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OPERATION THEATRE TRAFFIC AND ITS ASSOCIATION WITH SURGICAL SITE INFECTION RISK: A COMPREHENSIVE REVIEW

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Abstract

Background: *Surgical site infection (SSI) represents one of the most significant healthcare-associated infections (HAIs) responsible for 17–20% of all HAIs and is associated with morbidity, mortality and healthcare costs. Operation theatre (OT) traffic (movements of staff and openings of doors during surgical procedures) is the most consistently identified and modifiable risk factor known. In this review, the connection between staff traffic, OT door openings and incidence of SSI is considered.*

Methods: *A structured literature review was carried out in PubMed, Google Scholar, CINAHL and Cochrane Library. The twenty-nine studies that were identified, appraised and synthesized thematically between 2009 and 2025 focused on evaluating the relationship between intraoperative traffic (entry and exit of personnel, door openings) and the risk of SSI.*

Results: *Laminar airflow and positive pressure systems are disturbed, which raises the number of airborne bacteria in the vicinity of the sterile field by door openings and continuous OT traffic. Evidence has shown a relationship between increased OT traffic and increased SSI risk, as well as between each additional door opening for a specific increase in SSI risk. There was also a strong correlation between the cumulative door-open time and risk of infection.*

Conclusion: *OT traffic is a behaviour and environment factors that can be modified and has a significant effect on surgical field sterility. While more research with good quality is required in all surgical specialties, evidence today indicates that the adoption of measures to limit unnecessary staff movement and door openings is a strategy that has the potential to reduce the risk of SSI. Keywords: Airborne bacteria, infection control, surgical site infection, laminar airflow, healthcare, operating room.*

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1. INTRODUCTION

The term surgical site infection (SSI) is used to describe an infection that enters a surgical wound, usually within 30 days of surgery, or up to 1 year following the placement of an implant. These infections can be superficial, deep tissue, or in organs or body spaces. Infections in hospital settings (also known as HAIs) are one of the most prevalent and clinically relevant SSIs worldwide and lead to longer hospital stays, more use of antimicrobials, additional surgery, septicemia, and death. The cost is significant: SSIs cost, on average, 7 to 11 extra days in the hospital and significant extra treatment costs are added to health systems1. The prevalence of SSI is widely different around the world, from about 2% in high-income countries to more than 20% in resource-limited areas, and prevention of SSI is a priority concern for universal health care2. The OT environment is maintained sterile by laminar airflow systems, high efficient particulate air (HEPA) filtration, strict aseptic technique, and controlled access. These systems, however, do not stop the OT from being contaminated by environmental and behavioral factors. The most consistent factors that have been identified and modifiable are those associated with OT traffic, which involve the movement of personnel in and out of the OT during a surgical procedure3,4. When doors open, they cause a disruption in the positive pressure differential and laminar airflow over the sterile field, and ambient particulate matter and microorganisms would enter from adjacent corridors5. The operation theatre technologist is a key worker in the operating room and has a special role to play in establishing and maintaining the sterile environment, passing instruments and the sterile field and supervising activities in the operating room. Technologists also have a direct involvement in traffic management and SSI prevention, by controlling access to the OT during ongoing procedures. The literature specifically concerning the role of OTs in traffic regulation as a traffic SSI prevention strategy is not so widely available. This review is designed to bring together the evidence from 29 published studies to look at the link between OT traffic and SSI to guide clinical practice and OT professional education courses. Globally, surgical site infection (SSI) is still a major contributor to the post operative complications and financial burden. Too many door openings and unnecessary movements of staff in the OT have been recognized as a preventable risk factor for SSI6,7 over the past several years. While the link between OT and increased microbial levels and SSI risk has been established, there is no standardisation of traffic control protocols between settings. There is little literature to describe the traffic role of the operation theatre technologist during surgery. To fill this void, this review analyzed 29 sources and suggests three practice, policy and education recommendations for operation theatre technology.

1.1 Primary Objective :

To compare the relationship between the traffic in operation theatres and incidence of surgical site infections in published literature.

1.2 Secondary Objective

To find evidence-based operation theatre traffic management strategies reported in the literature that are effective in reducing surgical site infection rates.

2. LITERATURE SEARCH STRATEGY

The keywords and the medical subject headings (MeSH) used in searching were surgical site infection, operating room foot traffic, operating room door openings, operation theatre traffic, operation room traffic, infection control operating room, medical subject headings, and surgical site contamination. The searches were performed using PubMed, Google Scholar, CINAHL, and Cochrane Library and limited to publications from 2009 to 2025. Search terms were combined using boolean operators (AND, OR) and reference lists of included articles were screened for further relevant articles. Twenty-nine (29) eligible studies were identified, reviewed, and synthesized thematically.

2.1 Quality Assessment and Risk of Bias

The overall procedure for evaluating quality and risk of bias involves the following steps:

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Appropriate tools were used to assess the methodological quality depending on study design. The Newcastle-Ottawa Scale was utilized to score the observational studies (cohort, cross-sectional and case-control). The AMSTAR-2 checklist was used to evaluate systematic reviews and meta-analyses. The Clinical practice guidelines were assessed with AGREE II, experimental and quasi-experimental studies were assessed with Critical Appraisal Skills Programme (CASP) checklist. To map the available evidence as widely as possible, studies with critical risk of bias were not excluded, but rather retained and flagged in the narrative synthesis.

2.2 Inclusion Criteria

a) The studies included met the following criteria: (a) They examined the relationship between OR traffic (door openings or personnel movement) and the occurrence of SSI;
b) They used a cross sectional, cohort, case control, randomized controlled trial, systematic review or meta analysis design;
c) They had to be published in a peer-reviewed English language journal;
d) They were conducted in hospital operating rooms; and
e) They were published between 2010 and 2026.

2.3 Exclusion Criteria

Those papers that did not specifically address OR traffic or door openings during the SSI study, or that were letters, opinion articles, case reports, or editorials, or that were not conducted in an OR, or that were in non-English language, or that did not have published data, or that were published as conference abstracts, were excluded.

2.4 PRISMA Flow Diagram

Table 1 presents the PRISMA-style flow of literature identification, screening, eligibility assessment, and final inclusion of the 29 studies reviewed in this article.

Table 1. PRISMA flow diagram of study selection process.

Phase	Step	Number of Records
Identification	Records identified through database searching (PubMed, Google Scholar, CINAHL, Cochrane)	187
Identification	Additional records identified through reference list screening	22
Screening	Records after duplicates removed	143
Screening	Records screened (title and abstract)	143
Screening	Records excluded (irrelevant topic, wrong population, wrong setting)	89
Eligibility	Full-text articles assessed for eligibility	54
Eligibility	Full-text articles excluded (no outcome data, conference abstracts, non-English)	25
Inclusion	Studies included in the literature review	29

3. BODY / THEMATIC SECTIONS

3.1 The Burden of Surgical Site Infections

SSI are a significant and largely avoidable global problem. De Lissovoy et al.[1]showed that SSI patients have 7-11 days longer stay in hospital than those without SSI, regardless of the health system used, confirming the economic and clinical need for preventing SSI. In later investigations, it was

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concluded that 55-70% of HAIs (including SSIs) could be reasonably prevented using evidence-based protocols[8] and that OT traffic was one of the most modifiable environmental risk factors for SSI across all surgical specialties[9], following a detailed review. Taken together, these results suggest that SSIs do not have to be a foregone conclusion during surgery, but they can be significantly decreased using proper environmental control, specifically OT traffic management.,

3.2 Guideline-Level Recognition of OT Traffic as a Modifiable Risk Factor

The Centers for Disease Control and Prevention (CDC) formally endorsed OT traffic as a significant, modifiable risk factor in 2017 in their guideline on the prevention of SSI[2], bringing evidence from many research streams together and recommending behavior change interventions to minimize unnecessary staff movements as a part of a larger SSI prevention bundle. Complementary work on strategies to prevent SSI in acute care hospitals also highlighted the need for traffic measure[10]

The global guidelines from the World Health Organization (WHO) for SSI prevention also call for environmental control measures, such as limiting access to the OT during active procedures[11] From an operational point of view, traffic minimization is reinforced as an essential part of SSI prevention practice in the Association of periOperative Registered Nurses (AORN) . practice[12]. The collection of guideline-level suggestions forms the basis of an accepted international standard of care for traffic control in OT.

3.3 Mechanisms by Which OT Traffic Increases Microbial Contamination

During orthopedic trauma implant surgery, there was a significant rise in airborne particle and colony forming unit (CFU) levels near the surgery area when the door was opened, and contamination was high for several minutes after the door was closed[3]. Similarly, a review of factors that influence airflow and surgical wound contamination found that disruption of laminar airflow by door openings is still a major mode of personnel traffic to infection risk[4].

This mechanism was tested in an operating room with mixing ventilation, and it was found that the openings in the doors significantly affect the effectiveness of the ventilation in the sterile field and the contamination field[13]. Positive pressure has also been shown to be directly reduced with door opening during joint arthroplasty[5] and with frequent openings sustained positive pressure needed to maintain sterility is also sterility[14]. A systematic review of the air microbial loads in the OR was conducted and it was found that the incidence of SSI increased with the increase in the microbial load in the OR air[15].

3.4 Quantification of OT Traffic and Its Clinical Consequences

. One prospective observational study performed during total joint arthroplasty documented an average of 67 door openings per surgery, many of which may have been by personnel who were not directly essential to the surgery, including students, administrative personnel, and supply runners, whose activities could be reasonably performed outside of critical surgery time periods[16]. Additional research revealed that traffic volume, location of OR and proximity to the sterile field were all independent factors predicting high microbial load[17].

Retrospectively, a positive association between OR traffic and SSI incidence[18] was identified after arthroplasty, with the effect of OR traffic remaining significant after adjustment for patient-level risk factors such as BMI, diabetes and surgical duration, after a second cohort duration[19]. In orthopedic surgery, a narrative review found studies showing a clear association between open doors and an increased risk of contamination in cases involving implants, such as prosthetic joint infection[20].

3.5 Synthesized and Meta-Analytic Evidence

.The highest level of synthesized evidence on this topic was reported in an umbrella review that combined evidence from several systematic reviews and meta-analyses, showing that higher numbers of door openings were consistently

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linked to higher risk for SSIs in surgical specialties and geographic settings[6]. Individual-patient data meta-analysis of complementary data revealed an odds ratio (OR) of 1.04 for an extra door opening for SSI[7],

3.6 Specialty-Specific Findings

An extensive review of orthopedic evidence[20] supports evidence linking OT traffic to SSI risk in orthopedic surgery and implant surgery, which carries often serious and consequence irreversible[5],[14],[16],[19]. In addition to orthopedics, observational studies in operating rooms for neurosurgical procedures provided baseline estimates of door traffic in these ORs for specialty-specific traffic reduction strategies[21], and traffic-related spatial dynamics have been described in several surgical specialties[17].

3.7 Intervention Studies and Traffic Reduction Strategies

To assess the effect of signage, a quasi-experimental study was conducted at OR entrances where unnecessary entries were reduced by about 30% after the signage was placed, which shows that simple low-cost behavioral interventions can be effective and yield meaningful results in reducing OT traffic[22]. Likewise, a traffic-reduction program with team-based education and accountability systems was effective in reducing unindicated patient safety interventions and unnecessary staff entries in an academic medical center[23].. A more inclusive look at SSI-prevention strategies also revealed that behavioral interventions that influence OR traffic patterns have been shown to significantly and permanently decrease infection risk[24].

3.8 Team Dynamics, Role Clarity and OR Design

A mapping of team dynamics and traffic in the OT using mixed methods found role-specific factors that influence infection-related practices among surgical team members, thus establishing that OT traffic is not solely due to physical movement but also to organizational and interpersonal movement[25]. Another review of OR design highlighted that physical design and entry-control measures are crucial to minimizing unnecessary traffic and SSI risk[26].All of these findings emphasize the importance of a comprehensive strategy to infection prevention that includes traffic control, team dynamics, role clarification, and OR design[27],[28], all of which are within the scope of the trained operation theatre technologist .The importance of standardised definition of SSI has also been highlighted as a key to assessing the impact of future interventions[29].

4. DISCUSSION

A synthesis of 29 published studies reveals a consistent and mechanistically coherent relationship between OT traffic and SSI risk.The synthesis of 29 published studies shows that there is a consistent and mechanistically coherent relationship between OT traffic and SSI risk. Evidence ranges from observational and experimental studies, systematic reviews and meta-analyses to an umbrella review that all share a common thread: the presence of laminar airflow and positive pressure is key to maintaining sterility in the OT, with door openings and the movement of people leading to measurable and clinically relevant increases in the level of airborne microbial load in the immediate vicinity of the surgical field.

It is helpful to have quantitative estimates from various studies. Traffic management policy can be directly informed by the direct and communicable measure of SSI odds[7], which increased by 1.04 with each additional door opening. In routine surgical practice the risk may be significant, as an average of 67 door openings are made during each arthroplasty procedure[16]. Notably, small signage measures were shown to lower unnecessary entries by about one-third[22] , indicating that small behavioural interventions can lead to significant decreases in traffic and, consequently, infection risk.

A common theme throughout the literature is the role of non-essential personnel (students, administrative staff, supply runners) in creating unnecessary traffic; pre-procedural briefings, role delineation and access policies are effective practical preventive measures. The role of operation theatre technologists in traffic

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management is not well documented in literature; this review helps identify their role and suggests the need for further investigation.

There are also evident gaps in the evidence base, with the majority of high-quality studies focusing on orthopedic surgery and implant surgery compared to smaller numbers of studies with systematic evidence in general surgery, neurosurgery and cardiovascular surgery[21] . Most intervention studies are quasi-experimental or quality improvement studies and there are no dedicated randomized controlled studies of traffic-reduction interventions. The type of measurement (door-opening count, staff movement tracking, or CFU counting) also adds to the difficulty of comparing studies. Nevertheless, the collective strength of the CDC[2], WHO[11], and AORN[12] guidelines, and the primary and synthesized evidence presented here, offers a solid base on which to formulate and implement formal OT traffic management protocols in surgical environments.

Limitations of This Review

This review has some limitations.There are a number of limitations to this review. Firstly, some language bias may be introduced if the literature studied in English is different from the relevant literature in other languages. Second, as in narrative reviews in general, studies with significant associations between OT traffic and SSI are more likely to be published than studies with null results, leading to an overestimate of the evidence. Third, the findings are reported as a narrative synthesis and there was no formal meta-analysis performed, which reduces the power of the findings. Fourth, most of the good primary studies are from orthopedic and arthroplasty practices, and applying the findings to other surgical specialties should be applied with caution. Fifth, grey literature, conference abstracts and unpublished data were not searched, which may have led to the exclusion of further relevant evidence. The overall results should be interpreted with regard to these restrictions.

5. CONCLUSIONS AND FUTURE DIRECTIONS

This study shows that what happens in the operating room, like when doors are opened and staff move around during surgery, can actually increase the risk of infection at the surgical site. The evidence is clear and consistent, and it's also supported by guidelines from around the world. Every time a door is opened, it makes the operating room a little less sterile, and that means the risk of infection goes up. The more people moving around and doors opening, the higher the risk of infection. This is something that can be controlled and prevented, which is important for keeping patients safe.Traffic-reduction measures — including restrictive signage, team-based education, structured access procedures, and OR design modifications — have demonstrated effectiveness at low cost relative to their potential impact. As custodians of the sterile field and controllers of OT access, operation theatre technologists occupy a key role in implementing and sustaining such practices.

To move forward, researchers should focus on a few key areas. First, they need to do studies that look at how operating theater traffic affects the risk of surgical site infections across different types of surgery. This will help them understand how big of a role traffic really plays. They should also test different ways to reduce traffic in the operating theater to see what works best. Another important area is to figure out how the people who work in the operating theater can help manage traffic to prevent infections. Lastly, they need to create tools that can measure operating theater traffic in a way that everyone agrees on, so they can compare results from different studies. By doing these things, researchers can build a stronger foundation of evidence and make it easier for hospitals to put traffic management plans into action. This will help keep patients safer during surgery.

6. DECLARATIONS

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6.2 Conflicts of Interest

The authors declare no Conflict of Interest.

6.3 Funding Disclosure

This study didn't get any money or support from government agencies, companies, or nonprofit organizations.

6.4 Use of Artificial Intelligence (AI) Tools

The writers used computer programs to fix grammar and make the language sound better when they were getting their manuscript ready. These programs were not used to collect or analyze data, or to figure out what it means. The people who wrote the manuscript are responsible for making sure everything is correct and honest. They didn't use the computer programs to write the manuscript, and the programs are not considered authors.

6.5 Ethical Considerations

This paper is a review of what's already been written on a topic, so it didn't need to involve real people or animals, collect new data, or test anything directly. Because of this, it didn't require approval from an ethics committee or consent from participants.

7. DATA EXTRACTION TABLE

Table 2 summarizes the key details of each of the 29 studies included in this literature review, including the first author and year, study design, and principal finding relevant to OT traffic and surgical site infections.

Table 2. Summary of 29 included studies on OT traffic and surgical site infections.

Sr.	First Author (Year)	Study Title (Short)	Study Design	Key Finding
1	Alizo et al. (2019)	OR foot traffic: a risk factor for SSIs	Retrospective cohort	Higher foot traffic significantly associated with increased SSI rates
2	Anderson et al. (2014)	Strategies to prevent SSIs: 2014 update	Evidence-based guideline	Traffic reduction among top preventive strategies for SSIs in acute care
3	Andersson et al. (2012)	Traffic flow in the OR during orthopaedic surgery	Observational descriptive	Door openings elevated airborne particle and CFU counts near surgical field
4	Andrew & Florez (2021)	Decreasing OR traffic to improve patient safety	Quality improvement	Structured traffic reduction protocol reduced unnecessary personnel entries
5	Berríos-Torres et al. (2017)	CDC guideline for prevention of SSI, 2017	Clinical practice guideline	Updated CDC guidelines identified OR traffic as a modifiable SSI risk factor
6	Buckner et al. (2022)	Decreasing foot traffic in orthopaedic OR	Narrative review	Literature consistently links door openings to contamination in orthopaedic ORs

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Sr.	First Author (Year)	Study Title (Short)	Study Design	Key Finding
7	Chiletzari et al. (2025)	Microbial load, OR air quality and SSIs	Systematic review	Microbial load in OR air correlates directly with SSI incidence across specialties
8	De Lissovoy et al. (2009)	SSI: incidence and impact on hospital costs	Economic analysis	SSIs added 7–11 days to hospital stay and significantly increased treatment costs
9	Drago et al. (2025)	Intraoperative traffic and door openings on SSIs	Umbrella review	Strong evidence that door openings increase contamination risk and SSI incidence
10	Erivan et al. (2024)	Signage restricting OR access and staff traffic	Quasi-experimental	Restrictive signage reduced OR traffic by approximately 30% during procedures
11	Groenen et al. (2025)	Door openings in OR and SSI: meta-analysis	Individual-patient data meta-analysis	Each additional door opening independently increased SSI risk (OR = 1.04)
12	Heinke et al. (2023)	Safety in health care: OR design impact	Narrative review	OR design features including entry controls reduce unnecessary traffic and SSI risk
13	Leaper et al. (2013)	Surveillance of SSI: more accurate definitions needed	Commentary/review	Standardized SSI definitions essential for accurate surveillance and prevention
14	Leaper & Edmiston (2017)	WHO global guidelines for prevention of SSI	Guideline review	WHO guidelines emphasize environmental controls including OR traffic management
15	Leaper & Ousey (2015)	Evidence update on prevention of SSI	Evidence review	Behavioural interventions targeting OR staff significantly reduce SSI risk
16	Mears et al. (2015)	Door opening affects OR pressure during arthroplasty	Experimental	Door openings reduced OR positive pressure, compromising sterile field integrity
17	Panahi et al. (2012)	OR traffic is a major concern during total joint arthroplasty	Prospective observational	Average 67 door openings per procedure; correlated with contamination levels
18	Paras et al. (2023)	Alternate care site infection prevention: systematic review	Systematic review	Infection control practices including traffic regulation reduce HAIs across settings

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Sr.	First Author (Year)	Study Title (Short)	Study Design	Key Finding
19	Pobre (2022)	SSIs: reducing foot traffic to minimize risk	Project/report	Foot traffic reduction interventions demonstrate measurable reductions in SSI risk
20	Pokrywka & Byers (2013)	Traffic in the OR: factors influencing airflow and contamination	Literature review	Personnel movement disrupts laminar airflow and increases wound contamination risk
21	Rezaei et al. (2025)	Surgical site infections: a comprehensive review	Comprehensive review	OR traffic identified as a top modifiable environmental risk factor for SSIs
22	Schafer (2023)	Neurosurgical OR door traffic observation for SSI prevention	Observational study	Baseline door traffic data used to inform targeted intraoperative prevention strategies
23	Spruce (2014)	Back to basics: preventing surgical site infections	Practice review	AORN guidelines support traffic minimisation as a standard SSI prevention measure
24	Surendran et al. (2023)	Mapping team dynamics and traffic in the OT	Mixed-methods	Team dynamics and role-specific traffic patterns linked to infection-related practices
25	Taaffe et al. (2018)	Influence of traffic and location on OR microbial load	Prospective observational	Traffic and area location were independent predictors of elevated microbial load
26	Umscheid et al. (2011)	Estimating preventable HAIs and related costs	Systematic review	Up to 55–70% of HAIs including SSIs are reasonably preventable with proper protocols
27	Wang et al. (2021)	Impact of door opening on SSI risk in mixing ventilation OR	Simulation/experimental	Door openings significantly compromised ventilation effectiveness and sterility
28	Wanta et al. (2016)	OR traffic as a modifiable risk factor for SSI	Retrospective cohort	Increased OR traffic independently associated with higher SSI rates post-arthroplasty

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Sr.	First Author (Year)	Study Title (Short)	Study Design	Key Finding
29	Weiser et al. (2018)	Effect of door opening on positive pressure and airflow in ORs	Experimental	Frequent door openings reduced sustained positive pressure, elevating contamination risk

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