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Editorial

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Addressing perioperative anxiety in surgical patients

Perioperative anxiety is a common yet often underestimated psychological response to surgery that can significantly impact patient outcomes and overall health care experiences. As perioperative nurses we witness first-hand how fear and apprehension can affect our patients before surgery whether it's an elective or emergency procedure.

Anxiety can present itself in many forms – psychological symptoms like fear and excessive worry or physical symptoms such as increased heart rate high blood pressure and nausea[1]. A recent study also found that the nearly one third (32.4%) of adult patients undergoing elective surgery experienced pre-operative anxiety[2]. Despite its prevalence, pre-operative anxiety often goes undiagnosed and untreated leading to adverse effects on recovery and patient satisfaction. As surgical care moves towards a more holistic patient-centred approach it's essential for us to understand the causes, adverse effects and effective management strategies for perioperative anxiety. As perioperative nurses we play a key role in recognising, managing and reducing anxiety in our patients.

There are several causes of perioperative anxiety including fear of the unknown, concerns about anaesthesia, fear of pain and worries about the surgical outcome[3]. Many patients feel anxious because they perceive a loss of control, especially when general anaesthesia is involved. Anxiety may be further intensified in patients who have had negative past surgical experiences or heard about the bad experiences of others. Factors related to the surgery itself – such as the complexity of the procedure or the risk of severe outcomes – can also increase anxiety levels[4].

Perioperative anxiety can affect anyone, but certain groups are more vulnerable. Younger patients, for example, tend to report higher levels of anxiety compared to older adults[5]. Women are also more prone to experiencing perioperative anxiety due to a combination of biological and psychosocial factors[6]. Additionally, patients with limited information about their upcoming procedure those with previous negative experiences and individuals with pre-existing mental health conditions, such as anxiety or depression, are at greater risk[7].

Untreated perioperative anxiety extends beyond psychological discomfort. High levels of anxiety are linked to negative physiological outcomes such as increased anaesthetic requirements and intra-operative complications[8]. Post-operatively anxious patients often experience more intense pain, require larger doses of pain medication and have longer recovery times[7]. Anxiety can also delay wound healing, increase the risk of infections and lead to extended hospital stays[3]. Additionally, the emotional toll of anxiety can decrease patient satisfaction with their overall surgical experience potentially leading to negative long-term perceptions of health care.

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To manage perioperative anxiety effectively we need to use a combination of pharmacological and non-pharmacological strategies. Medications like anxiolytics are commonly used to reduce anxiety before surgery but they carry risks such as drowsiness, respiratory depression and interactions with other anaesthetic agents[9]. Due to these side effects non-pharmacological interventions are becoming more popular as safer holistic options for anxiety management.

Some effective non-pharmacological strategies include patient education, music therapy and virtual reality (VR). Patient education is one of the most powerful strategies for reducing anxiety as it addresses the fear of the unknown. It helps patients feel more in control by providing them with knowledge about the surgical procedure, anaesthesia and what they can expect in terms of outcomes[8]. Music therapy and VR are also gaining attention as effective tools for creating a calming environment, distracting patients from their anxiety and, ultimately, improving patient satisfaction[10,11].

Despite how common perioperative anxiety is, it is often underdiagnosed and undertreated. A recent study conducted in a major metropolitan hospital in Australia found that the prevalence of clinically significant pre-operative anxiety was 32.4 per cent among adult patients undergoing elective surgery[1,2]. One of the biggest barriers to effective management is the lack of routine screening for anxiety during pre-operative assessments. Too often health care providers focus only on the physical aspects of surgical preparation neglecting the psychological needs of patients. Even when anxiety is identified treatment often relies too heavily on pharmacological solutions despite growing evidence supporting non-pharmacological interventions[9,11]. The absence of standardised protocols for identifying and managing perioperative anxiety leaves many patients without the support they need.

As perioperative nurses we are uniquely positioned to address perioperative anxiety because of our close relationships with patients throughout their surgical journey. We are often the first to recognise signs of anxiety and are in the best position to provide education and support. It is crucial that we incorporate routine screening for anxiety into our pre-operative assessments using validated tools like the Amsterdam pre-operative anxiety and information scale (APAIS) to identify patients at risk[8].

Beyond screening we can implement and advocate for non-pharmacological interventions. Techniques such as guided relaxation, breathing exercises and music therapy are simple yet effective and can easily be incorporated into routine pre-operative care. Educating our patients about the surgical process also helps demystify the experience and alleviate their fears[5]. By collaborating closely with anaesthetists and other health care professionals we can ensure that anxiety management is holistic, addressing both the psychological and physical needs of our patients.

Perioperative anxiety is a significant but often overlooked issue that can have serious consequences for surgical outcomes and patient satisfaction. As health care continues to evolve towards a more patient-centred approach, addressing perioperative anxiety must be a priority. As perioperative nurses, we are in the best position to take the lead in recognising and treating anxiety. By integrating routine assessments, advocating for evidence-based interventions and providing compassionate patient-centred care we can help reduce the negative impacts of perioperative anxiety and improve outcomes for our patients.

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Discussion paper

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Exploring wellbeing and turnover intention among perioperative nurses: A discussion paper

Abstract

In the perioperative environment, the safety and wellbeing of nursing staff are paramount for ensuring the delivery of high-quality, safe and sustainable health care services. Various factors contribute to the wellbeing of perioperative nurses, and significantly influence their decisions to stay in their current roles or seek employment elsewhere. The implications of high turnover rates among perioperative nurses extend beyond individual job satisfaction to encompass broader consequences for hospital systems, including compromised quality of patient care and increased operational costs.

While the existing body of research on the wellbeing of perioperative nurses is relatively limited, available findings underscore the critical importance of staff wellbeing within the health care sector. These findings highlight the urgent need for proactive initiatives to promote the wellbeing of perioperative nursing professionals.

This discussion paper aims to comprehensively explore wellbeing within the context of perioperative nursing. It will delve into the various domains and characteristics of wellbeing related to perioperative nurses, shedding light on the intricate relationship between wellbeing and turnover intentions in this specialised nursing setting. Furthermore, the paper will discuss current interventions designed to promote the wellbeing of nurses.

Keywords: wellbeing, perioperative nurses, turnover intention, initiatives, strategies, policies

Introduction

Supporting and protecting health care workers' safety and wellbeing is linked to the provision of high-quality, safe and sustainable health care[1]. Wellbeing has been a longstanding concern among stakeholders in the health care sector[2] and the emergence of the recent COVID-19 pandemic has intensified these concerns. A 2021 nationwide survey in Australia involving 9518 frontline health care workers, including 3088 nurses, reported that 60 per cent of respondents had some degree of anxiety, 71 per cent experienced moderate to severe burnout, and 57 per cent suffered from a degree of depression[3]. In a recent annual mental health survey of health care professionals, an average of 80 per cent of respondents reported experiencing burnout over the past three years, with 50 per cent indicating they had left their jobs and 78 per cent being affected by staff shortages[4]. Poor psychological wellbeing among nurses has been a persistent issue, and it is crucial that the adverse impacts on the wellbeing of health care staff are addressed[1].

In recent years, wellbeing has emerged as a prominent topic of inquiry across various disciplines within the social sciences[5]. Wellbeing encompasses various dimensions including emotions, behaviours, cognition and interpersonal relationships[5]. Wellbeing can be defined as 'feeling good and functioning well'[5, p.1]. Wellbeing encompasses positive emotions, realising one's potential, having control over one's life, finding purpose and having positive relationships[5], which all contribute to sustainable growth and thriving[6]. Wellbeing should always be present, albeit in varying degrees depending on individual circumstances and contexts[7,8]. Research has shown that wellbeing significantly influences various aspects of one's life. Individuals with high levels of wellbeing tend to exhibit greater productivity in the workplace, engage in more effective learning, demonstrate increased creativity, exhibit more prosocial behaviours and foster positive relationships[6,9].

While there is research about the wellbeing of nurses who work in the emergency department and intensive care unit, research about the wellbeing of perioperative nurses is lacking[10]. This phenomenon may be attributed to the scarcity of available time, energy and support for research in the perioperative setting[11]. A study conducted in the United States of America highlighted key factors crucial for the wellbeing of perioperative nurses – meeting personal needs, fair treatment, support, transparent policies, reasonable compensation, career opportunities, safety, autonomy, low stress, work–life balance and avoiding office politics[12]. In Australia, a perspectives brief by the Australian Healthcare and Hospitals Association (AHHA) stressed that protecting health care workers' wellbeing is a priority for attracting and retaining members of the health care workforce[13].

The following discussion will provide an overview of wellbeing and its correlation with turnover intention among perioperative nurses. Additionally, it will assess the effectiveness of interventions to enhance nurses' wellbeing and make recommendations to support the wellbeing of perioperative nurses based on current evidence.

Discussion

High nurse turnover presents a major challenge for health care leaders, affecting the quality of patient care and resulting in significant financial costs related to staff replacement[12,13]. Nurses working in perioperative settings are more susceptible to experiencing compromised wellbeing compared to their counterparts in general ward settings[12,14,15]. This is mainly attributable to demanding and intense work, rapid patient turnover, advanced techniques and the necessity to collaborate within multidisciplinary teams[14,16,17]. Therefore, it is crucial to understand the impact of wellbeing on the decision-making processes leading to perioperative nurse resignations, and develop mitigating strategies to minimise perioperative nurse turnover intention.

Association between wellbeing and turnover intention among perioperative nurses

The qualitative study by Mayes and Cochran[12] identified that perioperative nurses' decisions to stay in or leave a position are influenced by factors like compensation (salaries), career growth, wellbeing and work–life balance. Of these factors, wellbeing serves as a central category because the other factors traditionally represent different dimensions of wellbeing[12]. As pictured in Figure 1, culture fostered within the department and the organisation can strongly influence the dimensions of wellbeing, consequently affecting the decision to leave[12,18]. Nurses with low levels of wellbeing are more likely to leave their organisation, whereas promoting wellbeing can strengthen work commitment and performance, thus resulting in reduced turnover intention[9]. Therefore, ensuring health care workers' wellbeing is a priority for attracting and retaining the workforce[12,13].

In their perspectives brief, Huggins et al.[13] note that a health care worker's wellbeing is influenced by intrinsic, personal factors – such as personal traits, values and social circumstances – as well as job-related elements – such as demanding work, workplace culture and co-workers. Huggins et al.[13] also identify positive feelings, job satisfaction and a sense of contentment at work as important elements of wellbeing. Among these, job satisfaction has been identified as the most critical factor in motivating and retaining health care workers[18–21].

The perioperative environment is a demanding place to work and perioperative nurses often face physical and psychological stressors. They are frequently exposed to occupational hazards such as chemicals, radiation, bloodborne pathogens, sharp objects, surgical smoke and anaesthetic gases[15,16,22,23]. The work environment is fast-paced and involves complex procedures, advanced technologies and rapid patient turnover[24–27]. Physical and psychological stress can make perioperative nurses susceptible to fatigue and burnout[26–28]. Night shift, unexpected events, excessive workloads and inadequate resources can further contribute to burnout

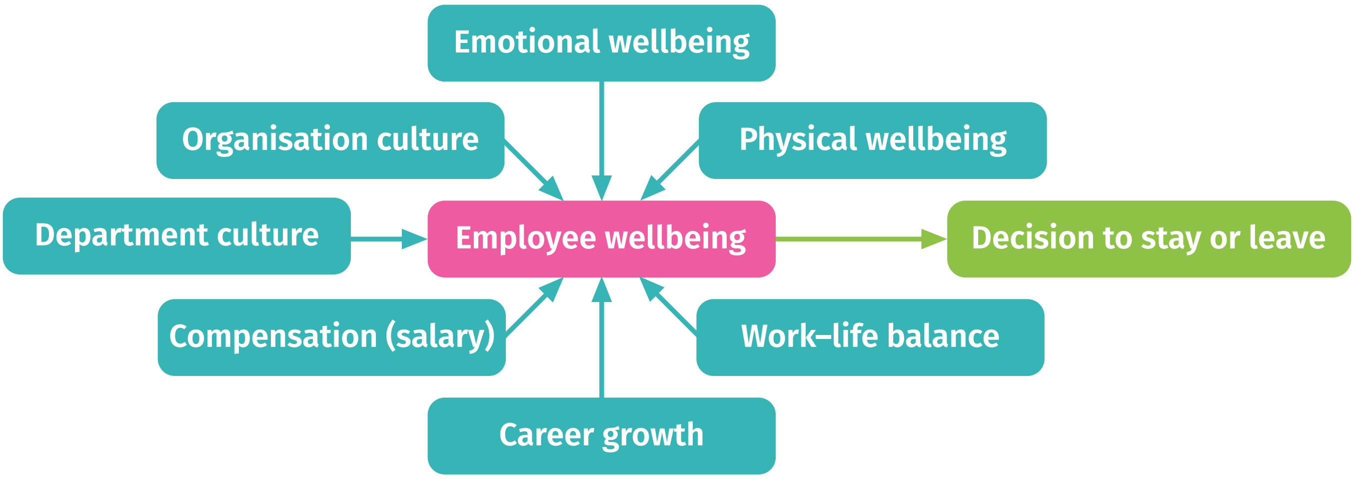

Figure 1: Factors influencing wellbeing and perioperative nurse turnover intention

Adapted from Mayes and Cochran[12] perioperative nurse turnover decision-making theory model

among perioperative nurses[29] and lead to increased turnover intention.

Workplace culture and co-workers can affect personal wellbeing. Disruptive behaviours like incivility and bullying are persistent concerns in the perioperative environment[30–37] and impact the resilience and psychological wellbeing of perioperative nurses[30,35]. An Australian cross-sectional study by Lang et al.[30] found that 61 per cent of perioperative nurses have encountered workplace bullying, a rate slightly higher than that observed in other nursing specialties across Australia. Health care professionals caution that this emotional damage can last for weeks to months[34] and, without prompt intervention, will persist[38], even lasting for five years or more[39–41]. Workplace bullying and incivility are identified as significant predictors of turnover intention among perioperative nurses[31,34,42–44].

Many factors may foster incivility and bullying behaviours in the workplace. These factors include hierarchy[31,45], disempowering work environments, lack of teamwork, workplace insecurity, ill-defined roles, misuse of organisational processes, staffing shortages and harmful alliances between parties with shared interests[45] Additionally, organisational tolerance of bullying and uncivil behaviours among high-performing individuals, facilitated by their focus on productivity and the misuse of authority, contributes to the institutionalisation of workplace bullying and incivility[46]. Significantly, bullying perpetrators often include senior nurses or individuals in higher positions[45]. Managers are frequently identified as the main perpetrators, abusing legitimate organisational processes, such as workload and performance management, to bully others in the workplace[46].

Failure to report workplace bullying and incivility perpetuates these behaviours. In their integrated review, Jones[45] highlights that the fear of retaliation prevents many victims and witnesses from reporting incivility and bullying behaviours promptly. Similarly, it has been noted that many victims hesitate to report bullying incidents, as the bullying persists despite their reports[30]. Additionally, even when incidents are reported promptly, organisations often rely on conflict-based mediation, which may overlook underlying organisational problems and inadvertently empower perpetrators[46]. This approach offers minimal protection for victims, especially when managers, who may be perpetrators themselves, are involved[46].

Given the significant link between workplace hazards and staff wellbeing, which heavily influences retention decisions, it is crucial to examine current practices aimed at promoting employee wellbeing.

Current practices to ensure wellbeing of perioperative nurses

There are a number of practices implemented to bolster the wellbeing of workers across various sectors. In their report 'The mental health and wellbeing of nurses and midwives in the United Kingdom' Kinman et al.[47] categorise wellbeing interventions into three levels: primary, secondary, and tertiary (see Table 1).

Primary-level interventions are aimed at organisations and seek to prevent or reduce the risk of negative impact on worker wellbeing.

Table 1: Wellbeing interventions levels

Intervention level	Aim of intervention	Example interventions
Primary	To eliminate or reduce work-related factors that may negatively affect wellbeing.	• organisational design of roles and management of workloads • adequate staffing, resourcing and support • organisational policies and procedures • management training • supervision and mentorship programs
Secondary	To optimise worker responses to work-related factors that may negatively affect wellbeing and reverse or delay harmful effects.	• training in mindfulness, resilience etc. (helping the individual react constructively to situations) • training in time management, assertiveness etc. (helping the individual manage their environment better) • training in procedures and using technology etc. (helping the individual develop skills they need in their work)
Tertiary	To reduce or minimise harmful effects of decreased wellbeing and restore ability to work normally.	• employee assistance programmes • counselling and therapy services • return-to work programmes

For example, through job design, workload management, policies and procedures, and supervision and mentorship[47]. Secondary-level interventions are aimed at individual workers and seek to enhance individuals' coping skills in the workplace in order to reverse or delay health problems caused by decreased wellbeing. For example, through reaction training to increase resilience, environmental management to improve time management and assertiveness, and development of work-related skills[47]. Tertiary-level interventions are aimed at individual workers and seek to rehabilitate individuals whose work has been affected by health problems caused by decreased wellbeing. For example, employee assistance programs, counselling and return-to work programs[47].

Most of the currently used interventions aimed at enhancing nurses' wellbeing are secondary-level strategies[2,48] aimed at enhancing coping skills through social support, humour, prayer/meditation[49], exercise[48,50], mindfulness and resilience training[47], and e-mental health screening[51]. Although effective in reducing stress and enhancing coping, further longitudinal studies and objective assessments are required to determine their long-term sustainability[2,47,48].

Recently, more focus has been given to tertiary-level interventions. Effective strategies reported in this domain include workers' health surveillance and consultation with occupational health physicians[51], psychological interventions through employee assistance programs[52–57], and return-to-work policies, programs and practices[58]. However, these interventions encounter challenges such as staff lacking awareness, access barriers[53,54], stigma concerns, confidentiality, lack of expertise among occupational health services, and managers disregarding return-to-work plans[47].

Secondary and tertiary interventions within health care settings that exclusively address individual behaviours may present certain limitations. These interventions primarily concentrate on individual targets, often due to the lower implementation costs for organisations[47]. The focus on altering individuals rather than the organisation itself, poses a problem as it overlooks the structural origins of stress[38,47,59]. Moreover, factors such as age, gender, resilience, personality, coping behaviours and self-efficacy have less influence on wellbeing than organisational and occupational factors[2]. While stress management and resilience-building initiatives can be effective, it is essential to acknowledge that even the most resilient nurses and midwives may find it challenging to cope with pathogenic working conditions[47,55].

Interventions aimed at the individual are also criticised for diverting attention from the collective responsibility of society to safeguard employees, and for reinforcing the status quo and relieving organisations of their duty of care[47]. Furthermore, interventions aimed at the individual suggest an individual's inability to manage workplace challenges may be perceived as a personal failure rather than recognising the influence of contextual factors like excessive work demands and limited resources[47,60]. Failure to acknowledge the influence of broader contextual factors may result in the underlying structural causes of reduced wellbeing remaining unaddressed[2]. Leaders are advised to avoid oversimplifying the challenges encountered by health care professionals and to refrain from offering generic one-size-fits-all human resources programs that do not address the specific needs of their workforce[38]. The absence of emphasis on primary-level interventions, aimed at the organisation, underscores the imperative for leaders to seek out more holistic and impactful approaches for enhancing employee wellbeing.

Recommended strategies to support wellbeing of perioperative nurses

Strategies to promote nurses' wellbeing have emerged from research conducted across various countries. The research concludes that primary interventions, that address the root causes of work stress, demonstrate greater effectiveness and sustainability compared to secondary or tertiary interventions[47]. A study about supporting mental wellbeing of nurses in the United Kingdom, recommended mostly primary interventions (57%) to be implemented at an organisational level, while only two per cent of recommended strategies were targeted at the individual worker[2].

Another study, conducted in the United States of America, supports this perspective by stressing that staff resilience is a shared responsibility at both the collective and organisational levels[38]. A systematic review that investigated the effectiveness of intervention programs aimed at improving the nursing work environment, found that interventions improving the work environment increased job satisfaction, promoted a healthy atmosphere, and enhanced care excellence and safety[61].

In Australia, the AHHA recommends that safeguarding the wellbeing of nursing staff should involve policy initiatives, interventions and ongoing monitoring at departmental and organisational levels[13]. Similarly, WorkSafe Victoria suggests that making mental health improvement projects successful involves leaders creating positive workplaces, fostering teamwork and adjusting workplace practices[62].

Sustained and comprehensive effort is necessary in health care for implementing workplace wellbeing strategies, owing to the diverse factors impacting staff wellbeing[47]. The strategies should cover all levels of the organisation and be customised to address the unique needs of individual sites, departments and teams[47]. To develop effective interventions, perioperative leaders and staff should thoroughly comprehend the factors influencing perioperative nurses' decisions to leave their positions[12]. To foster optimal professional fulfilment and workplace wellbeing, leaders should prioritise addressing organisational culture, enhancing operational efficiency and promoting resilience[13,38,59]. Besides reducing burnout[59], leaders should establish a supportive and safe culture and minimise modifiable determinants of poor staff wellbeing[13]. The hazards at work should be carefully and regularly assessed to inform and facilitate the establishment of policies and practices for safe work, and strategies to mitigate risks should be carried out and regularly assessed[13,47]. Moreover, ensuring lasting improvements entails sustained dedication throughout all organisational tiers, recognising that tangible changes may not manifest immediately[47].

Despite the existence of recognised strategies, there remains a notable lack of primary studies examining how organisations and leaders perceive, define, monitor and assess wellbeing within the perioperative nursing domain. Moreover, there is a significant gap in research investigating holistic approaches aimed at improving the wellbeing of perioperative nursing professionals.

Conclusions

In the perioperative setting, the wellbeing of nursing staff is crucial for maintaining high-quality, safe and sustainable health care. This discussion paper identifies the dimensions of wellbeing and the factors that significantly influence perioperative nurses' retention. Current interventions to maintain the wellbeing of perioperative nurses predominantly concentrate on the individual, rather than the employing organisation. This trend potentially diverts attention from organisational duty of care for their employees. Notably, departmental and organisational interventions targeting the root causes of work-related stress are proven to be more effective than interventions that focus on the individual. Considering the array of factors impacting staff wellbeing, adopting a comprehensive and sustained strategy that not only addresses both contextual and individual aspects but is also tailored to individual needs, is essential. Furthermore, the absence of primary research examining and promoting the wellbeing of perioperative nurses underscores the necessity for additional studies in this area.

Declaration of conflicting interests

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Discussion paper

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Innovative solutions for surgical education: A digital approach to health literacy and learning style assessment

Abstract

Introduction: The perioperative journey is filled with anxiety for patients, often exacerbated by poor communication and inadequate understanding of pre-operative information. Ineffective perioperative practices can lead to adverse outcomes, including poor health outcomes, increased surgery cancellations, extended hospital stays and higher health care costs. Addressing patients' health literacy levels and learning preferences is crucial for developing effective educational resources.

Discussion: This paper takes the stance that health literacy and learning needs are essential components of pre-operative assessment and workup. To achieve this, validated instruments and decision support tools must be integrated into the pre-operative workflow to assess and plan patient-centred pre-operative education. This paper proposes a digital tool to assess and measure health literacy and learning preferences, aiming to tailor educational interventions for surgical patients. By incorporating validated health literacy assessments alongside learning style questionnaires, clinicians can be provided with reputable recommendations for personalising patient education. Effective patient education, aligned with individual learning styles, enhances comprehension and engagement, ultimately allowing for improved surgical outcomes and reduced health care costs.

Conclusion: Integrating digital tools for health literacy and learning style assessment in surgical education has the potential to significantly improve patient outcomes and optimise resource utilisation. This patient-centric approach ensures personalised, effective education thus enhancing patient care and potentially reducing overall health care costs. Policymakers and health care providers should invest in the potential of these types of digital tools to promote equitable and effective health care delivery. Further research is needed to explore the development of such tools and evaluate the long-term benefits and scalability of personalised education in diverse settings.

Keywords: surgery, health literacy, learning preferences, e-health, digital

Introduction

The perioperative journey is complex, and navigating this journey can be an anxiety-provoking experience for patients. A large component of the anxiety felt by patients commences in the pre-operative period, as a result of poor communication from health care workers and a patient's inability to understand or recall information[1]. Poor pre-operative preparation can contribute to avoidable patient-initiated surgery cancellations and delayed treatment, which significantly affect a patient's physical and psychological wellbeing including undiagnosed medical issues, higher analgaesic requirements and prolonged hospital stays[2,3]. Ineffective perioperative practices can lead to adverse outcomes, which globally afflict approximately 25 per cent of surgical patients, with serious post-operative complications affecting 15 per cent and rates of readmission within 30 days ranging from 5 to 15 per cent[4,5]. As well as compromising patient wellbeing, the consequences of ineffective perioperative practices inflict considerable financial strain upon the health care system. For the benefit of both patients and health care systems, innovative pathways are required to ensure patients are adequately educated regarding their surgical procedure and understand the intricacies of the surgery journey.

Patient education is the term given to processes, involving various planned educational methods, that aim to enable patients to develop and maintain abilities to optimally manage their lives with their disease[6]. Patient education is crucial for improving health outcomes and enabling patients to engage in self-management, modify lifestyle behaviours and participate in decision-making[6,7]. Despite its importance, patient education often suffers from time constraints and a one-size-fits-all approach, leading to poor compliance and increased surgical cancellations[2]. Compounding this, traditional approaches to patient education often fail to address the diverse health literacy levels and learning preferences of patients[1,8]. Understanding patient health literacy levels and learning preferences is essential for developing effective educational resources.

Health literacy, the ability to understand and make decisions based on health information, significantly impacts surgical outcomes. Low levels of health literacy are strongly associated with extended lengths of stay, complications and reduced adherence to pre-operative instructions[9]. Although there is an abundance of information available for educating patients, the resources provided often reflect the choices and learning styles of health care providers rather than those of the patients[10]. Considering a patient's preferred learning styles – visual, auditory, or kinaesthetic – can enhance the effectiveness of educational materials. Findings from our recent study assessing the pre-operative preparation, health literacy, learning preferences and knowledge resource needs of Australian elective surgery patients, highlighted significant deficits in traditional surgical education methods, including inadequate consideration of health literacy levels and learning preferences[11]. A large proportion of the population surveyed (38%) were categorised as having either marginal or limited health literacy, which is consistent with globally reported data[9,11,12].

Digital tools offer numerous advantages in surgical education, including the ability to provide timely, validated information and facilitate patient engagement in self-managed care[13,14]. Given this, it is appropriate to suggest that digital methods for early assessment of patient health literacy levels and learning style preference prior to education provision should be further explored by health care providers. Findings from our previous study support this suggestion with a significant proportion of participants (46%) indicating they would prefer to receive digital pre-operative education[11]. Additionally, nearly all participants (92%) had access to a smartphone, and the majority (64%) reported feeling confident in using applications[11].

Although the context for this paper is surgery, there is no doubting the widespread health literacy and poor health education provision across all facets of the health care industry. Building upon our previous research, this paper proposes a concept for a digital tool for assessing patient health literacy and learning style preference and makes recommendations for clinicians about education provision.

Discussion

Proposed solution concept

This paper proposes that a digital tool for assessing and measuring health literacy, learning preferences and knowledge needs while collecting patient feedback and qualitative data before patient–clinician interactions is required to optimise patient education. This digital solution would enable clinicians to tailor educational interventions, enhancing patient understanding, engagement and health outcomes.

To achieve this and ensure clinical accuracy, the digital solution would need to incorporate one, or a combination of, validated health literacy and learning style preference assessment tools. Regarding health literacy, examples include the Test of Functional Health Literacy in Adults (TOFHLA), the Rapid Estimate of Adult Literacy in Medicine (REALM), and the Newest Vital Sign (NVS)[15–17]. These standardised questionnaires evaluate patients' comprehension of medical instructions, medication labels and health information, while categorising literacy levels into low, medium and high. Regarding learning style preference assessment, example validated tools include the VARK (visual, aural, read/write or kinaesthetic) questionnaire, Kolb's learning style inventory, and the Honey and Mumford learning styles questionnaire[18–20]. These assessments identify patients' preferred learning style as either visual, auditory, kinaesthetic or a combination of styles.

For clinicians, the digital solution would need to provide a dashboard with personalised reports displaying detailed patient profiles, health literacy levels and learning styles with recommended educational suggestions. The solution would comprise an educational resource library tailored to different literacy levels and learning styles, based upon academically validated information.

In terms of design, it is essential that a codesign approach with end-users is used to ensure the digital solution is a user-friendly interface with clear instructions, easy to navigate and ensures equitable access through such features as multilingual support, text-to-speech and adjustable font sizes[11,21]. Due to the ever-changing nature of perioperative care, the ability to update education information and incorporate other learning style theories ensures the tailored approach to patient education remains relevant. Successful implementation of such a solution is dependent on integration with existing electronic health record (EHR) systems, comprehensive training for clinicians, cybersecurity requirements and navigating organisational issues including political, cultural and financial factors[22,23].

Design brief for a digital health solution

Figure 1 is an example digital health solution. Based on our previously published study, a digital health solution would integrate the validated instruments Brief Health Literacy Screening (BHLS) tool and the Learning Channel Preference Checklist (LCPC)[24,25]. The BHLS tool is a validated tool, comprising four questions, that asks individuals to read and interpret common medical terms and concepts, and evaluates an individual's level of health literacy as limited, marginal or adequate[24]. The LCPC consists of a scoring system in which responses to questions are tallied and categorised by learning style (visual, aural and kinaesthetic)[25].

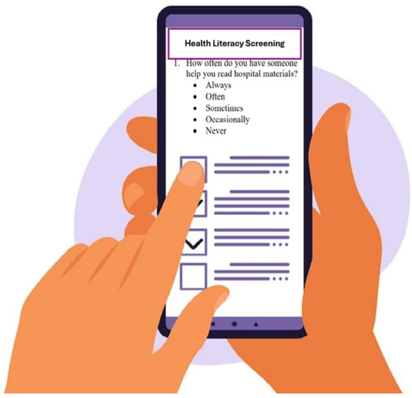

Figure 1: Example of a digital tool – survey for patients

Patients would be provided with the BHLS tool and LCPC to complete prior to their consultation, ensuring that their health literacy levels and learning style preferences are assessed in advance. The results from these assessments would be available to clinicians before the consultation, along with prompts for recommended communication methods and styles drawn from the solution's database, which is informed by extensive academic literature (see Figure 2). This approach aims to tailor the educational and communication strategies to each patient's needs, thereby enhancing patient comprehension, engagement and overall health outcomes.

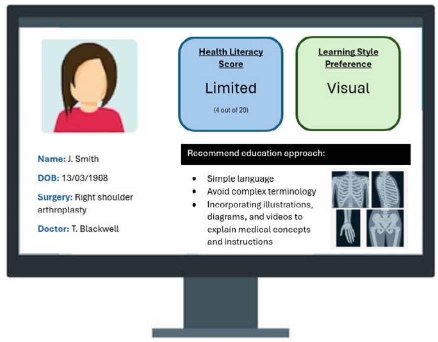

Figure 2: Hypothetical example digital tool – Clinician dashboard

A limited and marginal health literacy reading would recommend clinicians focus on providing repeated oral instructions and visual aids to overcome health literacy difficulties. Clinicians would be provided with examples of and advised to use simple language, avoiding complex terminology, and incorporating illustrations, diagrams and videos to explain medical concepts and instructions[26,27]. Repeating key instructions and confirming understanding through teach-back methods, as well as hands-on demonstrations, can enhance comprehension[28]. It is essential to provide materials written at an appropriate reading level, combining written instructions with verbal explanations and visual aids[29]. Offering additional support through one-on-one explanations or small group sessions can be beneficial.

For patients with adequate health literacy, providing comprehensive written materials, including pamphlets, booklets and online resources, caters to their informational needs and capacity[30]. Offering digital resources, such as websites, apps and online support groups, along with interactive educational sessions like workshops or webinars, can deepen their understanding and engagement[31].

Based on the patient's preference, the digital solution would recommend a learning style to clinicians and provide examples of the appropriate communications methods. Visual learners benefit from diagrams, charts, videos and written instructions. Effective methods include infographics, clear headings, bullet points, colour-coded information, visual demonstrations and recommending websites or apps with visual content[32]. Auditory learners prefer listening and verbal communication. Key strategies include verbal explanations, recommending podcasts, engaging in group discussions, repeating key points and encouraging questions with detailed verbal answers[33,34]. Kinaesthetic learners need hands-on activities. Effective techniques include demonstrations, practice sessions, physical models, activity-based learning and encouraging movement or gestures during explanations[35,36]. Ultimately, the digital solution would be able to provide any clinician with a foundation point for providing effective, relevant and appropriate education materials and enhanced communication to any patient.

To enhance the effectiveness of the digital solution, artificial intelligence (AI) could be integrated to personalise and optimise patient education and communication strategies. AI tools including natural language processing (NLP) and learning algorithms could analyse assessment data to generate tailored profiles, recommending appropriate educational materials and communication methods[37]. AI-powered chatbots and virtual assistants could provide real-time, personalised support, ensuring information is accessible and comprehensible[38]. AI could also monitor patient engagement and adapt content accordingly, offering clinicians support in decision-making and predictive insights to refine their communication approaches[39]. This integration of AI would aim to improve not only patient comprehension and engagement but also patient health outcomes through personalised educational interventions.

Importance to health care

A digital solution assessing health literacy and learning styles offers key benefits for patients, clinicians and the health care system through enhancing patient outcomes, optimising resources and increasing satisfaction and engagement. Personalised education improves patient comprehension, self-management and adherence to medical advice[40]. For health care workers, the digital solution could enhance communication and ensure an efficient use of time and resources as well as boosting patient engagement and satisfaction by tailoring educational approaches to patients. For the health care system, the improved communication and improved health outcomes can reduce readmissions, emergency visits, resource allocations and overall costs.

Despite this knowledge being known for decades, there is a lack of uptake. Effective stakeholder engagement and a co-design approach are crucial to address issues like funding and technology integration, and to align interventions with user needs[41]. Prioritising e-health interventions, despite budget constraints and resistance to change, is essential for optimising health care delivery and advancing outdated one-size-fits-all, traditional perioperative care models[2,21].

Recommendations

Policymakers should integrate health literacy and learning style assessments into health care quality standards to promote equitable and effective health care delivery. Given that assessment of patient health literacy and learning style preference prior to patient–clinician interaction is largely unexplored, this paper recommends that health care providers and policymakers should integrate digital assessment tools into pre-operative education programs. Health care institutions should develop repositories of educational resources catering to various health literacy levels and learning styles. Digital platforms can facilitate access to these resources, ensuring they are available in formats tailored to visual, aural and kinaesthetic learning styles. Further research should assess the long-term benefits of personalised education to patient adherence to instructions and health outcomes as well as health care costs. Studies should also explore the feasibility and scalability of these assessments in diverse settings.

Conclusion

In summary, integrating digital tools to assess health literacy and learning style preferences in surgical education offers a transformative approach to enhance patient outcomes. This paper highlights the deficiencies of traditional methods and the benefits of tailored, patient-centric education. By using validated instruments for health literacy and learning style evaluations, health care providers can deliver personalised, effective educational interventions, improving patient understanding, engagement and adherence to instructions. This digital approach not only enhances patient care but can also optimise resource utilisation and reduce health care costs. Policymakers and health care institutions should prioritise the development and adoption of such digital tools to promote equitable and effective health care delivery. Further research should explore the long-term benefits and scalability of personalised education in diverse settings.

Declaration of conflicting interests

The authors have declared no competing interests with respect to the research, authorship and publication of this article.

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Perioperative bladder management: Assessment of residual pre-operative bladder volume to mitigate post-operative urinary retention

Abstract

Background: Effective perioperative bladder management aims to limit post-operative urinary retention and its complications. Catheterisation, a standard treatment for post-operative urinary retention, can cause urinary tract infections and trauma. This study aimed to assess pre-operative bladder volume, compare nurse-documented and patient-reported last void times, and evaluate the influence of known risk factors, including urinary symptoms, on pre-operative bladder volume, as well as potentially identifying interventions to reduce post-operative urinary retention.

Method: Over three months, bladder ultrasound scans were performed on 200 pre-operative patients at a public hospital in Perth, Western Australia. The study followed the Standards for quality improvement reporting (SQUIRE) guidelines, and the SQUIRE checklist is declared in the materials and methods section.

Results: Most patients (79%, n = 158) had bladder volumes below 150 ml; the remainder (21%, n = 42) had volumes exceeding this threshold. Male patients had significantly higher bladder volumes than females, and there was a weak positive correlation between age and pre-operative bladder volume. Older male patients (≥55 years) were more likely to have a bladder volume of more than 150 ml than younger male patients (<55 years). No significant difference was found between nurse-documented and patient-reported last void times, validating the accuracy of nursing records. Female gender and existing urinary symptoms were not significantly associated with pre-operative bladder volumes over 150 ml.

Conclusion: Male patients aged over 55 are at increased risk of having pre-operative bladder volumes equal to or exceeding 150 ml and therefore require proactive bladder management to prevent post-operative urinary retention and reduce the need for catheterisation, which may result in infection and trauma. This study highlights the effectiveness of bladder ultrasound scans and accurate nursing documentation in assessing the risk of post-operative urinary retention, promoting informed clinical decision-making and reducing avoidable patient harm.

Impact: This study underscores the importance of pre-operative bladder volume assessment in reducing the risk of post-operative urinary retention thus minimising the need for catheterisation and the incidence of related complications, including infection and trauma.

Patient contribution: Patients reviewed and improved the written information consent form, enhancing the clarity and effectiveness of the consent process.

Keywords: bladder management, bladder ultrasound scans, pre-operative bladder volume, post-operative urinary retention, residual bladder volume, catheter-associated urinary tract infection

Introduction

Effective bladder management in the perioperative period aims to limit the incidence and complications of post-operative urinary retention (POUR) and reduce avoidable patient harm. Urinary catheterisation is a common treatment for POUR and is associated with complications, including catheter-associated urinary tract infection (CAUTI) and urinary tract trauma[1–3]. Assessment of pre-operative bladder volume by ultrasound may identify patients at risk of high post-operative bladder volume and POUR and reduce unnecessary urinary catheterisation, reducing the incidence of CAUTI and the risk of urinary tract trauma[4–8].

POUR is generally described as the inability to void in the presence of a full bladder within four hours of surgery[4 9–11]. Symptoms may include abdominal discomfort, pain and a feeling of fullness accompanied by a palpable bladder[4,9,11]. However, POUR may go unnoticed by a patient for some time, creating the necessity for vigilance in monitoring and a proactive response to evolving signs of the onset of POUR[4,12].

The prevalence of POUR in patients within the first 24 hours following surgery is reported in the range of 5 to 84 per cent, differing across surgical specialities. It is influenced by patient-related factors including age, gender and existing urinary symptoms[4,13–16]. In the general surgical population, the incidence is cited as between 3.8 and 13 per cent, increasing to 52 per cent in the colorectal surgical population and rising as high as 84 per cent in some subspecialties of orthopaedic surgery[4,15,17,18]. The reported variance in POUR is influenced by the disparity in definitions, making it challenging to extricate an authentic source of variation across factors[3,4,16,19].

Risk factors of POUR include age, benign prostatic hypertrophy, existing urinary symptoms and extended time of procedure[4,12,15,17,20,21]. Increasing age is a significant risk factor for POUR due to age-related changes such as reduced detrusor muscle contractility and increased comorbidities affecting the lower urinary tract[4,15,17,20–22]. The POUR risk may be further accentuated by additional intra- and post-operative factors, including volume and type of intravenous fluid administered, anaesthetic agents, analgesics and procedure-specific medications[3,4,15,17,20,23–25].

In addition to the increased risk of CAUTI and urinary tract trauma, complications of POUR include over-distension of the bladder which, if not relieved, may lead to longer-term detrusor muscle damage and voiding dysfunction[6,7,12,20,26]. POUR may also trigger an autonomic response resulting in increased heart rate and blood pressure and cardiac arrhythmias, which are potentially harmful to patients with existing cardiovascular pathology[6,27].

Prevention, education, early diagnosis and prompt evidence-based treatment are essential to prevent long-term harm and minimise potential complications of POUR. Regular and repeated use of bladder ultrasound scans supported by evidence-based bladder management protocols have been shown to reduce unnecessary urinary catheterisation, CAUTI and urinary tract trauma by promoting bladder emptying prior to surgery[3,4,15,28].

Aims

The study aims were to:

- identify the pre-operative bladder volume in patients transferred to the operating theatres
- identify any significant variation between nurse-documented and patient-reported time of the last void
- identify the prevalence of patients attending operating theatres with identified risk factors for POUR.

Materials and methods

Study design

A prospective observational methodology was employed. This study followed the Standards for quality improvement excellence (SQUIRE) guidelines. Institutional approval was obtained for this study as a low-risk activity (GEKO#50218).

Recruitment and consent

Patients attending operating theatres were approached in the admission ward before transfer to the operating theatre and provided verbal and written information about the study's objectives and procedures. After transferring to the pre-operative unit holding area, patients were approached again and asked if they consented to participate in the study. If they agreed, this was considered verbal consent and was documented by the researcher. Patients were excluded if they met any of the following criteria.

Exclusion criteria

Patients were excluded from the study if they:

- had an indwelling urinary catheter
- performed intermittent self-catheterisation
- had a urinary stoma
- required an emergency procedure
- reported abdominal pain
- appeared visibly distressed.

Bladder ultrasound scan

Three experienced registered nurses competent in bladder ultrasound scanning conducted the scans using BladderScan® PRIME non-invasive bladder volume instrument with ImageSense™ deep learning technology. With the patient lying in a supine position and with the abdominal muscles relaxed, the patient's pubic bone was palpated. An ample quantity of ultrasound gel was applied midline on the patient's abdomen, approximately three centimetres above the pubic bone.

The probe was gently pressed onto the lower abdomen through the gel. The probe cable was oriented at 90 degrees to the sagittal plane of the patient, and the head of the image on the probe's LCD screen was pointing toward the patient's head. When scanning an obese patient, abdominal adipose tissue was lifted out of the way of the probe and more pressure was applied. With live B-mode enabled, the scan was activated after aligning the probe to display the bladder within the optimal target area on the display screen. After reviewing the scan result, repeat scanning was performed as necessary to adjust the aim or confirm the initial measurement.

All scan results were documented in the data audit tool. Where the scan result identified a bladder volume over 150 ml, the allocated pre-operative unit nurse was informed of the scan result and it was documented on the perioperative chart. Patients were encouraged to empty their bladder, and a second residual bladder ultrasound scan was performed and recorded. The pre-operative unit nurse communicated the findings of the scans to the anaesthetist or nurse who was receiving the patient for surgery.

Audit tool and data collection

The audit tool was developed using Research Electronic Data Capture (REDCap) with field validation active to ensure that the entered data met specific standards. The data collected included patient age, gender, surgery type, expected length of operation, pre-existing urinary tract symptoms, the nurse-documented time of last void, the patient-reported time of last void, the time the pre-operative bladder ultrasound scan was performed, the pre-operative bladder volume, the time of repeated scan (if performed) and the residual pre-operative bladder volume following second scan.

In this study, a residual bladder volume of 150 ml, or greater, prior to surgery was a threshold for notification and intervention. The reasoning for this volume is that adult urine production is between 0.5 to 1.0 ml per kilogram per hour, depending on hydration status and renal function[30]. Adding urine produced during the average operation time to a pre-operative residual bladder volume of 150 ml, or greater, will result in a post-operative bladder volume of 200 to 400 ml. Residual urine of more than 250 ml is significant, while more than 350 ml puts the patient at risk of upper urinary tract dilatation and renal insufficiency[30].

The data was downloaded to IBM SPSS® Statistics (Statistical package for the social sciences) for Windows, version 29.0, for analysis after two team members had carefully cleaned the data to remove any errors or inconsistencies.

Data analysis

Data were analysed using IBM SPSS® Statistics, version 29.0. Descriptive statistics were calculated and reported as means with standard deviation (SD) for continuous, normally distributed data. Medians and interquartile ranges (IQRs) were reported for continuous, non-normally distributed data. Categorical data were summarised using counts and percentages. Differences between groups for continuous data were assessed using t-tests, while chi-square tests were used for categorical variables. Pearson's correlation coefficient was used to evaluate linear correlations. Statistical significance was set at a 95 per cent confidence level.

Ethical considerations

This study received institutional approval as a Quality Activity (GEKO#50218) from Royal Perth Bentley Group on 3 October 2023.

Results

Between November 2023 and March 2024, 200 patients scheduled for surgical procedures across 13 surgical specialities consented to participate in the study. There was approximately twice as many males (64%, n = 128) as females (36%, n = 72). The age of participants ranged from 18 to 90 years (mean = 55.09, SD±17.816). For sub-analysis, patients were categorised into two age brackets based on whether their age was less than the mean age of 55 years (44%, n = 88) or equal to or greater than 55 years (56%, n = 112).

Surgical specialty and age bracket

Table 1 shows the distribution of patients between surgical specialties. The most common specialities in the study were orthopaedic surgery (26.0%, n = 52), plastic surgery (23.5%, n = 47) and general surgery (13.5%, n = 27). Higher proportions of patients in the older age bracket were found in vascular surgery (93.3%, n = 14 of 15), gastroenterology (80.0%, n = 4 of 5) and urological surgery (70.6%, n = 12 of 17).

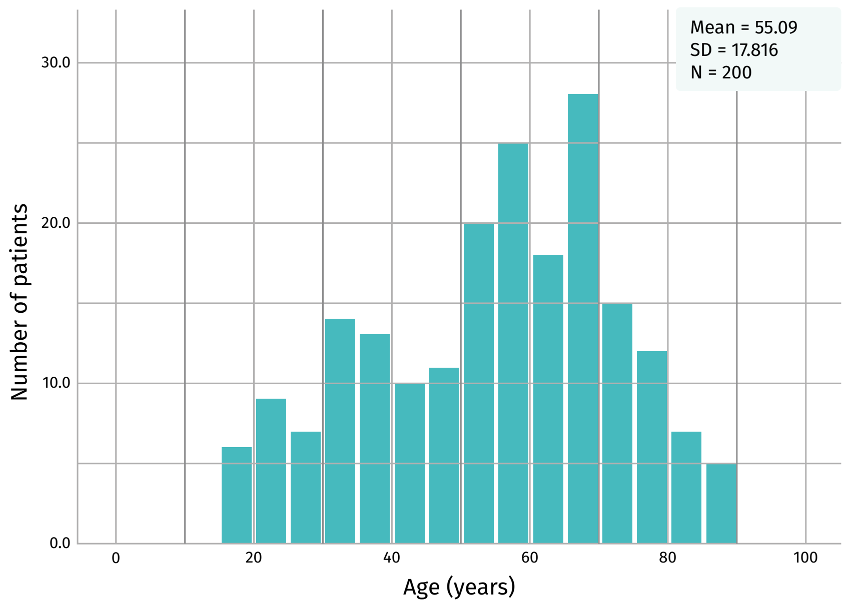

Figure 1: Age distribution of participants

Table 1: Surgical specialty and age bracket

Surgical specialty	Age < 55 years	%	Age ≥ 55 years	%
Orthopaedics (n = 52)	30	57.69	22	42.31
Plastics (n = 47)	22	46.81	25	53.19
General surgery, including breast surgery (n = 27)	13	48.15	14	51.85
Urology (n = 17)	5	29.41	12	70.59
Vascular (n = 15)	1	6.67	14	93.33
Ear, nose and throat (n = 11)	5	45.45	6	54.55
Ophthalmology (n = 10)	3	30.00	7	70.00
Maxilla facial (n = 6)	5	83.33	1	16.67
Gastroenterology (n = 5)	1	20.00	4	80.00
Respiratory (n = 3)	2	66.67	1	33.33
Colorectal (n = 3)	1	33.33	2	66.67
Endocrine (n = 2)	0	0.00	2	100.00
Gynaecology (n = 2)	0	0.00	2	100.00
Total	88		112	

Pre-operative bladder volume, gender and age bracket

Pre-operative bladder volumes ranged from zero to 900 ml (mean = 86.89, SD ± 134.895). There was a significant difference ($p = 0.004$) in mean bladder volumes between males (104.62 ml) and females (55.36 ml). There was a positive, weak correlation between pre-operative bladder volumes and age, suggesting pre-operative bladder volume increases with age ($r = 0.209$, $p = 0.003$). Of the 128 males in this study, 56 (43.8%) were less than 55 years old, and nine (16.1%) of these had a pre-operative bladder volume equal to or greater than 150 ml. Of the 72 (56.2%) males who were 55 or older, 23 (31.9%) had a pre-operative bladder volume equal to or greater than 150 ml. We found, in our cohort, that males aged 55 years or older were more than twice as likely to have a bladder volume of 150 ml or greater than their younger co-participants (OR 2.45, 95%CI:1.029,5.841, $p = 0.043$).

Of the 72 females in this study, 32 (44.4%) were less than 55 years old, and five (15.6%) of these had a pre-operative bladder volume equal to or greater than 150 ml. Of the 40 females who were 55 or older, five (12.5%) had a pre-operative bladder volume equal to or greater than 150 ml. There was no statistically significant association between age and female bladder volume.

Table 2: Pre-existing urinary symptoms and bladder volume

Patient-reported, pre-existing urinary symptoms	Urine volume < 150 ml	Urine volume ≥ 150 ml
Retention (n = 1)	1	0
Obstructed voiding (n = 5)	3	2
Enlarged prostate (n = 13)	12	1
Urinary stress incontinence (n = 4)	4	0
Urinary incontinence (n = 13)	11	2
Colovesical fistula, with pneumaturia (n = 1)	0	1
None (n = 163)	127	36
Total	158	42

Pre-existing urinary symptoms and bladder volume

Pre-existing urinary symptoms were reported by 37 patients (18.5%) and six (16.2%) of these had volumes equal to or greater than 150 ml (see Table 2).

There was no relationship between presence of pre-existing urinary symptoms and bladder volume of 150 ml or greater ($p = 0.323$). Similarly, there was no relationship between absence of pre-existing urinary symptoms and bladder volume of 150 ml or greater ($p = 0.508$). There were 36 patients with bladder volume of 150 ml or greater who had not reported pre-existing urinary symptoms. Of these, 25 patients had moderate pre-operative bladder volume ranging from 150 ml to 295 ml and the remaining 11 patients had a concerning and significant pre-operative bladder volume ranging from 388 ml to 830 ml.

Nurse-documented times of last void and patient reported-time of last void

The nurse-documented time of the last void was compared with the patient-reported time of the last void, and no statistically significant difference was found between the two ($p = 0.733$).

Surgical specialty and expected length of procedure

The majority of procedures (77.5%, n = 155) had an estimated length of less than two hours. Thirty-nine procedures (19.5%) had an expected length between two and four hours, and only six (3.0%) had an expected length of more than four hours (see Table 3).

Discussion

Our findings in this study revealed a need to properly assess pre-operative bladder volumes in order to protect patients from potential urinary tract injury, particularly male patients older

Table 3: Surgical specialty and expected length of procedure

Surgical specialty	< 2 hours	%	2–4 hours	%	> 4 hours	%
Orthopaedics (n = 52)	42	21.0	10	5.0	0	0.0
Plastics (n = 47)	44	22.0	2	1.0	1	0.5
General surgery, including breast surgery (n = 27)	18	9.0	6	3.0	3	1.5
Urology (n = 17)	12	6.0	5	2.5	0	0.0
Vascular (n = 15)	9	4.5	5	2.5	1	0.5
Ear, nose and throat (n = 11)	4	2.0	6	3.0	1	0.5
Ophthalmology (n = 10)	9	4.5	1	0.5	0	0.0
Maxilla facial (n = 6)	3	1.5	3	1.5	0	0.0
Other (n = 15)	14	7.0	1	0.5	0	0.0
Total	155	77.5	39	19.5	6	3.0

55 years. Pre-operative bladder volumes were significantly smaller in females than males.

Age and benign prostatic hypertrophy have been identified as patient-related risk factors for POUR. This study identified a two-fold risk of older males having a higher pre-operative bladder volume, putting them at greater risk for POUR and the need for catheterisation. The possible reason for this finding is that patients in this group have a high risk of having benign prostatic hypertrophy, which affects the ability to empty the bladder effectively[31], and is a patient-related risk factor for POUR. This benign condition is widespread in Australian males aged between 45 and 70 years, and is present in approximately half of all males aged over 65 years[32]. Older patients, particularly male patients, who have anaesthetics procedures, should be closely observed throughout their perioperative journey to avoid POUR.

Pre-existing urinary symptoms are also considered to be risk factors for POUR. Surprisingly, there was a lack of association between patient-reported, pre-existing urinary symptoms and pre-operative bladder volumes over 150 ml. A notable proportion of patients without pre-existing urinary symptoms (18%, n = 36) had pre-operative bladder volumes exceeding 150 ml. It became apparent during data collection that a proportion of male participants aged over 55 years did not perceive they had urinary retention or any lower urinary tract symptoms. Accordingly, this highlights the need for objective screening and avoidance of relying on patient-reported symptoms.

There are limited reports that examine pre-operative bladder volume in a mixed patient cohort such as our study. One study, of orthopaedic patients admitted through the emergency department, supported the need for regular pre-operative bladder scanning to prevent post-operative bladder distension and the need for catheterisation[33]. We found no relationship between pre-operative bladder volume and surgery type in our study. This may be because there were many surgical specialities in our study, and the procedures were deemed elective; therefore, our patient group did not match the at-risk group identified in the previous study[33].

Our study did not identify a significant difference between the time of the last void, as documented by the nurse, and the time reported by patients. Nursing documentation must be sufficiently relied upon to accurately capture the patient's voiding times. Precise documentation is essential in determining the risk of POUR and making timely decisions about bladder management. This will ensure timely patient care and safe clinical outcomes in the peri-operative environment.

There is a commonality within the literature regarding the definition of post-operative bladder distention at 500 ml or above[3, 4,15]. Identifying an acceptable and safe upper limit of pre-operative bladder volume is not as clear cut. In this study, we selected a volume of 150 ml based on the average adult urine production of 0.5 to 1.0 ml per kilogram per hour[29]. However, this would be highly variable and dependent on age, renal function, hydration status, medication and fluid administration. Joelsson-Alm et al.[33] used a pre-operative bladder volume threshhold of 200 ml when screening patients. Presently, no agreed safe pre-operative bladder volume is identified to ensure a patient will not develop bladder distension in the post-operative period. We would suggest that ongoing screening throughout the perioperative journey is vital in order to prevent POUR in patients who start their operation with over 150 ml in their bladder.

POUR poses significant economic and logistical challenges to service providers[6 7]. Patients diagnosed with POUR account for 20 to 25 per cent of unplanned hospital admissions following ambulatory general surgical procedures and have a comparatively longer hospital stay[12,34]. Managing POUR requires additional time and resources, potentially increasing health care costs and diverting staff from other critical aspects of patient care[24]. Additionally, patients with POUR may re-present to the emergency department following discharge and require additional outpatient follow-up with specialist services[12].

A potential positive proposition is to incorporate routine bladder ultrasound scanning into peri-operative protocols for male patients over 55, particularly before and after more prolonged surgical procedures and where patients have not been catheterised during their procedure. The insights from this study can inform the development of age-specific clinical guidelines and health care policies, ultimately enhancing the quality of care for ageing populations and reducing patient harm.

Limitations

We conducted this study with a sample size of 200 patients from a single tertiary public hospital in Perth, Western Australia. While this provided valuable site-specific insights, the relatively small sample and single-site focus may limit generalisation of our findings to broader populations or settings. While we found no significant difference between nurse-documented and patient-reported times of last void, minor discrepancies may exist. The study focused on measuring pre-operative bladder volumes without post-operative follow-up to assess the incidence of POUR, urinary catheterisation and urinary tract trauma. Therefore, we recommend that future studies consider a longitudinal design to track post-operative patient outcomes.

Conclusion

Detection of high pre-operative bladder volumes can be used to identify patients at risk of developing POUR so proactive bladder management can be implemented to prevent the need for catheterisation, thereby reducing patient harm. Our study found a significant positive correlation between age and bladder volume in males, indicating that bladder volume increases with age in this group. In contrast, no such correlation was found in females, highlighting a potential gender difference in bladder volume dynamics.

Our findings support targeted pre-operative bladder ultrasound scans in male patients over 55 to identify those at potential risk of undiagnosed chronic urinary retention and to tailor bladder management strategies accordingly.

Declaration of conflicting interests

The authors have declared no competing interests with respect to the research, authorship and publication of this article.

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Coordination of procedural equipment and supplies for the surgical set-up in the perioperative environment: A scoping review

Abstract

Background: Defective, incorrect or missing procedural devices from the surgical set-up contribute to delay, interruption, cancellation and patient harm in the perioperative environment.

Objective: This scoping review aims to identify evidence to guide approaches to surgical set-up used by perioperative health service personnel, organisations or teams. In addition, the review aims to describe factors that hinder or support the surgical set-up, identify gaps in the literature and determine any issues impacting the quality of available evidence.

Methods: Empirical research and grey literature were retrieved from seven electronic databases. Titles and abstracts were screened before full text screening. A mixed method appraisal tool (MMAT) and quality improvement minimum quality criteria set (QI-MQCS) were used for critical appraisal. After data extraction from included studies, key concepts were synthesised, thematically analysed and reported.

Results: Forty-nine full texts were included. Evidence generated by nurses responsible for the surgical set-up is limited. The majority of studies were quality improvement studies to reduce inefficiencies through optimisation or mathematical modelling with outcomes measured in cost and time saved. There is limited evidence exploring how optimisation or mathematical modelling impacts the work of perioperative staff.

Conclusion: Technology will continue to influence work systems and processes of the surgical set-up. Implementing surgical set-up quality indicators within policy may aid waste and cost reduction of organisations. The impact of human factors upon the surgical set-up is relatively unaddressed. Nurse-led research on the surgical set-up would be valuable as nurses are key professionals contributing to delivery of, management of and policy about surgical set up.

Introduction

The effective, safe and timely management of surgical devices is fundamental to patient outcomes. Internationally, evidence suggests problems with surgical set-up processes contribute to delay, interruption or cancellation of surgery[1–3]. Problems include inadequate information regarding surgical supplies, waste from unused opened devices and superfluous, defective, incorrect or missing surgical equipment[2, 4–6].

A surgical set-up can be a dynamic, labour-intensive process fraught with complex, time sensitive challenges in a technological environment with evolving procedural techniques[7–9]. Many staff working at different times and locations contribute to surgical set-ups; these staff include technicians, medical device representatives and nurses. Confusion about equipment and procedural information has been reported with perioperative nurses being 'busy locating equipment' at the beginning of surgical lists[4, p.3]. For example, an observational study by Rappold et al.[10] in the United States of America (USA) recorded more than 4000 surgeon preference cards were unused, contributing to ineffective procurement, unused opened devices and superfluous instruments. Evidence regarding how to best approach and organise surgical set-up processes for perioperative personnel, organisations and teams would be valuable.

The aim of this review was to examine the availability of evidence to guide the surgical set-up. Primary scholarly literature was reviewed to identify and map available evidence and describe factors that hinder or support the surgical set-up. The review also aimed to identify gaps in the literature regarding the surgical set-up and to determine issues impacting the quality of available evidence.

Methods

A scoping review guided by Joanna Briggs Institute (JBI) methodology[11] was conducted and is reported according to the PRISMA-ScR (preferred reporting items for systematic reviews and meta-analyses, extension for scoping reviews)[12]. The JBI framework of population, concept and context (PCC)[13] was used with key terms defined as:

- **population** – health service personnel, organisations, groups or teams responsible for the surgical set up
- **concept** – the surgical set-up which involves timely, coordinated organisation of single-use and re-usable medical devices (RMD), biomaterials and ancillary equipment. A set-up, or case assembly, is defined as assembly of physical resources needed for a procedure and may include opening and laying out surgical set-up items within the procedural room[14]. This includes surgical instruments, single-use isolation drapes, implants and ancillary medical equipment such as laparoscopic carbon dioxide insufflation devices[15].
- **context** – the perioperative environment. The Australasian Health Facility Guidelines[14] identify the perioperative environment to be an environmentally controlled area with one or more operating rooms to support patient procedural interventions under inhalation or other anaesthetic agents.

Types of evidence

Primary studies including randomised and non-randomised controlled trials, quality improvement projects and case, case-controlled, observational and cohort studies were eligible for inclusion. Literature reviews or discussion papers were excluded. Studies focused on testing safety and efficacy of surgical devices for patient outcomes, such as trials of new surgical devices were also excluded.

Search strategy

A three-step search strategy included an initial search of Cumulative Index for Allied Health Literature (CINAHL) and Scopus identifying medical subject headings (MeSh) for key terms within titles and abstracts[16,17]. Seven electronic databases were subsequently searched using MeSh terms: CINAHL, Joanna Briggs Institute EPD (via OPD), Scopus, PubMed, Cochrane Central Register of Controlled Trials (CENTRAL). Grey literature was sought via Overton and ProQuest Dissertations and Theses Global (PQDT)™. The search strategy used for Joanna Briggs Institute EPD database is presented as Supplement 1. With a lack of access to translators, only papers in English were included. The publication timeframe was from database inception to 25 March 2023 to permit capture of trends over time. Reference lists from included sources were examined for additional relevant literature. A PRISMA-ScR flowchart is presented in Figure 1.

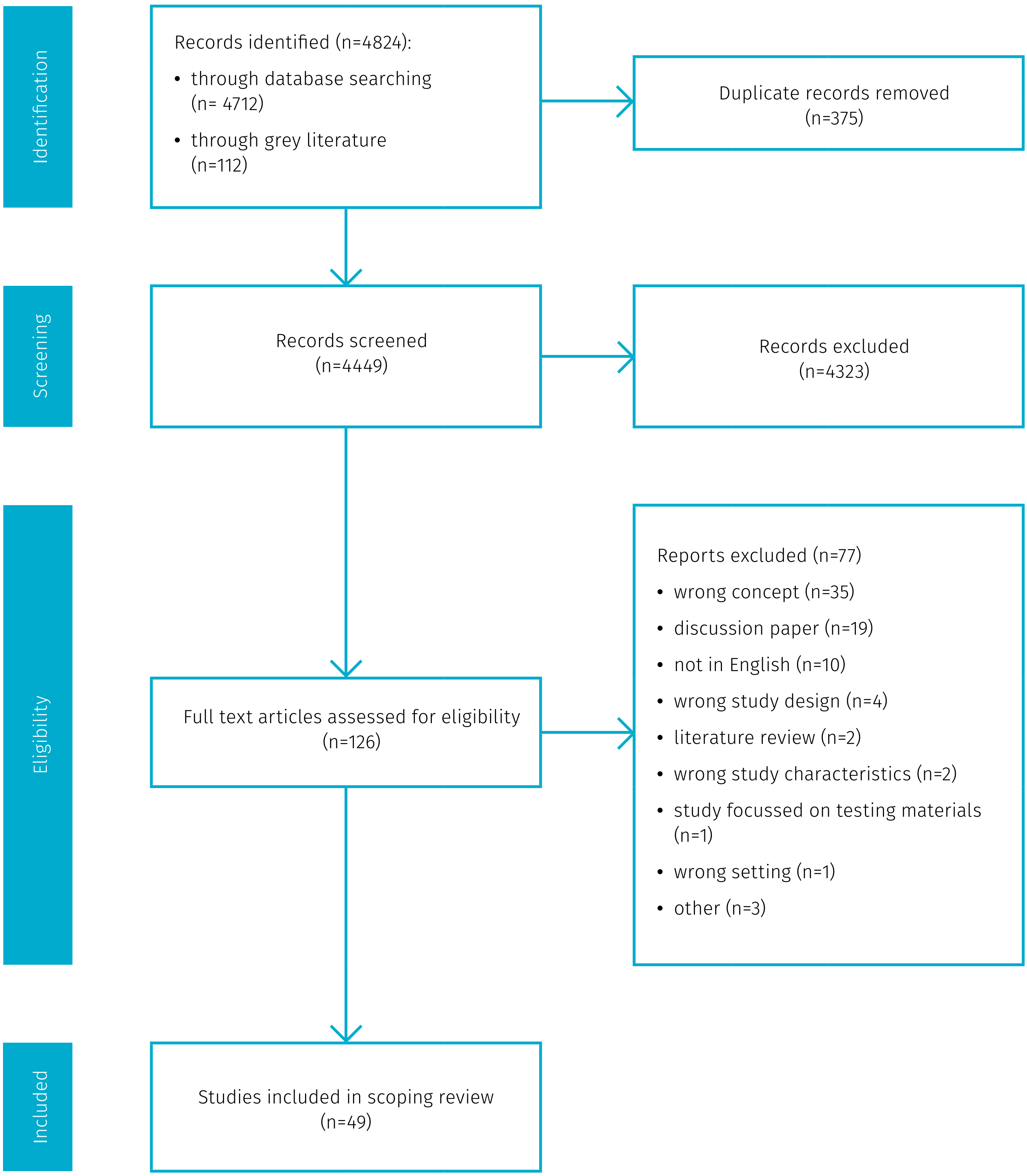

Figure 1: PRISMA flow diagram of paper selection process

Selection of evidence

Piloting of the eligibility criteria was undertaken by three reviewers (ML, JD, JM) screening three full texts followed by discussion (see Supplement 2). The eligibility criteria were rephrased for clarity prior to screening. Search results were imported to EndnoteTM and duplicates removed, then into CovidenceTM for review. Titles and abstracts were screened against the eligibility criteria by three reviewers (ML, JD, JM), then full texts were screened for eligibility by two independent reviewers (ML, JM). Disagreements were resolved through consensus. Reasons for exclusion are summarised in Figure 1.

Data charting process

An adapted JBI data extraction instrument (Supplement 3) was developed and pilot tested. Data was extracted independently from the aims of each study, and included the population, concept, context, type of evidence, citation, participants, country of origin and approaches used for the surgical set up. Factors that hinder or support a surgical set-up were also extracted from the results of each paper.

Critical appraisal

Critical appraisal was undertaken using the mixed method appraisal tool (MMAT)[18] and quality improvement minimum quality criteria set (QI-MQCS)[19] relevant to the study design. Studies were evaluated by methodology to identify trends and strengths or weaknesses.

Synthesis of results

Extracted data was synthesised into narrative and tabulated results addressing the population, concept and context outlined above. Approaches to the surgical set-up were mapped with key themes identified and narratively summarised. Factors that hinder or support the surgical set-up were thematically analysed and classified.

Results

Forty-nine papers are included in this scoping review[20–68]. Most studies were conducted in the United States of America (USA)[20–22,25–27,30–32,34–44,47,48,50,56,57,60–62,64,65,67] (n = 31).

The remainder were conducted in Europe[24,45,46,51–54,58,66] (n = 9), Singapore[29,33,63] (n = 3), Brazil[49,68] (n = 2), Canada[23,28] (n = 2), Australia[55] (n = 1) and Australia and Brazil binationally[59] (n = 1). Included studies were published over 35 years from 1986 to 2023. From 2005 the number of publications increased, with a sharp rise from 2015 (see Figure 2).

Characteristics of included studies

Supplement 4 summarises the characteristics of the included studies. Over half of included papers were quality improvement projects focused on waste minimisation[20–45] (54%, n = 26). Of these, more than three quarters aimed to eliminate inefficiencies, reduce costs and comply with the Patient Protection and Affordable Care Act[69] in the USA[20–22,25–27,30–32,34–44] (77%, 20/26).

Four mixed methods studies explored hazards or work systems responsible for re-usable medical devices, often within a human factors or failure effects model[46–49]. One mixed method study examined how physician preference card planning and communication influenced unplanned costs[50]. Nine observational studies sought to evaluate resource inefficiencies[51–59]. Four observational studies modelled the optimal number of resources needed

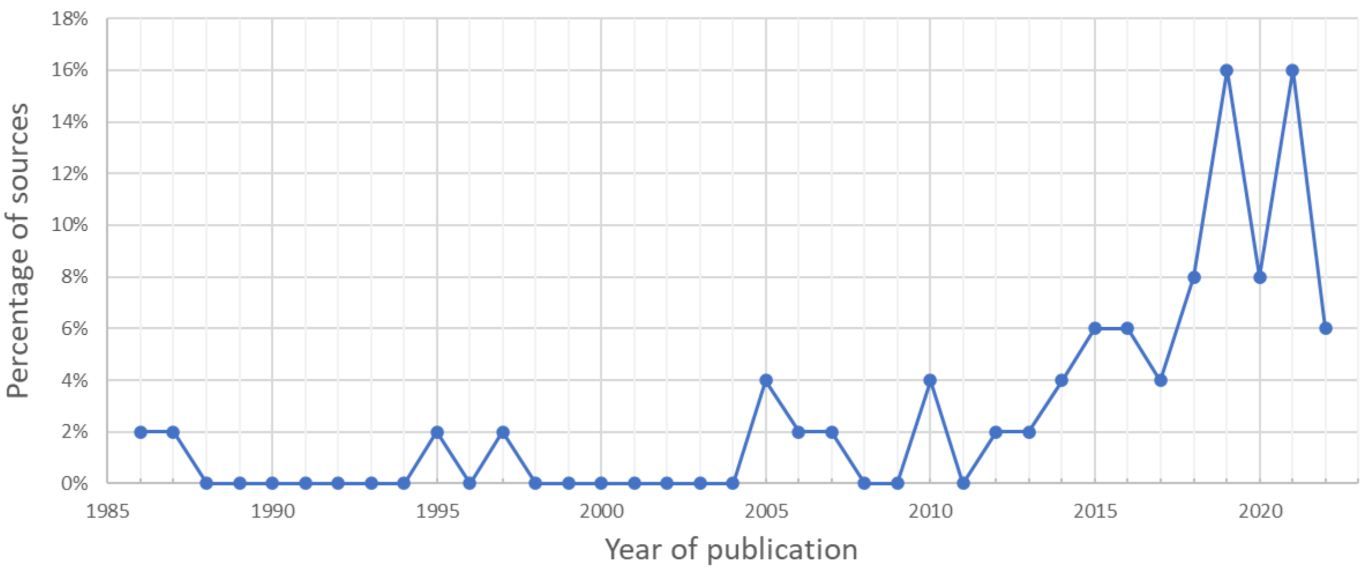

Figure 2: Distribution of published sources 1986 to 2022

to deliver surgical services[60–63]. Of three experimental studies, one compared costs between streamlined procedural and standard operating room packs[64], one compared sterility for procedural packs transported between hospital sites[65] and one analysed instrument descriptions used by nurses[66]. One qualitative study explained organisational strategies for influencing stakeholders involved in medical device procurement[67]. One case study mapped perioperative flow of instruments[68].

Factors that hinder the surgical set-up

Factors that hinder the surgical set-up are multidimensional, occurring at different times and locations throughout procedural departments. Three themes identified were waste, lack of governance and human factors.

Waste

The included studies focused on three sources of waste: medical device defects, unused opened medical devices and inefficient use of time.

Medical device defects

Eighteen types of defects were identified across seven studies[34,37,40,47,48,55,57]. The defects were classified as either sterile or non-sterile (see Table 2), according to the classification used by Palo et al.[37] where sterile defects are any problem compromising the sterile integrity of an RMD, and non-sterile defects are any problem influencing the accuracy, functionality or availability of an RMD.

Sterile defects were less frequent than non-sterile defects; the incidence of sterile defects ranged from two per cent[21] to six per cent[37] while the incidence of non-sterile defects ranged from 10.9 per cent[48] to 52.0 per cent[37].

Missing instruments was the most problematic non-sterile defect, with incidence ranging from 17.6 per cent[48] to 77 per cent[37]. One observational study[57] reported that the incidence of missing, broken or unplanned instruments or tray errors was higher (49%) when trays had over 40 instruments compared to when trays had less than 40 instruments (13%).

Unused opened medical devices

In a study of 23 commonly used orthopaedic instrument trays, Cichos et al.[22] reported low instrument utilisation resulting in waste – 23 per cent (n = 182/792) of all opened RMD were used. Across the studies, the incidence of unused opened RMDs for total knee arthroplasties varied from 13.0 per cent[57] to 54.5 per cent[32] (n = 47/87). Harris[62] reported that 70 748 instruments were opened and not used annually in a level three trauma centre with eight procedural rooms servicing 6000 procedures. A quality improvement project by Levine[31] found unused opened medical devices also included prosthetics, with 400 unused opened orthopaedic implants resulting in $425 000 lost over three years. An observational study by Chasseigne et al.[54] identified nurses' perceptions about why medical devices in the operating room were opened and unused; reasons included anticipation of surgeon needs (33%, 52/152), wrong choice or unsuitable supplies (20%, n=30/152) and aseptic mistakes (18%, n=27/152).

Inefficient use of time

A work sampling study by Ikuma[56] reported that, for 12 knee arthroplasties observed, 68 per cent (124/182 minutes) of surgical time was dedicated to preparing instruments, preparing the operating room and clean-up, compared to 54 per cent (100/182 minutes) dedicated to performing the procedure. However, authors noted the researcher was not always present when instrument preparation commenced, so instrument preparation time may be longer than reported[56]. An observational study by Chasseigne et al.[54] identified unintentional absence of the circulating nurse for up to one quarter of procedural time. Reasons for absences included

Table 2: Sterile and non-sterile re-usable medical device defects[34,37,40,47,48,55,57]

Sterile defects	Non-sterile defects
bioburden (microscopic or foreign body)	broken
contamination	damaged
instrument not disassembled	expired
missing chemical indicator	incorrect
non-bioburden debris (e.g. pen)	incorrect device pulled for set-up
	malfunctioning
	mislabelled
	mismatched instrument/set
	misplaced
	missing
	paperwork/turnover issue
	wrong storage location

additional surgeon demands (30%, n = 16/53), surgical set-up incompleteness (25%, n = 13/53), new supplies required (23%, n = 12/53), defects (19%, n = 10/53) and implant size error (4%, n = 2/53). Of 49 procedures observed by Stockert and Langerman[57] the surgeon was idle during non-operative time for 29 per cent of procedures (n = 14) due to instrument errors, with each interruption lasting eight minutes on average.

Lack of governance

The included studies highlighted a lack of governance for the surgical set-up. A health care failure model and effects analysis at two hospital sites by Guédon et al.[46] reported up to 172 hazards in the delivery of loaned orthopaedic instruments. One quarter of hazards (26%, n = 41/158) were not managed; rather, organisations reportedly accepted that adverse events may occur, with up to 31 per cent (n = 49/158) deemed high risk.[46] High risk hazards included incomplete pre-operative information in digital planning systems.[46] Only one per cent (n = 1/172) to five per cent (n = 8/158) of hazards were controlled in the delivery of loaned orthopaedic instruments across both hospitals.[46]

A cross-sectional study undertaken in Australia and Brazil by Tripple et al.[59] identified loaned devices did not conform to a recommended arrival time of 48 hours prior to surgery due to high loan turnover among health services, with approximately 63 per cent (n = 141/221) of loan devices arriving less than 24 hours prior to surgery. Alfred et al.[48] identified that the absence of instrument descriptions and photographs during sterile reprocessing resulted in incorrect or omitted instruments from trays. A quality improvement project by Prephan[40] identified instrument availability was reduced in the absence of repair and maintenance schedules.

Four studies reported routine purchasing, with no systematic data analysis to inform decision-making, encouraged excess quantities and wastage from expiration or obsolescence[22–24, 42]. Similarly, Levine et al.[31] found no records of inventory for orthopaedic implants, with unused opened implants costing $25 000 a month. A quality improvement project to standardise surgeon pick lists by Simon et al.[41] found duplicated products: five comparable laparoscopic clip appliers were stocked from three manufacturers, despite no clear clinical benefit of similar products. Del Carmen et al.[24] identified the need to address items being out of stock, stock mismatch and urgent restocking using technological inventory systems. A study modelling surgical instrument distribution for ad hoc orders[63] found that even when inventory systems were available, pre-procedural time constraints inhibited the documentation of last-minute device changes.

Human factors

Various human factors were observed to influence the surgical set-up, with themes of unaddressed communication issues and ineffective collaboration. A quality improvement project to improve instrument availability[40] identified skilled labour shortages coupled with inadequate orientation led to performance deficits for sterilisation technicians. A hazard analysis for delivery of orthopaedic loaned devices by Guédon et al.[46] found instruments were occasionally double booked suggesting a lack of multidisciplinary communication.

Two studies[48,66] reported that intra-operative comprehension of instruments decreased when nurses were temporarily assigned or unfamiliar with the surgery, or when one instrument had multiple names. Nonetheless, an observational study by Chasseigne et al.[54] reported nurses occasionally opened medical devices out of 'comfort' rather than patient need (12%, n=18/152). A quality improvement study by Nilsen[36] to determine appropriate operating theatre inventory identified that low surgical device supply generated employee stress, with staff hiding surgical cameras for fear of not having the device ready. A vicious cycle of camera unavailability persisted with impact on patients re-scheduled to an earlier start, although the exact impact was not clearly defined.

Factors that support the surgical set-up

The included studies primarily focused on optimisation – increasing procedural efficiency and reducing cost through standardisation, patient matched devices and eliminating unused medical devices[32,41,51]. One study reported initiatives to support technicians responsible for the surgical set-up included training for bioburden inspection, testing device functionality, instrument tray completeness and sterilisation processes[48]. There were no initiatives supporting professional development of perioperative nurses.

Optimisation

Twenty-one studies focused on optimisation of medical device use through eliminating unused devices, patient matched devices or standardisation, primarily in orthopaedics[20,22,32,43,45,51,52] (n = 7), otolaryngology[23,28,38,42,57] (n = 5) and various other specialities[25–27, 30, 39, 41, 44, 49, 64] (n = 9). Interventions included reducing the volume[20–23,25,27,28,32,38,39,42–45,49,51,52] (n=17) and weight[20–22,25,27,38] (n = 6) of devices on trays, with outcomes measured in time[20,21,23,25,27,28,32,35,41,42,44,45,51,52] (n = 14) and costs saved[20–22,25–28,30,32,38,39,41,42,49,51,52,64] (n = 17).

Eliminating unused devices and patient matched devices

Substantial cost savings were often achieved through eliminating unused intstruments. For example, a 30 per cent reduction (n = 31 616/106 959) in unused opened medical devices for total knee arthroplasty saved on average USD$191 434 ($18 653–$364 216) annually[32]. An observational cohort study[51] estimating the economic value of patient matched instrumentation saved 20 minutes per knee arthroplasty, or 7000 minutes annually, thereby increasing service capacity.

Dreyfus et al.[50] observed a curvilinear relationship between planning items needed for surgery and unplanned costs. Over two years, revisions to physician preference cards initially increased unplanned costs; however, unplanned costs dramatically fell after the sixth revision of physician preference cards[50]. A $5.83 billion waste reduction was achieved in this same study when physician preference cards were revised nine times over two years, with cost savings plateauing at 11 preference card revisions over the same timeframe[50].

Less frequently, studies assessed staff satisfaction when instruments were reduced or eliminated[28,42,44,45,54]. Through surveys, Wannemuehler et al.[42] identified that most scrub nurses (93.75%, n = 16) expressed satisfaction with the reduction of adenotonsillectomy instruments and, as a result, no longer needed to search through dozens of unused devices on instrument trays[42]. In their study of optimised otolaryngology surgical trays, Fu et al.[28] reported that eleven (92%) participants achieved enhanced set-up efficiency without impacting education, patient safety or operating time. An optimisation pre-post satisfaction survey by Toor et al.[44] identified that the percentage of staff members who reported that 'inventory configuration is unacceptable, and I am significantly concerned that it can affect clinical operations' fell from 48 per cent (n = 29/60) before optimisation to 3.3 per cent (n = 2/60) after optimisation[44, p.6]. Staff satisfaction surveys were conducted as part of larger studies conducted by Howard[64] and Capra et al.[20] but no results were reported.

Chasseigne et al.[54] found that waste prevention could be improved through effective communication between surgeons, instrument nurses and circulating nurses at the beginning of and during a procedure, followed by knowledge of surgical techniques.

Standardisation

Six studies explored medical device standardisation, with joint cost savings for hospitals and surgeons, in addition to vendor competitive bargaining[26,29,31,37,41,67]. Montgomery and Schneller's qualitative study[67] of physician behaviour and countering suppliers' power in purchasing devices defined models of standardisation, with methods and mechanisms to achieve standardisation. A quality improvement study by Goh et al.[29], focussed on instrument management within the sterile stock unit, found eliminating different vendors offering the same products decreased variability and duplication, resulting in a reduction from 75 general surgery sets to 45, saving S$64 000 per year while maintaining timely supply for surgery.

Staff professional development

Six studies implemented professional development opportunities for technicians responsible for the surgical set-up[29,33,35,37,48,63]. Strategies included preceptorship, training, orientation, formal education and in-service education[29,33,48]. Palo et al.[37] found technician cross-rotation, orientation and competency assessments aided reduction of non-sterile defects by 56 per cent (46.8 to 26.5 defects per 1000 cases). Staff redistribution informed by workload analysis as reported in a study by Lum et al.[33] reduced reprocessing time by five per cent (267 min/day from 89 procedures) and sterile stock room replenishment time by 29 per cent (254 minutes to 180 minutes).

Job redesign included reassignment of tasks – including delivery of instruments to operating rooms, packing, storing, decontamination and sterilisation – from nurses to technicians[33,70]. Task reassignment was proposed to enable nurses to spend more time with patients in the operating room[33,63]. Ngu[35] used weekly meetings to aid pre-operative planning for assigning preference cards, implants and medical devices to surgical cases. Goh et al.[29] found that supporting staff through successful implementation of instrument management systems increased workplace safety.

Critical appraisal of literature

Supplement 5 summarises critical appraisal of studies. Weaknesses apparent in observational studies[51–57,60–62,70] (n = 13) included limited use of reporting guidelines, unclear study design and unknown risk of non-response bias (limited response or dropout rates, and reporting of reasons for non-participation). Only six of the 26 quality improvement projects were reported according to the SQUIRE guidelines[20,23,28,37,39,71]. Patient health-related outcomes among quality improvement projects were rarely measured, despite four studies[26,27,31,32] describing patient safety and quality as a priority.

Gaps in evidence

This scoping review identified a lack of available evidence from the perspective of perioperative nurses despite their being key professionals responsible for the surgical set-up. Studies primarily reported attempts to reduce medical device waste through optimisation or mathematical modelling to support efficiency and cost reduction[20,25,51,60]; there was limited evaluation of impact on the perioperative environment, personnel responsible for the surgical set-up (including registered nurses) and patient outcomes. No studies examined organisational behaviours of perioperative team members responsible for the surgical set-up.

Discussion

This scoping review explored available evidence focused on the surgical set-up. Most included studies were organisational quality improvement projects, with outcomes of procedural efficiency measured by time and cost savings. Strategies to optimise procedural devices include elimination, standardisation and customised patient devices[72–74]. Enhancing efficiency also included mathematical modelling to predict how many people or devices are needed for surgery[60–62,75]. The review revealed the scarcity of primary research studies focusing on outcomes related to the surgical set-up, such as patient outcomes. The volume of quality improvement projects versus the lack of primary research identifies research opportunities, particularly from the perspective of intra-operative nursing as these specialties perform key roles in surgical set up processes[5,76].

An increasing volume of papers from 2005 onwards focused on waste management. This may reflect the importance of surgical set-up problems or the improvement in access to data over time, with the introduction of advanced tracking and monitoring systems[77,78]. As the complexity and diversity of procedural care evolves, solutions involving automation are increasingly common in health services. Despite numerous benefits, technology in the perioperative environment is known to negatively influence workflow[79]. Impacts to workflow include additional job demands for nurses who are also expected to be abreast of technology and troubleshooting[79–81].

The increase in technology and specialised procedures, for example patient positioning during robotic surgery, has transformed routine nursing care into a highly technical, complex and arduous responsibility[81]. Mastery of surgical set-up technology is stressful and can adversely impact the health, well-being and professional efficacy of nurses[81,82], and this impact is worthy of consideration by management. As technology and artificial intelligence continue to evolve, exploring how technology influences the work involved in a surgical set-up will require ongoing investigation as well as policy and practice reform.

A number of studies in this review implemented professional development for sterilisation technicians about the pre- and post-procedural phase[33,37,47,48,59]. However, there was limited focus on education for intra-operative nurses and other perioperative professionals. Evidence-based educational approaches are crucial for patient care and safety. Intra-operative nurses learning new technologies 'on the job' and during real time surgery is reported to cause nurses to experience fear and anxiety about harming the patient[82].

Schuessler et al.[81] recommend universally standardised training and certification for professionals involved in robotic surgeries, rather than the duration and content of education being determined by individual hospitals resulting in education of varying quality. Evidence-based methods of teaching and learning for perioperative nurses include a range of self-directed online training, high fidelity simulation, team-focused training and practice operations involving animal cadavers[83,84].

As evidenced by the focus on waste found in this scoping review, governance of the surgical set-up simply cannot keep pace with technology. The variation in physician experience and skill that influences device preferences combined with unpredictability of procedures makes it difficult to create and standardise protocols[10]. Effective governance is also made more challenging by fiscal and time constraints[10]. Subsequently, perioperative departments harbour excessive, outdated and obsolete medical devices with limited systematic organisation, and this results in waste.

A lack of governance may also be influenced by perioperative efficiency measures, such as theatre utilisation representing patient intra-operative time[85]. It is unclear if theatre utilisation metrics are reliable or useful to nurse managers, given that a number of quality improvement projects included in this review attempted to reduce intra-operative waste. The findings from this review suggest that there is a lack of efficiency measures that reflect contemporary intra-operative challenges for nursing.

Incorporating quality indicators within health service policy may be the first step in aiding governance reform for the surgical set-up. By doing so, health services can effectively streamline surgical set-up processes and optimise resources to reduce waste and costs. Examples of quality indicators for the surgical set-up include the availability and usability rates of devices and equipment[86]. Surgeon preference cards used to prepare surgical set-ups are often unreliable, with instruments added intra-operatively due to patient anatomy, contamination or error. Efforts to enhance the reliability of surgeon preference cards include frequent revision based on actual surgical requirements[25].

Without policy change, waste and inefficiencies will likely continue to impact patient outcomes such as surgical cancellations[87] and delays in emergency surgical operating lists[88]. Lost time caused by medical device waste has a knock-on effect of delaying surgery for other patients; waiting for instrument availability is a logistic factor known to influence the queue of surgical cases[88]. These delays reportedly lead to conflict between theatre managers and surgeons[88]; however, the impact on patient outcomes is not often measured.

Studies included in this scoping review suggested that unaddressed communication failures impact surgical set-up processes[27,50,54]. Although surgical devices are prescribed in advance, it has been argued that theatre nurses need more support and surgeons have passive involvement in surgical set-up processes[5,89]. Over-supply by perioperative services results in underutilisation. The volume of time and energy that perioperative nurses subsequently spend counting and managing complex medical devices is acknowledged within limited primary research[56,90]. Procedural interruptions arising from surgical set-up problems are a distraction to the surgical team and raise concerns for patient safety[1,91]. Apart from fixing excessive volume of surgical devices through optimisation downstream, there is limited research focused on proactively improving communication and collaboration between stakeholders to identify and effectively coordinate the surgical devices actually needed.

Chasseigne et al.[54] suggested that unused opened devices were mostly preventable through effective communication about the surgical set-up. Potential causes of perioperative communication failure include inadequate pre-operative preparation, lack of personnel and disruptive behaviours including the perception that nurses serve as 'secretaries and problem solvers for the whole team'[92, p. e4]. Addressing communication failures and the perception of nurses as secretaries will require a comprehensive approach to improve medical, nursing and relevant stakeholder collaboration and ensure necessary procedural devices are identified and planned in advance. Collaborative approaches must consider potential variations and unforeseen circumstance to minimise errors and omissions.

Limitations

The scoping review only included studies written in English language and therefore may be limited in generalisability in countries where English is not the first language.

Conclusions

Fixing the issue of surgical set-up waste through optimisation is a short-term solution to a complex and evolving long-term problem. Most research into the surgical set-up comprises quality improvement studies, with limited primary research available. Mathematical modelling to predict the optimal number of resources to deliver a service may be helpful from a limited management perspective; however, it does not resolve unaddressed human factors, such as communication and collaboration for the surgical set up. Addressing challenges through proactive engagement could foster a culture of effective teamwork among health care providers working towards productive and efficient surgical set-up processes and ultimately improved safety and quality of procedural care.

Declaration of conflicting interests

The authors have declared no competing interests with respect to the research, authorship and publication of this article.

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Coordination of procedural equipment and supplies for the surgical set-up in the perioperative environment: A scoping review

Supplement 1: Search strategy

Search strategy applied in Joanna Briggs Institute EPD (Via OVID)

((“Surgery+” or Surgicenters or “Surgery, Operative+” or “Robotic Surgical Procedures” or “Perioperative Nursing” or “Operating Rooms” or Hospitals+ or “Health Facilities+”) and (“Disposable Equipment” or “Equipment and Supplies+” or “Prostheses and Implants+” or “Surgical Equipment and Supplies+” or “Surgical Instruments”) and (analys* or Communication+ or efficiency or economics+ or ergonomics+ or “healthcare supply chain+” or “healthcare supply chain+” or human or management+ or “materials management” or “planning techniques+” or “quality assurance” or “quality improvement” or “resource allocation+”))

Supplement 2: Eligibity criteria

Response to questions must be ‘yes’ for paper to be included.

Question	Response	
	yes	no
1. Is the paper an empirical study?		
2. Does the context/setting include surgery in the perioperative environment? • Surgery is defined as invasive dissection of human tissue, such as an incision or excision with regional, general or sedative anaesthesia for control of pain.		
• Perioperative environment is defined as an environmentally controlled area with one or more operating rooms to support patient procedural interventions under inhalation or other anaesthetic agents[1].		
3. Does the population include health service personnel, organisations or teams responsible for the surgical set-up?		
4. Does the source include the surgical set up / case assembly concept? • Surgical set up involves the timely coordination and organisation of single-use and reusable medical devices (RMD), biomaterials and ancillary equipment. A set-up, or case assembly, is defined as assembly of physical resources needed for a procedure and may include opening and laying out surgical set-up items within the procedural room[1]. This includes surgical instruments, single-use isolation drapes, implants and ancillary medical equipment such as laparoscopic carbon dioxide insufflation devices[2].		
Eligible for inclusion?		

References

1. Australasian Health Infrastructure Alliance (AHIA). Australasian Health Facility Guidelines: Part B – Health Facility Briefing and Planning, 0520 – Operating Unit [Internet]. North Sydney: AHIA; 2016 [cited 2021 March 17]. Available from: https://aushfg-prod-com-au.s3.amazonaws.com/HPU_B.0520_5_0.pdf
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Coordination of procedural equipment and supplies for the surgical set-up in the perioperative environment: A scoping review

Supplement 3: Data extraction instrument

Adapted JBI data extraction instrument

Review objectives:

1. to identify and map available evidence for approaches to the surgical set up
2. to describe factors that hinder or support the surgical set-up
3. to identify gaps in literature, if any, regarding the surgical set up
4. to determine any issues impacting the quality of current available evidence.

PCC question: For health service personnel, organisations or teams, what are the existing evidence-based approaches and factors that hinder or support the surgical set-up in the perioperative environment?

Inclusion/exclusion criteria	
Population	
Concept	
Context	
Type of evidence	
Evidence source: details and characteristics	
Citation details	
Country	
Participants (details e.g. type/age/sex/number)	
Details/results extracted from source of evidence	
Primary aim (approaches)	
Secondary aim (approaches)	
Factors that hinder the surgical set up	
Factors that support the surgical set up	
Areas for further research	

Coordination of procedural equipment and supplies for the surgical set-up in the perioperative environment: A scoping review

Supplement 4: Summary of included studies

Author/s (year) Country	Study design	Study aim/s
Alfred et al. (2020) United States of America (USA)	mixed methods	Identify performance variation during decontamination of sterile reprocessing and identify areas for improvement.
Alfred et al. (2021) USA	mixed methods	Develop a comprehensive understanding of the assembly stage of sterile reprocessing.
Capra et al. (2019) USA	quality improvement	Evaluate the effect of surgical tray optimisation through surgeon consensus.
Chasseigne et al. (2018) France	observational longitudinal	Evaluate cost and reasons for wasted supplies and nurse circulator retrievals during surgery.
Cichos et al. (2017) USA	quality improvement	Evaluate the number of instruments sterilised and cost of standardised surgical instrument trays.
Cichos et al. (2019) USA	quality improvement	Assess the economic impact of optimising orthopaedic instrument trays.
Crosby et al. (2020) Canada	quality improvement	Identify time savings associated with surgical tray optimisation for ear, nose and throat (ENT) surgery.
Del Carmen León-Araujo et al. (2019) Spain	quality improvement	Assess inventory management for cardiothoracic surgeries with the implementation of StocKey® Radio Frequency Identification (RFID) Smart Cabinet.
Diamant et al. (2017) USA	observational longitudinal	Model re-usable medical device (RMD) inventory processes to predict optimal base stock level, expected service requirements and implied costs when RMDs are unavailable.
Dreyfus et al. (2019) USA	mixed methods	Examine how physician preference card planning and communication influences unplanned costs.
Dyas et al. (2018) USA	quality improvement	Streamlined instrument tray to optimise operative efficiency and cost for para/thyroid surgery.
Eiferman et al. (2015) USA	quality improvement	Management of operating room supplies with a shared-savings program returning 50 per cent of money saved to surgical divisions.
Friend et al. (2018) USA	quality improvement	Reduce waste of video-assisted thoracoscopic surgery (VATS). Design an instrument kit for sole use in VATS.
Fu et al. (2021) Canada	quality improvement	Optimise surgical trays for otolaryngology surgery and examine impacts to cost, operating room efficiency and patient safety.
Glaser et al. (2015) Germany	quasi-experimental	Analyse scrub nurses instrument descriptions from different surgical specialities, clinics and countries.
Goh et al. (2016) Singapore	quality improvement	Implement an instrument management system in video-assisted thoracoscopic surgery (TSSU)
Goldberg et al. (2019) USA	observational longitudinal	Model potential logistic and economic benefits of single-use instruments compared to traditional, re-usable instruments for video-assisted thoracoscopic surgery (TKA).

Author/s (year) Country	Study design	Study aim/s
Greene et al. (1987) USA	randomised controlled trial	Determine if procedural pack sterility is maintained when prepared and transported between two hospitals.
Guédon et al. (2016) Holland	mixed methods	Identify hazards in the delivery process of loaned orthopaedic surgical instruments and provide insight how information technology (IT) could support information availability and exchange.
Guimarães et al. (2016) Brazil	case study	Process mapping of VATS instruments.
Halton et al. (2014) Australia	observational longitudinal	Estimate the incidence and impact of unavailable instruments on surgical schedules and resource utilisation.
Harris (2019) USA	observational longitudinal	Model assignment of surgical instruments and trays to procedures to minimise unused instruments, instruments requested not assigned to a case and tray weight <30 lbs.
Hemingway et al. (2022) USA	quality improvement	Streamlining instrumentation through collaboration.
Howard et al. (1997) USA	quasi-experimental	Compare cost and operating time between streamlined operating room supply packs versus standard operating room packs for permanent central venous catheter (PCVC) placement.
Igesund et al. (2019) Norway	observational cross sectional	Map procedures for the set-up of instruments in sterile field.
Ikuma et al. (2020) USA	observational longitudinal	To evaluate efficiency of personnel activities and resource utilisation in TKA
Kirk (1986) USA	quality improvement	Determine if customised suture packs improved nursing efficiency and cost of cardiothoracic surgery.
Kumar and Shim (2006) Singapore	observational longitudinal	Model a new process of RMD distribution for ad-hoc orders and determine optimal number of health care assistants needed to deliver surgical instruments.
Levine et al. (1995) USA	quality improvement	To obtain cost containment through awareness and cost reduction, while maintaining and improving quality of care.
Lonner et al. (2021) USA	quality improvement	Assess economic impact of instrument tray optimisation for total joint arthroplasty (TJA).
Lum et al. (2019) Singapore	quality improvement	Identify theatre sterile surgical unit work processes, eliminate unnecessary workflow and achieve workload levelling.
Moerenhout et al. (2021) Switzerland	observational case control	Compare costs and operative time of patient-specific CT-based, single-use instruments versus conventional metal instruments for TKA.
Montgomery and Schneller (2007) USA	qualitative research	Analyse hospital strategies to shape physician behaviour and counter suppliers' power in purchasing physician preference items.
Mullaney, (2010) USA	quality improvement	Use lean principles to improve the process of supplying sterile instruments to the operating room.
Ngu (2010) USA	quality improvement	A multidisciplinary operating room project to control costs and efficiency of resources in arthroplasty surgery.
Nilsen (2005) USA	quality improvement	Determine appropriate operating room inventory and expense reduction initiatives to positively affect operational performance and staff member and patient satisfaction.
Palo et al. (2021) USA	quality improvement	Decrease instrument defect rates.

Author/s (year) Country	Study design	Study aim/s
Penn et al. (2012) USA	quality improvement	Reduce disposable waste for tonsillectomy surgery.
Pesigan et al. (2021) USA	quality improvement	Determine if editing surgeon preference cards reduced the volume and cost of opened and unused disposable items in urology.
Prephan (2005) USA	quality improvement	Improve instrument availability.
Ribes-Iborra et al. (2022) Spain	quality improvement	Investigate impact of 4S program in management of surgical instruments in trauma orthopaedic surgery.
Schneider et al. (2020) Brazil	mixed methods	Analyse the use of ophthalmic instruments and propose a management method.
Simon et al. (2018) USA	quality improvement	Designing standardised surgeon pick lists to decrease cost and equipment variability.
Stockert and Langerman (2014) USA	observational longitudinal	Quantify usage rate of instruments among common instrument trays across otolaryngology, plastic surgery, bariatric surgery and neurosurgery.
Tibesku et al. (2013) Switzerland	observational cohort study	Estimate the economic value of patient-matched instrumentation (PMI) compared to standard surgical instrumentation in TKA.
Tipple et al. (2021) Australia, Brazil	observational cross sectional	Evaluate the practices of management and reprocessing loaned devices.
Toor et al. (2022) USA	quality improvement	Implementation of surgical tray optimisation using Kotter's change model.
Ventimiglia et al. (2021) France	observational case control	Assess if single use flexible ureteroscopes used in complex endourological cases would prevent breakages and increase longevity versus re-usable flexible ureteroscope.
Wannemuehler et al. (2015) USA	quality improvement	A lean six sigma (LSS) pre-/post-intervention study to eliminate non-value-added instruments through surgeon consensus for adenotonsillectomy surgery.

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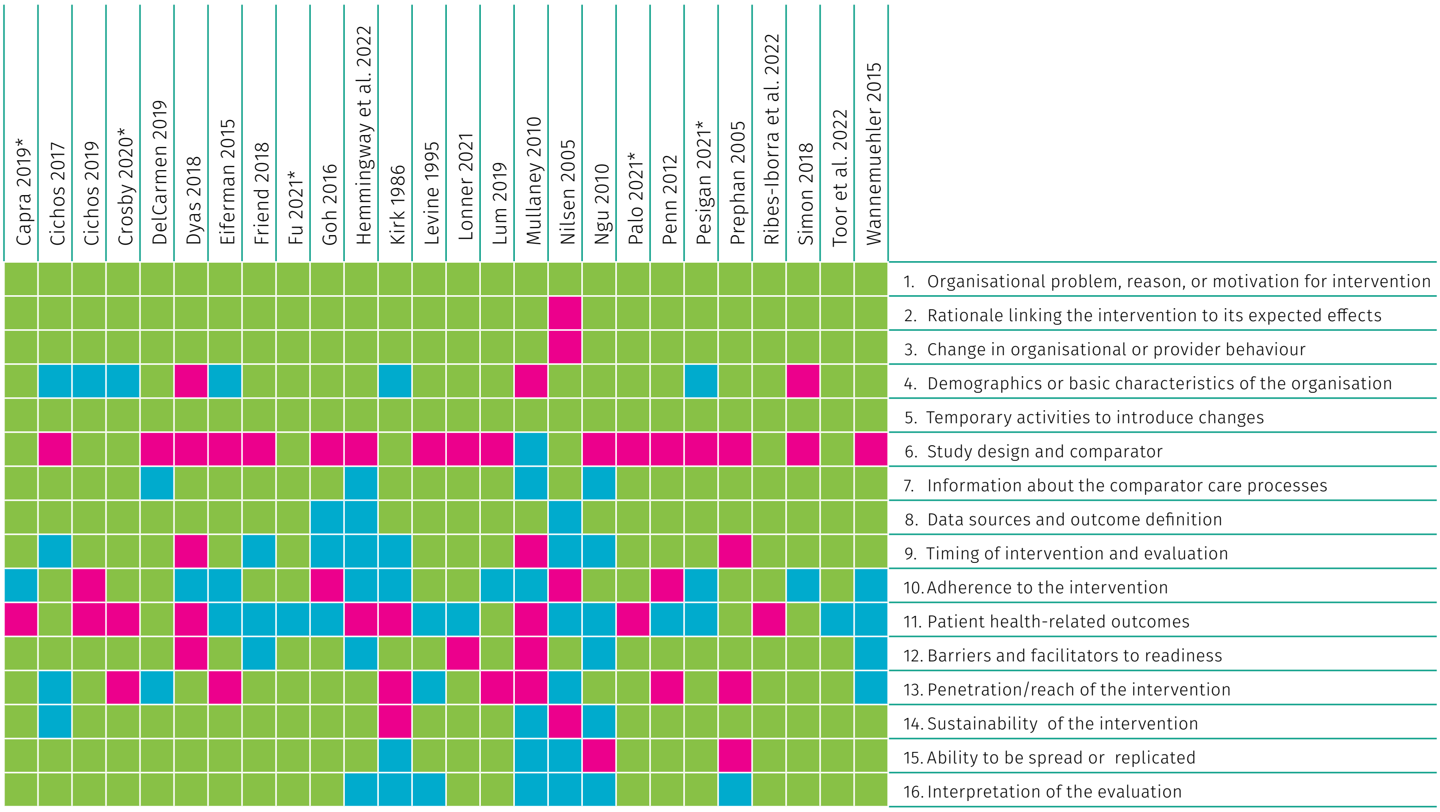
Supplement 5: Summary of critical appraisal

Quality Improvement Minimum Quality Criteria Set (QI-MQCS)[1]



NOTE: * Study acknowledged use of reporting guideline

Criterion clearly observed

Criterion not clear, or uncertain

Criterion not met

1. Hempel S, Shekelle PG, Liu JL, Sherwood Danz M, Foy R, Lim Y-W et al. Development of the quality improvement minimum quality criteria set (QI-MQCS): A tool for critical appraisal of quality improvement intervention publications [Internet]. BMJ Qual Saf. 2015[cited 2023 Dec 1];24(12):796–804. DOI: 10.1136/bmjqs-2014-003151

Mixed Method Appraisal Tool – Quantitative Descriptive[2]

Criterion	Chasseigne 2018	Diamant 2016	Goldberg 2019	Halton 2014	Harris 2019	Igesund 2019	Ikuma 2020	Kumar & Shim 2006	Moerenhout 2021	Stockert 2014	Tiple et al. 2021	Tibesku 2013	Ventimiglia et al. 2021
1. Are the research questions clear?	Observed	Observed	Observed	Observed	Observed	Observed	Observed	Observed	Observed	Observed	Observed	Observed	Observed
2. Do the collected data allow to address the research questions?	Observed	Observed	Observed	Observed	Observed	Observed	Observed	Observed	Observed	Observed	Observed	Observed	Observed
3. Is the sampling strategy relevant to address the research question?	Uncertain	Uncertain	Observed	Observed	Observed	Uncertain	Observed	Uncertain	Observed	Uncertain	Observed	Uncertain	Observed
4. Is the sample representative of the target population?	Uncertain	Uncertain	Observed	Observed	Uncertain	Uncertain	Uncertain	Uncertain	Observed	Uncertain	Uncertain	Uncertain	Observed
5. Are the measurements appropriate?	Observed	Observed	Observed	Observed	Observed	Uncertain	Uncertain	Observed	Observed	Observed	Observed	Observed	Observed
6. Is the risk of nonresponse bias low?	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Not met	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Observed
7. Is the statistical analysis appropriate to answer the research question?	Observed	Observed	Uncertain	Uncertain	Observed	Observed	Uncertain	Uncertain	Uncertain	Not met	Observed	Uncertain	Uncertain

Criterion clearly observed

Criterion not clear, or uncertain

Criterion not met

2. Hong QN, Pluye P, Fabregues S, Bartlett G, Boardman F, Cargo M et al. Mixed Method Appraisal Tool (MMAT) Version 2018 [Internet]. Montreal: McGill University; 2018 [cited 2023 Dec 1]. Available from: http://mixedmethodsappraisaltoolpublic.pbworks.com/w/file/fetch/127916259/MMAT_2018_criteria- manual_2018-08-01_ENG.pdf

Mixed Method Appraisal Tool - Mixed Methods[3]

	Alfred et al., 2020	Alfred et al., 2021	Guédon et al., 2016	Schneider et al., 2020	Dreyfus et al. 2019
1. Are there clear research questions?	Criterion clearly observed	Criterion clearly observed	Criterion clearly observed	Criterion clearly observed	Criterion clearly observed
2. Do the collected data allow to address the research questions?	Criterion clearly observed	Criterion clearly observed	Criterion clearly observed	Criterion clearly observed	Criterion clearly observed
3. Is there an adequate rationale for using a mixed methods design to address the research question?	Criterion clearly observed	Criterion clearly observed	Criterion clearly observed	Criterion clearly observed	Criterion clearly observed
4. Are the different components of the study effectively integrated to answer the research question?	Criterion clearly observed	Criterion clearly observed	Criterion clearly observed	Criterion clearly observed	Criterion clearly observed
5. Are the outputs of the integration of qualitative and quantitative components adequately interpreted?	Criterion clearly observed	Criterion clearly observed	Criterion clearly observed	Criterion clearly observed	Criterion clearly observed
6. Are divergences and inconsistencies between quantitative and qualitative results adequately addressed	Criterion not clear, or uncertain	Criterion not clear, or uncertain	Criterion not clear, or uncertain	Criterion not clear, or uncertain	Criterion not clear, or uncertain
7. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?	Criterion not clear, or uncertain	Criterion not clear, or uncertain	Criterion not clear, or uncertain	Criterion not met	Criterion clearly observed

- Criterion clearly observed
- Criterion not clear, or uncertain
- Criterion not met

3. Hong QN, Pluye P, Fabregues S, Bartlett G, Boardman F, Cargo M et al. Mixed Method Appraisal Tool (MMAT) Version 2018 [Internet]. Montreal: McGill University; 2018 [cited 2023 Dec 1]. Available from: http://mixedmethodsappraisaltoolpublic.pbworks.com/w/file/fetch/127916259/MMAT_2018_criteria- manual_2018-08-01_ENG.pdf

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Comparison of the effect of surgical site skin preparation with povidone-iodine antiseptic at two different temperatures on the microbial load and surgical site infection in laparotomy patients: A randomised controlled trial

Abstract

Background: Surgical site skin preparation is essential for reducing the skin's microbial load and preventing surgical site infection (SSI). Considering the importance of determining the effect of temperature on the antimicrobial property of povidone-iodine antiseptic, this study investigated the effect of povidone-iodine antiseptic at two different temperatures on microbial load and incidence of SSI in laparotomy patients.

Method: This study was a single-blinded, randomised, controlled trial conducted from April to July 2024 at two selected hospitals in Tehran (registration number: IRCT20240212060966N1). Laparotomy patients ($N = 126$) were randomly assigned to the control group (secondary preparation with 10% povidone-iodine at 22°C) and the intervention group (secondary preparation with 10% povidone-iodine at 35°C). The skin preparation was done in two stages (primary and secondary preparation). Both groups received the same primary preparation (7.5% povidone-iodine). Culture samples were collected before skin preparation, after the primary preparation and after the secondary preparation. A researcher-made checklist was also used to investigate the incidence of SSIs within 24 hours and 30 days after surgery. The data was analysed using Wilcoxon signed rank test, Mann-Whitney U test and Fisher's exact test.

Results: The microbial load after secondary skin preparation was significantly reduced in both the control ($p = 0.001$) and intervention ($p=0.003$) groups. However, there was no significant difference in microbial load before and after secondary skin preparation between the two groups ($p = 0.437$). The difference in SSI incidence between the two groups was not significant ($p = 0.164$).

Conclusion: Since there were no significant differences in microbial load and SSI between the two groups, it is recommended that povidone-iodine be used at room temperature for skin preparation.

Introduction

Surgical site skin preparation involves meticulous cleansing and disinfection of the surgical site with antiseptic solutions[1]. It aims to reduce the microbial load on the skin, remove debris and apply antimicrobial agents to inhibit microbial growth during surgery[1,2]. Suboptimal skin preparation with an inappropriate antiseptic solution can lead to a high microbial load remaining on the skin. As a result, the remaining microorganisms on the skin surface enter the body through the surgical incision, which can lead to complications such as infection of the surgical site[3–5].

Surgical site infection (SSI) is the second most common type of health care–associated infection (HAI), accounting for 20–31 per cent of these infections[6–8]. Despite advancements in surgical techniques, SSI remains a prevalent complication following abdominal surgeries, with an incidence rate of 25 per cent[9,10]. SSI can severely impact a patient's physical and mental wellbeing, leading to additional surgeries, increased pain and higher medical costs, while also increasing the risk of other health care–associated infections[11,12]. Depending on its severity, the cost of each SSI case can reach as high as $3000[13]. According to studies, common microorganisms causing SSIs include coagulase-negative *Staphylococcus*, *Staphylococcus aureus* and *Escherichia coli* that are typically found in the skin's natural flora[14]. Hence, safe and effective antiseptic solutions are crucial for controlling and preventing SSIs[3].

Povidone-iodine is a widely used antiseptic for surgical site skin preparation in operating rooms[15]. It has broad-spectrum antimicrobial properties, capable of eliminating a wide range of pathogens responsible for health care–associated infections[15,16]. The effectiveness of antiseptics can vary at different temperatures; however, according to studies, povidone-iodine antiseptic is as effective at 32°C as it is at 25°C[15]. It can be stored at 37°C for up to six months without reducing its available iodine content[17].

Researchers have demonstrated conflicting evidence regarding the effect of the temperature of antiseptic solutions used for surgical site skin preparation on microbial load and the rate of SSI. So, various studies have been conducted to clarify the effect of temperature on the antimicrobial properties of the povidone-iodine solution and the best temperature for its use. In a randomised controlled trial (RCT) conducted by Gezer et al.[18], the effects of chlorhexidine and povidone-iodine antiseptics were compared at two different temperatures (25°C and 37°C). They found that the incidence of SSI was significantly lower in the povidone-iodine at 37°C group compared to the 25°C group[18]. However, no significant difference was observed between the two chlorhexidine antiseptic temperature groups[18]. Hu et al.[5] conducted an RCT comparing the disinfection effect of iodophor at two different temperatures (25°C and 36°C) for surgical site skin preparation. They found that the disinfection effectiveness was higher at the higher temperature (96% at 36°C compared to 81.33% at 25°C)[5].

Leung et al.[15], conducted a study investigating the effect of temperature on the bactericidal properties of 10% povidone-iodine in two in vivo and in vitro experiment stages. They found no difference in the bactericidal properties of povidone-iodine used at 25°C and 32°C[15]. Kılıç et al.[19], in their RCT, compared the effect of 10% povidone-iodine antiseptic at room temperature and 36°C on hemodynamics and the incidence of SSI and did not find a statistically significant difference in the incidence of SSI between the two groups. A comparative prospective in vitro study by Smock et al.[16] investigated the antimicrobial effect of skin preparation solutions at different concentrations and temperatures used in burn surgeries. They did not find a significant difference in antimicrobial properties between 10% povidone-iodine solution stored at room temperature (25°C) and at 40–42°C[16].

The evidence regarding the effect of the temperature of the antiseptic solution used for surgical site skin preparation on microbial load and SSI is limited. Additionally, it is essential to identify factors that can enhance the effectiveness of the povidone-iodine antiseptic solution, which could help control and reduce SSI. Therefore, the researchers conducted this study to help provide more evidence about how the temperature of the povidone-iodine antiseptic affects the microbial load of surgical site skin and SSI rate.

Aim

This research aimed to achieve the following objectives:

1. to determine and compare the impact of surgical site skin preparation with povidone-iodine at room temperature and 35°C on the microbial load in patients undergoing a laparotomy
2. to determine and compare the effect of surgical site skin preparation with povidone-iodine at room temperature and 35°C on the SSI rate 24 hours and 30 days after surgery in patients undergoing a laparotomy.

Methods

This randomised controlled trial study was conducted at Firouzgar and Hazrat Rasul Akram, two medical training centres affiliated with Iran University of Medical Sciences, in Tehran, Iran, from April to July 2024. The study included 126 participants who underwent a laparotomy, which involved making incisions in the abdomen or pelvis. The researchers randomly divided the participants into a control group (n = 63) and an intervention group (n = 63) using a computer-generated table of random numbers. Those with even-numbered assignments were placed in the control group, while those with odd-numbered assignments were placed in the intervention group.

The skin preparation was conducted in two stages – primary preparation, using 7.5% povidone-iodine, and secondary preparation, using 10% povidone-iodine. In the control group, the secondary skin preparation was performed using 10% povidone-iodine at 22°C; in the intervention group, the secondary skin preparation was performed using 10% povidone-iodine at 35°C. In this study, a single-blinding method was used to ensure that the participants were unaware of the antiseptic solution temperature used for them. However, the researcher and the surgical team were aware of the specific temperature of the antiseptic used for each patient.

The required sample size was obtained from the following formula:

$$n_1 = \frac{(r+1)}{r} \times \frac{\sigma^2 (Z_{1-\beta} + Z_{\alpha/2})^2}{(d)^2}$$

With a power analysis of 80 per cent ($Z_{1-\beta}$ = 0.84), the Type I error of 5 per cent ($Z_{\alpha/2}$ = 1.96), a 1:1 ratio of group size (r = 1), and the effect size (d/σ) of 50 per cent, the required sample size for each group (n_1) was estimated to be 63 individuals. Therefore, the total sample size across the two groups (intervention and control groups) was 126 individuals.

Inclusion and exclusion criteria

The inclusion criteria for patient enrolment in this study were individuals aged 18 to 55, willing to participate, possessing at least a diploma as a minimum educational qualification, having a body mass index (BMI) of less than 35 and undergoing elective laparotomy surgery. The patient's level of education affects their understanding and adherence to surgical wound assessment instructions for recording SSI symptoms after discharge. Additional criteria included not having diabetes, no immune system deficiencies, no use of immunosuppressive drugs, no local or systemic infections, no history of allergies to povidone-iodine antiseptic and absence of severe skin rashes or lesions at the surgical site.

Participants who had used broad-spectrum antibiotics within one month before surgery were excluded due to possible effect on microbial load. Participants with urgent or contaminated surgeries, such as gastrointestinal tract perforations or peritonitis, and participants with colostomy, were excluded from the study due to the effect of these cases on the microbial load and the higher risk of infection. Participants who chose not to continue their participation were also not included in the study.

Data collection tools

Data collection tools comprised a demographic characteristics form, which gathered information on the following variables: age, gender, marital status, education level, BMI and household income. The microbial load registration form included the results of microbial cultures from the skin of the surgical site before skin preparation, after primary preparation (7.5% povidone-iodine) and finally after secondary preparation (10% povidone-iodine at room temperature or 35°C). The form for recording the symptoms of SSI (based on symptoms by the Centers for Disease Control and Prevention) was designed by Amiri et al.[14] and consisted of presence or absence of a high fever (above 38.5°C / 101.3°F), chills, pain, redness, swelling at the incision site and pus with an unpleasant odour discharging from the surgical wound.

The data collection forms were edited based on the evaluations and corrective comments of ten faculty members and experts in the field, and the validity of the forms was examined. To verify the reliability of the SSI symptoms form, the researcher and one of her colleagues independently observed the surgical sites of ten participants who underwent laparotomy after the surgery. They recorded the symptoms of SSI in the mentioned form. Then, the results were compared for reliability verification, and the similarity of the results was approved.

Microbiological culture sampling

The researcher who performed skin preparation and sampling wore a sterile disposable surgical gown and gloves. The microbial culture samples were obtained from an approximately 10 cm x 10 cm surface of the skin of the abdomen at the surgical incision site and periphery. Microbial culture samples were collected at three stages: before surgical site skin preparation, after the primary preparation and after the secondary preparation.

Sterile swabs were moistened with sterile normal saline and rubbed on the skin for 15 seconds in a circular motion to collect samples. Immediately, the swab was drawn over the entire surface of a sterile blood agar plate supplemented with sheep blood (5%). The microbial culture samples were kept cold and immediately transferred to the laboratory. The blood agar cultures were then incubated at 37°C for 24 hours. If no bacterial growth was observed, they were incubated for another 24 hours. After incubation, the bacterial colonies were counted under adequate illumination to ensure optimal visibility. Bacterial growth was quantified in terms of colony-forming units per unit of area (CFU/cm^2).

Interventions

In both groups, a baseline bacterial sample was obtained from the skin at the surgical site before initiating the surgical site skin preparation. This work involved swabbing the skin with a sterile, saline-moistened swab and then drawing the swab over a blood agar culture medium, as previously described.

In both control and intervention groups, the surgical site skin preparation process was performed with povidone-iodine antiseptic after induction of anesthesia and proper positioning. The equipment used for skin preparation included sterile gowns and gloves, a sterile preparation set containing sponge forceps and gallipot, and simple sterile gauze pads (without radiopaque lines). The operating room temperature was 24°C.

The skin preparation process had two stages – primary and secondary. In both the control and intervention groups both stages of skin preparation were performed using a standard concentric circular technique, beginning at the centre of the proposed surgical incision site and progressing outward to the periphery with three separate simple sterile gauze pads. According to the Association of Surgical Technologists' recommendation[20] and in concordance with the manufacturer's instructions, the antiseptic solution was wiped away using a sterile dry cloth after five minutes.

The primary skin preparation consisted of applying 7.5% povidone-iodine solution at room temperature in both groups. After the primary skin preparation, a second bacterial sample was taken from the surgical site in both groups using the same method as was used for taking the baseline bacterial sample.

The secondary skin preparation consisted of applying 10% povidone-iodine solution. In the control group, the solution was applied at room temperature. In the intervention group the solution was applied at 35°C after the unopened plastic bottle of solution had been warmed in an electric thermostatic water bath for 30 minutes. The temperature of the pre-warmed solution was measured with a laser thermometer before use.

Finally, the third bacterial sample was obtained from the surgical site using the same method in both groups. The surgical site was then draped, and the surgical procedure was commenced. The culture samples taken from both groups were immediately transported to the laboratory for microbial load determination.

Twenty-four hours after surgery, the researcher and doctor changed the dressing on the surgical site for the first time. They carefully examined the surgical area for any signs of SSI and recorded their observations on the SSI symptoms form to document the symptoms.

Following the surgery, the patient received guidance on assessing and observing the surgical site. They, or their caregivers, were given the SSI symptoms form to track any potential signs of SSI that could appear within the first month (30 days) after surgery. This form enabled the patient to routinely check the surgical site and record any symptoms or issues of concern. The researcher followed up on the patient's condition for 30 days. At the end of 30 days, the researcher collected the form by making phone calls to participants, contacting the participants or their caregivers through messaging apps or visiting the clinics in person to meet participants at outpatient visits.

Finally, the microbial load and incidence of SSI of the control and intervention groups were compared. In this research, there was no missing data and all samples were present until the end of the follow-up process (see Figure 1).

Statistical analysis

Data analysis was performed using SPSS version 16.0. Descriptive statistics were calculated to describe the characteristics of the participants, including mean, standard deviation, median, frequency, quartiles and percentages. The Kolmogorov-Smirnov test was used to evaluate the normality of the data.

Due to the non-normality of the microbial load data, the Wilcoxon signed-rank test was used to compare the microbial load between skin preparation stages in each group. The Mann-Whitney U test was

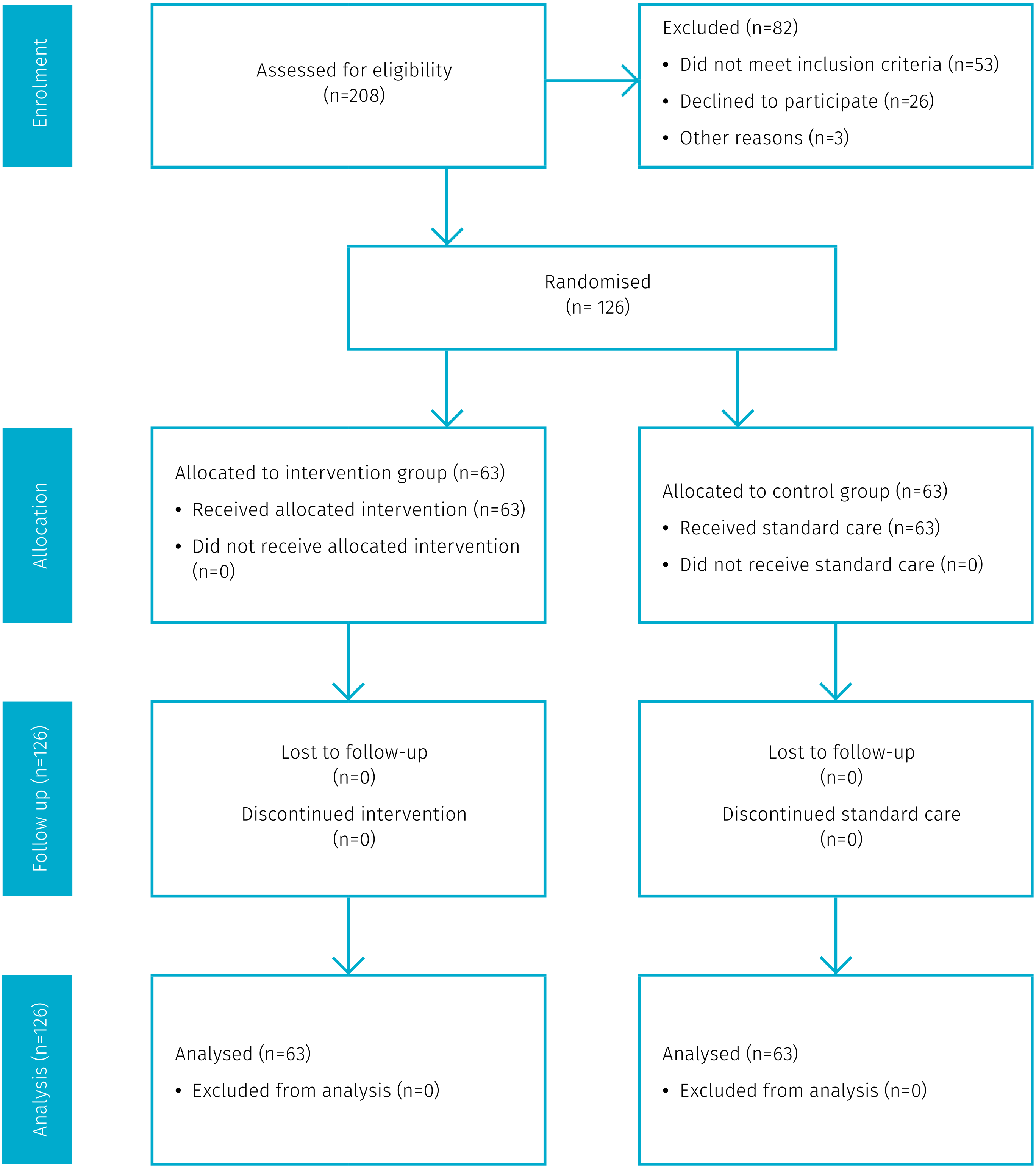

Figure 1: CONSORT research flow diagram

used to compare the microbial load of skin preparation stages between groups. Bonferroni correction was applied to the Wilcoxon and Mann-Whitney U tests and the significance level in these two tests was $p < 0.016$. Additionally, the microbial load results are presented in the tables as the median (first quartile and third quartile) due to the non-normality of the data. Fisher's exact test was used to compare the SSI rates between the control and intervention groups. The threshold for statistical significance in this test was $p < 0.05$.

Ethical considerations

Ethical approval for this study was granted by the Research Ethics Committee of Iran University of Medical Sciences, Tehran, Iran (code: IR.IUMS.REC.1402.1008). The study was also registered with the Iranian Registry of Clinical Trials Registration Centre (number: IRCT20240212060966N1). Before participation, participants received a clear explanation of the study's purpose and provided written informed consent. They were assured of their right to voluntary participation and withdrawal at any time. The research complied with the ethical standards outlined in the Declaration of Helsinki that guides medical research involving human subjects[21]. In the data analysis sheets, participants were assigned numerical labels ranging from 1 to 126; thus, participant information remained confidential. Archived data collection forms were securely stored offline only.

Results

Demographic characteristics

Table 1 shows the demographic characteristics of the 126 participants. Just over half of them (50.8%) were women, most (60.3%) were aged between 45 and 55 years, most (77.8%) were married, close to half (48.8%) had diploma degrees and most (78.6%) stated that they had enough income. The BMI of nearly half the participants (44.4%) was between 18 and 22 kg/m^2 and the average BMI of all participants was 28.4±3.72 kg/m^2.

Microbial load

Bacteria grew in 62 (98.41%) of 63 cultures of samples taken before skin preparation in both the control group and the intervention group.

Table 1: Demographic characteristics of participants in the control and intervention groups (N=126)

Characteristic		Control (n = 63)	Intervention (n = 63)	Total (N = 126)
Age (in years)	mean±SD median (min–max)	42.08±10.35 43 (21–55)	46.97±10.71 52 (18–55)	44.52±10.77 47 (18–55)
Gender (frequency and percentage)	female	33 (52.4%)	31 (49.2%)	64 (50.8%)
	male	30 (47.6%)	32 (50.8%)	62 (49.2%)
Marital status (frequency and percentage)	married	47 (74.6%)	51 (81%)	98 (77.8%)
	single	16 (25.4%)	12 (19%)	28 (22.2%)
Education level (frequency and percentage)	diploma	29 (46%)	32 (50.8%)	61 (48.4%)
	associate degree	8 (12.7%)	12 (19%)	20 (15.9%)
	bachelor degree	24 (38.1%)	16 (25.4%)	40 (31.7%)
	master's degree	2 (3.2%)	3 (4.8%)	5 (4%)
Income (frequency and percentage)	sufficient	51 (81%)	48 (76.2%)	99 (78.6%)
	insufficient	12 (19%)	15 (23.8%)	27 (21.4%)
BMI (kg/m2)	mean±SD median (min–max)	25.3±3.99 25 (19–34)	24.3±3.38 24 (19–34)	28.4±3.72 24 (19–34)

SD = standard deviation

Of the samples taken after the secondary stage of skin preparation, bacteria grew on nine of 63 (14.28%) cultures in the control group and six of 63 (9.52%) cultures in the intervention group. Eleven culture samples (six from the control group and five from the intervention group) were incubated for an additional 24 hours to detect bacterial growth not evident after the initial incubation.

The normal microbial load of skin can vary according to body region and skin type[22]. Bacterial counts can also differ depending on ecological and individual factors[22,23]. Approximately 4×10^4 CFU/cm^2 is the average bacterial count on human abdominal skin[24,25]. This study compared the microbial load present at three stages – before skin preparation, after primary skin preparation (with 7.5% povidone-iodine solution) and after secondary skin preparation (with 10% povidone-iodine at two different temperatures – room temperature and 35°C). Table 2 summarises these comparisons.

Comparison of microbial load at skin preparation stages

In the control group, the median of the microbial load before skin preparation was 200, with a first quartile (Q1) of 50, a third quartile (Q3) of 1000 and a range of 2000 (min = 0, max = 2000). The median of the microbial load after primary skin preparation was zero, with Q1 of zero, Q3 of one and a range of 50 (min = 0, max = 50). After the secondary skin preparation using the solution at room temperature, the median of the microbial load was zero, with Q1 of zero, Q3 of zero and a range of 40 (min = 0, max = 40).

The microbial load in the control group after primary skin preparation was significantly reduced compared to before skin preparation ($W_1 = 0.00$, $P_1 < 0.001$). The microbial load after the secondary skin preparation was also significantly reduced compared to after the primary skin preparation ($W_2 = 13.50$, $p_2 = 0.001$). And the microbial load after secondary skin preparation was significantly reduced compared to before skin preparation ($W_3 = 1.00$, $P_3 < 0.001$).

In the intervention group, the median of the microbial load before skin preparation was 120, with Q1 of 32, Q3 of 700 and a range of 2000 (min = 0, max = 2000). The median of the microbial load after primary skin preparation was zero, with Q1 of zero, Q3 of zero and a range of 100 (min = 0, max = 100). The median of the microbial load after secondary skin preparation was zero, with Q1 of zero, Q3 of zero and a range of 30 (min = 0, max = 30).

The microbial load in the intervention group after primary

Table 2: Comparison of microbial load at three skin preparation stages and using solution at two different temperatures (N=126)

Stage / Solution temperature	Microbial load (CFU/cm^2) median (first quartile to third quartile range): Before skin preparation	After primary preparation	After secondary preparation	Wilcoxon signed rank test (W)	p value (0.016)
room temperature (control, n = 63)	200 (50–1000)	0 (0–1)	0 (0–0)	$W_1 = 0.00$ $W_2 = 13.50$ $W_3 = 1.00$	**$p_1 < 0.001$** **$p_2 = 0.001$*** **$p_3 < 0.001$***
35°C (intervention, n = 63)	120 (32–700)	0 (0–0)	0 (0–0)	$W_1 = 0.00$ $W_2 = 20.50$ $W_3 = 0.00$	**$p_1 < 0.001$** **$p_2 = 0.003$*** **$p_3 < 0.001$***
Mann-Whitney U-test (U)	U = 1877.00	U = 1894.00	U = 1895.00		
p value (0.016)	p = 0.599	p = 0.572	p = 0.437		

W_1/p_1 = before skin preparation compared with after primary skin preparation, W_2/p_2 = after primary skin preparation compared with after secondary skin preparation, W_3/p_3 = before skin preparation compared with after secondary skin preparation

* It should be noted that due to the existence of non-zero data in the microbial load after primary and secondary skin preparation stages in both groups, despite the median and the first and third quartiles being zero, the ranking of the data for each stage in the Wilcoxon test was different. As a result, when these stages were compared, the difference was statistically significant.

skin preparation was significantly reduced (W_1 = 0.00, p_1< 0.001). The microbial load after the secondary skin preparation was also significantly reduced compared to after the primary skin preparation (W_2 = 20.50, p_2 = 0.003). And the microbial load after secondary skin preparation was significantly reduced compared to before skin preparation (W_3 = 0.00, p_3 < 0.001).

Effect of solution temperatures on microbial load

The median microbial load before skin preparation in the control group was 200 (Q1 = 50, Q3 = 1000) compared to a median of 120 (Q1 = 32, Q3 = 700) in the intervention group; however, this difference was not statistically significant (p=0.599). After primary skin preparation, the median microbial load in the control group was zero (Q1 = 0, Q3 = 1) while the intervention group had a median of zero (Q1 = 0, Q3 = 0). Again, this difference was not statistically significant (p=0.572). Similarly, after secondary skin preparation, the median microbial load in the control group was zero (Q1 = 0, Q3 = 0) while the intervention group had a median of zero (Q1 = 0, Q3 = 0), and this difference was also not statistically significant (p=0.437). As a result, the difference in the microbial load before and after skin preparation was not statistically significant between the control and intervention groups.

Effect of solution temperatures on surgical site infection

There was no difference between the control group and the intervention group in terms of SSI within 24 hours after surgery as there were no infections within that time in either group. In the 30 days after surgery, SSIs were detected in nine (7.1%) of the 126 participants – seven (11.1%) in the control group and two (3.2%) in the intervention group (see Table 3). However, this difference was not statistically significant (p = 0.164).

Discussion

Surgical site infection is a critical and persistent challenge for health care professionals and the global health system, demanding evidence-based and comprehensive solutions. Appropriate surgical site skin preparation is crucial for preventing SSI. Understanding factors like antiseptic solution temperature can optimise the effectiveness of skin preparation, improving patient outcomes and lowering health care costs.

This study compared the microbial load present before skin preparation, after primary skin preparation (with 7.5% povidone-iodine solution) and after secondary skin preparation (with 10% povidone-iodine solution). The study also compared the microbial load and incidence of SSI after using skin preparation solution at room temperature (control group) and 35°C (intervention group).

According to our results, the microbial load was significantly reduced after secondary skin preparation compared to before skin preparation in both groups. Also, the microbial load after secondary skin preparation using solution at 35°C was not significantly different to the microbial load after secondary skin preparation using solution at room temperature. Based on our findings, using 10% povidone-iodine solution at 35°C rather than room temperature did not affect its antimicrobial properties, and this antiseptic solution could significantly reduce the microbial load of the surgical site skin at both temperatures.

Our findings add to the growing body of literature regarding antiseptic solution temperature in surgical site skin preparation and were consistent with most other studies. Leung et al.[15], in their two-stage in vitro and in vivo study, did not find a difference in the bactericidal properties of 10% povidone-iodine at 25°C and 32°C (0 CFU/plate after disinfection in both groups). Smock et al.[16], in their comparative prospective in vitro study, did not find a significant difference in the antimicrobial

Table 3: Comparison of surgical site infection rates using solution at two different temperatures (N=126)

Solution temperature	Surgical site infection rate frequency (percentage): During 24 hours after surgery	Surgical site infection rate frequency (percentage): During 30 days after surgery	Fisher's exact test (FE) p value (0.05)
room temperature (control, n = 63)	0 (0%)	7 (11.1%)	FE = 2.991 p = 0.164
35°C (intervention, n = 63)	0 (0%)	2 (3.2%)	

efficacy of the 10% povidone-iodine solution stored at room temperature (25°C) compared to the solution stored at 40–42°C. Wistrand et al.[26] conducted an RCT investigating skin microbial colonisation after skin disinfection using preheated (36°C) and room temperature (20°C) chlorhexidine-alcohol solution in cardiac pacemaker implantation surgery. They reported no difference in the incidence of skin microbial colonisation – the proportion of participants with microbial growth was the same (28.6%) in both groups[26]. In contrast, an RCT by Hu et al.[5] showed that surgical site skin disinfection was more effective with the iodophor at 36°C (96%) compared to 25°C (81.33%).

With regard to the incidence of SSI 24 hours and 30 days after laparotomy surgery, we found the difference between the two groups was not statistically significant. In line with our results, an RCT by Kılıç et al.[19] found no significant difference in SSI rate between caesarean section patients who received skin preparation with 10% povidone-iodine at room temperature and those who received skin preparation using the solution at 36°C. Similarly, Wistrand et al.[26] did not find a significant difference in the incidence of SSI when comparing chlorhexidine-alcohol solution used at room temperature and 36°C. In contrast, Gezer et al.[18] reported that using povidone-iodine antiseptic at 37°C on surgery patients with malignant and premalignant gynaecologic conditions led to fewer SSIs than using it at 25°C. Patients with gynaecological malignancies are at a higher risk of developing SSIs due to factors such as older age, higher BMI and the presence of other health conditions[18].

Hypothermia can delay wound healing and create a suitable microenvironment for infection development by causing vasoconstriction and reducing tissue oxygenation[27–29]. Current evidence on warm disinfection to prevent hypothermia is limited, particularly regarding its effectiveness and patients' experiences during surgical site skin preparation[30]. Wistrand et al.[30] found that warm disinfection, using 38°C chlorhexidine, resulted in the skin losing less heat than using chlorhexidine at 20°C (-1.4°C after warm disinfection versus -2.5°C after room-temperature disinfection). Also, participants reported experiencing less discomfort after being disinfected with chlorhexidine solution at 38°C[30].

Hu et al.[5] reported that the body temperature of participants was higher after skin preparation using iodophor at 36°C than using it at 25°C (36.24°C after 36°C disinfection versus 35.67°C after 25°C disinfection). In addition, , fewer patients reported their skin feeling cold after skin preparation when the iodophor was used at 36°C than when it was used at 25°C (2.67% after 36°C disinfection versus 12.00% after 25°C disinfection) .[5] Although we did not observe a significant difference between the control and intervention groups regarding microbial load and incidence of SSI, our research outcomes add to the growing evidence into warm disinfection.

Limitations

A limitation of this study was that the temperature of the 7.5% povidone-iodine solution could not be altered during primary skin preparation due to the effect of temperature change on the antiseptic solution's effectiveness. Another limitation of the study was the self-reporting of SSI occurrence by patients or their caregivers. In this study, the link between patient demographic variables and the methods of reporting the SSI was not investigated. Future research could examine these relationships to provide a more comprehensive understanding.

Conclusion

No significant difference was found on the microbial load and incidence of SSI between using 10% povidone-iodine antiseptic at room temperature and using it at 35°C. Since warming the povidone-iodine solution is a precise, controlled process that requires time and energy, it is recommended to use the solution at room temperature for routine surgical site skin preparation.

Competing interests

The authors have declared no competing interests.

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Discussion paper

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Emotional intelligence education for perioperative nurses

Abstract

The social and professional applications of emotional intelligence (EI) in health care leadership are widely supported with evidence; however, there is limited contemporary literature on EI in the perioperative environment. How this skill can most effectively be taught to clinical perioperative nurses for improved patient and staff safety and wellbeing is imperative for future research.

EI is correlated to positive patient care outcomes via effective communication, improved teamwork and critical thinking. EI has been found to mediate professional issues such as stress, burnout and conflict, as well as promote resilience and optimism. Educators are asked to consider incorporating EI into learning programs, both formally and informally. The literature describes a range of teaching and learning strategies for facilitating the development of EI in nurses in both planned education sessions and through ad hoc reflection upon clinical practice. This discussion outlines how vignettes of patients in the Post Anaesthesia Care Unit (PACU) were used to challenge postgraduate perioperative nursing students to understand and apply EI concepts.

Keywords: emotional intelligence, nursing education, reflection, perioperative nursing

Introduction

Emotional intelligence (EI) is a set of skills used in appraising, regulating and using feelings to motivate, plan and solve problems[1]. It involves the accurate interpretation and understanding of emotion, both within the self and others[1]. EI is considered a trait of the effective leader[2], and much research exists on this important issue. It is a crucial part of generalist pre-registration nursing education in many countries and is cited as being necessary for the provision of competent clinical nursing care[3]. Contemporary literature further highlights the importance of EI for nurses both in the general ward and intensive care unit (ICU) settings. However, there is an absence of research into the impact of EI for perioperative nurses and how EI can be most effectively taught to current perioperative clinicians.

This discussion paper will provide an overview of EI for the clinical perioperative nurse working in the Post Anaesthesia Care Unit (PACU) – what EI is, why it is important and how it can improve patient care. Insightful use of EI has implications for patients, nurses, nurse educators and the micro-cultures in each perioperative clinical workplace. This discussion will describe how the theoretical underpinnings of EI were introduced to a group of postgraduate nursing students. Tips for sparking self-reflection and critical thinking will be outlined alongside the vignettes used to ensure a clear link from theory to practice. Student feedback was positive and it is hoped this discussion paper will be of benefit to clinical nurses and, in particular, to preceptors.

Discussion

Emotional intelligence

Now an increasingly valued interpersonal skill, EI is applied in a variety of professional environments. While many iterations exist, EI requires nurses to identify emotions in themselves and others, understand motivating factors and regulate their own emotions to influence colleagues or patients[4]. EI is the salient relationship between knowledge and emotion, and makes visible the degree to which these attributes are integrated into an individual's nursing practice[5].

There are many theories, frameworks and models used to describe EI[2,6,7]. Trait theory is commonly identified in contemporary nursing literature, as it is simple and clear[2,7]. Encompassing personal aspects, such as self-awareness and self-reflection[2,7,8], trait theory has strong links to the qualities of transformational leadership[8].

While the nursing profession is known to attract people with higher levels of EI[9], this skill can be emphasised and enhanced via explicit training[10]. In education, each EI component is considered through the lenses of self (self-awareness, control and motivation), social interactions (social awareness, empathy, interpersonal skills and communication skills) and actions (critical thinking, problem solving and decision making)[7].

Importance of EI

Much literature exists about the importance of teaching EI to pre-registration nurses and it is a core feature in many programs of study[7]. A recent systematic review highlights that education in EI is beneficial for nursing students, not only for managing feelings in stressful situations but also for developing resilience and improving clinical performance and communication[6]. Knowledge and use of EI in clinical nursing care helps to mitigate the stressors of the role, such as staff shortages, workload demands and challenging interpersonal relationships[7]. Nurses are exposed to a wide range of emotions, as patients in their care experience pain and suffering[11], and EI facilitates decision making, assists with managing ethical dilemmas and lessens burnout[5].

For practising clinical nurses, burnout is an issue of particular concern[12,13]. Evidence from the ICU field shows a lack of EI leads to stress, high rates of attrition, lack of motivation, an unhappy workplace, dissatisfaction with the profession and poor care delivery[5]. Conflicts with colleagues, patients and their families are also cited[5]. On the other hand, EI can empower nurses to be better psychologically adjusted and more self-compassionate, leading to increased resilience and job satisfaction[9] and improved physical and mental wellbeing[14].

While links can be made from both the generalist nursing and ICU settings, there is a lack of contemporary literature relating to the use of EI for perioperative clinicians providing direct patient care. It can be surmised that the insight into self and others gained from EI education in these settings will similarly impact perioperative nurses. Such understanding will have a flow-on effect to patient care, and a positive impact on the micro cultures to be found in each theatre and PACU.

EI in individual team members contributes to improved team performance, positively influencing patient safety and care outcomes in the perioperative environment[15]. EI can strengthen critical thinking in nurses, an essential component in clinical judgement and optimal patient care outcomes[16]. Theoretically, EI supports effective clinical communication[4,10]and the resolution of both intrapersonal and interpersonal conflicts and problems. EI contributes to holistic care of patients and improved work performance[17], ultimately enhancing the patient's experience[14].

A recent study examined perioperative staff culture, identifying threats to and enablers of a positive multidisciplinary environment in theatres[18]. EI was identified as important in establishing trust between co-workers, and clinicians acting as mediators of cultural change would be facilitated by systematic training in EI[18].

An understanding of one's own current level of EI is required when integrating EI into clinical perioperative practice. Perioperative educators and leaders – including clinical preceptors – are needed to highlight the theoretical concepts of EI and to support and facilitate reflection for growth by using day-to-day clinical scenarios.

EI education

Teaching of EI is overall successful, but inconsistently applied[6]. Many studies describe the incorporation of EI within formal learning programs, such as a bachelor syllabus[11]. Short training programmes are an effective way to improve the EI skills of nurses and support them to maintain their emotional and mental well-being. In the perioperative environment, in-service time could be used to introduce the theory of EI. Experiential learning within the clinical environment can build on this, facilitated by role modelling and mentorship for junior staff[4]. However, this requires senior staff to have a good understanding of EI and be proficient in its use, which is not necessarily the case.

Teaching postgraduate nurses is different to pre-registration education[3] and training in the clinical area. Perioperative nurses bring their own unique experiences, beliefs and values to the classroom. While the level of EI exhibited by clinical nurses is positively impacted by their own academic background and amount of clinical experience[5], currently there are few educational opportunities for nurses to learn EI[11]. Much like the theoretical concept of surgical conscience, the authors have found that EI is not specifically identified as a foundational knowledge requirement for the provision of safe and competent perioperative nursing care. Rather, it is just passively and implicitly transferred via micro-interactions or developed by reflection on adverse events.

The prevalent formal method of learning EI is via classroom-based teaching activities[7,16]. Commonly used strategies include learner self-assessment, opportunity for reflection and problem-based learning, for example through concept mapping and simulation[3,7]. EI can be taught via lectures, role play, case studies and discussion[6]. In tandem with the clinical environment, experiential learning allows students to share and reflect upon their own experiences thus learning new ways to manage clinical situations which challenge them emotionally[7]. Reflection allows insight into their strengths and areas for development, not only personally but also socially and practically[19].

How EI was introduced to a group of postgraduate nursing students

The PACU is a high stress area, where perioperative nurses must build a rapid rapport and ensure the patient's psychological safety, while assessing and responding to clinical indicators[20]. It provides a rich setting for EI education. Unlike other areas of perioperative nursing, patient interaction may be extensive and, given the nature of the environment, personal. Providing professional, compassionate and patient-centred care can sometimes be difficult when patient values and decisions are contradictory to or misaligned with the ones held by the perioperative nurse providing care.

Reflection on teaching practice and observed clinical deficits in provision of patient-centred care led the education team to include a session on EI in a postgraduate program of study. The gynaecological surgery module was used as a basis, due to the ease with which to devise patient vignettes.

Theoretical underpinnings of EI were introduced via a short didactic lecture and supported with an 'infographic' visual representation. Fictional patient vignettes were purposefully chosen to spark student emotion.

A safe space for discussion was created for the students, as psychological safety is important in education[21,22]. Facilitator-guided discussion supported participants to identify their immediate emotional reactions then link their feelings to their personal values. Discussion then highlighted professional, patient-centred nursing care delivery. This enabled students to clearly link EI theory to practice, using reflection upon the self and others. Facilitators encouraged verbal role play of real-life clinical actions, such as potential statements to the patient, through the lens of EI-empowered, patient-centred, respectful care.

The students engaged in robust discussion, facilitated by the educator, to express different life values and experiences which informed the expressed emotions. Students were then challenged to formulate responses based on respect and professionalism to meet the PACU patient's physical, emotional, social and spiritual needs Examples are detailed in Table 1.

Self-reflection is an important precursor to learning and development and it is important for individual nurses to have an understanding of their current level of EI to use as a springboard for growth[15].

On review of the session delivered, ideas for potential improvement included a pre- and post-test evaluation of the objective effectiveness and value of the teaching activity[23]. The student group gave informal feedback at the end of the day, which identified increased knowledge, increased skill and intention to share knowledge of and implement EI in their workplaces. Altering the introduction of EI training to earlier in the learning program may increase clinical use and, secondarily, may perhaps work as a stress mediator in terms of balancing advancing clinical practice with a new study workload, shiftwork and other life commitments[4].

Perioperative leaders could facilitate development with interested and motivated staff (such as the preceptor group) to embed EI training within their own clinical environments or micro cultures. There may be opportunities for clinical partners to link their

Table 1: Vignettes

Patient (age) surgical procedure	Case notes	Facilitation notes including tips for sparking self-reflection and critical thinking using the Hamad and Gurbutt[7] lenses of self, social interactions and actions
Patient 1 (23 years) surgical termination of pregnancy (STOP)	Past history of three surgical terminations in the last two years.	After highlighting the overturning of the Roe vs Wade case in the United States of America (social awareness, critical thinking), students were asked to reflect on their own beliefs about what it means to provide patient-centred care (empathy, motivation, problem solving, critical thinking), and to articulate their attitudes and values around access to reproductive services in the context of unplanned pregnancy here in Australia (self-awareness and control, empathy, social awareness, interpersonal and communication skills, critical thinking).
Patient 2 (30 years) elective re-anastomosis of fallopian tubes, five years post tubal ligation	Past history of four vaginal births. All four children are in state care. Patient in unstable short-term relationship, drug use.	After an emotive first vignette, students were asked to consider their own beliefs about access to public health and equitable care provision (self-awareness, control and motivation; social awareness, empathy; interpersonal and communication skills; critical thinking; problem solving). How best to support this patient throughout the surgical journey? (interpersonal and communication skills, decision-making, critical thinking)
Patient 3 (35 years) surgical termination of unviable twin foetus via laser ablation of umbilical cord	Past history of depression and in vitro fertilisation (IVF)	Evoking an alternative yet still potentially uncomfortable response (self-awareness, control and motivation; social awareness, empathy, communication skills; critical thinking), students were asked to consider their feelings and thoughts from a different perspective (decision-making).

postgraduate students with motivated clinical champions to further role model, mentor and support experiential learning within the clinical environment[4].

Supporting the findings of contemporary literature, this educational initiative has highlighted the need for formalised research into how both clinical perioperative nurses and post-registration students manage their own and others' emotions in situations they may find personally challenging[7]. EI should be clearly and consistently taught to perioperative nurses. There is a need for formalised research to determine which methods are best suited for nurses in this unique environment[7].

Conclusion

Perioperative nurses working in the PACU provide care to patients in clinical situations where their own emotions may be challenged. Rapidly building rapport and ensuring a safe physical and emotionally supportive environment for the patient while working in a high stress situation where clinical decisions need to be made quickly can hijack nurses' best intentions. Teaching EI highlights the importance of managing one's own and others' emotions and the tangible difference this makes not only to the patient but also to nurses and the teams in which they work.

The anecdotal feedback received from students was heartening and provided concrete evidence that the EI classroom activity was engaging, interesting and, above all, useful. Students were able to describe the impact that new knowledge and personal insight had on their clinical practice. Changes will be made to future iterations of the activity incorporating more formal self-assessment of EI and linking with motivated role models, such as preceptors, within the clinical environment. As the students move forward into leadership roles, it is hoped that the benefits they have gained from linking EI to the provision of professional, respectful, empathetic and patient-centred perioperative care will eventually become visible on a broader scale.

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Improving communication components of the surgical safety checklist in the perioperative setting

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Abstract

Effective communication between members of the health care team and patients is essential for providing safe and consistent care. Despite this, communication errors continue to occur, being involved in over 70 per cent of sentinel events and contributing to patient morbidity and mortality. Standardised frameworks exist to guide structured communication, with the surgical safety checklist used in the perioperative setting to improve patient safety and teamwork. However, the elements which facilitate interdisciplinary communication are those most commonly overlooked. Continual auditing and critical evaluation are necessary to ensure workplace communication frameworks are implemented in a manner that aligns with service delivery and provides optimal patient outcomes. This paper describes the communication components of and evidence behind the surgical safety checklist, the commonly experienced challenges implementing it in the workplace and strategies to improve compliance in the clinical setting.

Keywords: surgical safety checklist, teamwork and communication, clinical governance, framework

Introduction

Effective communication is vital for the provision of safe, high quality patient care[1]. It is known that poor communication is a leading cause of preventable medical error, implicated in over 70 per cent of sentinel events, and associated with a higher risk-adjusted patient mortality[2,3]. One study found that communication errors occurred in approximately one third of team exchanges in the operating theatre, with a further third of those jeopardising patient safety[4].

To mitigate this, standardised frameworks exist to promote multidisciplinary communication and increase teamwork while reducing risk[5]. This is particularly important in the operating theatre[1], with the surgical safety checklist (SSC) being an important aspect of perioperative clinical practice. Clinical governance is the process through which health organisations ensure good clinical outcomes by partnering with clinicians, consumers, health organisations and other stakeholders[6]. This is supported by frameworks such as the SSC, which allow for a consistent approach to build collaborative working relationships with the goal of patient safety, clinical effectiveness and quality improvement[6].

Discussion

Surgical safety checklist

The SSC is a 19-item tool published by the World Health Organisation (WHO) in 2008 to improve teamwork and patient safety[7]. The SSC is a structured communication process which requires multidisciplinary participation and sharing of critical information between perioperative nurses, surgeons and anaesthetists[5]. It is structured in three sections based on three phases of the operation: the 'sign in' section applies to the phase before induction of anaesthesia, the 'time out' section applies to the phase after induction and before skin incision, and the 'sign out' section applies to the phase from wound closure to when the patient leaves the operating theatre[7].

Each section has a component that focusses on communication. The sign in section begins with communication with the patient to confirm their identity, the operative site, the planned procedure and their consent, as well as providing an opportunity for the patient to ask questions and communicate any concerns[7]. The time out section includes all team members introducing themselves and their role, and the surgical team, anaesthetic team and nursing team discussing any anticipated critical events[7]. This team-building process is crucial, providing an environment where members feel included and comfortable expressing concerns, and promotes trust[8]. Finally, the sign out section of the checklist involves communication between the surgeon, anaesthetist and nurse about any concerns for recovery, which facilitates appropriate handover to recovery staff and the ongoing management of the patient.

The SSC has been widely endorsed by key governing bodies, beginning with the Australian Commission on Safety and Quality in Health Care (ACSQHC) in 2009[9]. The Royal Australasian College of Surgeons (RACS) endorses the SSC as a 'minimum standard' for safe surgical care, noting a reduction in communication failures by two-thirds following its implementation[10]. The Australian College of Perioperative Nurses (ACORN) endorses the use of the SSC for all procedures to improve patient safety and foster team communication[11]. Finally, the Australian and New Zealand College of Anaesthetists (ANZCA) have included adherence to the SSC with pre- and post-operative huddles in their perioperative care framework[12]. Level 2a evidence demonstrates that SSC implementation results in reduced complications and mortality, and improved communication[13,14]; however, despite this wide endorsement and evidence of benefit, compliance with and participation in the SSC is suboptimal[8]. Given the potential impact to patient safety, this demonstrates the clear need for improvement in clinical practice.

Best practice

The WHO SSC Implementation Manual[15] clearly delineates how to implement the SSC according to best practice. Every item must be confirmed and verified by the entire team rather than relying on memory[7]. Adaptation of the checklist to conform to normal operative workflow is encouraged to ensure maximum compliance; however, pauses must still occur to complete the sign in, time out and sign out sections. Ideally, a checklist coordinator, such as a circulating nurse, would guide this process and prevent progression until all items are reasonably addressed. In addition, best practice involves appropriate documentation and auditing to improve adherence to safe standards, and these are an important component of clinical governance[7,9].

Despite clear processes, several deviations from best practice have been identified when workplace implementation of the SSC is studied. These deviations are broadly categorised into lack of engagement, non-compliance with introductions and debriefing, and insufficient auditing. Contributing factors include misperceptions of importance, perceived time delays, inadequate education to address obstacles, duplication of work, uncertainty regarding roles and poor leadership and accountability[16]. It is important to identify these specific areas of concern to target quality improvement initiatives[17].

Workplace challenges

When comparing best practice with workplace practice, the first concern is lack of engagement from all team members. The entire team – nurses, surgeons and anaesthetists – should actively participate in each of the three sections of the checklist and stop all other activity during this time[7]. A multicentre prospective cross-sectional study found team members to be absent in more than 40 per cent of cases[18].

Another challenge to SSC implementation is different attitudes of team members. Studies have found that nurses value and participate in the SSC far more than other staff members but are limited by feeling undervalued by colleagues[5,16]. Conversely, anaesthetists have been found to express the least positive attitude toward the SSC, citing lower perceived usefulness given overlap with existing anaesthetic checks and that the SSC occurs during a period of high workload[16,19]. Surgeon attitudes relate to perceived time constraints, duplication, loss of autonomy and poor understanding of benefits extending to teamwork and collaboration[13]. Despite this, 90 per cent of physicians still desired the SSC to be used on themselves if they were undergoing surgery, thus demonstrating a deeper acknowledgement of the safety benefits[13].

Perceptions of risk can also create challenges to ideal SSC implementation. Team member introductions must occur as part of the time out section of the checklist for every surgical procedure, even when a procedure is later in an operative day and team members have been working together previously. Pre-operative team briefing to discuss critical issues, and post-operative team debriefing to discuss any problems are crucial for communication and, along with team introductions, also constitute best practice. Team introductions and briefings are often poorly executed compared to other checklist items, possibly reflecting team members perceptions of 'risk'[8]. For example, the 'antibiotic prophylaxis' and 'confirmation of patient details' items of the checklist relate to avoiding direct risk and are routinely performed, while team member introductions facilitate communication and mitigate indirect risk and are least consistently performed[8].

Improvement avenues

Given a considerable number of deviations from best practice relate to misperceptions, education and training is a key avenue of improvement to target, as well as being a pillar of clinical governance. As evidence-based professions, physicians and nurses should be educated regarding the purpose of and evidence behind the SSC and its role in situational awareness, communication and hospital-specific workplace processes such as timing of pauses throughout the perioperative period. Misconceptions, such as the commonly held belief that the SSC causes time delays, must be addressed. Studies have demonstrated clinical efficiency and effectiveness by reducing delays through minimising confusion and miscommunication, another component of clinical governance[20].

A further area of improvement is multidisciplinary engagement. Cultivating enthusiasm requires stakeholder leadership, a change in safety culture which may require a short-term local champion during the transition period, and buy-in from nursing, surgical and anaesthetic disciplines[20]. Finally, practices must be reviewed to ensure the SSC does not duplicate other surgical and anaesthetic checks, its relevance is maintained and its implementation aligns with evolving surgical practice[14].

Implementation of teaching and education is most successful when it occurs through a multimodal approach. Short teaching sessions, such as 'fast talks', concise 15-minute practical teaching sessions, have the benefit of fitting into daily work routines and can occur during previously designated educational sessions[3]. Nominating a nurse team leader can help with instruction of correct practices and encourage participation, particularly in areas of introductions and debriefing. Visible senior leadership is critical for implementing teamwork initiatives in health care, thus having senior support through 'safety leadership walkarounds' can help to encourage consistent compliance[20].

One-off training programs have limited durability, thus continued reinforcement is necessary, ideally through local champions[20]. Concept posters in the operating room, such as those used for scrubbing protocols, also reinforce previous teaching and provide reminders throughout the day[3].

Another strategy that has been suggested to improve checklist performance is presenting the SSC on a whiteboard with each checklist item being crossed off when it is completed, rather than one person ticking a paper checklist. This can help to improve shared team ownership of the checklist[21]. In addition, the 'theatre cap challenge' where each team member's name and role is written on surgical headwear, has been used to improve knowledge and retention of team members within the theatre[22].

Prospective observational auditing is important for data integrity, and has been shown to improve compliance from 3.5 to 63 per cent[21]. Furthermore, this allows for ongoing review of processes to ensure improvement. A mechanism for employees to provide feedback is essential to facilitate ongoing improvement, e.g. a whiteboard in theatre allowing the opportunity to provide timely, anonymous and informal feedback[21].

Conclusion

Widespread endorsement and implementation of the SSC has resulted in considerable improvements in operating staff communication and patient safety[14]. This benefit is most pronounced when each element of the checklist is appropriately implemented; however, studies have found that elements are overlooked, most commonly those that facilitate interdisciplinary communication[8]. This is partly due to commonly held misperceptions, poor knowledge of the purpose of and evidence behind the SSC, and lack of enforced workplace processes targeted at ongoing engagement and compliance with the SSC. Improvements can occur through regular structured teaching, local champions, leadership walk arounds, posters and whiteboard checklists. Prospective auditing has the dual role of assessing the impact of the intervention and improving compliance with this important communication process in the operating theatre. The SSC is an important aspect of clinical practice and is relevant to areas of clinical governance in the perioperative setting.

Competing interests

The authors have declared no competing interests.

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The effectiveness of the surgical helmet system in reducing infection and contamination in arthroplasty procedures: An integrative review

Abstract

Background: Peri-prosthetic joint infections are a serious complication of primary arthroplasty procedures. While surgical helmet systems are commonly used, limited guidelines exist to support their effectiveness in preventing infection.

Aim: This integrative review aims to synthesise relevant literature on the role of the surgical helmet system in arthroplasty procedures.

Design: An integrative review process was undertaken.

Method: A literature search was conducted for primary literature in PubMed, Scopus and ESBCO using the keywords 'surgical helmet' AND 'contamination OR infection' AND NOT 'COVID'. Studies involving COVID-19 were excluded. Of the 44 retrieved studies, 13 met the inclusion criteria after removing duplicates and reviewing titles. This included one randomised controlled trial, six quasi-experimental studies, five observational analytical studies, and one observational descriptive study. The quality of the literature was assessed using EQUATOR network (Enhancing QUAlity and Transparency Of health Research network) guidelines.

Findings: Findings indicate that the use of the surgical helmet system is associated with lower infection rates in arthroplasty procedures when compared to standard surgical attire. Additionally, the literature explores techniques to further reduce contamination rates with the surgical helmet system, including wrapping the glove–gown interface, treating the sterile surgical helmet system hood as unsterile, delaying fan activation, running the fan for three minutes before entering the operating room, covering the back of the surgical gown and having a non-sterile team member apply the sterile surgical helmet system hood.

Conclusion: The use of a surgical helmet system in arthroplasty procedures reduces infection rates compared to standard surgical attire. This integrative review highlights the importance of implementing additional practices to reduce intra-operative contamination rates when using the surgical helmet system. Further research is needed to strengthen the findings from this integrative review.

Keywords: surgical helmet, contamination, peri-prosthetic joint infection, perioperative attire, orthopaedic surgery, glove–gown interface

Introduction

Peri-prosthetic joint infection is a serious complication of elective arthroplasty procedures[1]. It can result in decreased quality of life and restricted mobility for the patient, and an increased rate of mortality and morbidity[2]. Furthermore, it places a significant financial burden on the health care system[3]. The causes of peri-prosthetic joint infections are complex and multifactorial[4].

Sterile surgical attire, worn by the surgical team intra-operatively, routinely includes the use of the surgical helmet system (SHS) in arthroplasty procedures[5]. Once surgical hand antisepsis is complete, a sterile hood is placed over the SHS before the gown and gloves are donned. The SHS offers full coverage of the face and head, serving as personal protective equipment against surgical debris[6]. However, despite its common application in arthroplasty procedures, there are limited guidelines on the intra-operative use of the SHS and its impact on peri-prosthetic joint infection rates[5].

Aims

This integrative review focuses on the effectiveness of the SHS in reducing infection and contamination in arthroplasty procedures. This paper aims to provide relevant literature that assists perioperative nurses in making informed decisions about using the SHS in arthroplasty procedures.

Methods

Design

This review used an integrative review design where both quantitative and qualitative research data were included and followed the framework of Whittemore and Knafl[7].

Search strategy

A comprehensive literature search was undertaken using the databases PubMed, Scopus, ESBCO: CINAHL Complete, Health Source: Nursing/Academic Edition, Medline and Medline Complete. The search strategy included Boolean operators and keywords/phrases as follows: 'Surgical helmet' AND 'Contamination OR infection' AND 'NOT COVID'.

Inclusion and exclusion criteria

Inclusion criteria included literature that was published in English within the last five years, full text articles and research that focused on the SHS and either infection or contamination.

Exclusion criteria included poor quality papers that did not align with the EQUATOR network (Enhancing QUAlity and Transparency Of health Research network) checklists, non-primary literature, papers older than five years, papers that discussed modifying the SHS for any reason and research that investigated SHS application in COVID-19 cases because during the pandemic the SHS was used in surgeries other than those it is traditionally used in.

Data extraction

Guided by the research aims, a total of 44 studies were initially retrieved. The removal of duplication papers left 16 articles. The titles and abstracts were screened and articles that did not meet the inclusion criteria were removed. A total of 13 articles remained and were included in this review. This is represented in Figure 1 as the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram[8]. The quality of the studies varied. There was one randomised control trial, six quasi-experimental studies, five observational analytical studies, and one observational descriptive study.

Data evaluation

The EQUATOR network guidelines were used to appraise the primary research studies included in the review to ensure that the selected papers were of good quality. CONSORT (Consolidated Standards of Reporting Trials) was used for randomised control studies, TREND (Transparent Reporting of Evaluations with Non-randomized Designs) for quasi-experimental studies and STROBE (STrengthening the Reporting of OBservational studies in Epidemiology) for observational studies.

Discussion

The SHS is commonly used in orthopaedic arthroplasty procedures to protect against surgical debris[6]. The SHS consists of a helmet with an internal fan and is covered during a procedure with a single-use sterile hood with a visor, applied by either a sterile or non-sterile team member[6]. The SHS surgical attire is made up of the SHS with a sterile hood, gown and gloves[6]. A variant, known as the Toga, combines the sterile hood and gown into one piece with a zipper to close the gown at the back[9]. Standard surgical attire includes a surgical cap or hood, mask, gown and gloves[6]. Although there may be differences in the sterile attire that can be worn intra-operatively, perioperative nurses must follow evidence-based standards of practice set out in the Australian College of Perioperative Nurses (ACORN) Asepsis standard[10] to ensure the quality and safety of health care provided to patients. However, there are currently no standardised guidelines for the use of the SHS

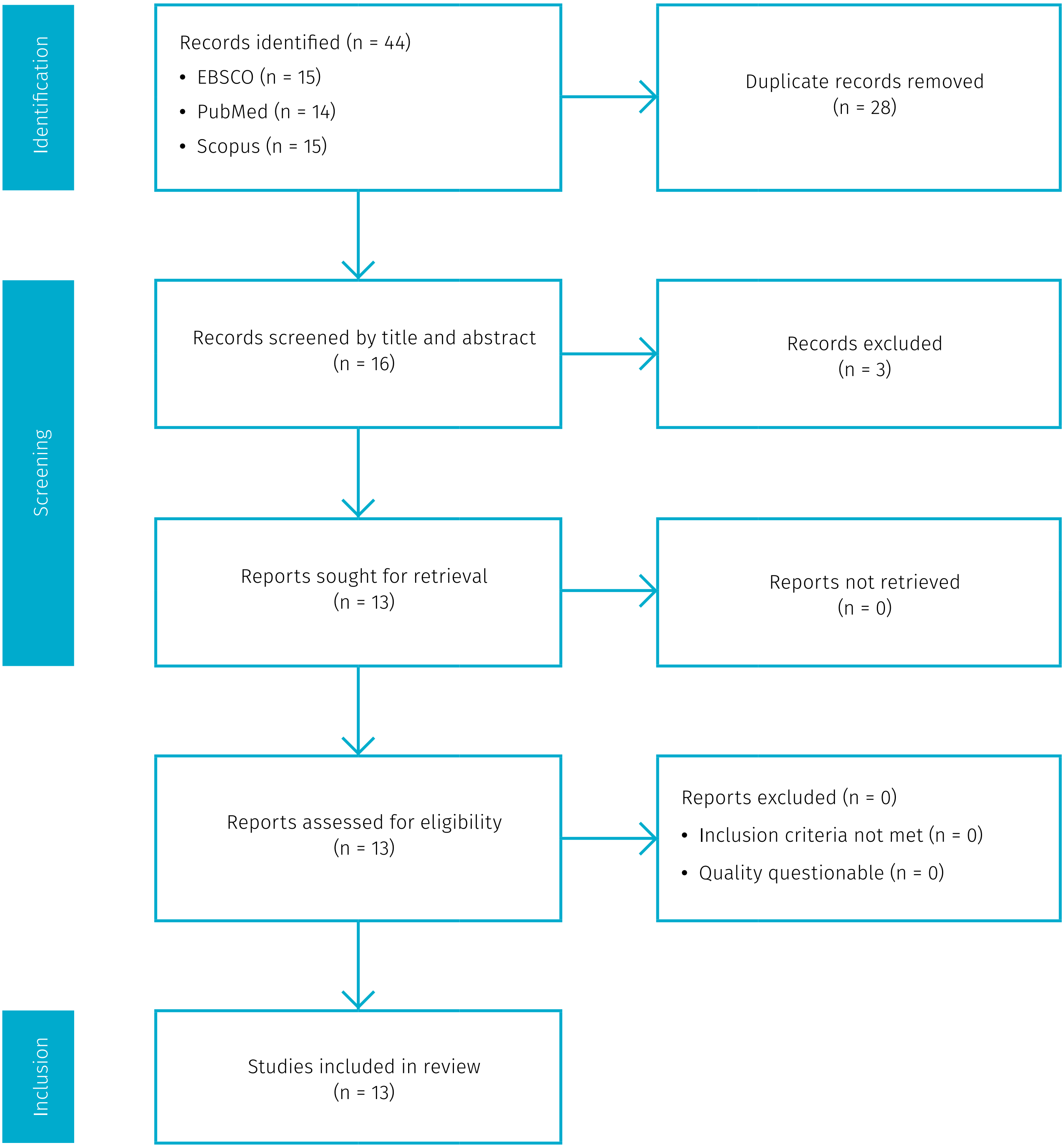

Figure 1: PRISMA flow diagram of paper selection process

during arthroplasty procedures. This integrative review aims to address this knowledge gap and promote evidence-based practices.

Of the thirteen papers included in this review a thematic analysis highlighted four themes – 'infection control in surgery – the case for using the surgical helmet system and its effect on patient outcomes and team contamination', 'impact of delayed fan activation in the surgical helmet system', 'evaluating positive pressure challenges of the surgical helmet system' and 'optimising donning techniques for the surgical helmet system'.

Infection control in surgery – the case for using the surgical helmet system and its effect on patient outcomes and team contamination

The SHS not only protects the patient from possible surgical site infection but also protects the wearer from contamination by airborne particles. Two of the included studies[5,10] analysed post-operative infection rates in arthroplasty procedures, comparing the SHS surgical attire to standard surgical attire. Rahardja et al.[5] performed an observational analytical study with a case-controlled design (n = 19 322) investigating prosthetic joint infection after primary total knee arthroplasty surgery. Data was collected from the New Zealand Surgical Site Infection Improvement Programme and the New Zealand Joint Registry. A lower rate of prosthetic joint infection was found when SHS surgical attire was used compared to when standard surgical attire was used – 0.35 per cent compared to 0.58 per cent ($p = 0.008$)[5]. After adjustment, the revision rate for deep infection with the SHS surgical attire was 0.42 per cent compared to 0.49 per cent for standard surgical attire, with a statistically significant difference (adjusted OR = 0.55, $p = 0.022$)[5]. The significant p values indicate a reduction in infection and revision associated with the SHS compared to standard surgical attire in primary total knee arthroplasty surgery[5]. This study was performed in New Zealand but remains highly relevant to the Australian context due to comparable standards of care.

On the other hand, So et al.[11] performed an observational analytical study of total ankle arthroplasty patients that compared infection rates with the surgeon wearing SHS surgical attire (n = 109) and the surgeon wearing standard surgical attire (n = 151). No significant difference was detected in overall infection or peri-prosthetic joint infection rates ($p = 0.411$)[11]. However, this study only analysed ankle arthroplasty procedures conducted in multiple centres in the United States with a sample size of 260, which affects the robustness of the findings[11]. In comparison, Rahardja et al.[5] analysed a sample size of 19 322. Furthermore, the arthroplasty procedures performed in both studies are different, which may contribute to the different results.

As well as protecting the patient, SHSs also protect the wearer from exposure to airborne contaminating particles. In their observational descriptive study employing a cross-sectional design, Putzer et al.[12] demonstrated the need for staff members exposed to high amounts of contamination from aerosol-generating procedures to wear an SHS. The simulation experiment investigated the particles and aerosol created during high-speed burring and found that particles smaller than 0.3µm were generated[12]. Surgical masks may not filter such small particles; therefore, it is recommended that all sterile staff wear the SHS during aerosol-generating procedures[12].

Impact of delayed fan activation in the surgical helmet system

The SHS fan can be activated before or after donning sterile attire. Eggers et al.[13] explored this in a randomised controlled trial comparing contamination rates for three cohorts – standard surgical attire, SHSs with delayed fan activation and SHSs without delayed fan activation. The Toga style of SHS hood was used (a combined gown and SHS hood with a zipper at the back[9]). Various areas of the sterile person within the sterile field were swabbed at the end of the procedure (n = 180).

Positive culture rates for the surgical cases were 15 per cent for the standard surgical attire, 18 per cent in the SHS surgical attire with delayed fan activation and 25 per cent in the SHS surgical attire without delayed fan activation ($p = <0.05$)[13]. After excluding positive culture rates from the SHS hood, contamination rates were seven per cent for the SHS surgical attire with delayed fan activation and eight per cent for the SHS surgical attire without delayed fan activation[13].

Contamination rates from the face shield were 18 per cent for the SHS surgical attire with delayed fan activation and 25 per cent ($p = <0.05$) for the SHS surgical attire without delayed fan activation but the difference was not statistically significant[13]. Based on their results, the authors recommend delaying fan activation and excluding the helmet and face shield from the sterile field[13].

A limitation of this study is that the standard surgical attire cohort included any orthopaedic procedures while the two SHS cohorts included arthroplasty procedures[13].

Thaler et al.[14] explored the contamination of the SHS helmet and surgical gloves during and after arthroplasty procedures. In this observational study without a control group (n = 49) swabs were taken during and at the end of the arthroplasty procedure from the sterile team member's gloves and the SHS helmet. The researchers found that contamination of either the gloves or the SHS helmet was evident in 20 of the 49 arthroplasty procedures studied[14]. These results reinforce those of Eggers et al. that contamination can exist on the SHS helmet intra-operatively and it should be deemed unsterile. However, as Thaler et al. did not measure contamination rates of standard surgical attire their findings, while valuable, lack significance when comparing the SHS surgical attire to standard surgical attire[14].

Moores et al.[15] compared contamination of hands and gown when using standard orthopaedic hoods and SHSs with the fan activated and not activated in a quasi-experimental prospectively controlled study (n = 18). The researchers counted particles and took culture samples three times from two locations, inside and outside laminar flow areas, when a standard orthopaedic hood was used and when the SHS was used, with and without the fan activated. No positive cultures were found on the agar plates in the experiment; however, the background colony count increased 3.7 times with the SHS fan switched on (p = 0.004)[15]. This suggests that when the fan from the SHS is on it could contribute to the contamination of surgical attire and parts of the sterile field that are close to the SHS[15].

Similarly, an experimental prospectively controlled study (n = 21) by Kang et al.[6], found that if the fan in the SHS was activated before the surgeon donned their gown and gloves, contamination was evident in most body regions of the surgeon. In contrast, when the fan in the SHS was activated later, after the surgeon donned their gown and gloves, minor levels of contamination were found in only two of 11 body regions[6]. Additionally, when the fan in the SHS was activated before the surgeon donned their gown and gloves, contamination occurred on the sterile member donning the sterile SHS hood[6].

Furthermore, in an observational study without a control group (n = 20), Lynch et al.[16] analysed the relationship between bacterial load and the initial run time of an SHS fan. Agar plates were placed under the outflow vents of surgical helmets and exchanged at different time points. The results indicate that the first minute of fan operating time produced the highest number of colonies (27) on the agar plate, possibly indicating dispersal of contaminants present on the helmet before the fan was activated[16]. There was a significant reduction in the number of colonies at three, four and five minutes (five, three and four colonies (p = <0.01), respectively)[16]. The researchers recommend that SHS fans are run for at least three minutes before entering the operating room[16].

Similarly, Tarabichi et al.[17] demonstrated the SHS as a contamination source in an observational study without a control group (n = 132) that involved swabbing the SHS. Among the swab samples from the SHS, 73 per cent yielded bacteria on culture[17]. This study demonstrated that SHSs harbour common pathogens that could cause surgical site infections[17] and the fan could facilitate their spread onto the sterile field.

The results of these studies suggest that combining the recommendations – that is, turning the fan on for three minutes outside the operating room, then turning it off until after scrubbing and donning surgical attire – may be worth considering.

Evaluating positive pressure challenges of the surgical helmet system

Positive pressure is created when air is blown into the SHS suit. Chen et al.[18] conducted a quasi-experimental prospectively controlled study that compared leakage through the glove–gown interface when SHS was used, when SHS was not used and when the glove–gown interface was sealed and not sealed. The results identified a consistently higher leakage intensity via the glove–gown interface when SHS was used and the glove–gown interface was not sealed (p=0.05)[18]. Sealing the glove-gown interface is recommended when using SHS to reduce the risk of contamination[18].

Positive pressure in the SHS results in particles being blown out through areas of low resistance. Some SHSs have a second fan to release air and, in theory, reduce pressure. Vermeiren et al.[19] conducted a quasi-experimental prospectively controlled study comparing particle contamination of the gown in single-fan versus two-fan SHSs (n = 20). No difference was found in overall gown particle contamination between the systems but all tests displayed contamination at the gown–glove interface[19] further suggesting the need for the glove-gown interface to be sealed.

The back of the sterile surgical gown provides a way for air and airborne contaminants to escape from the SHS[9]. Konopitski et al.[9] conducted a quasi-experimental prospectively controlled study (n = 36) comparing contamination rates of a standard, rear-tied gown, a standard gown with a vest that covers the back of the gown, and Toga-style gown closed with a zipper. Airborne microbial particles were collected on agar plates positioned behind the surgeon, and bacterial colony-forming units (CFUs) were counted after the plates were incubated[9]. The highest contamination rate was found with the standard gown (331.7 ± 52.0 CFU/m2/h), the rate decreased by 45 per cent (182.2 ± 30.8 CFU/m2/h) with the gown and vest, and by 49 per cent (170.5 ± 41.9 CFU/m2/h) with the Toga-style gown (P = 0.01)[9]. The researchers recommend that staff within the surgical field either use a vest to cover the back of the sterile surgical gown or wear a gown closed by a zipper to reduce contamination rates in the surrounding sterile field[9].

Optimising donning techniques for the surgical helmet system

There is a range of techniques used for donning SHS hoods and currently no recommendations for the most appropriate method[20]. McAleese et al.[20] conducted a quasi-experimental prospectively controlled study (n = 100) comparing the bacterial contamination on the gloves of two groups of surgeons each using a different SHS hood–donning technique performed under laminar airflow with late fan activation. In the first group, the scrubbed and gloved surgeon placed the SHS hood over a colleague and then immediately press-inoculated all five fingers of both gloves in separate agar plates. In the second group, a non-sterile colleague, wearing sterile gloves, placed the SHS hood on the scrubbed but not gloved surgeon. The surgeon then donned sterile gloves and immediately press-inoculated all five fingers of both gloves in separate agar plates. The researchers found no significant difference in bacterial contamination between the groups; nonetheless, the researchers advise that operating surgeons should be very careful when putting an SHS hood on a colleague to reduce the risk of contamination.[20]

McAleese et al.[20] also investigated the baseline sterility of the SHS hood. Immediately after the hood was over the helmet, sterile culture swabs were collected from the screen and neckline. Six of the 50 hoods tested (12%) were found to have a positive culture that isolated an organism. The researchers therefore suggest that the SHS hood should not be presumed to be sterile after application and intra-operative adjustment is inadvisable.

Kang et al.[6] investigated the effect of early and late SHS fan activation and found that contamination levels of a gowned and gloved scrub nurse who put the SHS hood on the surgeon were higher when the SHS fan was activated before the surgeon donned their gown and gloves (early activation) than when the SHS fan was activated after the surgeon donned their gown and gloves (late activation)[6]. This indicates that optimal donning technique should include a non-sterile team member applying the sterile SHS hood before the SHS fan is activated but after the sterile team member has donned their gown and inner gloves[6].

Conclusion

This integrative review provides an overview of recent literature about the effectiveness of the SHS in reducing infection and contamination in arthroplasty procedures. The findings indicate that the SHS reduces the rate of infections in arthroplasty procedures, compared to standard surgical attire, and protects the surgical team from debris and aerosol particles. Best practices to minimise potential contamination include wrapping the glove–gown interface, treating the sterile SHS hood as unsterile, delaying fan activation, running the fan for three minutes before entering the operating room, covering the back of surgical gown or using a zipper-closed gown, and having a non-sterile team member apply the SHS hood.

The insights gained from this integrative review can inform perioperative nursing practices involving the SHS for arthroplasty procedures, enabling high-quality and safe health care for patients. Nonetheless, further research into the use of SHSs in arthroplasty procedures is needed to develop evidence-based practice recommendations.

Declaration of conflicting interests

The authors have declared no competing interests with respect to the research, authorship and publication of this article.

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