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RISK FACTORS FOR GYNAECOLOGY OPERATION THEATRE (OT) CONTAMINATION AND ITS MANAGEMENT

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ABSTRACT

Operation theatre contamination is one of the most important areas of ensuring aseptic conditions, especially in gynaecology, where contact with mucous membranes and internal organs that act as potential reservoirs of microorganisms is involved in the surgical process. Physical, chemical, biological, and behavioral risk factors all play a part in contaminating the gynaecology operation theatre environment. Chemically, ineffective sterilization methods, incorrect dilutions, and the applications of less effective disinfectants all result in inadequate decontamination of equipment and surfaces. Contaminated air, water, and bedding enhance the biological load of infections by Staphylococcus aureus, Escherichia coli, and Pseudomonas aeruginosa, and it is mainly transmitted to humans, i.e., personnel and patients. Bacterial contamination appears to be prevalent and varies depending on hospital layout, environmental cleanliness standards, and adherence to infection-control guidelines. It is thus essential to apply efficient prevention and management techniques, which entail regular checking of the environment, maintenance of proper air filtration systems, sterilizing the surgical instruments through cleaning, and adherence to aseptic precautions. The use of quality disinfectants, implementation of infection-controlled audits, and routine training of gynaecology operation theatre personnel also improve contamination control. Identification and management of these risk factors improve surgical results, patient safety and also contribute to advancing overall hospital cleanliness and infection control practice.

Keywords: *Contamination, Gynaecology, Management, Operation, Risk factors, Theatre*

INTRODUCTION

A complex setting that has also long been believed to have a high risk of infection the gynaecological operating room can result in illness among patients as well as health personnel through exposure for an extended duration to a vast array of deleterious chemical, physical and biological agents (1). Contamination of the operation theatre is among the most important hospital infection control issues, with immediate ramification regarding patient safety outcomes and the incidence of surgical site infections. Involvement in complicated surgical procedures has a greater risk of infectious complications. Therefore, it is imperative that proper measures are enforced for the minimization of the incidence of such associated infections for ensuring optimal results from the surgical procedures. Infection control practices involve proper scrubbing practices for the patient and the operator, specific protocols that must be followed by the operating personnel during procedures, correct handling of instruments, and maintaining an aseptic field during the whole procedure (2).

Depending on the environment and monitoring techniques, the percentage of samples collected from OT surfaces and air that test positive for microbial growth varies from about 4% to almost 60%, according to several surveillance studies. For example, a five-year retrospective surveillance study conducted in a North Indian tertiary care hospital revealed that 4.4% of roughly 4,387 surface and equipment samples had bacterial growth. In comparison, a study of 350 swab specimens from operating room surfaces in Northern Nigeria found a significantly higher contamination rate of almost 58.6%.

Similarly, 48.3% of samples taken from surfaces, equipment, air, and water sources in high-risk locations, such as gynecology OTs, in a hospital in Erbil City had positive cultures (3). Although the surgical procedures are carried out under carefully monitored aseptic settings, this sterility may be compromised by a number of risk factors. These risk variables fall into three general categories: biological, chemical, and physical (4). There are several sources in each category that can lead to microbial contamination and raise the risk of infection for patients and medical personnel. It takes an awareness of these factors to ensure that the highest infection control standards and preventive measures are adopted (5).

PHYSICAL RISK FACTORS

The operating room functional procedure, the architecture of the building, and the environmental variables are all considered being physical risk factors. Ventilation and air quality are two of the most critical factors determining sterility of the gynaecology OT. Poor ventilation systems, malfunctioning high-efficiency particulate air (HEPA) filters, or inadequate air exchanges per hour can all easily permit the spread of airborne bacteria. Positive pressure ventilation and laminar airflow systems are implemented in order to ensure that filtered air is directed from the clean areas to less clean areas, reducing the microbial load. The air becomes a bacterial and fungal spore medium when such systems fail or become unclean, increasing the risk of surgical site infection (6).

Temperature and humidity control is also critical to maintaining the aseptic environment in the gynaecology OT. Ideal temperatures are between 20-24°C and relative humidity between 40-60% for a gynaecology OT (7). Whereas excessive dryness may cause discomfort to staff and static electricity that can detract from equipment performance, excessive humidity promotes the development of bacteria and molds (8). Dust accumulation is another serious hazard because dust particles can carry microorganisms and other particle pollutants, can enter the gynaecolgy OT environment through inadequate cleaning practices, wall or ceiling fractures, and adjacent construction operations. Dust particles bring bacteria into vital locations by landing on surgical tools, supplies, and open wounds. Strict adherence to cleaning procedures and upholding a sterile, dust-free atmosphere are necessary to prevent this (9).

The contamination level is greatly influenced by personnel movement and traffic flow. Research has indicated that the more people and movement there is within the gynaecology operation theater, the more airborne microorganisms there are. Poor zoning, unnecessary personnel entry, and frequent door openings create air turbulence and let contaminants infiltrate sterile areas (10).

The increased activity enhanced the dispersion of bacteria 10% of the 10,000 skin scales that are shed by movement per minute include clusters of microorganisms. These will contain coagulase-negative S*taphylococc*i and *Staphylococcus aureus*, which are common sources of infection. Movement is minimized and the spread of cutaneous organisms is decreased in a well-managed and organized operation theater (11). Additionally, structural issues like condensation inside sterilizers, wet corners, or water leaks might foster the growth of *Aspergillus* species and other fungi. To avoid physical contamination in the gynaecology OT, it is crucial to implement strict maintenance protocols, restricted access, and carefully regulating of environmental conditions (12).

CHEMICAL RISK FACTORS

The misuse or improper handling of cleaning supplies, disinfectants, and sterilizing agents that are necessary to maintain asepsis in the gynaecology OT is the main cause of chemical risk factors. Standard criteria for temperature, pressure, and duration must be followed for sterilization to be effective. Microorganisms are able to survive on surgical instruments when autoclaves or sterilizers are overloaded, packed improperly, or not calibrated on a regular basis. This risk is compounded by a lack of validation of sterilization cycles or the failure to use or interpret chemical indicators properly (13).

One of the most important chemical problems is the misuse of disinfectants. To guarantee their effectiveness, disinfectants must be manufactured and utilized at effective concentration. Microbial activity in solutions is greatly lost when the solutions are over diluted or expired solution are used. Phenolic chemicals, for instance, degrade over time, while alcohol-based disinfectants evaporate rapidly and become

ineffective if left without storage. Further, Incompatible disinfectants either produce hazardous byproducts or reduce their disinfection efficacy. Furthermore, using outdated or ineffectively diluted disinfectants significantly lowers their effectiveness (14).

Disinfectants commonly used in gynaecology OTs include hydrogen peroxide, sodium hypochlorite, glutaraldehyde, and quaternary ammonium compounds. All of these have a recommended dilution ratio and contact time to provide the best microbial kill. Staffing personnel may, however, bend the rules due to workload pressures or lack of proper training. Sodium hypochlorite solution, for instance, must be prepared fresh daily as the chlorine loses its efficacy over time. Based on the type of surface, presence of organic material, and type of bacteria being targeted, the choice of disinfectant should be made (15).

Chemical residues from a sterilizer or a detergent could also be hazardous. If surgical instruments are not properly rinsed after chemical disinfection, residues such as detergent films or ethylene oxide could be left behind. These residues can serve as a medium for microbial colonization besides tissue toxicity during surgery. In addition, the chemical compounds in disinfectants can also be oxidized by poor storage conditions, including exposing them to air, heat, or light. Hence, gynaecology OT contamination by chemical factors can be prevented by strict compliance with manufacturer recommendations, proper documentation, and regular chemical concentration monitoring (16).

Reusing cleaning cloths or mop heads without decontamination would potentially lead to cross-contamination. It is important to regularly clean disinfectant storage containers to prevent biofilm formation and the introduction of resistant organisms into cleaning solutions. Using substandard or counterfeit chemical products, which are frequently utilized in under-resourced hospitals with a view to saving costs, is another dangerous hazard (17). Low-quality agents may lack adequate antibacterial action and could even contain unsafe contaminants. Also, inappropriate aeration of sterilizing chemicals such as formaldehyde or ethylene oxide could harm employees' health and create residues in machinery that influences surgical outcomes (18).

In order to minimize chemical hazards in an OT-based gynaecology setting, it is thus essential to adhere to strict sterilization and disinfection protocols. Adhering to disinfection manufacturer guidelines and routine chemical validation testing are valuable steps to ensure that these protocols are safe and effective in instances of OT contamination (19).

BIOLOGICAL RISK FACTORS

Most of the biological contamination within the gynaecology operating rooms is due to the presence of airborne and bloodborne microorganisms. The patients and the operating team are the primary source of such microorganisms while the usage of infected instruments and the contaminated air from the VCCC (Ventilation and Conditioning system with Controlled Contamination) system are the secondary ones. The most significant source of the infected germs is the surgical team (20). Bacteria that colonise human skin are constantly shed by each of us and released into the atmosphere (21). Spread of these microbes into the operating theatre environment is a source of microbial contamination (22) and infection of the surgical wound (23). Approximately 10% of the hospital infections are found to be caused by airborne bacteria and indeterminate percentage of these, not only in immunocompromised hosts but also normal hosts, can be responsible for the respiratory pathologies. During an operation, masks are not always required in the operating room, with the exception of those at the table, because bacteria from the skin are more significant than those from the respiratory system. Masks that serve as barriers for protection are another emerging issue (24).

Because biological risk factors involve living microbes that can survive and proliferate in the theater environment, they are the most significant and direct contributors of gynaecology OT contamination among all other categories (25). One of the main sources of microbial contamination is the human body, which includes both patients and medical staff. Transient and resident microbes are frequently carried by healthcare professionals on their skin, hair, or nasal passages. The most prevalent pathogens detected in surgical staff members' nasal passages are *Staphylococcus aureus*, especially methicillin-resistant *S. aureus* (MRSA), *Streptococcus pyogenes* on their skin, and Gram-negative bacteria on their hands (26). These

microbes can spread to sterile instruments and surgical sites due to poor hand hygiene, inappropriate glove use, and failure to follow aseptic procedures. Other risk factors include jewelry, long sleeves, untrimmed nails, and improper mask use (27).

Patients are another major source of biological contamination. Bacteria such as *Staphylococcus epidermidis*, *Escherichia coli*, and *Enterococcus* species, capable of inducing surgical site infection, are often found in their skin, in the mucous membranes, or in infected wounds (28). Vaginal and cervical flora in gynecology often consists of *Lactobacillus, E. coli*, and at regular intervals pathogenic bacteria such as *Gardnerella vaginalis* and *Candida albicans* (29). During surgeries near these sites, the risk of endogenous contamination may be elevated, particularly if the patient herself has a history of urinary tract infection/predisposition or *bacterial vaginosis* (30). In order to diminish this risk, the practice of safe removal of hairs, proper preoperative cleansing of the skin, and prophylaxis through antibiotic administration are imperative (31). Reusable medical instruments/ improperly cleaned or inadequately sterilized instruments also become a serious biological threat. Left organic material from surgical instruments such as the laparoscope, the suction tubes, or the catheter which are incompletely cleaned and unsterilized can facilitate the survival and multiplication of the bacterial growth of germs. Bacterial colonization may occur due to even tiny drops of blood or other bodily fluids which are left unclean immediately (32).

Numerous microorganisms can be found in the gynaecology OT's environmental sources, including the air, water, and surfaces. Open wounds and sterile equipment can become contaminated by airborne germs like *Bacillus* species and fungus spores like *Aspergillus* (33; 34). *Pseudomonas aeruginosa* and *Legionella* organisms, which like wet conditions, can invade water systems, such as taps, humidifiers, and sterilizers. Humans are surrounded by a range of waterborne opportunistic pathogen, including *Legionella pneumophila*. Other members of the group include the amoebae, including *Acanthamoeba* spp., and the bacteria, *Pseudomonas aeruginosa*, *Mycobacterium avium* complex (MAC), *Mycobacterium abscessus*, *Stenotrophomonas maltophilia*, and *Acinetobacter baumannii*. Collectively, they are called opportunistic premise plumbing pathogens (OPPPs). Because these opportunistic infections invade and survive in drinking water in homes, apartments, schools, hospitals, and offices, humans are constantly exposed to them. These pathogens pose a special risk to patients with weakened immune systems (35). Biofilms, which are complex microbial communities embedded in a protective matrix, can also develop on water lines, drains, and surgical tools. Biofilms can serve as chronic reservoirs of infection and are resistant to disinfectants (36).

Biological risks are further increased by improper management of medical waste. Unless contaminated items like gloves, surgical drapes, or sharps are discarded in the right way, they can turn into receptacles for pathogens which can re-enter the operating theatre setting (37). To identify microbiological contamination at an early point in time and direct the right corrective action, environmental monitoring should be conducted regularly. Air sampling and surface swabbing are part of routine environmental monitoring (38). Moreover, infection control was further made difficult with the advent of antibiotic-resistant organisms like ESBL-producing *Klebsiella* and MRSA (*Methicillin-Resistant Staphylococcus aureus*). Because the aforementioned organisms are capable of resisting regular cleaning activities and survive and remain on the surfaces in the gynaecology OTs, stringent biological control procedures are essential (39).

BEHAVIORAL AND PROCEDURAL RISK FACTOR OF GYNAECOLOGY OPERATION THEATRE

Infection control in gynaecology OTs also depends largely on the OT personnel and adherence to standardized protocols. In the majority of health care centers, lack of optimal aseptic practice in aseptic procedures remains a deep-rooted problem. Most frequent errors are touching sterile zones with non- sterile hands, failing to carry out surgical hand cleaning in an approved method, and incorrect donning and doffing of sterile gowns (40). Air turbulence becomes increases significantly while the gynaecology OT becomes overcrowded with additional personnel, visitors, or students, and this breaks laminar airflow and increases the microbial load (41).

The lack of training and supervision is also a regular issue. Inadequate infection control training among junior staff and cleaners can lead to inefficient segregation of the waste and cleaning surfaces.

Irregularly conducted or rapidly carried-out schedules of cleaning can lead to the residual bioburden at table tops, overhead light fittings, and floors. Additionally, errors are also not reported since there is no dedicated infection control officer who can oversee procedures in the gynaecology OT (42).

Behavioural problems involve staff preparation in addition to patient preparation. Inadequate pre-operative antisepsis leads to post-operative microbial invasion, including failing to properly clean the perineal area or the use of contaminated or improperly stored antiseptic solutions. Ineffective communication among the surgery and cleaning teams can also result in scheduling issues, which gives cleaning solutions insufficient contact time prior to the initiation of the next procedure. With the passage of time, such inefficiencies in procedures heighten the chances of gynaecology OT contamination (43).

MANAGEMENT AND PREVENTION STRATEGIES FOR GYNECOLOGY OPERATION THEATRE

Proper management of contamination within the gynaecology operation theatre requires a comprehensive integration of environmental, structural, and behavioural controls that collectively safeguard patient outcomes. A well-maintained operating theatre is a highly sophisticated system where architectural design, air-handling mechanisms, sterilization equipment, and human behaviour intersect to influence the risk of microbial contamination. The literature consistently highlights that pathogenic microorganisms are frequently introduced through the theatre environment, operating personnel, and improperly processed instruments, all of which contribute to exogenous surgical site infections (44). Sterile practice is a composition of different methods and procedures undertaken to leave materials and places with no microbes, and it is one of the essential measures of patient protection, that reduces the chance of microbial spread during operations (45).

Therefore, perioperative nurses need to communicate with all members of the operation room team, and they should be authorized to discuss breaks in sterile techniques (46). Nurses concern towards aseptic technique varies across countries; 65% of London, 99.5% of Italy, 95.2% of Philippines, 80% of Egypt, and 72.4% of Iran possessed good knowledge of the aseptic technique process (47). On the other hand, 62% of India, 20% of Iraq, 8% of Zimbabwe, and 68% of Nigeria possessed poor knowledge of aseptic techniques used in operation theaters (48). As has been covered in guidelines and discussed literature, the practice of today's surgical antisepsis is through the adoption of sterile techniques in the operation theatre (49). Because aseptic and sterile techniques in surgery are required for early recovery as well as in order to avoid postoperative infection in the patient (50).

Somewhere in the range of 234 million surgeries are performed annually and so surgical care becomes an essential part of the healthcare system worldwide (51). Nevertheless, surgical therapy also poses a high complication and potential death risk. Furthermore, the state of the gynaecology operating theatre also significantly affects the incidence rate of surgical wound infection. Any kind of pollution source and transformation in the microenvironment are intensely regulated in a healthy and safe operating theatre. Systematic planning alone, routine inspection and maintenance, proper and continuous training of staff can do this. To prevent microbial deposits, the physical layout of the OT should have rounded corners, smooth non-porous surfaces, and washable paint finishes for the walls. To prevent loss of sterility during procedures, doors and windows should remain closed. Finally, it should be noted that all operating room personnel surgeons, operating room attendants, anesthesiologist, and house staff have to comply with stringent hygiene regulations (52).

In order to prevent gynaecology operation theatre infection, a complete infection control plan that simultaneously accounts for all the physical, chemical, and biological parameters ought to be implemented. Clean and efficient disinfection of operating rooms is extremely important because of the rapid succession of patients. Pathogens in the environment are transferred directly or indirectly to patients through the hands of operating room (53).

Infection control interventions are essential for achieving safe surgical outcomes, and therefore the modern operating room must have well-developed infection control policies. Infection prevention and control ensure that patient who undergo any surgical procedure within the operating theatre receive safe

and effective care. Standard precautions including hand hygiene, environmental cleaning and disinfection, injection and medication safety, risk assessment with appropriate personal protective equipment (PPE), minimizing potential exposures, and reprocessing reusable medical equipment between patients are universal practices that prevent healthcare personnel or the environment from transmitting infections to other patient (54).

Guideline in prevention of infection contamination and transmission, hand hygiene and gloves are essential and personal protective equipment (PPE) should be used to protect the mucosa of mouth, nose and eyes from contaminated droplets and fluids. Gowns or coveralls, protective footwear, and head covers help to prevent transmission through non-intact skin and inadvertent contamination of mucosa from soiled skin (55). To prevent and impede the transmission of infections, it is necessary to use sterilized materials and equipment, especially in surgical centers where areas or parts of the human body are open. During the last decade, the incidence and prevalence of nosocomial infections have increased and have received substantial attention (56).

Useful use of sterilization and disinfection is very important in preventing infections related to health services. The sterilization service is responsible for the supply and distribution of sterile surgical and medical equipment, which is used in the diagnosis, treatment, and care of patients. This service works on removing and destroying infectious agents on the surface of medical equipment. When the equipment is properly disinfected and sterilized, we can ensure safety in the use of invasive and non-invasive equipment. The slightest negligence in maintaining the cleanliness of the OR environment and sterile parts leads to serious risks for patients who are to undergo surgery (57). Sterilization procedures must comply with established standards and are classified as critical, semi critical, and non-critical depending on the item's contact with tissues. Failures in disinfection and sterilization remain common in healthcare facilities, requiring rigorous evaluation and corrective measures (58).

Hand hygiene plays a central role because hands easily transfer pathogens to other body parts and individuals. All healthcare workers including aides and cleaners must perform hand hygiene as part of standard precautions. Practices include washing with soap and water for 10–15 seconds, thorough drying, and the use of antibacterial soap for surgical hand and arm scrubs (59). Members of the surgical team should scrub arms and hands with an antiseptic solution for at least three minutes before the first procedure of the day, and subsequent procedures may require shorter scrubs; alcoholic chlorhexidine solutions provide superior residual antimicrobial activity. Waterless alcohol-based scrubbing can be equally effective and better tolerated. Effective surgical hand antisepsis removes debris, reduces transient and resident flora, and must last five minutes initially and three minutes subsequently; accidental contact with unsterile surfaces necessitates restarting the scrub (60).

PPE complements hand hygiene. Gloves must be worn whenever contamination is expected but must not replace hand washing. They must be intact, changed between patients, and removed before handling clean items (61). Gloves alone cannot prevent infection; masks provide barriers against airborne organisms, blood, and body fluid splashes, protecting both staff and patients. Surgical personnel entering the operating room for an active procedure should wear masks and headgear that fully cover hair, sideburns, and the neckline because bacteria can be shed from hair, skin, and mucous membranes. Barriers to PPE adherence such as communication challenges, workload, infrastructure limitations, equipment accessibility, and organizational factors have been identified among nursing professional. During surgery and anesthesia induction, protective eyewear shields mucous membranes from splashes of blood or secretions. Together, these integrated measures standard precautions, rigorous hand hygiene, sterilization protocols, and proper use of PPE form the foundation of infection prevention in the gynaecology operating theatre (62).

Preventing surgical site infections in gynaecology operation theatres requires strict adherence to recommended practices, particularly regarding surgical attire, hand hygiene, and environmental management. Nurses' knowledge and compliance with surgical attire protocols are critical. Educational interventions improve clinical knowledge and practice, although few such interventions have focused

specifically on operating theatre nurses. The lack of regional research, particularly in low-resource settings, highlights the need for structured training programmes. Hospitals play a central role in ensuring patient safety by maintaining the operating room environment, HVAC systems, and equipment. Personnel responsible for disinfection and sterilization must rigorously follow aseptic techniques to minimize microbial load. Contamination from air, water, staff clothing, instruments, infected body fluids, and personal items must be controlled using disciplined, evidence-based practices (63).

Environmental cleaning and disinfection are essential components of infection control in gynaecology OTs. Proper surface disinfection in HVAC-equipped theatres supports an infection-free environment. Disinfection removes microorganisms but must be performed using appropriate agents. While formaldehyde and glutaraldehyde are effective, they pose carcinogenic risks; modern alternatives such as Bacillocid and Bacillol are efficient and safer for routine use. Adequate cleaning removes dust, debris, organic matter, and microbial contaminants and forms the foundation for effective disinfection. The three-bucket cleaning method, using purified water and diluted disinfectants, ensures systematic cleaning from cleaner to dirtier areas. These procedures also apply to walls, floors, shelves, and anesthesia equipment, which must be cleaned routinely according to evidence-based guidelines (64).

Instrument processing is central to infection prevention. Guidelines from the American OR Nursing Committee outline steps including initial rinsing, ultrasonic cleaning with antiseptic agents like cetrimide and chlorhexidine, mechanical scrubbing, hot-air drying, and proper packing before sterilization. Cleaned instruments must be wrapped in sterile fabrics, packed in stainless steel bins, labeled, sterilized within recommended timelines, and stored under controlled conditions. Biomedical waste management segregation, sharps disposal, wastewater treatment, and protective equipment for waste handlers is essential for maintaining asepsis and preventing environmental contamination (65).

Medical waste management is increasingly important given the significant volume of waste generated in operating theatres. Recycling initiatives, sustainable waste reduction measures, minimizing anesthetic gas emissions, and reducing energy consumption enhance environmental safety. Efficient OT management improves surgical workflows, resource allocation, and staff coordination (66). Automated doors and scrub stations reduce contact and contamination risks while supporting hand hygiene compliance. Airborne contamination remains a challenge in gynaecology theatres, influenced by door openings and personnel movement; automated hygiene systems improve safety by maintaining airflow control and reducing manual touch points (67).

HEPA filtration systems are critical for maintaining air quality in gynaecology OTs, removing airborne pathogens and lowering infection rates (68). Air purification technologies, UV irradiation in ventilation ducts, and positive pressure systems support clean air circulation and prevent contaminated air ingress. Continuous monitoring of particle counts, microbial load, and environmental parameters ensures compliance with air-quality standards. HVAC systems regulate temperature, humidity, pressure gradients, and particulate counts to maintain clean room conditions. Proper maintenance of AHUs, ducts, compressors, HEPA filters, and laminar airflow systems is essential for patient safety and asepsis (69).

Cleaning of surgical instruments requires high-quality water, such as distilled or reverse-osmosis purified water. Thorough rinsing, antiseptic decontamination, ultrasonic cleaning, and hot air drying are essential to prevent microbial persistence and ensure successful sterilization. Manual cleaning methods such as the four-bowl technique may be used when automated systems are unavailable. Proper drying, inspection under magnification, packaging in instrument rolls, and autoclaving complete the sterilization process. Any retained moisture diminishes sterilization effectiveness and may reintroduce microbes (70).

Operating theatre cleaning protocols including daily, weekly, and monthly procedures are required to prevent environmental contamination. Traditional fumigation with formaldehyde, though effective, is now considered hazardous and is increasingly replaced with safer alternatives like Bacillocid Rasant and Virkon. Daily cleaning focuses on wiping furniture and surfaces, while weekly activities include cleaning of ceilings, shelves, and AC filters. Monthly deep cleaning involves comprehensive disinfection of equipment

and structural surfaces. OT-dedicated water tanks must be cleaned routinely to avoid microbial contamination (71).

Maintaining asepsis in the gynaecology OT requires structural, procedural, and behavioural compliance. Architectural design such as separation of clean and dirty zones, positive pressure airflow, and laminar airflow supports aseptic conditions. Staff behaviors, including proper scrubbing techniques, correct draping, minimizing theatre traffic, and adherence to sterile practices, remain the most important factors. Sterilizer performance must be monitored using physical, chemical, and biological indicators to identify failures early. High workload density, stress, and understaffing can compromise cleaning and sterilization processes, increasing infection risks (72).

Human factors such as inadequate knowledge, risky behaviors, and negligence significantly increase microbial transmission risks. Personnel must wear protective clothing, maintain sterility, and avoid behaviors like incorrect mask use, glove misuse, or carrying personal items into the OT. Hand hygiene is vital given the microbial load released during talking, coughing, or sneezing. Instruments and sterile materials must be transported using clean, covered carts by trained personnel; poorly maintained transport systems increase contamination risk. Inadequate OT architectural design, such as single-corridor layouts where sterile and contaminated items cross paths, increases microbial spread. Contaminated instruments should be transported in closed containers, and zones for sterile and unsterile workflows must be clearly separated. Aseptic technique, encompassing hand hygiene, glove use, surgical attire, preoperative skin preparation, instrument preparation, and environmental control, is essential to minimize pathogens in gynaecology operation theatres (73).

Operation Theater should be equipped with totally aseptic and sterile devices and instruments because there are increased chances of contamination of freshly treated incised and traumatized tissues. Therefore, any unwanted contaminates or unsterile object or instrument can easily transfer the microbes from the surfaces to the sites of wound. All operative procedures are performed under sterile conditions. Most common problems of surgery are high levels of infections among surgical procedures. Variety of compounds polluted the indoor air quality such as particulate matter, carbon monoxide, volatile organic compounds (VOCs) and microorganisms e.g. bacteria, fungi, viruses etc (74).

Environmental monitoring including microbiological testing of air, surfaces, and equipment is essential for detecting contamination and tracking microbial trends (75). Routine monitoring aids in identifying risks, understanding microbial resistance patterns, and assessing air quality, ultimately contributing to the prevention of intra operative and postoperative infections. Reducing microbial contamination through improved cleaning, disinfection, sterilization, surveillance, ventilation management, and consistent adherence to aseptic practices enhances patient safety and significantly reduces surgical site infections. Holistic implementation of these strategies ensures that biological, chemical, and physical risks are addressed collectively, enabling healthcare institutions to uphold high-quality surgical care while minimizing the burden of hospital-acquired infections (76).

CONCLUSION

Cross-infection of gynaecological OTs continues to be a risk to patient safety and surgical success. Physical, chemical as well as biological hazards all should be managed in relation to each other to ensure that an OT is sterile. Safety checking points are to maintain optimum ventilation condition, regulated temperature and humidity, efficient sterilization, and strict aseptic operation. The human effects such as employee cleanliness, self control and awareness are also very crucial in preventing the transmission of microbes. Small errors in infection management can be fatal in an age of increasing antibiotic resistance. Consequently, staff instruction hence should rank top most in the list and rigorous monitoring as well as stem compliance of infection control measures needs to be strictly maintained.

Conflict of interest:

Authors declared no conflict of interest.

Authors' contribution:

SK & MKT Conceived and designed the study; SK, H & MK Performed the literature search and data collection; RR, MA & FK Contributed to data interpretation and critical analysis; NR, MS, and SKh Assisted in manuscript drafting and formatting. IT Provided supervision and critically revised the manuscript for important intellectual content.

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