique to prevent introducing infection into susceptible areas. **Vaginal examinations in labor**, while frequent, carry a risk of ascending infection, especially after rupture of membranes. The use of sterile, single-use lubricant and sterile gloves is essential, with careful attention to not contaminating the gloved hand during the examination [13]. **Catheterization**, either urinary or for epidural anesthesia, requires a full aseptic setup, including sterile drapes, gloves, and a pre-packaged sterile catheter kit, with meticulous cleansing of the meatus or insertion site. **Perineal repair** following spontaneous tears or episiotomy is a surgical procedure requiring full surgical asepsis. This includes a sterile field created with drapes, sterile gloves and gown, sterile instruments from a processed pack, and sterile suture material. The midwife must also manage the field to avoid contamination from adjacent areas like the anus [14]. **Newborn procedures** such as umbilical cord clamping and cutting should use sterile instruments. **Intravenous line insertion** follows the same stringent aseptic standards as in any other clinical field, including skin antisepsis with an appropriate agent like chlorhexidine gluconate and the use of a sterile dressing. The consistent, disciplined application of aseptic technique for every relevant procedure, regardless of setting (home, hospital, or birth center), is a non-negotiable hallmark of professional midwifery care.

8. Environmental Hygiene and Management of the Birth Setting

The physical environment where care is provided plays a significant role in infection transmission dynamics. Surfaces, equipment, and furnishings can become reservoirs for pathogens, which can then be transferred via hands or direct contact. A rigorous environmental hygiene protocol is therefore indispensable. All clinical areas require regular cleaning and disinfection of high-touch surfaces (e.g., bed rails, door handles, faucet taps, examination couches, blood pressure cuffs, computers) using an EPA-registered hospital-grade disinfectant with a label claim for effectiveness against relevant pathogens [15]. The frequency of cleaning must be increased in high-activity areas and immediately after any contamination with blood or body fluids. In the birth setting specifically, special attention must be paid to cleaning and disinfecting the birth pool or tub according to manufacturer guidelines between uses to prevent biofilm formation and transmission of waterborne organisms [16]. Floors, walls, and lighting should be cleanable and in good repair. Linens should be handled with minimum agitation to avoid dispersing microorganisms into the air, transported in sealed bags, and laundered at high temperatures. Clinical waste, especially sharps (needles, scalpels), must be disposed of immediately in puncture-resistant containers at the point of use to prevent needlestick injuries. General waste contaminated with blood or body fluids should be sealed in appropriate bags. A clean, organized, and well-maintained environment not only reduces infection risk but also promotes a sense of safety, order, and professional competence for the woman and her family.

9. Waterbirth and Infection Control Considerations

Waterbirth, an option offered in many midwifery-led settings, presents unique infection control considerations for both the mother and the newborn. The primary concern is the potential for waterborne pathogens to cause maternal or neonatal infection, particularly if the water is contaminated or the pool is not cleaned properly. Maintaining water quality is paramount. The pool should be filled with clean, potable water close to the time of birth. The use of disposable liners for single use is a highly effective method to ensure a clean barrier. If a liner is not used, the pool must be meticulously cleaned and disinfected with a protocol effective against bacteria, viruses, and fungi before and after each use [17]. The water temperature should be monitored and maintained within a comfortable range (typically 36-37°C) to prevent maternal hyperthermia, which could theoretically increase infection risk. For the newborn, the risk of water aspiration and subsequent infection is a theoretical

concern, though large observational studies have not shown an increased incidence of proven waterborne infections compared to land birth [18]. The midwife must maintain standard precautions, including appropriate hand hygiene and the use of gloves for any direct contact with the woman or baby in the water. Instruments used in the pool, such as a Doppler for fetal heart monitoring, should be waterproof and disinfected between uses. Careful drying and warming of the newborn after birth, with immediate skin-to-skin contact, are essential. Clear protocols, staff training, and informed choice discussions with women choosing waterbirth are necessary to balance the benefits of hydrotherapy with meticulous infection prevention.

10. Protecting the Vulnerable Newborn: Neonatal Infection Prevention

The newborn infant, with an immature and naive immune system, is exquisitely vulnerable to infection. Midwifery care extends its protective mantle directly to the neonate from the moment of birth. Initial practices are foundational. Delayed cord clamping, now standard practice for its hemodynamic benefits, does not increase infection risk if performed with clean technique [19]. Immediate and thorough drying of the newborn, especially the head, prevents hypothermia, a condition that can compromise immune function. Unnecessary suctioning of the mouth and nose should be avoided unless the baby is not breathing or has obvious obstruction, as it can cause mucosal trauma and introduce pathogens [20]. Early, uninterrupted skin-to-skin contact with the mother promotes colonization with the mother's flora, which is protective against more pathogenic environmental bacteria, and facilitates early breastfeeding. **Breastfeeding** itself is a powerful infection prevention strategy, providing the infant with immunoglobulins (especially secretory IgA), white blood cells, oligosaccharides, and other bioactive factors that protect against gastrointestinal, respiratory, and systemic infections [21]. Supporting successful lactation is therefore a core midwifery infection control activity. **Umbilical cord care** recommendations have evolved; current WHO guidelines recommend dry cord care (keeping the cord clean and dry and exposed to air) in settings with low infection rates, while application of chlorhexidine may be recommended in high-mortality settings [22]. Bathing should be delayed for at least 24 hours to preserve the protective vernix caseosa, which has antimicrobial properties. Minimizing visitor contact in the immediate postpartum period, ensuring all handlers practice scrupulous hand hygiene, and maintaining a clean environment around the newborn are all crucial protective measures.

11. Antibiotic Stewardship and Prophylaxis in Midwifery

The prudent use of antibiotics is an integral component of modern infection prevention, aimed at treating actual infections effectively while preventing the emergence of antimicrobial resistance. Midwives play a key role in both therapeutic use and prophylactic administration. A prime example is the intrapartum antibiotic prophylaxis (IAP) for the prevention of early-onset Group B *Streptococcus* (GBS) disease in neonates. Following evidence-based guidelines, midwives screen women for GBS colonization, typically between 36-37 weeks of gestation, and administer intravenous penicillin G (or an alternative for allergic women) during labor to those who are colonized or have other risk factors [23]. This protocol has significantly reduced neonatal GBS sepsis. Prophylactic antibiotics are also standard for cesarean sections, administered within 60 minutes before skin incision to reduce surgical site infections [24]. For women with premature rupture of membranes (PROM), antibiotic regimens like erythromycin are used to prolong latency and reduce maternal and neonatal infections [25]. Beyond prophylaxis, midwives must be vigilant in recognizing signs of actual infection—such as endometritis, mastitis, or urinary tract infections—to ensure prompt diagnosis and appropriate antibiotic treatment. In all cases, principles of antibiotic stewardship apply: using the right drug, at the right dose, for the right duration. Patient education is vital; midwives must explain the purpose of antibiotics, the importance of completing prescribed courses, and the risks of resistance. This balanced approach ensures antibiotics remain effective tools for protecting maternal and neonatal health.

12. Professional Accountability, Education, and Auditing

The establishment and maintenance of a culture of safety in midwifery practice regarding infection prevention are sustained through robust systems of professional accountability, continuous education, and systematic auditing. Compliance with infection control practices is not automatic; it is influenced by knowledge, attitudes, resources, and workplace culture. Therefore, ongoing education and competency validation are mandatory. All midwifery staff, including students, must receive initial and annual training on core topics: hand

hygiene, PPE use, standard precautions, aseptic technique, and specific protocols for device reprocessing and environmental cleaning [26]. Training should be interactive, scenario-based, and include practical demonstrations. Competency in skills like performing a sterile perineal repair or donning and doffing PPE correctly must be formally assessed. Beyond individual competence, the practice must engage in regular **auditing and surveillance**. This involves monitoring process indicators (e.g., hand hygiene compliance rates via direct observation or product usage, audits of sterile instrument packs) and outcome indicators (e.g., rates of postpartum endometritis, perineal wound infections, neonatal sepsis) [27]. Data from audits should be fed back to staff transparently and used for continuous quality improvement. Leadership commitment is critical; managers must prioritize infection prevention, allocate necessary resources (soap, ABHR, PPE, functioning sterilizers), and model impeccable practices. A non-punitive, systems-focused approach to addressing lapses encourages reporting and problem-solving. Ultimately, every midwife holds personal accountability for integrating these practices into every clinical encounter, embodying the principle that safe care is the irreducible minimum standard of professional practice.

13. Challenges and Barriers in Diverse Clinical Settings

Implementing ideal infection prevention and control (IPC) protocols faces significant and varied challenges across the global spectrum of midwifery practice. These barriers are multifaceted. **Resource limitations** in low-resource settings are perhaps the most profound, encompassing shortages of clean water, soap, alcohol-based hand rub, reliable electricity for running autoclaves, and basic PPE [28]. In such contexts, midwives must adapt evidence-based principles using available means, such as using boiled water and soap for handwashing when ABHR is unavailable, or using high-level disinfection for instruments when sterilization is not feasible—always prioritizing the highest achievable standard. **Workload and staffing pressures**, common in understaffed hospitals, can lead to shortcuts, such as skipping hand hygiene between patients or inadequate cleaning times [29]. **Knowledge gaps** and inadequate training, particularly in non-hospital settings or among traditional birth attendants, persist and require targeted educational outreach. **Cultural and behavioral factors** can also present barriers; for instance, some communities may have traditional postpartum practices that conflict with sterile wound care principles, requiring sensitive negotiation and health education [30]. In home birth settings, the midwife has less control over the environment and must transport all sterile supplies and manage waste effectively. Addressing these challenges requires a tailored, context-specific approach that combines advocacy for resources, innovative low-cost solutions, persistent education, and the empowerment of midwives as change agents within their communities and healthcare systems.

14. The Future of Infection Prevention in Midwifery: Innovation and Integration

The field of infection prevention is dynamic, with ongoing research and technological innovation promising to enhance midwifery practice. Several areas are poised for development. **Advanced disinfection technologies**, such as ultraviolet-C (UVC) light robots for terminal room disinfection or antimicrobial surface coatings, may become more accessible and find application in birth centers and hospital maternity units [31]. **Point-of-care diagnostics** are rapidly evolving; for instance, rapid molecular tests for GBS colonization with results available during labor could refine antibiotic prophylaxis, reducing unnecessary exposure [32]. **Telehealth and digital health tools** offer new avenues for infection prevention, such as pre-visit screenings for infectious symptoms or remote postnatal check-ups that reduce unnecessary exposures in clinical settings [33]. **Biomaterial science** may lead to improved umbilical cord dressings with sustained-release antimicrobial properties for high-risk settings. Furthermore, the integration of **human factors engineering**—designing equipment and workflows to minimize error—holds great promise. Examples include designing sinks and ABHR dispensers for optimal accessibility, color-coding cleaning equipment for different areas, and standardizing set-ups for procedures to reduce cognitive load [34]. Perhaps the most profound future direction is the deeper integration of IPC into the very philosophy of midwifery care. This involves framing infection prevention not as a separate set of tasks but as an intrinsic expression of the midwife's role to "first, do no harm" and to create a physical and psychological space of safety, where the physiological process of birth is protected from preventable threats, allowing for a truly safe and empowering experience.

15. Conclusion:

In conclusion, safe nursing care and meticulous sterilization practices constitute the non-negotiable foundation upon which trustworthy, effective, and respectful midwifery is built. This commitment to infection prevention is a multifaceted endeavor, weaving together historical wisdom, microbiological science, technical skill, environmental management, and profound professional responsibility. From the simple, powerful act of handwashing to the complex protocols of instrument sterilization and aseptic surgery, each practice is a vital thread in the protective fabric surrounding the mother and newborn. It requires a holistic understanding that encompasses the chain of infection, the specifics of midwifery procedures, the unique vulnerabilities of the perinatal period, and the challenges of diverse practice settings. Ultimately, excellence in infection prevention is inseparable from excellence in midwifery itself. It demonstrates a commitment to evidence-based practice, to continuous quality improvement, and above all, to the sacred duty of safeguarding the health and well-being of women and infants at one of the most critical junctures of human life. By mastering and conscientiously applying these principles, midwives honor their professional legacy and affirm their role as essential guardians of safe childbirth in the 21st century and beyond.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
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