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LETTER FROM OUR **EDITOR-IN CHIEF**

Dear Esteemed Professionals,

It is a privilege to introduce the Inaugural Issue of The Operating Room Global Journal (TORGJ). This first volume represents a milestone in our shared effort to advance global surgical systems and highlight the essential human factors that influence the safety, quality, and equity of perioperative care. As surgical teams around the world adapt to evolving clinical and operational demands, the need for evidence-informed practice has never been greater.

This edition features ten diverse and timely articles that collectively reflect the broad spectrum of challenges and innovations shaping modern surgical environments. The opening review on uterine leiomyomas provides a comparative analysis of uterine fibroid embolization and myomectomy offering meaningful insight for improving decision-making in women's health. The article on glycaemic control in minimally invasive cardiac surgery reinforces the significance of metabolic optimization in reducing complications and improving recovery. The systematic review assessing nurse workforce levels in UK hospitals. highlights a universal truth: adequate staffing and empowered nursing teams directly influence patient outcomes and system efficiency. Complementing this is a Delphi study capturing healthcare providers' perspectives on patient involvement in surgical decision-making in LMICs, emphasizing the importance of shared decision-making as a core human factor in global surgical care.

Innovation in sterile services forms another critical theme in this issue. The review of automated sterilization tracking systems discusses how digital tools can strengthen traceability, compliance, and workflow reliability in CSSDs. Further, a cross-sectional study from Northwest Nigeria explores how organizational and environmental stressors affect surgical teams and patient safety, an area central to understanding human performance in high-risk settings.

Two articles shift focus to mental health: one assesses pregnant and postpartum women in Anambra State, and another examines anxiety and depression in rural communities during pandemic lockdowns both reminding us that psychosocial stability remains tied to broader health outcomes. The evaluation of infection control practices among OT professionals in Lahore highlights the ongoing need for training, monitoring, and accountability in operative spaces. Finally, the review on scaling laparoscopic surgery in LMICs offers policy-driven strategies to expand minimally invasive services through innovation and capacity-building.

Collectively, these articles illustrate how clinical excellence, system design, and human-centred practice must converge to strengthen surgical ecosystems globally. I extend my appreciation to all contributors who helped shape this inaugural issue.

With warm regards,

Asst. Prof./ Dr. Zakir Hussain Parray

EDITOR-IN-CHIEF,
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Complications of Uterine Leiomyomas: A Comparative Review of Uterine Fibroid Embolization and Myomectomy in Management and Outcomes

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ABSTRACT

Uterine leiomyomas (fibroids) are the most common benign gynaecological tumors in women of reproductive age and may result in significant complications. Uterus-preserving treatment options recommended by the American College of Obstetricians and Gynaecologists (ACOG) and central to this review are Uterine Fibroid Embolization (UFE) and myomectomy. This review compares UFE and myomectomy in terms of recurrence, fertility preservation, and quality-of-life outcomes. A comparative analysis was conducted using major electronic databases, including PubMed, Google Scholar, Scopus, and Science Direct, with searches restricted to human studies published in English between January 2013 and May 2025. Fibroids are most prevalent among women aged 30 to 50 years and disproportionately affect Black women. Myomectomy, though more invasive, is preferred in women desiring future fertility. UFE has a higher intervention rate (OR 1.84; 95% CI 1.62–2.10; P < 0.01; I2 = 39%), hysterectomy rate (OR 4.04; 95% CI 3.45–4.72; P < 0.01; I2 = 59%), and symptom-severity score (OR − 4.02; 95% CI 0.82, 7.22; P = 0.01; I2 = 0%) compared to myomectomy at a four-year follow-up. UFE has a lower risk of early complications (OR 0.44; 95% Cl 0.20-0.95; P = 0.04; I 2 = 25%) and readmission rate (OR 1.16; 95% Cl 1.01-1.33; P=0.04; I 2 = 0%) in comparison with myomectomy. Both procedures effectively relieve symptoms and preserve the uterus, but data on fertility outcomes are inconclusive. Treatment decisions should be personalized based on patient preferences and clinical context.

KEYWORDS: Uterine Fibroid Embolization; Fibroids; Myomectomy; Fertility Preservation; Minimally Invasive Procedures

INTRODUCTION

Uterine leiomyomas (fibroids) are the most common benign gynecological tumors in women of reproductive age and often impair quality of life and reproductive potential [1]. They pose a major global health concern, constituting a large portion of gynecological visits, surgical procedures, and healthcare costs. Globally, fibroids account for as much as 70% of hysterectomies, with around 30% of women impacted needing active treatment due to intense symptoms, such as anemia, infertility, or discomfort related to mass size [2].

Despite being common and having significant effects, the clinical practice guidelines for their management are still inconsistent. This inconsistency is indicative of the lack of strong comparative data and leads to differences in treatment methods among various institutions and regions. This review explores the complications associated with uterine fibroids and compares Uterine Fibroid Embolization (UFE) and myomectomy in terms of recurrence rates, fertility outcomes, and effects on quality of life. For patients unresponsive to medical therapy and who desires uterine preservation, UFE and myomectomy offer viable therapeutic options. Given the overlapping indications yet differing outcomes of UFE and myomectomy, this review addresses a central question: Which uterus-preserving intervention yields more favorable long-term outcomes in terms of recurrence, fertility preservation, and patient satisfaction in symptomatic fibroid cases? Through an examination of existing epidemiological and clinical data, this analysis aims to support informed decision-making among patients and clinicians.

METHODOLOGY

A comparative analysis was conducted using existing epidemiological data, clinical guidelines, and outcome-based research on the use of uterine fibroid embolization (UFE) and myomectomy in the management of uterine fibroids. A systematic search was conducted across major electronic databases including PubMed, Google Scholar, Scopus, and Science Direct. Relevant articles were retrieved using a combination of search terms and Medical Subject Headings (MeSH) such as “Uterine Fibroids” OR Leiomyomas”, “Uterine Fibroid Embolization” OR “UFE”, “Myomectomy”, “Complications”, “Fertility”, and “Recurrence”. Searches were limited to human studies published in English between May 2013 and May 2025. Inclusion Criteria Include: Original peer-reviewed studies, studies comparing UFE and Myomectomy in symptomatic fibroids, and studies reporting on outcomes such as recurrence, fertility preservation, complication rates, and recovery time. Exclusion criteria were: Non-English publications, Studies not focused on UFE or myomectomy as treatments of uterine fibroids, opinion pieces, non-peer-reviewed materials, and studies with insufficient or irrelevant outcome data.

EPIDEMIOLOGY AND PREVALENCE

Uterine leiomyomas are the most prevalent benign gynecological tumors, affecting approximately 30% of women globally, predominantly between the ages of 30 and 50 [1]. They occur three to four times more frequently in Black women, with an estimated 80% lifetime incidence. While many women remain asymptomatic, around 30% develop severe symptoms [3]. A Nigerian tertiary institution study reported that uterine fibroids accounted for 6.4% of all gynecological admissions and 22.3% of major gynecological surgeries [3]. In Ghana, incidence rates ranged from 66.77 to 92.40 per 100,000 women annually, peaking among women aged 35 to 39.4 In the United States, uterine fibroids affect approximately 70% of women, surpassing the prevalence of several other female-specific conditions [5].

PATHOPHYSIOLOGY

Uterine fibroids develop from a single smooth muscle cell in the myometrium that undergoes a somatic mutation, resulting in monoclonal tumour growth. The growth of fibroids is influenced by hormonal factors, primarily oestrogen

and progesterone, which promote cellular proliferation and extracellular matrix accumulation. Growth factors such as transforming growth factor-beta (TGF-beta), epidermal growth factor (EGF), and insulin-like growth factor (IGF) have also been implicated in fibroid development and progression. Multiple molecular studies have identified distinct gene mutations linked to the development of leiomyomas, with the most frequently observed being mutations in the MED12 gene, located on the X chromosome at position q[13.6,7] This gene encodes a subunit of the mediator complex [subunit 12], which plays a critical role in regulating RNA polymerase II activity. Alterations in MED12 are found in approximately 70% of uterine leiomyomas.

Additionally, mutations in the fumarate hydratase gene are associated with hereditary leiomyomatosis and renal cell carcinoma [HLRCC] syndrome, which can involve uterine leiomyomas. However, these hereditary forms are significantly less common than the sporadic leiomyomas typically driven by MED12 mutations. Other notable genetic alterations implicated in leiomyoma pathogenesis include mutations in high mobility group AT-hook 1 and 2 [HMGA1 and HMGA2], as well as collagen type IV alpha 4 and 6 [COL4A4 and COL4A6] genes [5]. Uterine fibroids are composed of extracellular matrix made up of collagen, fibronectin, and proteoglycan. They are relatively avascular, having a blood supply arising from the pseudo-capsules of surrounding myometrial tissue, and are hypersensitive to oestrogen. The course of the fibroid depends largely on the location of the fibroids, the size, the number of fibroid nodules, and the prevalent hormonal milieu [9].

COMPLICATIONS

Although benign, fibroids may cause complications that significantly affect quality of life. Common manifestations include heavy menstrual bleeding, pelvic pain, urinary frequency, and constipation. In addition to these symptoms, uterine fibroids are associated with infertility, adverse perinatal outcomes, postpartum hemorrhage, and maternal anemia. Submucosal fibroids are particularly associated with higher complication rates due to their intrauterine location, which disrupts implantation and exacerbates bleeding. Large fibroids can impinge on adjacent pelvic organs, leading to bladder and bowel dysfunction [10].

MANAGEMENT OF UTERINE FIBROIDS

The American College of Obstetricians and Gynecologists (ACOG) and the National Institute for Health and Clinical Excellence (NICE) have both established safe, effective, and reliable standards for fibroid management. The two bodies recommend an individualized, symptom-driven approach that considers the severity of the patient's symptoms, the patient's age, reproductive plans, and preferences. They both recommend medical therapy as the first-line for bleeding and pain, while minimally invasive measures and surgery are available when conservative measures are insufficient to control patients' symptoms. Uterine fibroid embolization (UFE), myomectomy, and hysterectomy are the recommended non-medical treatment options. Myomectomy and UFE are the management options that will be the focus of this review [10].

MYOMECTOMY IN FIBROID MANAGEMENT

Myomectomy is the surgical removal of uterine fibroids with the sole aim of preserving fertility and reducing complications of fibroids. The uterus is preserved due to the patient's desire for fertility. Studies done on the prevalence of uterine fibroid resection amongst women with this condition suggest a myomectomy rate of 14.6 per 10,000 patients over the last year. While myomectomies have given women with fibroids a chance at preserving their fertility, hysterectomy due to uterine fibroids accounts for 40-60% of all hysterectomies, raising a question as to why hysterectomy due to fibroids a common procedure is still, especially since the advent of myomectomies [11]. Hysterectomy is the surgical removal of the uterus and the cervix, which can be due to several factors relating to the

uterus that can pose a threat to the patient's life. While this surgery is recommended for women who have completed childbearing and post-menopausal women, the presence of cancers, fibroids, and other pathologies of the uterus could be indications for a hysterectomy. While most women would still prefer to preserve their fertility by doing a myomectomy, hysterectomy is a more definitive way of treating uterine fibroids, and several factors like the site, size, and quantity of the fibroids can be decisive in considering the treatment option to take [12]. Doing a myomectomy in situations where the fibroid is too large that a reasonable repair of the uterus would not be possible or the fibroid has implanted too deep into the myometrium and endometrium, would pose a great risk and patients are counselled on the possibilities of doing a hysterectomy, taking into consideration their desire for fertility.

UTERINE FIBROID EMBOLIZATION

As an addition to the procedures for treating uterine fibroids, uterine fibroid embolization (UFE) has been introduced as a treatment for fibroids under the umbrella of uterine artery embolization (UAE). This procedure has brought a less invasive way of taking care of uterine fibroids, which does not require large abdominal incisions, but rather uses an image-guided approach through blood vessels in the groin or wrist to reach the blood supply of the fibroid [13].

INDICATIONS FOR UFE

- UFE is an effective procedure, but it may not necessarily be done on every patient who presents with uterine fibroids. Patients who benefit from UFE are:

- Patients who are experiencing uterine fibroid symptoms
- Patients who are not viable for surgery (obesity, bleeding disorders, anemia)
- Patients who want to retain their uterus
- Patients who refuse to collect blood or blood products
- Patients who do not want to undergo surgery

CONTRAINDICATIONS FOR UFE

- Patients who are not experiencing fibroid symptoms
- Patients who have gynaecological cancers (cervical, endometrial, or ovarian)
- Patients with active pelvic infections
- Patients who desire fertility preservation
- Patients with impaired renal function who have not yet undergone dialysis

COST AND ACCESSIBILITY CONSIDERATIONS

Beyond clinical outcomes, financial considerations and health system availability can influence the choice between UFE and myomectomy. Myomectomy, especially via open or laparoscopic approaches, may require specialized surgical teams and longer hospital stays. UFE, though less invasive, involves access to interventional radiology suites, which may be unavailable in lower-resource settings. A study done over a 2-year time horizon discovered that UFE was associated with higher mean costs when compared to myomectomy. The same study looked at the outcome over four years, and UFE was associated with a higher mean cost. It was concluded that myomectomy was a cost-effective option for the treatment of uterine fibroids in comparison to UFE, though the differences in costs are small [14]. Insurance coverage and local expertise often dictate the accessibility of either treatment.

UFE PROCEDURE

In uterine fibroid embolization, the patient is initially sedated, and the interventional radiologist then inserts a thin catheter into an artery in the groin or wrist. With the help of imaging, the catheter is carefully mobilized to the uterine

artery, where embolic agents are released to block blood supply to the fibroid. Imaging is done to ensure the arteries are blocked, the catheter is removed, and pressure is applied to the incision site [15]. This procedure leads to the shrinking of the fibroids due to the reduction in their blood supply. The fibroids are said to shrink by about 50% of their original volume, with several research studies indicating a 20% reduction in diameter. Results are not immediate, as shrinkage of the fibroids can take up to several months, but signs of relief can be seen in most patients after six months [16]. But how exactly is it different from myomectomy in terms of recurrence, fertility preservation, and an increase in quality of life? Due to this procedure being less invasive and having a shorter recovery time, it is generally believed that UFE is a better option than myomectomy in all areas of consideration. The reasons can be said to be the presence of minimal scarring, shorter hospital stays, and the preservation of the uterus, excluding important factors like age and desire for childbirth. Several research studies have presented a better assessment of the two procedures, putting important factors and outcomes into consideration.

UFE VS MYOMECTOMY

UFE and myomectomy both have specific patient interests they appeal to, and both are great options for managing the symptoms that complicate uterine fibroids. Considering various factors such as age, interest in childbearing, cosmetics, and the time it takes for recovery, patients can choose which of the two procedures best appeals to their interests. UFE has been advised against in women who still consider childbearing, but it is a good management option for older women who are done with childbearing or women who do not desire future fertility [17]. Having a shorter time to recovery makes it a perfect management option for patients who cannot stay away from work for too long and presents them with an opportunity to return to normal activities in good time.

Considering cosmetics, UFE has a better cosmetic appeal as there are no surgical incisions on the abdomen that could cause patients to be mindful of any scars that surgery might leave. Myomectomies, on the other hand, may not be best for a quicker or a more cosmetically pleasing outcome, but it is considered the best option for women who still choose to preserve their fertility, making it a good option for younger patients [15]. The 2021 ACOG guidelines recommend myomectomy as the preferred option for women desiring fertility and also caution on the use of UFE as it may affect fertility [10]. Several studies have been done to compare UFE and myomectomies and assessed them based on recurrence, fertility preservation, and improvement in quality of life. The findings suggested that myomectomy was a better option for fertility preservation, but UFE was a quicker and less invasive way of taking care of the complications that arise from fibroids [15]. Table 1 below highlights the major differences between UFE, myomectomy, and hysteroscopy.

LONG-TERM OUTCOMES AND FOLLOW-UP

Long-term follow-up studies have shown variable outcomes for both myomectomy and UFE, stating that the risk of intervention after 5 years (60 months) was 12.2% and 14.4% for myomectomy and UFE, respectively [19]. A recent meta-analysis comprising of 13 studies (9 observational and 4 randomized controlled trials), highlighted that UFE presented with a higher intervention rate (OR 1.84; 95% CI 1.62–2.10; $P < 0.01$; $I2 = 39\%$), hysterectomy rate (OR 4.04; 95% CI 3.45–4.72; $P < 0.01$; $I2 = 59\%$), and symptom-severity score (OR − 4.02; 95% CI 0.82, 7.22; $P = 0.01$; $I2 = 0\%$) compared to myomectomy at a four-year follow-up. But also stated that UFE was associated with lower risks of early complications (OR 0.44; 95% Cl 0.20-0.95; $P = 0.04$; $I 2 = 25\%$), and readmission rate (OR 1.16; 95% Cl 1.01-1.33; P+0.04; $I 2 = 0\%$) in comparison with myomectomy [20]. Post-operatively, patients are seen for follow-up 2-6 weeks after their surgery [21]. A pelvic exam is performed at 3 months, 6 months, and 1 year to assess for recurrence [22]. Due to symptom recurrence, UFE may require repeat embolization or eventual surgical intervention. Both groups benefit from scheduled imaging

and symptom-based follow-up. Regular gynaecological care remains essential for detecting regrowth, new fibroid formation, or other complications, such as endometrial changes [23].

Table 1. Comparative Characteristics of Uterine Fibroid Embolization (UFE), Myomectomy, and Hysterectomy in the Management of Uterine Fibroids

Category	UFE (Uterine Fibroid Embolization)	Myomectomy	Hysterectomy
Invasiveness and procedure type	Minimally invasive (catheter via groin/wrist); imaging-guided, performed by an interventional radiologist	Invasive (open, laparoscopic) surgical removal of fibroids, performed by a gynaecologic surgeon	Most invasive (abdominal, laparoscopic) surgical removal of the uterus, performed by a gynaecologic surgeon
Uterus Preservation	Uterus preserved; good for avoiding surgery, not focused on fertility	Uterus preserved; preferred for fertility preservation	Uterus removed; no future pregnancy possible
Fertility Impact	May reduce fertility; risk to ovarian function or uterine lining	Best for preserving fertility; recommended for women trying to conceive	Eliminates fertility; suitable for women past childbearing age
Symptom Relief and Recurrence	Good relief; recurrence possible;14.4% recurrence, may need repeat treatment	Excellent relief; 12.2% recurrence in 5 years, especially in younger women	Complete and permanent relief; no recurrence
Recovery Time	1–2 weeks; minimal hospital stays (often outpatient)	2–6 weeks, depending on type; hospital stay varies	4–8 weeks; hospital stay 2–5 days
Cosmetic and Physical Impact	Minimal scarring; cosmetically preferred	Visible scars (especially open surgery); less cosmetic	Scars vary by method; they may have hormonal/physical effects
Cost and Accessibility	Higher upfront cost; needs interventional radiology; limited access in low-resource areas	Cost-effective over time; requires surgical facilities	High initial cost but definitive, widely available
Ideal Candidates	Women seeking relief without surgery, not focused on fertility	Women wanting to preserve fertility and manage fibroid conditions	Women done with childbearing, severe symptoms, or high malignancy risk

(This table outlines crucial clinical, surgical, and patient-centred factors associated with each procedure, including their invasiveness, effects on fertility, symptom relief, recovery duration, cosmetic results, financial considerations, and the profiles of ideal candidates. Both UFE and myomectomy are options that preserve the uterus, whereas hysterectomy is a definitive procedure that removes fertility. The choice of treatment should be guided by the patient's goals, the characteristics of the fibroids, and the resources available).

CONCLUSION

Both Uterine Fibroid Embolization (UFE) and myomectomy remain important uterus-sparing treatment options for women dealing with complications caused by uterine fibroids. Myomectomy is still the preferred method for those seeking to preserve fertility, providing more favourable reproductive outcomes, while UFE is more appealing to

individuals looking for a less invasive option with a quicker recovery period. Clinical decisions should be personalized, considering patient goals, characteristics of the fibroids, existing health conditions, and the availability of resources. Looking ahead, there is an urgent need for comprehensive, large-scale, multicenter randomized controlled trials to thoroughly assess long-term fertility outcomes and recurrence rates associated with UFE. Current research is constrained by varying methodologies, brief follow-up durations, and an inadequate representation of women actively seeking pregnancy. Comparative studies that account for the type and location of fibroids, as well as the age of patients, are crucial for refining selection criteria and accurately assessing the risks and benefits of each treatment option. Creating clearer, evidence-based guidelines based on high-quality data will facilitate more customized, effective, and patient-centred approaches in the treatment of uterine fibroids.

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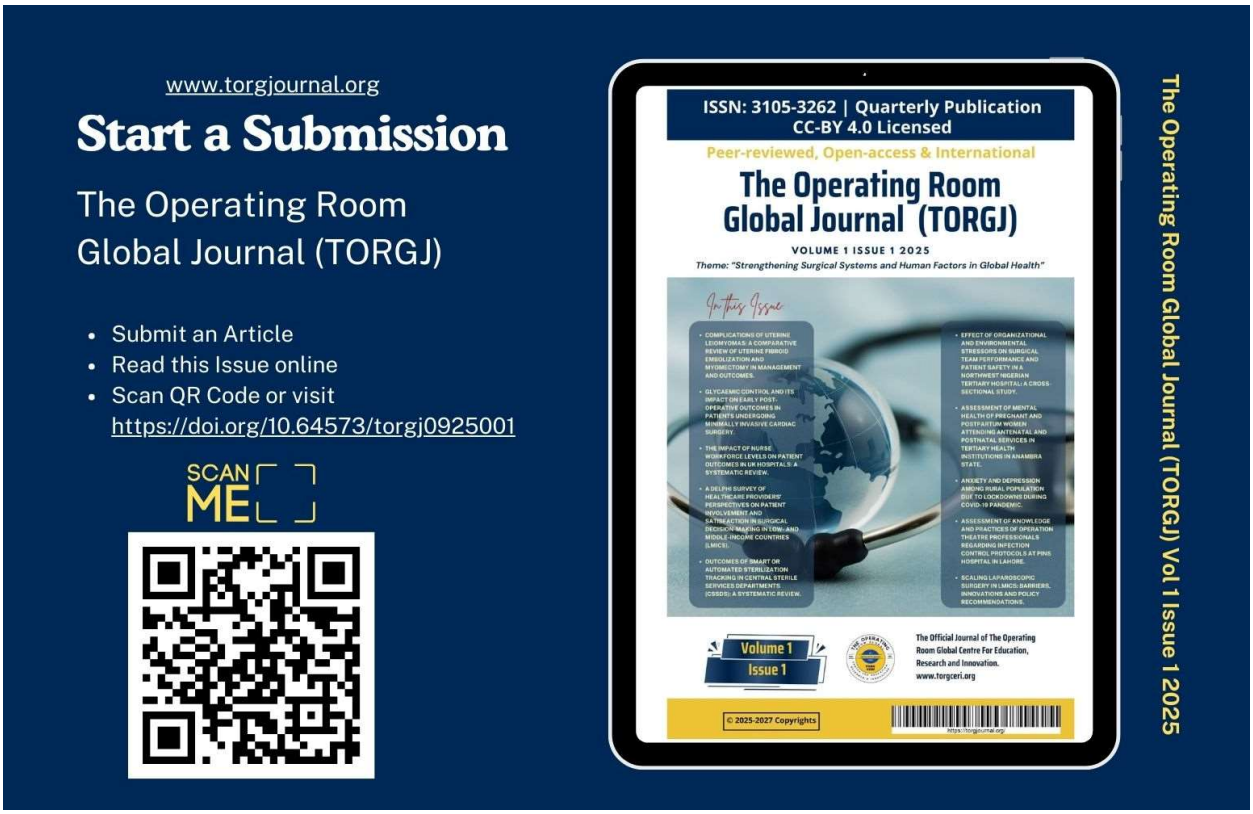

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Glycaemic Control and its Impact on Early Post-Operative Outcomes in Patients undergoing Minimally Invasive Cardiac Surgery

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ABSTRACT

Background: Minimally invasive cardiac surgery (MICS) offers benefits such as reduced surgical trauma and faster recovery. However, intraoperative hyperglycaemia during cardiopulmonary bypass (CPB) is a concern due to its association with adverse outcomes. While glycemic control has been studied in conventional cardiac procedures, limited data exist on its impact in MICS. **Objective:** To assess whether intraoperative blood glucose levels influence early postoperative outcomes in patients undergoing MICS. **Methodology:** A retrospective observational study at a tertiary care hospital was conducted over 8.5 months. 40 patients undergoing elective MICS were divided into two groups based on intraoperative blood glucose levels: Group A (≤200 mg/dL, n=15) and Group B (≥201 mg/dL, n=25). Preoperative, intraoperative, and postoperative data were collected, including neurocognitive outcomes (Mini-Mental State Examination), duration of mechanical ventilation, ICU stay, and need for inotropic support. Statistical analysis was performed using SPSS v26.0 with $p<0.05$ considered significant. **Results:** Baseline characteristics were comparable, except for higher creatinine clearance in the hyperglycaemic group. No significant differences were found in neurocognitive function or mechanical ventilation time between groups. However, a trend toward longer ICU stays was observed in Group B ($p=0.082$), and cooling temperatures during CPB were significantly higher in this group ($p=0.046$). One mortality occurred in the hyperglycaemic group. **Conclusion:** Although not all findings reached statistical significance, intraoperative hyperglycaemia in MICS was associated with increased ICU stay and cooling intervention requirements. These findings suggest a potential role for improved intraoperative glucose management to support better recovery and resource efficiency in MICS. Larger, prospective studies are recommended.

KEYWORDS: Glycemic Control, Minimally Invasive Cardiac Surgery, Cardiopulmonary Bypass, Hyperglycaemia, Postoperative Outcomes, Neurocognitive Function, ICU Stay.

INTRODUCTION

Minimally invasive cardiac surgery (MICS) has revolutionized the field of cardiac surgery by providing a less invasive alternative to conventional sternotomy-based procedures. Over the past two decades, MICS has gained significant attention due to its potential benefits, including reduced postoperative pain, shorter hospital stays, faster recovery, and improved cosmetic outcomes [1], [2]. Unlike traditional open-heart surgery, which requires a full median sternotomy, MICS involves smaller incisions, specialized instrumentation, and video-assisted techniques to achieve the same surgical objectives with reduced trauma to the patient [3]. Despite these advantages, MICS presents unique intraoperative challenges, particularly in terms of metabolic regulation, hemodynamic stability, and neurocognitive outcomes [4]. One of the critical factors influencing postoperative recovery in MICS is glycemic control during surgery, as intraoperative hyperglycemia has been associated with adverse outcomes in cardiac surgical patients [5].

Glycemic control is a fundamental aspect of perioperative management, especially in cardiac surgery, where patients often experience metabolic dysregulation due to stress-induced hyperglycemia [6]. This phenomenon occurs due to the physiological stress response triggered by surgical trauma, anesthesia, and cardiopulmonary bypass (CPB), which leads to increased secretion of counter-regulatory hormones such as cortisol, catecholamines, and glucagon [7]. These hormonal changes promote hepatic gluconeogenesis and insulin resistance, resulting in transient hyperglycemia even in non-diabetic patients [8]. The detrimental effects of hyperglycemia during cardiac surgery have been well-documented, with studies linking elevated blood glucose levels to increased risks of postoperative infections, delayed wound healing, renal dysfunction, prolonged mechanical ventilation, and higher mortality rates [9], [10]. However, most research in this domain has focused on conventional cardiac surgery, with limited studies specifically examining the impact of glycemic control in the context of MICS [11].

The scope of this study encompasses an in-depth analysis of intraoperative glycemic control and its impact on early postoperative outcomes in patients undergoing MICS. This research was conducted over a period of 8.5 months at a high-volume tertiary care center, analyzing a cohort of 40 patients who met the inclusion criteria from an initial pool of 197 screened individuals. This study focuses on evaluating key postoperative parameters such as neurocognitive function, duration of mechanical ventilation, length of intensive care unit (ICU) stay, postoperative complications, and overall recovery patterns. Patients were categorized into two groups based on intraoperative blood glucose levels: those maintaining blood glucose levels ≤200 mg/dL and those with levels ≥201 mg/dL. The study aims to provide a comprehensive understanding of the role of intraoperative glycemic management in optimizing patient outcomes after MICS and to identify potential strategies for improving perioperative metabolic control [12].

The importance of this research lies in its potential to address a critical gap in the existing literature. While strict glycemic control has been widely advocated in general cardiac surgery, its role in the specialized setting of MICS remains underexplored [13]. Given the rising popularity of MICS and its increasing adoption worldwide, understanding the impact of intraoperative hyperglycemia on early postoperative recovery is essential for improving surgical protocols and patient safety [14]. This study seeks to contribute valuable insights into the ongoing debate regarding optimal glycemic targets during cardiac surgery and their influence on clinical outcomes [15]. Future advancements in perioperative glucose management could help refine existing strategies, minimize complications, and enhance patient recovery following MICS [16].

MICS has been increasingly recognized as a transformative approach in cardiac surgery, offering advantages over traditional sternotomy-based procedures in terms of reduced trauma, faster recovery, and lower complication rates

[17]. However, the metabolic challenges associated with MICS, particularly those related to glycemic fluctuations during surgery, remain an area of ongoing investigation [18]. Intraoperative hyperglycemia, often exacerbated by cardiopulmonary bypass (CPB) and surgical stress, has been linked to adverse clinical outcomes, including increased risk of infections, prolonged intensive care unit (ICU) stays, and delayed wound healing [19]. While numerous studies have explored the effects of hyperglycemia in conventional cardiac surgery, relatively few have specifically examined its impact in the context of MICS, where different surgical techniques and reduced tissue trauma may alter the metabolic response and postoperative outcomes [20].

One of the primary mechanisms contributing to perioperative hyperglycemia is the neurohormonal stress response induced by surgery. The activation of the hypothalamic-pituitary-adrenal (HPA) axis leads to increased secretion of cortisol, catecholamines, and inflammatory cytokines, which collectively promote insulin resistance and hepatic glucose production [21]. Furthermore, the use of CPB itself has been associated with systemic inflammatory response syndrome (SIRS), leading to endothelial dysfunction, oxidative stress, and impaired glucose metabolism [22]. In MICS, where CPB is still frequently used, albeit with modified techniques such as peripheral cannulation and lower systemic heparinization, the metabolic implications of hyperglycemia remain an area of concern [23]. Given that even transient episodes of intraoperative hyperglycemia have been associated with poor postoperative outcomes in conventional cardiac surgery, there is a need to determine whether similar trends are observed in MICS patients or whether the reduced surgical trauma confers a protective effect against glycemic fluctuations [24].

The clinical consequences of intraoperative hyperglycemia extend beyond metabolic derangements and have been implicated in neurocognitive dysfunction following cardiac surgery. Studies have shown that hyperglycemia-induced oxidative stress, endothelial dysfunction, and pro-inflammatory cytokine release can contribute to neuronal injury, increasing the risk of postoperative cognitive dysfunction (POCD) [25]. While POCD has been widely studied in the context of traditional cardiac surgery, its prevalence and severity in MICS remain less well defined [26]. Some evidence suggests that MICS may be associated with lower rates of POCD due to reduced systemic inflammation and shorter CPB durations, but whether intraoperative hyperglycemia modulates this risk remains unclear [27]. In our study, we assessed neurocognitive function postoperatively using the Mini-Mental State Examination (MMSE) to determine whether intraoperative glycemic fluctuations had any measurable impact on early cognitive recovery in MICS patients [28].

In addition to neurocognitive outcomes, glycemic control during MICS may influence other key postoperative parameters, including the duration of mechanical ventilation, length of ICU stay, and overall morbidity. Hyperglycemia has been associated with impaired pulmonary function and increased susceptibility to ventilator-associated pneumonia (VAP), leading to prolonged mechanical ventilation times and higher ICU resource utilization [29]. Moreover, patients with poor glycemic control often experience increased inflammatory responses and endothelial dysfunction, which may prolong ICU stays and delay overall recovery [30]. By stratifying patients based on intraoperative glycemic levels and analyzing their postoperative course, this study aims to provide evidence regarding the role of glycemic management in optimizing recovery after MICS [31].

Despite the well-documented risks associated with intraoperative hyperglycemia in conventional cardiac surgery, there remains considerable debate regarding the optimal glycemic targets in MICS. Some studies advocate for tight glucose control (blood glucose <180 mg/dL), citing reduced rates of infection and improved wound healing [32]. However, others caution against overly aggressive glucose management due to the potential for hypoglycemia, which is equally detrimental and has been linked to increased mortality in critically ill patients [33]. The balance between preventing

hyperglycemia-induced complications and avoiding hypoglycemia-related risks is particularly crucial in MICS, where patients often undergo shorter surgical durations and experience reduced physiological stress compared to traditional open-heart procedures [34]. Our study sought to address this issue by comparing outcomes in patients with intraoperative glucose levels ≤200 mg/dL versus those with levels ≥201 mg/dL, aiming to determine whether stricter glycemic control is necessary in the context of MICS [35].

One of the most important aspects of postoperative recovery in cardiac surgery patients is ICU length of stay. Previous research has established a correlation between poor glycemic control and prolonged ICU admissions, primarily due to higher incidences of infection, organ dysfunction, and delayed extubation [36]. In MICS, where early extubation and fast-track recovery protocols are increasingly implemented, maintaining optimal glycemic levels could play a crucial role in ensuring shorter ICU stays and improved patient throughput [37]. Findings of this study suggested that patients with higher intraoperative glucose levels exhibited a trend toward prolonged ICU stays, although statistical significance was not reached. Nevertheless, the observed pattern supports the hypothesis that effective glycemic management may contribute to more efficient postoperative recovery in MICS patients [38].

In addition to ICU stay duration, another critical postoperative parameter is the need for inotropic support. Patients undergoing cardiac surgery often experience transient myocardial stunning and vasoplegia, requiring inotropes or vasopressors for hemodynamic stabilization [39]. Hyperglycemia has been implicated in worsening endothelial dysfunction and impairing myocardial contractility, potentially increasing the need for pharmacologic hemodynamic support [40]. In this study, it was assessed whether intraoperative hyperglycemia correlated with higher inotropic requirements, providing further insights into the cardiovascular effects of glycemic fluctuations during MICS [41]. While results did not show a statistically significant increase in inotropic use among hyperglycemic patients, the trend of prolonged ICU stays in this group suggests that glycemic control remains a relevant factor in perioperative hemodynamic stability [42].

Ultimately, this research highlights the importance of optimizing intraoperative glycemic control in MICS patients. While the immediate neurocognitive impact of hyperglycemia appeared minimally, trends toward prolonged ICU stays and increased intraoperative intervention requirements suggest that better glucose regulation may enhance overall recovery. Given the increasing global adoption of MICS, developing standardized perioperative glucose management protocols tailored to this surgical approach is essential [43]. Future studies should focus on larger patient cohorts, longer follow-up periods, and randomized controlled designs to further refine glycemic management strategies in MICS. By addressing this critical aspect of perioperative care, we can continue improving surgical outcomes, reducing morbidity, and enhancing the overall safety and efficiency of MICS procedures [44].

METHODOLOGY

This study was a retrospective observational analysis conducted at Mayo Hospital Lahore, a high-volume tertiary care center in Pakistan, over a period of 8.5 months. The research focused on patients undergoing MICS, with data obtained from electronic medical records and patient charts. Institutional review board (IRB) approval was secured before initiating data collection, ensuring compliance with ethical standards and patient confidentiality regulations.

A total of 197 patients who underwent elective MICS were initially screened, out of which 40 patients met the inclusion criteria and were selected for final analysis. Inclusion criteria required patients to be adults (≥18 years), undergoing elective MICS with preoperative glycemic data available and early postoperative neurocognitive assessments completed. Patients with pre-existing neurological disorders, poorly controlled diabetes mellitus (HbA1c >9.0%), emergency surgeries, or severe intraoperative complications requiring conversion to full sternotomy were excluded.

Patients were categorized into two groups based on intraoperative blood glucose levels recorded at multiple time points during surgery: Group A (glucose levels ≤200 mg/dL) and Group B (glucose levels ≥201 mg/dL). Blood glucose levels were measured preoperatively, at hourly intraoperative intervals, and postoperatively in the ICU for the first 24 hours. Standardized anesthetic and perfusion protocols were followed to minimize variability, with all surgeries performed via a right mini-thoracotomy or upper hemi-sternotomy approach. Cardiopulmonary bypass (CPB) was established using peripheral femoral arterial and venous cannulation, and myocardial protection was achieved through antegrade and/or retrograde cardioplegia administration.

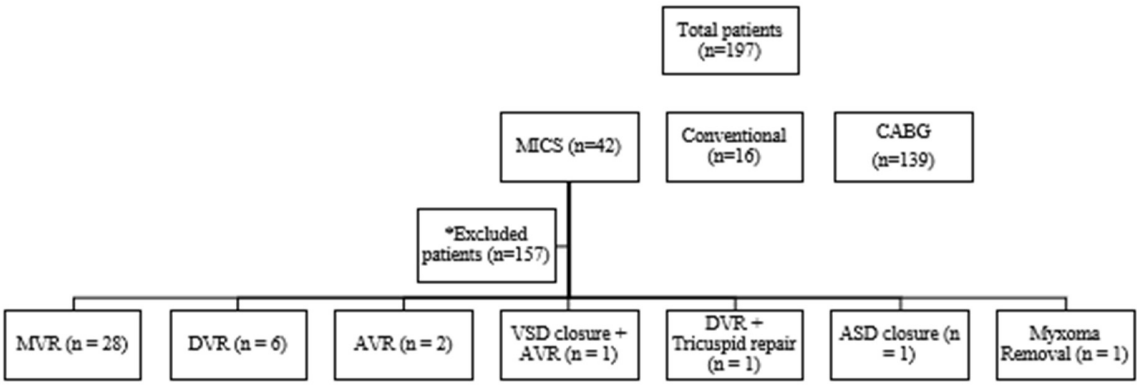

Figure 2.1: *Total patients n = number of patients; MICS = Minimal Invasive Cardiac Surgery; CABG = Coronary Artery Bypass Grafting; MVR = Mitral Valve Replacement; DVR = Double Valve Replacement; AVR = Aortic Valve Replacement; VSD = Ventricular Septal Defect; ASD = Atrial septal defect; MMSE = Mini-Mental State Examination. (*Patients which do not follow inclusion criteria).*

This study evaluated multiple postoperative outcomes, including neurocognitive function, duration of mechanical ventilation, ICU length of stay, postoperative blood loss, inotropic support requirements, and complications such as infections, atrial fibrillation, and renal dysfunction. Neurocognitive function was assessed using the Mini-Mental State Examination (MMSE) preoperatively and postoperatively at 24 and 72 hours. The duration of mechanical ventilation was measured from surgery completion to extubation, while ICU stay was recorded in total hours before transfer to a step-down unit. Postoperative blood loss was quantified as total chest drain output within the first 24 hours, and inotropic support was defined by the need for vasopressors beyond 24 hours postoperatively.

All statistical analysis were performed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation (SD) and compared using independent t-tests or Mann-Whitney U tests, while categorical variables were analyzed using chi-square or Fisher's exact tests. A p-value of <0.05 was considered statistically significant. By structuring the methodology in this manner, the study ensured a comprehensive evaluation of intraoperative glycemic control and its impact on early postoperative outcomes in MICS patients.

RESULTS

This study cohort comprised 40 patients undergoing MICS, divided into two groups based on intraoperative blood glucose levels. Group A (n=15) included patients with glucose levels ≤200 mg/dL, whereas Group B (n=25) encompassed those with levels ≥201 mg/dL. The baseline characteristics between the two groups were statistically comparable,

ensuring a balanced comparison. The mean age in Group A was 36.73 ± 13.32 years compared to 35.29 ± 11.67 years in Group B (p=0.665). Gender distribution was nearly equivalent, with Group A having 9 males and Group B 7 males (p=0.057). Furthermore, the body mass index (BMI) of Group A was 21.78 (range: 16.40–34.33) versus 24.48 (range: 16.46–45.32) in Group B (p=0.103), confirming no significant disparity in body composition across the cohorts.

Table 3.1: Baseline characteristics of patients undergoing Minimally Invasive Cardiac Surgery

Parameter	Blood Sugar Level		p-value
	≤ 200 mg/dl (n=15)	≥ 201 mg/dl (n=25)	
Gender; male; n (%)	9 (22.50)	7 (17.50)	0.057
Age (years)	36.73±13.32	35.29±11.67	0.665
Height (cm)	165.74 (154-186)	166.58 (149-185)	0.415
Weight (kg)	57.73±12.19	63.92±13.79	0.684
Body Mass Index (BMI) (kg/m²)	21.78 (16.40-34.33)	24.48 (16.46-45.32)	0.103
Body Surface Area (m²)	1.64 (1.37-1.98)	1.64 (1.20-2.05)	0.765
Hypertensive; n (%)	1 (2.50)	7 (17.50)	0.147
Diabetes; n (%)	1 (2.50)	2 (5)	0.849
Smoking; n (%)	2 (5)	0 (0)	0.066
Ejection Fraction (%)	57.00 (35-65)	59.67 (50-70)	0.323
Pre operate Hb (g/dl)	13.63±2.43	13.41±2.42	0.850
Platelets (10^9/l)	238.42±99.33	264.20±74.44	0.293
Urea (mg/dl)	28.43 (15-41)	27.47 (13-71)	0.283
Creatinine (mg/dl)	0.75 (0.56-1.34)	0.75 (0.43-1.10)	0.338
Creatinine Clearance Ratio	93.91 (51.45-186)	113.56 (77.74-236.89)	0.044

(Data is presented as mean ± SD for normally distributed variables and as n (%) for categorical variables where n = no. of patients. The p-values indicate the level of significance in the differences between the two groups ≤ 200 mg/dl and ≥ 201 mg/dl)

The renal function parameter, represented by the creatinine clearance ratio, was the only baseline variable that demonstrated statistical significance, with Group A showing a median value of 93.91 (range: 51.45–186) and Group B exhibiting a higher median value of 113.56 (range: 77.74–236.89) (p=0.044). Other parameters, such as ejection fraction and preoperative hemoglobin levels (13.63 ± 2.43 g/dL for Group A and 13.41 ± 2.42 g/dL for Group B, p=0.850), did not differ significantly between the groups, which reinforces the similarity in baseline clinical status.

During the intraoperative phase, several parameters were analyzed to ascertain the influence of glycemic control on surgical management. Pre-bypass hemoglobin levels in both groups were virtually identical (13.40 ± 2.25 g/dL in Group A vs. 13.42 ± 2.06 g/dL in Group B, p=0.617). The activated clotting time (ACT) before bypass was comparable, with Group A recording a median of 93.13 seconds (range: 90–117) and Group B 89.32 seconds (range: 90–128) (p=0.466). During CPB, the ACT values remained statistically similar between Group A (median 681.23 seconds; range: 343–1500) and Group B (median 612.92 seconds; range: 436–1500) (p=0.921), suggesting consistent anticoagulation management across groups.

In addition, hemoglobin levels during CPB were analyzed; Group A had a median of 9.57 g/dL (range: 8.29–14), while Group B recorded a median of 8.97 g/dL (range: 4.70–16.50) (p=0.212). Although not statistically significant, these values

underscore the uniformity of intraoperative blood conservation measures. Aortic cross-clamp time, a critical parameter reflecting surgical complexity, showed a median of 94.88 minutes (range: 63–170) in Group A compared to 124.32 minutes (range: 54–230) in Group B, with the p-value at 1.000 indicating no significant difference. Notably, cooling temperature exhibited a statistically significant difference between the groups, with Group A averaging 30.39 ± 1.41°C and Group B 30.57 ± 2.18°C (p=0.046), hinting at a metabolic modulation effect in the hyperglycemic cohort.

Table 3.2. Intraoperative characteristics of patients undergoing Minimally Invasive Cardiac Surgery

Parameter	Blood Sugar Level		p-value
	≤ 200 mg/dl (n=15)	≥ 201 mg/dl (n=25)	
Intraoperative phase			
Pre Bypass Hb (g/dl)	13.40±2.25	13.42±2.06	0.617
Pre Bypass ACT (sec)	93.13 (90-117)	89.32 (90-128)	0.466
ACT during CPB (sec)	681.23 (343-1500)	612.92 (436-1500)	0.921
Hb during CPB (g/dl)	9.57 (8.29-14)	8.97 (4.7-16.50)	0.212
Aortic Cross Clamp Time (min)	94.88 (63-170)	124.32 (54-230)	1.000
Cooling temperature (^{0}C)	30.39±1.41	30.57±2.18	0.046
Bypass time (min)	143.46 (93-207)	158.16 (78-342)	0.638
Autologous Blood (ml)	40 (0-250)	64 (0-450)	0.786
ACT after CPB (sec)	103.73 (90-142)	97.04 (90-114)	0.103

Collectively, the intraoperative data presents a picture of uniformly applied surgical and perfusion protocols, except for the cooling temperature parameter. The consistency in pre-bypass and CPB parameters supports that the only observed significant intraoperative variable, cooling temperature, might be reflective of the physiological adaptations due to hyperglycemia. This baseline and intraoperative statistical analysis lay the foundation for understanding how these factors might influence postoperative outcomes.

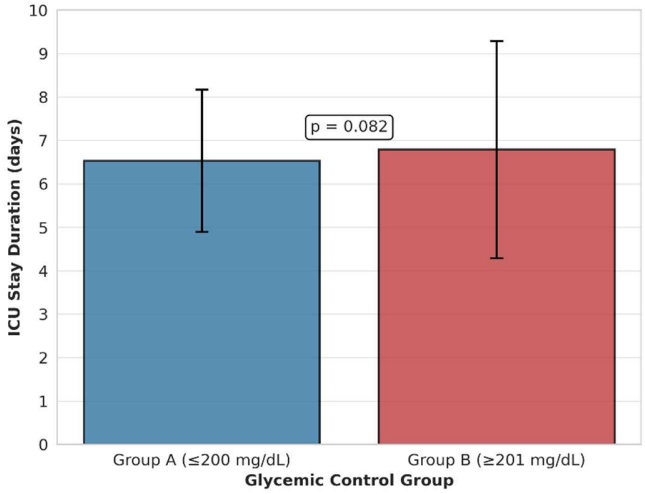

Figure 3.1: Glycemic Control vs. ICU Stay Duration

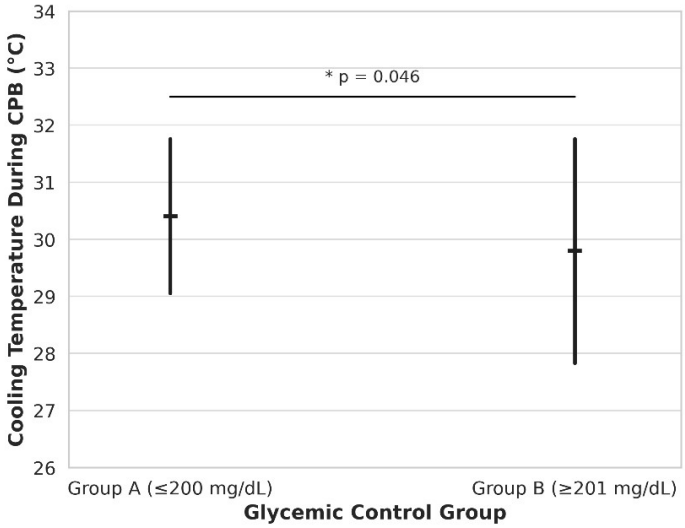

Figure 3.2: Cooling Temperature During CPB

Table 3.3: Postoperative and postoperative characteristics of patients undergoing Minimally Invasive Cardiac Surgery

Post-operative phase			
Hb after CPB	9.69 (7.84-15)	9.27 (0-11.57)	0.679
ACT in ICU (sec)	117.73 (97-181)	131.72 (90-190)	0.809
Ventilation Time (minutes)	195 (90-935)	191.72 (52-1050)	0.110
Blood Transfusion (FFP bags)	0.06 (0-1)	0.04 (0-1)	0.898
Blood Transfusion (PCV bags)	0.20 (0-2)	0.28 (0-2)	0.853
Urea (mg/dl)	35.22±12.97	31.48±14.09	0.918
Creatinine (mg/dl)	35.22 (17-62)	31.32 (0-62)	0.368
Blood drainage (ml)	727.67 (300-1710)	827 (290-2350)	0.578
Platelets count (10^9/ L)	195.99 (121-275)	170.89 (0-469)	0.368
Adrenaline (mcg/kg/min)	0.06±0.02	0.05±0.03	0.431
Nor-Adrenaline (mcg/kg/min)	0.13 (0.05 - 0.24)	0.12(0.21−0.03)	0.319
Dopamine (mcg/kg/min)	3.87(4.0−3.0)	4.52(11.0−3.0)	0.332
Post-MMSE score	24.22 (19-27)	22.52 (18-27)	0.432
ICU stay (days)	6.53±1.64	6.79±2.50	0.082
Mortality; n (%)	0 (0.00)	1 (2.5%)	0.831

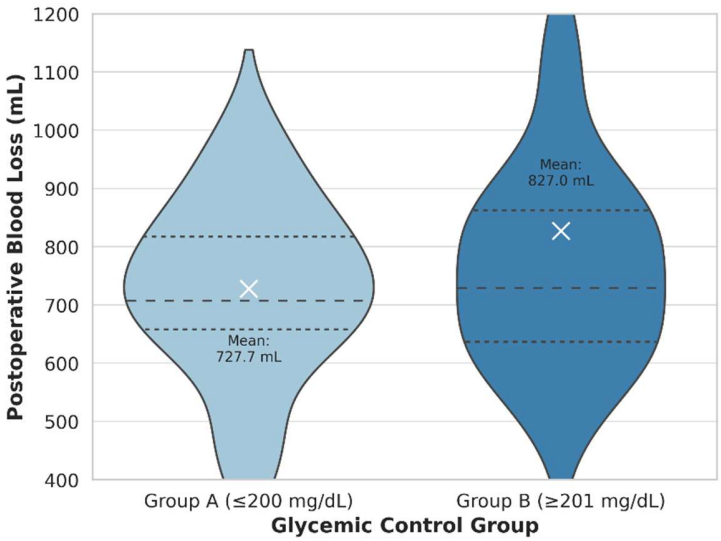

Figure 3.3: Postoperative Blood Loss Comparison

Postoperative outcomes were comprehensively evaluated using a series of quantitative measures to assess the impact of intraoperative glycemic control on recovery in minimally invasive cardiac surgery (MICS) patients. Neurocognitive function, measured by the Mini-Mini Mental State Examination (MMSE), served as one of the primary endpoints. Preoperative MMSE scores were comparable between Group A (median score 25, range: 19–27) and Group B (median score 25, range: 18–27), establishing a similar baseline cognitive function across the study cohorts. Postoperatively, MMSE scores recorded at 24 and 72 hours revealed a slight decline in both groups; however, statistical analysis indicated no significant difference between Group A and Group B (p=0.432). These findings suggest that intraoperative hyperglycemia, defined by blood glucose levels ≥201 mg/dL, did not have a deleterious effect on early neurocognitive recovery in the immediate postoperative period.

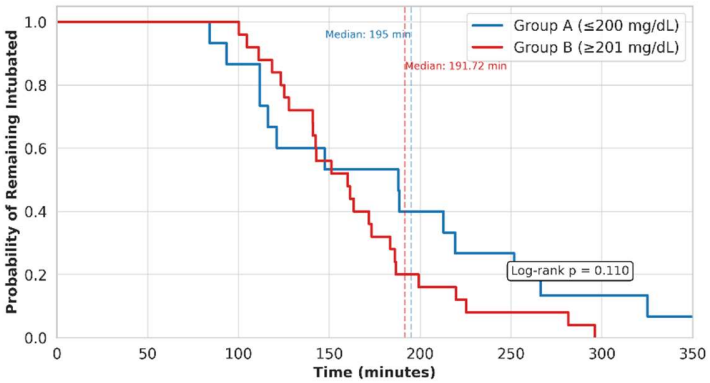

Figure 3.4: Mechanical Ventilation Time

The duration of mechanical ventilation, another critical postoperative parameter, was analyzed next. Group A had a median ventilation time of 195 minutes (range: 90–935 minutes) compared to 191.72 minutes (range: 52–1050 minutes) in Group B, with statistical analysis yielding a p-value of 0.110. Although the difference did not reach statistical significance, the data suggests that ventilatory support requirements were largely independent of intraoperative glycemic variations. In terms of ICU stay, a trend towards longer durations was observed in the hyperglycemic group. Group A demonstrated a mean ICU stay of 6.53 ± 1.64 days, whereas Group B had a mean stay of 6.79 ± 2.50 days (p=0.082). While this difference did not achieve statistical significance, the trend hints at an

association between elevated intraoperative blood glucose and prolonged ICU resource utilization, a finding that aligns with previous studies linking hyperglycemia with delayed recovery.

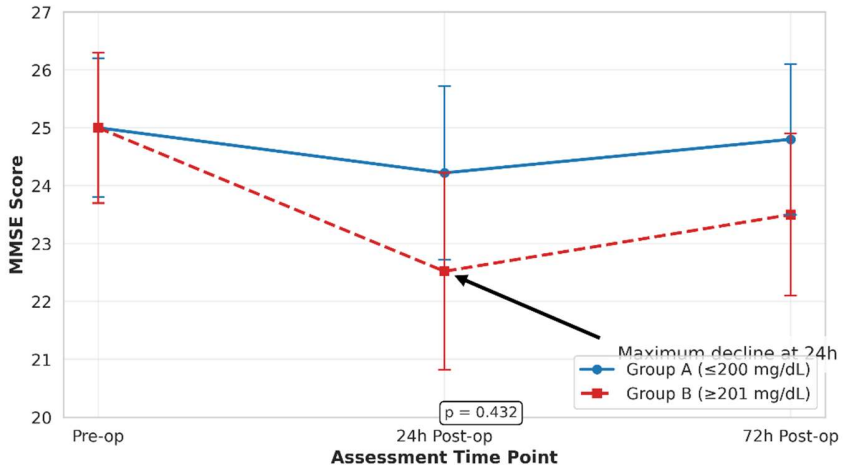

Figure 3.5: Neurocognitive Function (MMSE Scores)

Postoperative blood loss was quantified by measuring chest drain output over the first 24 hours following surgery. Group A exhibited a median output of 727.67 mL (range: 300–1710 mL) compared to 827 mL (range: 290–2350 mL) in Group B (p=0.578). This similarity in blood loss between groups indicates that intraoperative glycemic control did not significantly influence hemostatic stability post-surgery. Additionally, inotropic support requirements were assessed by recording the dosages of administered agents such as adrenaline, noradrenaline, and dopamine. The results demonstrated comparable infusion rates between the groups, with adrenaline administered at 0.06 ± 0.02 mcg/kg/min in Group A versus 0.05 ± 0.03 mcg/kg/min in Group B (p=0.431) and noradrenaline at 0.13 mcg/kg/min (range: 0.05–0.24) in Group A versus 0.12 mcg/kg/min (range: 0.03–0.21) in Group B (p=0.319). Dopamine infusion rates were similarly not statistically different between the groups (p=0.332), indicating that the hemodynamic support requirements were not significantly altered by the degree of glycemic control during surgery.

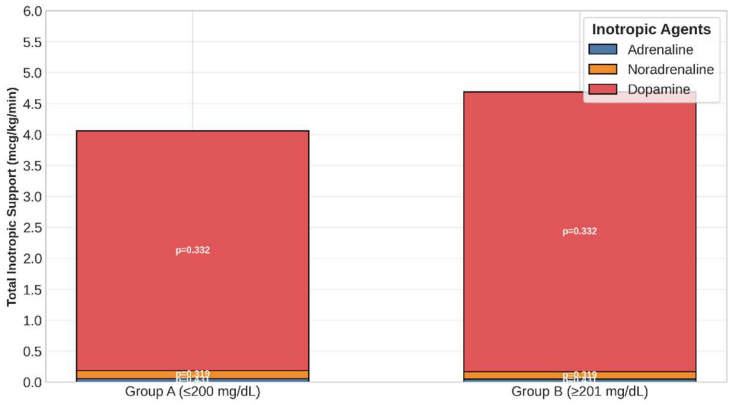

Figure 3.6: Inotropic Support Requirements

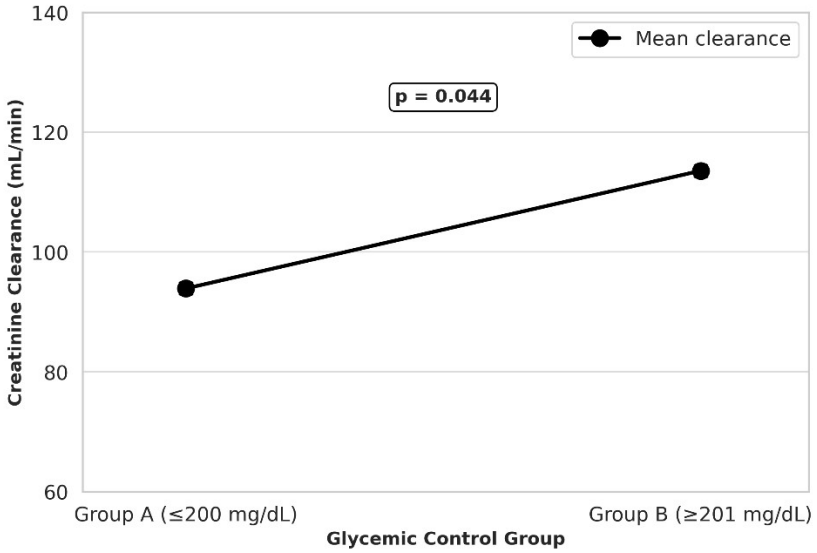

Figure 3.7: Creatinine Clearance Ratio

Finally, mortality was analyzed as a binary outcome. Although one death was recorded in Group B (2.5%) and none in Group A, the difference was not statistically significant (p=0.831). Overall, the postoperative results underscore that while certain trends, such as prolonged ICU stay, may be associated with intraoperative hyperglycemia, the majority of key clinical outcomes including neurocognitive function, ventilation time, and blood loss remained statistically comparable between patients with controlled versus elevated blood glucose levels. These findings provide critical insight into the complex interplay between glycemic management and postoperative recovery in MICS, setting the stage for further research to validate and refine these observations in larger, prospective studies.

DISCUSSION

The findings of this study contribute significantly to our understanding of the role of intraoperative glycemic control in MICS, and they offer both expected and unexpected insights when compared with the existing literature. In investigation, patients with intraoperative blood glucose levels above 200 mg/dL demonstrated a trend toward prolonged intensive care unit (ICU) stays and increased cooling temperature requirements during CPB, although other key outcomes such as neurocognitive function, mechanical ventilation time, and postoperative blood loss did not differ significantly between groups. These results align with several previous studies in conventional cardiac surgery that have linked hyperglycemia with increased postoperative complications, including longer ICU stays and higher rates of morbidity [45]. However, findings regarding neurocognitive outcomes were somewhat unexpected, as previous literature has suggested that hyperglycemia might exacerbate neurocognitive decline following surgery [46]. This discrepancy raises important questions about whether the reduced surgical trauma and shorter CPB times associated with MICS might mitigate the neurocognitive risks commonly observed in more invasive procedures.

Study's design and methodological approach played a critical role in shaping these outcomes. By employing strict inclusion criteria and standardized intraoperative protocols, confounding variables that could obscure the true relationship between glycemic control and postoperative outcomes were minimized. For example, the uniform application of anesthetic and perfusion techniques ensured that differences in outcomes were more likely attributable to metabolic differences rather than variations in surgical technique. This methodological rigor is consistent with recommendations from previous studies that emphasize the need for standardization in cardiac surgery research [47]. Nevertheless, the relatively small sample size and retrospective nature of the study may have limited our ability to detect statistically significant differences in some outcomes, such as neurocognitive function and inotropic support, which might require larger cohorts to fully elucidate their clinical significance [48].

The observed association between higher intraoperative glucose levels and increased cooling temperature requirements is particularly noteworthy. It suggests that hyperglycemia may impose additional metabolic stress, thereby necessitating adjustments in temperature management during CPB. This finding is in agreement with other research that has noted a compensatory response in hyperglycemic patients during surgery [49]. Additionally, while the trend toward prolonged ICU stay in the hyperglycemic group did not reach statistical significance, it is clinically relevant and may indicate a subtle but important impact of glycemic variability on postoperative recovery. Such trends underscore the potential benefits of optimizing glycemic control not only to improve patient outcomes but also to reduce healthcare resource utilization, an aspect that is increasingly important in contemporary clinical practice.

The discussion of our results must also address the broader implications for future research. The differences observed in cooling temperature and ICU stay, though modest, point to the need for further prospective studies with larger sample sizes and longer follow-up periods to verify these preliminary findings. Moreover, our results suggest that additional factors such as the interplay between glycemic control and inflammatory responses should be explored to fully understand the mechanisms underlying postoperative recovery in MICS patients. Future studies could also investigate whether more aggressive glycemic control strategies, while avoiding hypoglycemia, might yield even better outcomes in terms of reducing postoperative complications. As such, our findings contribute to a growing body of evidence that underscores the importance of individualized metabolic management in cardiac surgery, particularly within the evolving field of minimally invasive techniques [50].

Building upon the insights gained from our study, it is imperative to delve deeper into the implications of our findings and how they inform future clinical practice and research in the field of MICS. One of the key takeaways is that intraoperative hyperglycemia appears to exert a multifaceted impact on postoperative recovery. Although the anticipated neurocognitive decline was not observed to a statistically significant degree, the trends noted in prolonged intensive care unit (ICU) stays and increased cooling temperature requirements warrant further scrutiny. These observations underscore the complexity of metabolic regulation during MICS, suggesting that even modest hyperglycemic excursions may trigger compensatory physiological mechanisms, such as alterations in thermal management strategies during cardiopulmonary bypass (CPB) [50]. The interplay between glycemic control and these intraoperative adjustments is an area ripe for future exploration.

Study's results echo findings from previous research, which have highlighted the role of systemic hyperglycemia in exacerbating inflammatory responses and oxidative stress, both of which are critical factors in postoperative morbidity [51]. It is plausible that hyperglycemia may amplify the production of pro-inflammatory cytokines, thereby contributing to subtle disruptions in organ function that manifest as prolonged ICU stays. Such physiological stress responses have been well documented in the context of traditional cardiac surgery [52], yet their specific impact in the realm of MICS remains less well defined. By controlling for variables such as surgical technique and CPB duration, our study provides a focused lens through which to examine these metabolic effects. Nonetheless, the retrospective nature of our research imposes certain limitations, notably in establishing causal relationships and fully accounting for all potential confounders.

Another significant aspect of discussion relates to the methodological rigor that underpinned our study. The decision to stratify patients based on intraoperative blood glucose levels allowed us to draw meaningful comparisons between groups with different metabolic profiles. This stratification is supported

by the growing body of evidence that advocates for tighter glycemic control during cardiac procedures [53]. However, our study also highlights the challenges associated with implementing such protocols in clinical practice, particularly the risk of hypoglycemia when aggressively managing blood glucose levels [54]. Thus, it is essential that future research not only seeks to confirm our findings in larger, prospective cohorts but also explores the optimal balance between preventing hyperglycemia and avoiding the pitfalls of overcorrection.

Moreover, our study raises important questions about the broader applicability of our findings to diverse patient populations. The relatively homogenous sample in terms of demographic and baseline clinical characteristics suggests that the effects of glycemic control may vary in populations with different comorbidities or in settings where MICS is performed under different surgical or anesthetic protocols [55]. Future investigations should aim to include a more diverse patient population and consider stratifying results based on additional variables such as the severity of pre-existing conditions and variations in perioperative care.

In light of these considerations, one recommendation for future research is to undertake randomized controlled trials that specifically target the impact of tailored glycemic management strategies in MICS. Such studies could employ continuous glucose monitoring and advanced insulin delivery systems to refine our understanding of the metabolic thresholds that optimize surgical outcomes [56]. Additionally, exploring adjunctive therapies that mitigate the inflammatory and oxidative effects of hyperglycemia may prove beneficial in further improving patient recovery and reducing postoperative complications. Ultimately, our findings contribute to an evolving narrative that emphasizes the critical importance of metabolic management in cardiac surgery and highlight the need for ongoing research to refine clinical protocols for MICS [57].

CONCLUSION

In conclusion, this study successfully achieved its primary aim of evaluating the impact of intraoperative glycemic control on early postoperative outcomes in minimally invasive cardiac surgery (MICS) patients. The research demonstrated that while most baseline and intraoperative parameters were comparable between patients with controlled (≤200 mg/dL) and elevated (≥201 mg/dL) blood glucose levels, hyperglycemia was associated with a statistically significant increase in cooling temperature requirements and a trend toward prolonged intensive care unit (ICU) stays. These findings align with our initial hypothesis that maintaining optimal glycemic levels can favourably influence postoperative recovery, particularly in terms of resource utilization and overall patient stability.

Although neurocognitive outcomes, as measured by the Mini-Mental State Examination, did not differ significantly between the groups, the observed trends in other critical parameters underscore the importance of stringent metabolic management during MICS. The study's design, which involved a retrospective review of 40 carefully selected patients and standardized intraoperative protocols, provided a robust framework for isolating the effects of glycemic variability. However, the limited sample size and the retrospective nature of the investigation are acknowledged as key limitations, suggesting that the results should be interpreted with caution.

Future research should focus on prospective, randomized controlled trials with larger cohorts to further validate these findings and explore the potential benefits of advanced glycemic monitoring and management strategies, such as continuous glucose monitoring systems. Ultimately, the significance of this work lies in its contribution to the growing body of evidence supporting the optimization of

intraoperative glycemic control as a means to enhance surgical outcomes in MICS, thereby offering a valuable approach to improving patient recovery and reducing postoperative complications.

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A Delphi Survey of Healthcare Providers' Perspectives on Patient Involvement and Satisfaction in Surgical Decision-Making in Low- and Middle-Income Countries (LMICs)

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ABSTRACT

Background: Patient involvement in surgical decision-making is increasingly recognized as a cornerstone of patient-centered care, yet evidence from low- and middle-income countries (LMICs) remains limited. Understanding healthcare providers' perceptions of patient participation, satisfaction, and the role of technology in these settings is essential to inform practice and policy.
Methods: A Delphi survey was conducted on The Operating Room Global (TORG) platform with 184 healthcare professionals, including surgeons, nurses, anesthesiologists, and allied staff from 12 LMICs. The survey explored frequency, challenges, and determinants of patient involvement in surgical decision-making, as well as satisfaction levels and technology utilization. Quantitative data were analyzed using descriptive statistics, and qualitative responses underwent narrative analysis.
Results: Most respondents reported frequent patient involvement in surgical decision-making (34.6% often; 31.4% very often), with influencing factors including physician recommendations (59.1%), treatment options (61.0%), and patients' medical history (54.6%). Key barriers included lack of patient education materials (63.0%), time constraints (57.1%), language barriers (50.7%), and cultural differences (50.7%). Preoperative counseling was the predominant method of assessing patient understanding (86.4%), whereas decision aids were underutilized (36.6%). Patient satisfaction was generally positive, with 67.9% satisfied or very satisfied, though 30.6% reported neutral or negative experiences. Technology, particularly online resources (45.1%) and telemedicine (16.4%), emerged as facilitators of patient engagement.
Conclusion: Patient involvement in surgical decision-making is valued but inconsistently practiced across LMICs. Addressing systemic barriers such as language and cultural gaps, expanding educational resources, and integrating decision aids and digital health tools can enhance patient-centered surgical care and satisfaction.
Keywords: Patient Involvement; Surgical Decision-Making; Patient Satisfaction; Decision Aids; Low- And Middle-Income Countries; Delphi Survey

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INTRODUCTION

Patient involvement in surgical decision-making has emerged as a cornerstone of patient-centered care, directly influencing satisfaction, adherence to treatment, and overall healthcare outcomes [1]. In high-income countries, increasing emphasis has been placed on shared decision-making models, yet evidence from low- and middle-income countries (LMICs) remains limited and fragmented. LMICs, as defined by the World Bank, are nations with gross national income per capita below the threshold for high-income economies [2]. Understanding how patients are engaged in surgical decision-making in these settings is critical for improving healthcare delivery and aligning surgical care with patients' values and preferences.

The dynamics of patient participation in LMICs are shaped by multiple factors. Cultural norms and social expectations often determine whether patients are encouraged to express their preferences or defer decisions to family members and healthcare providers [3]. Language barriers and limited health literacy further restrict patients' ability to understand treatment options, risks, and benefits [4]. In many LMIC healthcare systems, resource limitations, understaffing, and overcrowding compound these challenges, leaving little time for thorough patient-provider dialogue [5]. Collectively, these factors create variability in patient involvement across diverse healthcare contexts.

Although evidence demonstrates that patient participation enhances satisfaction and treatment outcomes, several barriers continue to hinder its consistent implementation in LMIC surgical care. Disparities in socioeconomic status and access to healthcare resources often exacerbate inequities in decision-making opportunities, particularly for patients from rural or marginalized communities [6]. Moreover, while decision aids, such as brochures, preoperative counseling tools, and digital applications, are proven to improve patients' knowledge and engagement [7], their use remains underdeveloped in LMICs. Emerging technologies, including telemedicine, online resources, and mobile health applications, show promise in bridging communication and educational gaps, but their adoption is still uneven [8].

Given these gaps, there is a pressing need to systematically explore healthcare providers' perspectives on patient involvement in surgical decision-making within LMICs. Such an inquiry can identify not only prevailing practices but also the cultural, systemic, and logistical barriers that limit patient participation. By engaging a diverse group of professionals across multiple LMICs, the present Delphi survey seeks to provide insights that can guide context-specific interventions.

This study therefore aims to determine the frequency of patient involvement in surgical decision-making, identify challenges and facilitators, assess the role of decision aids and technology, and evaluate patient satisfaction. The central research question is: What are the current practices, challenges, and impacts of patient involvement in surgical decision-making within low- and middle-income countries?

METHODOLOGY

STUDY DESIGN

This study employed a Delphi survey methodology to explore healthcare providers' perceptions of patient involvement in surgical decision-making in low- and middle-income countries (LMICs). The Delphi technique is well-suited for achieving consensus among experts across diverse settings and has been widely used to prioritize research and clinical practices [9]. The survey was conducted on The Operating Room Global (TORG) platform using an online questionnaire hosted on SurveyMonkey.

SAMPLING AND DATA COLLECTION

A deliberate sampling strategy was applied to capture perspectives from a broad range of surgical care providers. Eligible participants included surgeons, anesthesiologists, perioperative nurses, surgical technologists, perfusionists, and other allied professionals actively engaged in surgical care across LMICs.

Invitations were distributed through professional networks, healthcare associations, and targeted email lists. The survey was conducted with five participants to ensure clarity and refine the questionnaire before full dissemination. Out of more than 1,000 invitations, 184 respondents completed the survey, representing a diverse cross-section of healthcare roles, countries, and years of professional experience. The target sample size was calculated at 278 for a 95% confidence level; the final sample (n = 184) reflects a 66.2% response relative to this target. The questionnaire included items on demographic and professional characteristics, frequency and methods of involving patients in surgical decision-making, challenges encountered, satisfaction levels, and the use of decision aids and technology. Both closed-ended and open-ended questions were included to capture quantitative metrics and qualitative insights. Informed consent was obtained electronically, and participation was voluntary.

DATA ANALYSIS

Quantitative data were analyzed using descriptive statistics, including frequencies and percentages for categorical variables. Qualitative responses from open-ended questions were coded and examined through narrative analysis to identify recurring themes, success stories, and recommendations for improvement [10]. To strengthen validity, responses were anonymized and reviewed by multiple members of the research team.

ETHICAL CONSIDERATIONS

Ethical approval for this study was obtained from the Institutional Review Board (IRB) of *The Operating Room Global* (Ref. No: TORG/IRB/001/2025). Anonymity and confidentiality were maintained throughout the study. No personally identifiable information was collected, and responses were stored on encrypted servers accessible only to the research team. All participants provided informed consent after being presented with the study objectives, voluntary nature of participation, and data protection measures. A copy of the consent form is included in Appendix B.

RESULTS

A total of 184 participants from 12 LMICs completed the survey, providing a diverse representation of demographic and professional backgrounds. The analysis highlights patterns in patient involvement in surgical decision-making, associated challenges, and strategies employed by healthcare providers.

Demographic and Professional Characteristics

The respondents included a balanced gender distribution (56.5% female, 43.5% male) with minimal representation of non-binary participants (0.5%). The largest age group was 36–45 years (38.6%), followed by 26–35 years (28.3%), with 14.1% aged 56 and above. Participants were drawn from multiple LMICs, with notable representation from Nigeria (17.6%), Rwanda (13.0%), and Ghana (13.0%).

Professionally, theatre and perioperative nurses formed the majority (56.9%), followed by surgical technologists (13.3%), registered nurse first assistants (9.4%), and surgeons (2.2%). Respondents had varied levels of experience, with 30.9% reporting more than 16 years in practice and 22.8% within the first five years of their careers. These findings underscore the breadth of perspectives represented across roles, seniority, and regions.

Table 1. *Respondents' Socio-Demographic Characteristics, Professional Background, and Years of Experience in Healthcare*

Variable	Frequency	Percentage (%)
Age of Respondents		
18–25	13	7.07
26–35	52	28.26

36–45	71	38.59
46–55	22	11.96
56 and above	26	14.13
Sex distribution		
Male	80	43.48
Female	104	56.52
Non-binary	1	0.54
Prefer not to say	0	0.00
Country (LMIC)		
Nigeria	32	17.58
Rwanda	24	13.00
Tanzania	2	1.10
Zimbabwe	2	1.10
Ethiopia	2	1.10
Pakistan	18	9.80
Ghana	24	13.00
Philippines	2	1.10
Eswatini	2	1.10
India	3	1.60
Zambia	3	1.60
Kenya	6	3.30
Professional Background		
Surgeon	4	2.21
Theatre & Perioperative Nurse	103	56.91
Surgical Resident	1	0.55
Anesthesiologist	4	2.21
Anesthesia Technician	6	3.31
Medical Student	2	1.10
Registered Nurse Anesthetist	6	3.31
Surgical Technologist	24	13.26
First Assistant	3	1.66
Registered Nurse First Assistant	17	9.39
Perfusionist	4	2.21
Non-Medical Student	7	3.87
Years of Experience		
0–5 years	42	22.83
6–10 years	40	21.74
11–15 years	34	18.48
16+ years	57	30.98
Retired	11	5.98

Frequency of Patient Involvement and Key Influencing Factors

Most respondents reported frequent patient involvement in surgical decision-making, with 34.6% indicating "often" and 31.4% "very often." However, a smaller proportion noted occasional (18.3%) or rare (11.8%) involvement, while 3.9% reported patients were never involved.

Key factors influencing patient participation included the availability of treatment options (61.0%), physician recommendations (59.1%), patients' medical history (54.6%), and financial considerations (52.0%). Patient preferences and values were also highlighted as significant determinants (51.3%).

Preoperative counseling sessions were overwhelmingly reported as the primary method for assessing patient understanding (86.4%), while educational materials such as pamphlets and brochures were rarely used (8.4%). Patient expression of preferences was variable: 34.4% of respondents noted that patients "often" shared their views, 11.0% reported "very often," while 33.1% observed only occasional input, and 17.5% reported it as rare.

Table 2. *Patient Involvement, Key Influencing Factors, Assessment Methods, and Expression of Preferences in Surgical Decision-Making*

Category	Response Option	Percentage (%)
Frequency of Patient Involvement	Very Often	31.37
	Often	34.64
	Occasional	18.30
	Rare	11.76
	Never	3.92
Key Factors Influencing Patient Involvement	Physician Recommendations	59.09
	Availability of Treatment Options	61.04
	Patients' Medical History	54.55
	Financial Considerations	51.95
	Patient Preferences and Values	51.30
Methods for Assessing Patient Understanding	Preoperative Counseling Sessions	86.36
	Pamphlets and Brochures	8.44
Patient Expression of Preferences	Very Often	11.04
	Often	34.42
	Occasional	33.12
	Rare	17.53

Together, these findings demonstrate that while patient involvement is frequently observed, it is influenced by a complex mix of clinical, financial, and cultural factors. Opportunities remain for expanding educational methods beyond traditional preoperative counseling to ensure broader and more equitable patient participation.

Challenges to Patient Involvement

Respondents identified multiple challenges to involve patients in surgical decision-making. The most frequently reported barriers were lack of patient education materials (63.0%) and time constraints (57.1%). Language barriers (50.7%) and cultural differences (50.7%) were also highlighted as substantial obstacles. Other factors, such as limited institutional support or patient reluctance, were mentioned by 9.7% of respondents.

To address language-related difficulties, respondents reported employing multilingual staff (47.4%) and using translation services (22.6%). Professional interpreters (17.3%) and translated written materials (8.3%) were less frequently utilized.

Decision aids, while recognized as important, were underutilized. Only 36.6% of respondents confirmed their use, while 32.8% reported not using them, and 30.6% were unsure.

Table 3. *Challenges in Patient Involvement, Addressing Language Barriers, and Use of Decision Aids*

Variable	Frequency (n = 184)	Percentage (%)
Specific challenges in involving patients		
Time constraints	88	57.14
Language barriers	78	50.65
Lack of patient education materials	97	62.99
Cultural differences	78	50.65
Other	15	9.74
Addressing language barriers		
Professional interpreters	23	17.29
Translation services	30	22.56
Use of translated written materials	11	8.27
Multilingual staff	63	47.37
Other	6	4.51
Using decision aids		
Yes	49	36.57
No	44	32.84
Not sure	41	30.60

Patient Satisfaction

Overall, patient satisfaction with involvement in surgical decision-making was encouraging. More than two-thirds of respondents (67.9%) perceived their patients as satisfied or very satisfied, while 25.4% reported neutral feedback and 5.2% noted dissatisfaction. Preoperative counseling sessions were identified as the most effective tool for enhancing understanding and satisfaction (75.8%), followed by visual aids (10.6%) and mobile applications (7.6%).

Technology Use in Patient Engagement

Digital innovations were increasingly reported as facilitators of patient involvement. Online educational resources (45.1%) and telemedicine consultations (16.4%) were the most frequently cited, followed by mobile applications (17.2%) and virtual reality tools (10.7%). Patient satisfaction surveys were also used, though their application varied: 31.7% reported routine use, 13.0% used them very often, while 27.6% applied them occasionally and 19.5% rarely.

Conflict Resolution in Decision-Making

When conflicts arose during the decision-making process, nearly half of respondents (47.5%) preferred a shared decision-making approach. Others reported seeking second opinions (28.7%) or following physician recommendations (18.9%).

Qualitative Insights

Open-ended responses emphasized several recurring themes. Many respondents highlighted the importance of transparent communication and the need for supportive patient–provider relationships. Others stressed the role of patient empowerment through education, noting that patients often lacked sufficient information to actively participate in their care decisions. Some professionals also emphasized the necessity of training and retaining skilled surgical experts to ensure that patient involvement could be consistently prioritized.

Together, these findings illustrate that while patient engagement is valued and frequently practiced, systemic barriers, including resource limitations, cultural differences, and underutilization of decision aids, continue

to restrict its consistency. Technology and feedback mechanisms represent promising avenues to bridge these gaps and enhance patient-centered surgical care in LMICs.

DISCUSSION

This Delphi survey provides valuable insights into healthcare providers' perspectives on patient involvement in surgical decision-making across low- and middle-income countries (LMICs). The findings highlight both progress and persistent challenges in promoting patient-centered surgical care, underscoring the need for context-specific strategies to enhance patient engagement. A key observation is that patient involvement was reported as frequent, with most providers indicating that patients are "often" or "very often" engaged in decision-making. This trend aligns with global shifts toward shared decision-making models that emphasize patient autonomy and collaboration [11]. However, the variability noted, ranging from high engagement to rare or absent involvement, suggests inconsistency in practices across healthcare settings. Such discrepancies may stem from differences in cultural expectations, institutional resources, and provider attitudes, echoing findings from earlier studies in LMIC contexts [12,13].

Several barriers were consistently identified, including lack of patient education materials, time constraints, language barriers, and cultural differences. These obstacles mirror those reported in prior research, where limited health literacy and cultural norms were shown to restrict patients' ability to actively participate in their care [14,15]. While preoperative counseling sessions were widely utilized, the limited use of decision aids such as brochures, translated materials, or digital tools highlights missed opportunities for reinforcing understanding. Studies have demonstrated that decision aids improve patients' knowledge and confidence in making surgical choices [16], yet their underuse in LMICs points to systemic gaps in training, dissemination, and accessibility.

Despite these challenges, patient satisfaction was reported as generally high, with more than two-thirds of providers perceived their patients as satisfied or very satisfied with their involvement. This finding suggests that even modest levels of engagement can positively influence patient experiences. Nevertheless, the proportion of patients perceived as neutral or dissatisfied underscores the need for continued investment in structured, patient-centered approaches. Technology emerged as a promising facilitator of patient engagement. Online educational resources, telemedicine consultations, and mobile applications were cited as useful tools for improving communication and understanding. This finding aligns with global evidence on the role of digital health in bridging communication gaps, particularly in resource-constrained environments [17]. However, uneven adoption across respondents highlights the need for infrastructure development, digital literacy initiatives, and integration of culturally appropriate content.

Conflict resolution strategies also reflected a patient-centered ethos, with shared decision-making being the most common approach. However, the reliance on physician recommendations in some cases reveals the ongoing influence of paternalistic models of care that may limit patient autonomy [18]. Taken together, these findings reinforce that while healthcare providers in LMICs value patient participation, significant barriers continue to restrict its consistent application. Tailored interventions that combine cultural competence training, expanded use of decision aids, and digital innovations could address many of these gaps.

Implications for Policy and Practice

The results carry important implications for healthcare systems in LMICs. First, the development of standardized guidelines for patient involvement could help ensure more uniform practices across institutions. Second, training initiatives focused on communication skills, health literacy, and cultural awareness are essential for empowering providers to engage patients effectively. Finally, leveraging technology, through mobile health applications, online resources, and telemedicine, can expand patient access to reliable

information and reduce barriers linked to language and geography. By addressing these areas, LMIC healthcare systems can strengthen patient-centered surgical care and enhance both satisfaction and clinical outcomes.

CONCLUSION

This Delphi survey highlights that while patient involvement in surgical decision-making is valued and frequently practiced in LMICs, its application remains inconsistent. Healthcare providers identified multiple barriers, including lack of educational materials, time constraints, language barriers, and cultural differences, that limit patients' ability to participate fully in surgical decisions. Despite these challenges, most providers perceived patients as satisfied with their involvement, and emerging technologies such as online resources and telemedicine were recognized as important facilitators of engagement. Enhancing patient-centered care in LMICs requires addressing systemic, cultural, and resource-related obstacles. By implementing targeted strategies, healthcare systems can improve communication, empower patients, and strengthen overall satisfaction with surgical care.

RECOMMENDATIONS

Based on the findings, the following recommendations are proposed:

1. Develop and adopt guidelines to ensure consistent patient involvement in surgical decision-making, tailored to local cultural and healthcare contexts.
2. Expand the availability of patient-friendly materials, including brochures, visual aids, and translated documents, to improve health literacy and informed participation.
3. Invest in training healthcare providers to enhance communication skills, cultural sensitivity, and shared decision-making practices.
4. Integrate structured decision-support tools, such as counseling checklists and visual aids, into routine practice to reinforce patient understanding.
5. Leverage online platforms, mobile applications, and telemedicine to increase access to accurate information, especially in underserved and linguistically diverse populations.
6. Implement routine patient satisfaction surveys to monitor involvement practices and identify areas for improvement.
7. Conduct complementary studies exploring patients' perspectives on their involvement in surgical decision-making to provide a more holistic understanding of engagement.

LIMITATIONS

This study acknowledges a few limitations. First, it exclusively captured the perspectives of healthcare providers; patient voices were not directly included, potentially limiting the comprehensiveness of insights. Second, as a self-reported survey, responses may be influenced by recall or social desirability bias and may not fully reflect actual practices. Lastly, reliance on an online platform may have excluded professionals without reliable internet access, thereby introducing digital divide bias. Despite these limitations, the study offers valuable contributions to understanding patient involvement in surgical decision-making across LMICs, highlighting areas for policy action, capacity building, and further research.

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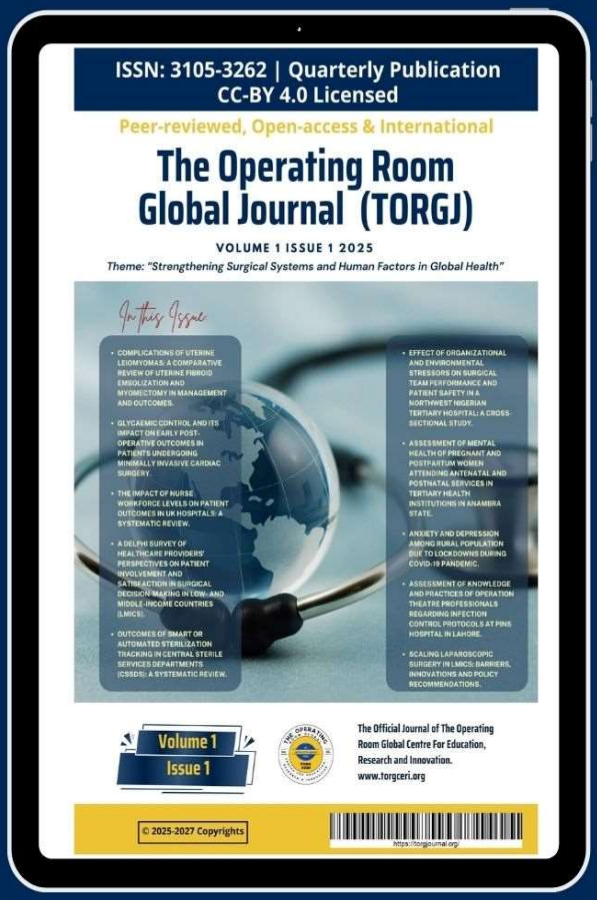

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The Impact of Nurse Workforce Levels on Patient Outcomes in the UK Hospitals: A Systematic Review

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ABSTRACT

Background: This study investigates how nurse staffing levels influence patient outcomes in UK hospitals, with particular emphasis on how increased workloads affect the quality and safety of patient care.

Aim: To evaluate the relationship between nurse-to-patient ratios, workload pressures, human factors, and patient outcomes, and to explore potential strategies to improve staffing efficiency and service quality.

Methods: A systematic review was conducted using the PRISMA framework to identify, screen, and select relevant studies. Databases including CINAHL and EMBASE were searched extensively. Only studies examining the association between nurse staffing levels and patient outcomes in UK hospitals were included. From 1,065 records screened, 14 studies met the inclusion and exclusion criteria. The Critical Appraisal Skills Programme (CASP) tool was used to assess methodological quality and relevance.

Results: Findings indicate that high nurse workloads are consistently associated with increased medication errors, higher patient mortality, reduced patient safety, and increased nurse fatigue and burnout. Optimal staffing ratios and human factors engineering approaches were identified as potential solutions to improve care delivery.

Discussion: The review highlights the importance of aligning healthcare workforce planning with the UN Sustainable Development Goal 3 (Good Health and Well-Being), ensuring that quality healthcare services remain accessible and sustainable.

Conclusion: Improving nurse-to-patient ratios, integrating human factors principles, and supporting ethical workforce management practices can enhance patient safety and care outcomes across UK hospitals.

Keywords: Healthcare Workforce, Nurse Staffing, Nurse Burnout, Patient Outcomes, SDG-3, Workload

INTRODUCTION

The healthcare workforce is crucial to reaching Sustainable Development Goal (SDG) 3, which focuses on ensuring healthy lives and fostering well-being for everybody [1]. In the UK, the rising demand for healthcare services has placed enormous strain on nurses, resulting to high workloads that negatively affect both patient outcomes and nurse well-being [2]. High nurse workloads have been associated to many undesirable consequences, including inadequate oversight in care, prescription mistakes, and higher death rates [3]. Furthermore, heavy workloads can affect decision-making, impede collaboration with other healthcare professionals, and lead to burnout, which further deteriorates the quality of treatment offered [4]. This

systematic analysis intends to evaluate the influence of nurse workforce levels on patient outcomes in the UK hospitals and offer measures for boosting nurse staffing, in line with SDG-3.

METHODOLOGY

This systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria [5]. The study focuses on studies undertaken in the UK hospitals, exploring the link between nurse staffing levels and patient outcomes. Electronic databases such as PubMed, CINAHL, and Embase were searched using keywords like "nurse staffing," "patient outcomes," "workload," and "UK hospitals." Studies were considered if they offered empirical data on nurse staffing levels and patient outcomes, and if they were published in peer-reviewed publications. The inclusion criteria utilized were papers published in English from 2010 onwards and concentrating on the UK hospitals. Any papers published before 2010 and not concentrating on the UK hospitals were omitted. The systematic search method involves employing Boolean operators such as AND and OR to combine important phrases including "nurse staffing," "patient outcomes," "workload," and "UK hospitals." This analysis employs the Systems Engineering Initiative for Patient Safety (SEIPS) paradigm to stress how work system factors including staffing, workflow, and the environment impact nurse performance and patient outcomes [6]. By optimizing these factors, the model indicates that excessive nurse workloads may be lowered, leading to better patient care and improved results (Figure 1). The study selection procedure involves a two-tiered method. Initial screening of titles and abstracts helped discover relevant research, followed by a rigorous full-text review to determine eligibility. A PRISMA flow diagram was utilized to publicly document the research selection process, providing clarity on the inclusion and exclusion of studies.

In the identification phase of this systematic review, an initial search was undertaken across numerous databases, including PubMed, CINAHL, Embase, and the Cochrane Library, generating a total of one thousand, nine hundred and sixty records (Figure 1 - PRISMA Flow Diagram). After deleting duplicates, the dataset was reduced to one thousand and sixty-five entries, which were evaluated for relevance based on title and abstract. During this screening procedure, eight hundred and ninety-five records were reviewed for eligibility. Of these, five hundred and forty-five records were removed because they were not relevant to the study topic, lacked adequate data on nurse staffing levels, or reported outcomes irrelevant to the scope of this review. This left three hundred and fifty full-text papers for further examination in the eligibility phase, a total of three hundred publications were removed mostly because they lacked empirical data relevant to the study issue or were done outside the UK. Since this evaluation focuses on the influence of nurse staffing levels in UK hospitals, studies that did not give data on UK settings or lacked empirical evidence were eliminated to ensure the study remained focused and relevant.

Twenty-six research were omitted owing to inadequate study design, meaning they lacked rigorous methodological techniques or did not match the inclusion criteria laid out in this review. Six studies were omitted because they provided insufficient criteria for measuring outcomes, failing to offer acceptable data or metrics on the patient outcomes connected to nurse staffing levels. Four research were eliminated due of language constraints, since these investigations were not available in English and translation was not practicable.

Therefore, fourteen publications were selected for the final evaluation, all of which fulfilled the stringent design and relevance requirements essential to answer the study issue. This meticulous selection process, which followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, ensured that only high-quality studies were included, enabling a focused and reliable examination of the influence of nurse staffing levels on patient outcomes in UK hospitals.

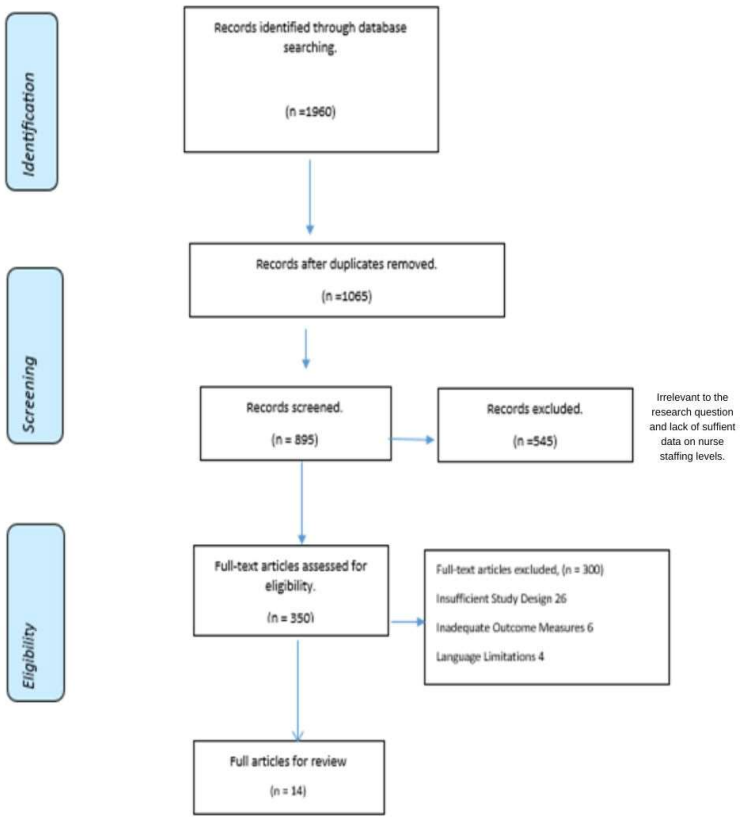

Figure 1: ***PRISMA Flow Diagram***

For the critical assessment of included studies, the Critical assessment Skills Programme (CASP) checklist was applied. This tool was used to evaluate the quality, relevance, and methodological rigor of the studies included in this systematic review. The CASP checklist guarantees that each study was critically reviewed for features such as clarity of research questions, suitability of research design, dependability of the results, and relevance of the findings to the review topic as indicated in Table 1 below.

Table 1: ***Summary of CASP Checklist Evaluation***

CASP Criteria	Evaluation
Clear Research Question	All included studies provided clear research questions relevant to the review focus.
Appropriate Research Design	The majority of studies utilized suitable designs to answer their research questions.
Recruitment Strategy	Studies outlined their recruitment processes, though a few lacked details on sampling methods.
Data Collection	Most studies provided a clear description of data collection methods, ensuring consistency.
Consideration of Ethical Issues	All studies included ethical considerations, with clear statements of ethics approval.
Data Analysis	The data analysis methods were appropriate, though the depth of analysis varied between studies.
Clear Statement of Findings	Most studies presented their findings clearly, though a few lacked details on statistical significance.

Validity and Reliability	Studies demonstrated good reliability and validity, with a few studies needing more robust validation.
Importance of Results	The results of most studies were important and relevant to healthcare workforce and patient outcomes.
Implications and Future Research	Most studies highlighted the implications of their findings, though only a few provided recommendations for future research.

Using the CASP framework, the evaluation showed that most studies satisfied high criteria of scientific rigor, with defined research questions, acceptable designs, and dependable findings. However, other studies have limits in recruiting techniques and depth of data analysis, stressing the need for more robust sampling methods and detailed analyses in future research.

Theoretical Foundation

The theoretical basis for this research is based on the Systems Engineering Initiative for Patient Safety (SEIPS) model, which highlights the role of work system factors such as staffing, workflow, and environment in impacting nurse performance and patient outcomes. This approach is particularly useful in healthcare, as the interplay between multiple system parts may considerably alter the quality of service given. The SEIPS model implies that modifying work environments and processes might offset the negative consequences of high nurse workloads, hence improving patient outcomes.

RESULTS

Themes have been found because of the critical appraisal and systematic assessment of the included publications. Thematic analysis was used to discover patterns and insights linked to nurse staffing levels and their influence on patient outcomes, nurse burnout, and work satisfaction. Each subject illustrates essential components of the nursing workforce's effect on healthcare delivery in UK hospitals.

Patient Outcomes

The analysis indicated a robust link between nurse staffing levels and patient outcomes. Studies repeatedly indicated that hospitals with greater nurse-to-patient ratios reported reduced death rates, fewer prescription mistakes, and increased patient satisfaction. For example, Olley et al. (2019) emphasized that introducing a minimal nurse-to-patient ratio, as witnessed in California and Queensland, resulted to considerable gains in patient safety and care quality. In accordance with SDG 3 (Good Health and Well-being), this study suggests that UK hospitals implement evidence-based staffing models, including minimum nurse-to-patient ratios, to increase patient outcomes, minimize needless death, and assure the provision of safe, high-quality care.

Nurse Burnout and Job Satisfaction

High workloads were consistently associated with nurse burnout, leading to decreased job satisfaction and higher turnover rates. Burnout was also linked to poorer patient outcomes, suggesting that improving nurse staffing levels could enhance both nurse well-being and patient care. Burnout among nurses is not only a personal issue but also a systemic one, affecting the entire healthcare delivery process. In alignment with SDG 3 (Good Health and Well-being), this study recommends implementing sustainable staffing practices, providing adequate support, and promoting workforce development programmes to reduce nurse burnout. These measures are essential for maintaining nurse well-being, improving job satisfaction, and ensuring high-quality patient care.

Barriers to Optimal Nurse Staffing

The analysis revealed various challenges to reaching ideal nurse staffing levels, including budget limits, an aging workforce, and the rising demand for healthcare services. These issues are worsened by the lack of

consistent staffing rules across the UK, resulting to heterogeneity in care quality. Additionally, environmental problems such as chaotic workstations and poor equipment add to the inefficiency of care delivery. In connection with SDG 3 (Good Health and Well-being), this study suggests that the UK healthcare system invest in uniform nurse staffing norms, infrastructure upgrades, and resource allocation. Addressing these hurdles is critical for boosting service quality, eliminating inequities in patient outcomes, and guaranteeing the sustainability of the healthcare workforce.

DISCUSSION

The findings underline the important need to address nurse staffing challenges as part of larger healthcare workforce planning. Aligning nurse staffing plans with SDG 3 is vital to improve patient outcomes and protecting the well-being of healthcare workers, preserving excellent treatment. As stated by Waterfield and Barnason (2022), high workloads impair nurses' capacity to cooperate with other healthcare professionals, which is vital for patient-centred care.[8] To solve these difficulties, the paper advises that hospitals apply human factors engineering (HFE) methodologies to rethink work systems. HFE focuses on enhancing the interaction between healthcare workers and their work settings to promote safety and efficiency. By implementing HFE principles, hospitals may systematically identify and fix the aspects contributing to high workloads, such as inefficient processes, poor communication, and inadequate resources. For instance, incorporating digital patient engagement technologies might assist minimize nursing workloads by automating mundane chores, allowing nurses to focus more on direct patient care and decision-making. These technologies allow better communication between healthcare practitioners and patients, enhancing the overall quality of care and patient satisfaction.

Moreover, setting minimum nurse-to-patient ratios can assist standardize staffing levels, equitable distribution guaranteeing that nurses are not overloaded and can offer the essential care to each patient. Implementing these ideas would not only reduce the demands experienced by nurses but also build an environment where patient safety and quality of care are paramount. Ultimately, these measures contribute to a healthier workforce and improved patient outcomes, aligned with the aims of SDG 3.

CONCLUSION

This systematic research reveals the considerable influence of nurse staffing levels on patient outcomes in UK hospitals. Addressing nurse workloads via strategic workforce planning and policy interventions is critical for enhancing patient care and reaching SDG 3. The findings suggest the necessity for continual research and the deployment of evidence-based staffing strategies that fit with global health goals.

RECOMMENDATIONS

1. Implementing Minimum Nurse-to-Patient Ratios: To standardize treatment and decrease the danger of burnout, it is necessary to set minimum nurse-to-patient ratios throughout UK hospitals. This plan connects with SDG 3 by improving excellent health and well-being via enhanced patient care.
2. Adopting Human Factors Engineering Approaches: Hospitals should invest in revamping work systems to optimize nursing processes and minimize workloads. This may be done by incorporating digital solutions that simplify mundane processes and promote patient interaction, contributing to better patient outcomes and aligned with SDG 3.
3. Continuous Workforce Development and Training: Regular training and development programs should be undertaken to provide nurses with the required skills to manage heavy workloads successfully. This method guarantees that the healthcare staff stays resilient and capable of providing high-quality treatment, in line with SDG 3.

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Outcomes of Smart or Automated Sterilization Tracking in Central Sterile Services Departments (CSSDs): A Systematic Review

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ABSTRACT

Objective: To evaluate the effectiveness and outcomes of smart or automated sterilization tracking systems in Central Sterile Services Departments (CSSDs) compared to conventional manual methods.

Methods: A systematic review was conducted following PRISMA guidelines. PubMed, Web of Science and Embase were searched from January 2010 to July 2025. Studies evaluating automated tracking systems in CSSDs were included. Data on clinical satisfaction, instrument cleaning and packaging qualification rates, and process outcomes were extracted. Study quality was assessed using JBI critical appraisal tools.

Results: Nine studies (390,130 instruments; 32 staff members) were included. Automated systems consistently outperformed manual methods across outcomes. Clinical satisfaction increased by 9-23% with automation. Cleaning qualification rates improved by 1-10%, while packaging qualification rates increased by 4-30%. Process efficiency also improved, with reductions in instrument turnaround times ranging from 1 to 5 minutes per item to 20 minutes per batch. All studies were of moderate to high methodological quality.

Conclusion: Implementation of smart, automated sterilization tracking systems in CSSDs leads to significant improvements in instrument processing quality, staff satisfaction, and operational efficiency compared to manual methods. CSSD managers and OR professionals should adopt smart sterilization tracking systems to ensure higher processing quality, improved efficiency, and safer patient outcomes. These technologies enhance patient safety and infection control practices in healthcare settings. Further research is needed to evaluate long-term clinical and economic impacts.

Keywords: Smart sterilization tracking, Central Sterile Services Department, automated systems, process efficiency, infection control, patient safety.

INTRODUCTION

Central Sterile Services Departments (CSSDs) are considered as backbone of safe diagnostic and surgical practices in modern clinical or healthcare settings. The primary roles of CSSDs are to sterilize, disinfect, assemble and distribute surgical instruments or devices that maintain the sterility until the point of use (1). Additionally, the CSSD has a direct impact on patient safety, surgical site infection (SSI), and overall hospital efficiency despite being a behind-the-scenes operation (2).

Any interruption in the sterilization chain or disrespect for established procedures may lead to contamination, postponed procedures, or expensive adverse outcomes. Thus, healthcare organizations all around the world are considering the optimization of CSSD procedure as a top priority (3, 4).

Historically, sterilization tracking in CSSDs has been practiced by manual processes that involved paper logs, staff documentation, and barcode systems to monitor instrument safety, load configurations and cycle parameters. Despite diverse functional outcomes in clinical settings, there are huge chances of human errors, difficult real-time monitoring, and incomplete documentation in manual processing of sterilization. Additionally, the immense rise in the number of instruments per tray, and frequency of processing cycles due to the increasing complexity of surgical procedures has also intensified workload on CSSDs (5, 6). Thus, there is an urgent need for more efficient and reliable tracking systems to reduce error rates and follow the guidelines outlined by the Association for the Advancement of Medical Instrumentation (AAMI), the Joint Commission, and ISO guidelines (7).

Smart or automated sterilization tracking systems have revolutionized the CSSDs in clinical settings by solving the challenges of manual processing. These systems relied on technologies such as Internet of Things (IoT) sensors, real-time data analytics, Radio Frequency Identification (RFID), and automated software platforms (8). RFID tags provide non-contact, mass, and continuous monitoring of surgical equipment throughout their lifecycle, in contrast to traditional barcode systems that need manual scanning. While smart dashboards give CSSD managers notifications, compliance reports, and predictive maintenance plans, IoT-enabled autoclaves and washers can automatically send cycle completion data to central databases. By enhancing accountability, traceability, and transparency in sterilization processes, these developments hope to reduce the risks brought on by human mistakes and inadequate documentation (9).

Several hospitals have reported diverse benefits after the adoption of smart tracking technologies in CSSDs. These benefits include significant improvements in turnaround time for surgical trays, reductions in lost or misplaced instruments, and better alignment with infection prevention goals and enhanced compliance with documentation requirements (10). Furthermore, it has been demonstrated that automated data capture increases staff productivity by lowering administrative workloads, freeing up CSSD employees to concentrate more on quality assurance than on human record-keeping. Automated tracking reduces instrument loss, lowers replacement costs, and supports preventive maintenance plans, all of which reduce costs in the larger framework of hospital administration. Despite these several benefits, the automated sterilization tracking has not yet been applied globally due to a few barriers. These barriers are interoperability issues, high implementation costs, and resistance to workflow change, old hospital information systems and the need for staff training that restricted its widespread use (11).

Smart and automated sterilization tracking represents a significant advancement in the modernization of CSSD operations. Few single-centre studies and case reports have reported the promising outcomes of automated systems in CSSDs (12). However, there is a lack of comprehensive evaluations across diverse healthcare settings. On the other hand, previous evidence suggested that these technologies enhance traceability, compliance, and efficiency, and systematic evaluation of their outcomes across diverse contexts remains limited. Thus, this study aims to evaluate the effectiveness or outcomes of Smart or automated Sterilization Tracking in Central Sterile Services Departments (CSSDs) in healthcare settings by adopting a systematic review research approach.

METHODOLOGY

Study Design

This systematic review was undertaken to evaluate and compare the effectiveness or outcomes of Smart or automated Sterilization Tracking in Central Sterile Services Departments (CSSDs) of hospitals. This

comprehensive review was conducted with transparency and integrity in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (13).

PICO framework

The PICO framework was used for screening and selection of research papers for this systematic review (14).
Population (P): Central Sterile Services Departments (CSSDs), including healthcare workers and hospital settings where surgical instruments and medical devices are sterilized.
Intervention (I): Implementation of smart or automated sterilization tracking systems (e.g., RFID, barcoding, AI-driven tracking, IoT-enabled sterilization monitoring).
Comparator (C): Conventional/manual sterilization tracking and documentation methods (e.g., paper-based logs, non-automated tracking).
Outcomes (O): Process outcomes (such as error reduction, and turnaround time), and Clinical outcomes, such as clinical satisfaction or improved patient safety, were primary outcomes of this research.

Search Strategy

A complete investigation of the literature was done to locate authentic studies or studies matching the eligibility criteria. Three electronic databases, such as PubMed, Web of Science and Embase, were thoroughly searched from January 2010 to July 2025. The search strategy for Pubmed was "(("Central Supply, Hospital"[Mesh] OR "Sterilization, Hospital"[Mesh] OR "Central Sterile Services Department*" OR "Central Sterile Supply Department*" OR "CSSD" OR "Sterile Processing Department*" OR "SPD")) AND (("Equipment and Supplies"[Mesh] OR "Surgical Instruments"[Mesh] OR "medical device*" OR "surgical instrument*")) AND (("Sterilization"[Mesh] OR sterilize* OR disinfection OR "reprocessing")) AND (("Management Information Systems"[Mesh] OR "Hospital Information Systems"[Mesh] OR "Data Collection"[Mesh] OR "Medical Records Systems, Computerized"[Mesh] OR "Quality Assurance, Health Care"[Mesh] OR "workflow" OR "traceability" OR "tracking system*" OR "quality control system*" OR "smart system*" OR "automated system*" OR "automation" OR RFID OR "Radio Frequency Identification" OR barcode* OR "QR code*" OR "Internet of Things" OR IoT OR "artificial intelligence" OR AI OR "machine learning")) AND (("outcome*" OR "process outcome*" OR "clinical outcome*" OR "workflow efficiency" OR "error reduction" OR "patient safety" OR "infection control" OR "surgical site infection*" OR "cost effectiveness" OR "staff productivity" OR compliance)) and similar was used for other databases. All previously published meta-analyses and systematic reviews on similar topics were searched to reach authentic data.

Study Selection Criteria

Inclusion Criteria

The inclusion criteria applied to identify eligible studies were: 1). The studies discussing or analyzing Central Sterile Services Departments (CSSDs), Sterile Processing Departments (SPDs), or equivalent hospital sterilization units dealing with the distribution of surgical instruments or medical devices, 2). Implementation or evaluation of smart or automated sterilization tracking systems, e.g., Radio Frequency Identification (RFID) systems, Barcode or QR code–based tracking, Internet of Things (IoT) systems and Artificial Intelligence (AI), 3). Studies comparing automated/ smart tracking systems with conventional or manual tracking methods, 4). Study design must be Randomized controlled trials (RCTs), quasi-experimental studies, cohort studies, case–control studies, cross-sectional studies and publications in English.

Exclusion Criteria

Those articles were excluded 1). Those not conducted in CSSDs/SPDs or hospital sterilization units, 2). Interventions unrelated to smart or automated sterilization tracking (e.g., studies focusing solely on disinfection methods, sterilizer performance, or microbiological outcomes without tracking systems), 3). Case

reports, editorials, letters to the editor, expert opinions, conference abstracts without full text, and narrative reviews, 4). Studies not reporting any relevant outcomes of interest (process, or clinical) and non-English studies.

Study Selection & Data Extraction

The identified studies' titles and abstracts were separately examined by two reviewers to determine whether they met the inclusion criteria. For ultimate inclusion, full-text publications of potentially qualifying research were gathered and evaluated. Any conflicts or differences between reviewers were settled by discussion or, if required, by consulting a third reviewer. The following information was extracted from each included study: study characteristics (authors, year of publication, study design), objectives, study population or settings, intervention, comparator details, outcome measures, and findings.

Quality Assessment of Included Studies

The Joanna Briggs Institute (JBI) critical appraisal checklist was used methodological quality assessment of included cohort studies for this meta-analysis. The methodological quality of the included cohort studies or empirical studies and the strategies they employed to address and minimize bias were evaluated using the JBI critical assessment instrument. Standardized critical appraisal questions or criteria are employed by JBI to evaluate the potential for various biases that may arise in quantitative research. Based on the methodology of studies, there are JBI-standardized appraisal instruments suitable for JBI reviews of efficacy (15).

RESULTS

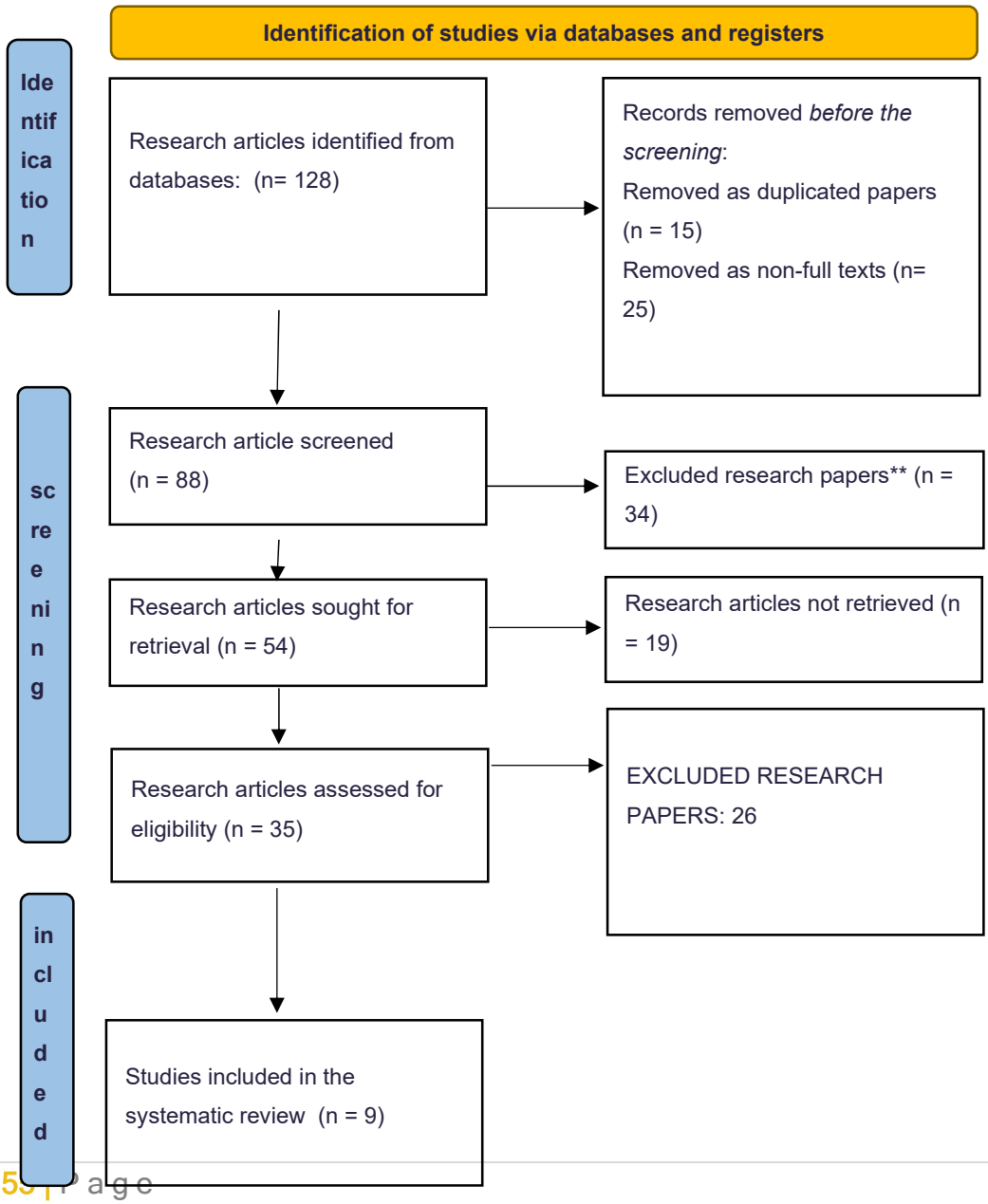

Figure 1: Flow chart for screening and selection of included studies under PRISMA guidelines

Study Selection

In this systematic review, the PRISMA guidelines were followed in the selection and screening of research articles pertaining to the study aim "Outcomes of Smart or automated Sterilization Tracking in Central Sterile Services Departments (CSSDs)." Database searches produced a total of 128 items, of which 88 remained after duplicates and insufficient text were eliminated. After an initial screening of 88 research publications, 54 papers were searched for retrieval. There were only 35 publications that assessed the eligibility requirements, and there were ultimately 9 research articles as shown in Figure 1.

Table 1: Characteristics of Included Studies

Author, Year	Country	Objective	Population	Intervention	Comparator	Clinical satisfaction	Instrument cleaning and packaging qualification rate	Process Outcomes	Findings
Yuan et al., 2024 (16)	China	To investigate the effectiveness of visual management flow diagrams in improving work quality, efficiency, error reduction, and clinical satisfaction in the CSSD	800 instruments: n = 400 instruments within a CSSD setting & n = 400 instruments in controls	Visual flow diagrams (used for instrument/equipment handling, infection control, and instrument package or management)	Conventional/ manual tracking methods (e.g., paper logs)	Observation group: 99% vs Control: 90%	**Cleaning** Observation: 99% vs Control: 95% And **Qualification** Observation: 96% vs Control: 92%		Triggered positive impact on the work quality and enhances clinical work satisfaction in the central sterile supply department
Zhu et al., 2024 (17)	China	To investigate the application and effectiveness of automated guided vehicles (AGV) and sterilization monitoring reports in the disinfection and	CSSD staff and processes at Nantong First People's Hospital	Automated guided vehicle (AGV) (used for auto loading/unloading & transport or monitoring sterilization process)	Manual transportation and recording of sterilization	Before automated tools: 75% After automated tools: 98.4%		Before automated tools: 5 mins After automated tools: 1 min	Reduction in occupational exposure, physical exertion, and error probability; improved working environment and professional experience.

		sterilization process							
Ding et al., 2024 (18)	China	To design and evaluate an IoT- and RFID-based automated visual quality tracking information system for CSSD to improve efficiency, traceability, and medical safety.	Instruments in CSSD at Shenzhen People's Hospital Observation: >280,000 Control: >100,000	IoT-based automated sterilization quality tracking system (RFID tags + data visualization + microservice architecture)	Conventional/ manual system (paper records, C/S software)		**Cleaning** Before: 99.59% After: 99.89% Packaging: Before: 99.93% After: 99.98%,	Before: 30 mins/ batch After: 10 mins/ batch	Improved medical safety: rapid tracing of instruments during infection events; stronger infection prevention through real-time monitoring
Hung et al., 2020 (19)	Taiwan	To optimize surgical instrument sterilization by monitoring temperature and time via IoT sensors	Hospital sterile supply center	High-temperature pressure sensors by internet of things (IoT) (used to monitor sterilization tempreture)	Conventional/ manual methods	Implied improvement in medical service quality by ensuring instruments are fully sterilized		Enabled detection of sterilization failures or errors immediately	Ensured the safety of the patient's use of surgical instruments, and reduced additional cost of emergency sterilization.
Palacio et al., 2018 (20)	Colombia	To develop an IoT-based method to improve steam quality monitoring in hospital autoclaves by applying thermodynamic principles	Hospital sterilization settings	IoT-enabled instrumentation (e.g., IoT platform, sensors and single board computer)	Conventional autoclave monitoring without IoT	Inferred enhancement of sterilization effectiveness		reduced inefficiencies and errors in sterilization cycles	Reduced risk of microbial contamination and improved accuracy by use of IoT enabled instrumentation
Yang et al., 2022 (21)	China	To evaluate whether applying the "defect management improvement mode" (automated systems) improves cleaning/disinfection effectiveness and	32 medical staff from CSSD Observation: 16 Controls: 16	Defect management improvement mode under JCI standards	Standardized management mode		Packaging Observation: 98.67% Control: 81.34% Cleaning Observation: 98.01 % Control: 88.54 %		Improved the cleaning effect of instruments, enhanced the work situation

		management quality in CSSD							
Ma et al., 2012 (22)	USA	To design and develop a real-time RFID-enabled workflow management framework for Sterile Processing Departments (SPDs).	SPD at John D. Dingell VA Medical Center	RFID-enabled real-time SPD operation management system integrated with a Service-Oriented Architecture (SOA) workflow system	Conventional manual SOP-driven SPD workflows				Improved traceability and monitoring of workflow steps and RMEs SOP rule engine introduced for automatic performance verification. Real-time data capture of locations, expiry, inventory status, and sterilizer/environment indicators (e.g., temperature). Enhanced failure handling with alerts for environmental deviations (e.g., sterilizer temperature mismatch)
Hu et al., 2025 (23)	Chin a	To evaluate the effects of quality traceability system in shared medical community disinfection centers.	Instrument packages; Observation group: 3,302 packages Control group: 3,028 packages	Implementation of a **quality traceability system**	Manual handling	Observation: 65% Control: 55%	Packaging: Observation: 96% Control: 66%		Improved the quality of medical community instrument management, increased efficiency, and improved staff satisfaction with the process.
Xiong et al., 2025 (24)	Chin a	To evaluate the effectiveness of a cleaning quality control module integrated	3,000 instrument sets	Augmented traceability	Routine/ manual procedures before module implementation	Observation: 99% Control: 91%	Cleaning Observation: 99.2% Control: 96.9%		Improved instrument cleaning quality, improved technicians training efficiency, and

		into the Disinfection Supply Center (DSC) for improving precision instrument cleaning quality							enhanced departmental operational efficiency

Characteristics of Included Studies

Our systematic review analyzed nine studies published between 2012 and 2025 that evaluated the role of smart and automated sterilization tracking systems in Central Sterile Services Departments (CSSDs) and Sterile Processing Departments (SPDs). The main characteristics of the included studies are summarized in Table 1. The studies were conducted across four different countries, including China (16-18, 21, 23, 24), Taiwan (19), Colombia (20) and the USA (22).

The primary objectives across these studies were to assess the effectiveness of digital innovations in sterilization tracking and quality control, including improving cleaning and packaging qualification rates, enhancing traceability, reducing errors, improving staff satisfaction, and strengthening infection control. A variety of automated technologies were adopted. These included visual management flow diagrams (16), automated guided vehicles (AGVs) with sterilization monitoring reports (17), and IoT- and RFID-based quality tracking systems (18, 22). Additional approaches involved high-temperature IoT pressure sensors to monitor sterilization (19), IoT-enabled autoclave steam quality monitoring (20), and a defect management improvement mode under JCI standards (21). More recently, quality traceability systems in community-based centers (23) and augmented cleaning quality control modules (24) demonstrated significant gains in efficiency and error reduction, as mentioned in Table 1.

Quality Assessment of Included Studies

The methodological quality of the included studies was assessed using a 9-point checklist covering aspects such as cause–effect clarity, comparability of groups, treatment consistency, control group presence, follow-up, outcome measurement, and statistical appropriateness. As shown in Table 2, most studies achieved **moderate-to-high or high quality**, with total scores ranging from 6/9 to 9/9. Three studies (16, 18, 20, 21) scored 8 or above, reflecting strong methodological rigor, particularly in outcome measurement reliability and statistical reporting. However, some studies lacked complete follow-up or adequate control groups, slightly lowering their overall ratings.

Table 2: Quality Assessment of included studies by JBI

Study (Author, Year)	Q1 Cause/Effect	Q2 Similarity of Groups	Q3 Similar Treatment	Q4 Control Group	Q5 Multiple Measurements	Q6 Complete Follow-up	Q7 Same Outcome Measured	Q8 Reliable Outcome Measurement	Q9 Appropriate Statistics	Total Score (out of 9)	Overall Quality
Yuan et al.,	✓	✓	✓	✓	✓	?	✓	✓	✓	8/9	High

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2024 (16)											
Zhu et al., 2024 (17)	✓	✓	✓	✗	✓	?	✓	✓	✓	7/9	Moderate–High
Ding et al., 2024 (18)	✓	✓	✓	✓	✓	✓	✓	✓	✓	9/9	High
Hung et al., 2020 (19)	✓	✓	✓	✓	✗	?	✓	✓	✓	7/9	Moderate–High
Palacio et al., 2018 (20)	✓	✓	✓	✓	✓	?	✓	✓	✓	8/9	High
Yang et al., 2022 (21)	✓	✓	✓	✓	✓	?	✓	✓	✓	8/9	High
Ma et al., 2012 (22)	✓	?	✓	✗	✓	?	✓	✓	✓	6/9	Moderate
Hu et al., 2025 (23)	✓	?	✓	✗	✓	?	✓	✓	✓	6/9	Moderate
Xiong et al., 2025 (24)	✓	✓	✓	✓	✗	?	✓	✓	✓	7/9	Moderate–High
Yuan et al., 2024 (16)	✓	?	✓	✗	✓	?	✓	✓	✓	6/9	Moderate

Primary Outcomes

1). Clinical Satisfaction

The graph illustrates clinical satisfaction (%) in observation vs. control groups across four studies (16, 17, 20, 23). Overall, observation groups that adopted automated or smart sterilization tracking systems consistently outperformed controls relying on conventional/manual methods. For instance, Yuan et al. (16) reported nearly universal satisfaction (99%) in the observation group compared to 90% in controls, highlighting the benefits of visual management flow diagrams. Zhu et al. (17) showed a significant improvement from 75% (pre-automation) to 98.4% (post-automation) when automated guided vehicles and sterilization monitoring reports were introduced. Similarly, Hu et al. (23) demonstrated a rise in satisfaction from 55% in manual handling to 65% with quality traceability systems. Xiong et al. (24) also revealed significant gains, with

observation groups reaching 99% satisfaction vs 91% in controls. Overall, these findings confirm that digital automation enhances staff satisfaction by reducing workload, minimizing errors, and improving workflow efficiency in CSSDs.

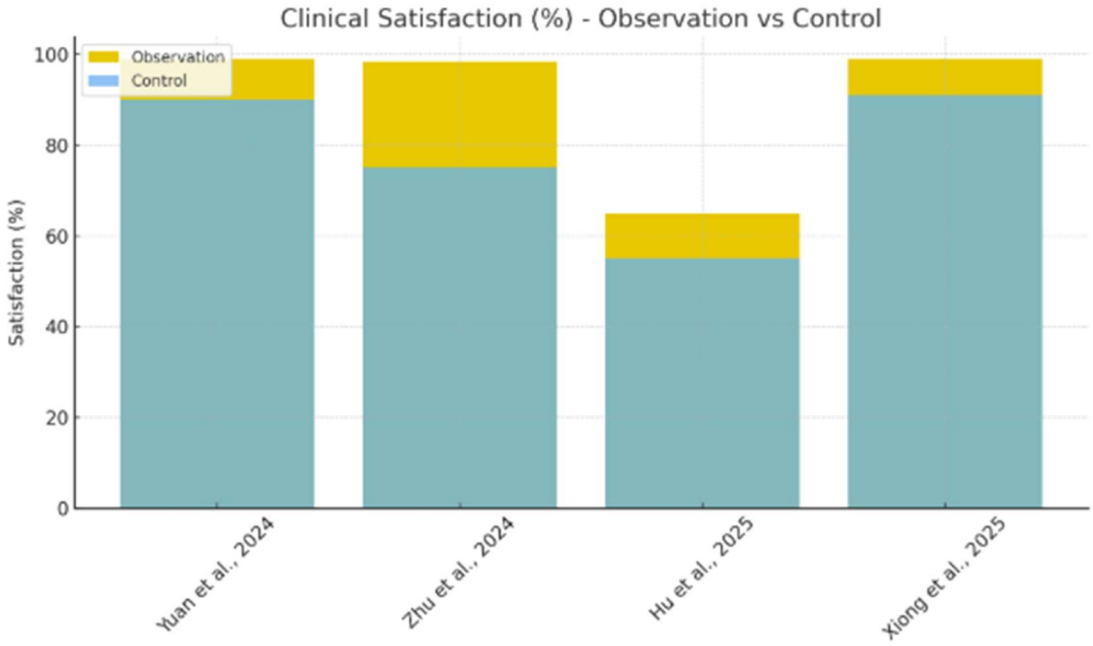

Figure 2: Graphical illustration of % percentage of clinical satisfaction as an outcome of automated systems

2). Instrument Cleaning qualification rate

The graph on cleaning qualification rates (%) clearly demonstrates the advantage of automated and smart sterilization systems over conventional manual methods across studies. Yuan et al. (16) reported a rise in cleaning qualification from 95% in controls to 99% in the observation group, reflecting the benefits of visual management flow diagrams. Ding et al. (18) showed a near-perfect improvement with IoT- and RFID-based tracking, where cleaning rates increased from 99.59% to 99.89% and packaging rates from 99.93% to 99.98%, alongside significant time savings per batch. Similarly, Yang et al. (21) demonstrated substantial gains with the defect management improvement mode, showing 98.01% vs 88.54% cleaning effectiveness between observation and control groups. Xiong et al. (24) also reported the effective outcomes, with cleaning qualification improving from 96.9% in controls to 99.2% in the automated system group. Overall, these results demonstrated how automation improves instrument reprocessing's accuracy, dependability, and safety while guaranteeing adherence to sterilization guidelines and reducing the mistakes and unpredictability that come with human procedures.

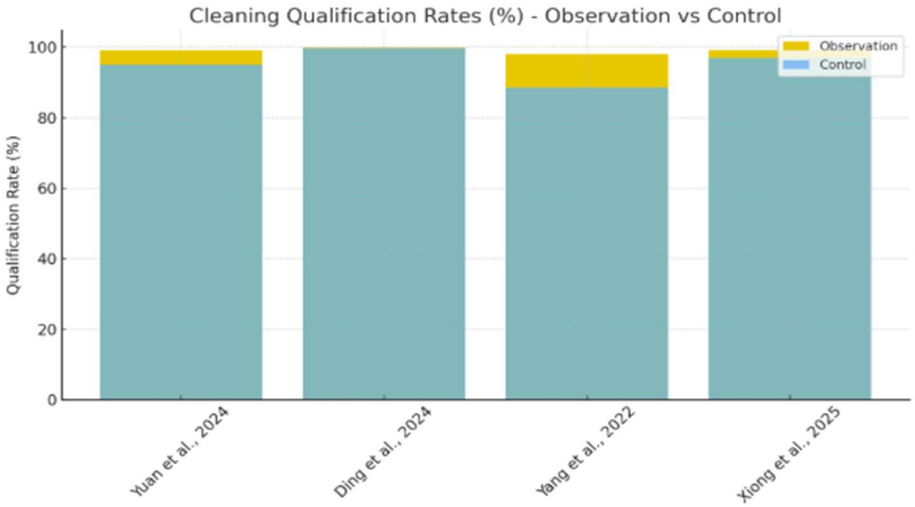

Figure 3: Graphical illustration of %age of cleaning qualification rates as outcome of automated systems

3). Packaging qualification rate

Major advantages of automated systems over traditional manual tracking techniques is shown in the graph showing packaging qualification rates (%). With the use of visual management flow diagrams, Yuan et al. (16) showed that packaging qualification increased from 92% in the controls to 96% in the observation group. Using their IoT and RFID-based tracking system, Ding et al. (18) reported almost flawless results, including a significant decrease in processing time per batch (30 minutes to 10 minutes) and an improvement in packaging rates from 99.93% to 99.98%. Yang et al. (21) demonstrated one of the most notable improvements, demonstrating the efficacy of defect management improvement according to JCI standards with packaging qualification rates of 98.67% in the observation group compared to only 81.34% in controls. Similarly, Hu et al. (23) proved important improvements through a quality traceability system, with 96% packaging qualification compared to 66% in manual handling. Overall, these findings suggested that automated systems not only enhance packaging reliability but also strengthen compliance with sterilization protocols, minimize errors, and improve efficiency in CSSDs.

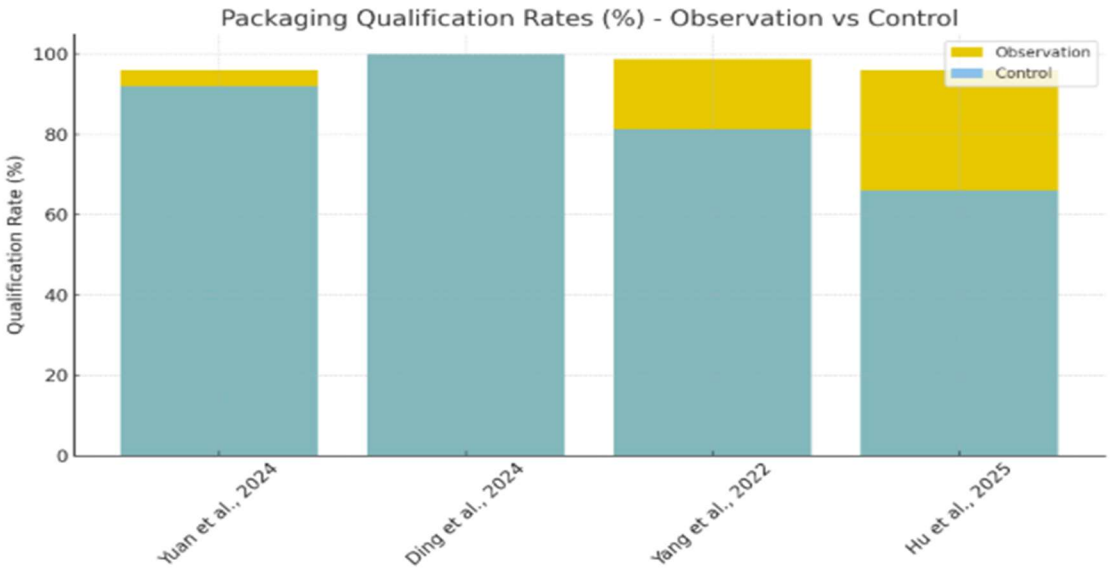

Figure 4: Graphical illustration of %age of packaging qualification rates as outcome of automated systems

Table no. 3: Summary of Key Outcomes of Automated vs. Manual Sterilization Tracking Systems in CSSDs

Study (Author, Year)	Clinical Satisfaction (%)	Cleaning Qualification Rate (%)	Packaging Qualification Rate (%)	Turnaround Time / Efficiency
Yuan et al. [17]	Obs: 99 vs. Ctrl: 90	Obs: 99 vs. Ctrl: 95	Obs: 96 vs. Ctrl: 92	Improved workflow efficiency
Zhu et al. [18]	Pre: 75 → Post: 98.4	–	–	Automated guided vehicles reduced delays
Ding et al. [19]	–	Obs: 99.89 vs. Ctrl: 99.59	Obs: 99.98 vs. Ctrl: 99.93	Turnaround time: 30 min → 10 min
Yang et al. [22]	–	Obs: 98.01 vs. Ctrl: 88.54	Obs: 98.67 vs. Ctrl: 81.34	Defect management per JCI improved efficiency
Hu et al. [24]	Obs: 65 vs. Ctrl: 55	–	Obs: 96 vs. Ctrl: 66	Traceability system reduced errors
Xiong et al. [25]	Obs: 99 vs. Ctrl: 91	Obs: 99.2 vs. Ctrl: 96.9	–	Improved accuracy and compliance

Overall, the included studies consistently reported that the implementation of automated tracking systems led to improved instrument cleaning and packaging qualification rates, higher clinical satisfaction, and enhanced operational efficiency, when compared with conventional manual tracking methods.

DISCUSSION

This study aimed to evaluate the effectiveness or Outcomes of Smart or automated Sterilization Tracking in Central Sterile Services Departments (CSSDs) by adopting systematic review research approach. This systematic review provided latest evidence about the implementation of smart and automated sterilization tracking systems in Central Sterile Services Departments (CSSDs) and Sterile Processing Departments (SPDs) as it improved multiple outcomes, including instrument cleaning and packaging qualification rates, staff satisfaction, and operational efficiency. Through analysis of 9 included studies and 390,130 instruments/ 32 medical staff members, the findings revealed that clinical satisfaction rates, cleaning qualification rates, packaging qualification rates, and instrument turnout time were improved after the integration of automated sterilization tracking system in clinical settings. Furthermore, the automated solutions, whether RFID-enabled frameworks, IoT sensors, visual flow diagrams, or automated guided vehicles enhanced accuracy and reduced errors compared with conventional manual approaches. All the studies included were of high to moderate quality, as assessed by JBI. Automated sterilization tracking systems directly enhance operating room (OR) turnover by reducing delays associated with missing or unsterile instruments. Faster instrument availability translates into improved workflow efficiency, reduced case delays, and better utilization of OR time. This improvement is critical for hospitals where surgical volume and efficiency directly affect patient flow and financial sustainability.

These findings are consistent with broader trends in literature, where digital health technologies have been shown to improve quality, traceability, and workflow efficiency in healthcare delivery. For example, prior systematic reviews on digitalization in hospital sterilization or infection control have similarly emphasized the role of smart monitoring in reducing errors and enhancing patient safety. Munir et al., (25) highlighted that RFID and IoT-based systems enhance traceability in surgical workflows, thereby minimizing retained surgical items. Likewise, Whitacre et al., (26) and Piaggio et al., (27) reviewed automation in infection control systems and found significant improvements in compliance and quality assurance. While these reviews were not exclusively focused on CSSDs, they align with the present study in showing the operational and clinical benefits of automation.

The findings of this study have proven that implication of automated sterilization tracking systems in hospital or clinical settings can improve the outcomes and avoid challenges, caused by manual tracing systems for biomedical instruments. By improving cleaning and packaging qualification rates, automated systems significantly strengthen infection prevention efforts. Fewer errors in sterilization reduce the risk of surgical site infections and hospital-acquired infections. In turn, this enhances surgical safety and contributes to improved patient outcomes, aligning with institutional quality and safety goals. Traceability is another critical advantage, as automated systems provide verifiable digital records of sterilization processes. This not only ensures compliance with regulatory standards but also offers strong documentation in medicolegal contexts, where the ability to demonstrate full sterilization traceability can be pivotal in litigation or audits (28).

The findings highlight that transitioning from manual to smart or automated sterilization tracking systems can significantly improve the quality and safety of instrument reprocessing in CSSDs. For managers, this means prioritizing investments in automation to enhance compliance with sterilization standards, reducing human error, and improve staff satisfaction. However, cost-benefit considerations and implementation feasibility remain critical factors. Initial investments in RFID or IoT-based systems may be substantial, and healthcare managers must weigh these costs against long-term savings from reduced surgical errors,

improved efficiency, and fewer hospital-acquired infections. OR professionals can expect more reliable instrument availability, fewer delays, and improved patient safety outcomes due to higher cleaning and packaging qualification rates. Implementing such systems not only optimizes workflow efficiency but also strengthens infection control, ultimately contributing to better surgical outcomes and reduced hospital-acquired infections.

From a global readership perspective, the study's applicability was highlighted for developed countries only (29). The adoption of automation may be slowed in low- and middle-income countries (LMIC) due to resource constraints. However, the proven advantages for infection prevention and workflow effectiveness imply that incremental implementation, possibly via hybrid systems, may still yield significant safety improvements in these contexts. Cost-effectiveness and implementation tactics in LMIC situations should be specifically examined in future studies.

The study followed PRISMA guidelines, ensuring transparency and reproducibility of the screening and selection process. By including studies from multiple countries (China, Taiwan, Colombia, USA), the review captured diverse contexts of CSSD automation. Unlike prior reviews that emphasized theoretical benefits, this analysis quantified improvements in cleaning and packaging qualification rates, clinical satisfaction, and operational efficiency (30, 31). Use of the JBI critical appraisal checklist ensured a structured evaluation of methodological rigor, highlighting studies of moderate-to-high quality. To our knowledge, this is the first systematic review specifically targeting CSSD-focused automated sterilization tracking systems, filling an important gap in infection control literature.

There are few limitations of this study despite enormous strengths. Only nine studies met inclusion criteria, reflecting the emerging nature of this research area. This small pool limits the generalizability of findings. The included studies used diverse technologies (RFID, IoT, AGVs, flow diagrams), making direct comparison challenging and preventing meta-analysis. Six of the nine studies were from China, potentially limiting applicability to other healthcare systems with different infrastructures. Additionally, the meta-analysis of such studies can provide more reliable results, but it was not possible due to heterogeneity of interventions/outcomes. Lastly, several studies lacked randomized designs or complete follow-up, introducing potential bias. Some studies reported clinical satisfaction, while others reported only process indicators, making it difficult to synthesize across uniform endpoints.

CONCLUSION

According to this systematic research, automated and intelligent sterilization tracking systems routinely perform better in CSSDs than traditional manual methods. The data shows definite advantages in terms of raising clinical satisfaction, decreasing human mistake, increasing operational efficiency, and raising cleaning and packaging qualification rates. These results provide insights specific to CSSD and are consistent with previous systematic evaluations in the areas of infection control and healthcare automation. Conclusively, automated sterilization tracking is a vital development to contemporary CSSDs, which directly benefits the safety of surgical operations and more effective operating room operations. The evidence shows that its implementation contributes to a significant improvement in the quality of processing, the satisfaction of staff, and traceability. Thus, automation should be regarded as a strategic aspect that hospital administrators and OR managers should focus on to improve patient safety. Long-term economic and clinical outcomes should be solidified in further multi-center studies. To solidify these findings, the evidence needs to be strengthened by further high-quality, multi-center randomized controlled trials evaluating long-term economic and clinical outcomes. Additionally, cost-effectiveness assessments will be crucial to guide the widespread scaling up of these technologies.

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SCAN ME

Effect of Organizational and Environmental Stressors on Surgical Team Performance and Patient Safety in a Northwest Nigerian Tertiary Hospital: A Cross-sectional Study

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ABSTRACT

Background: Organizational and environmental stress has a significant impact on the job performance and patient's safety in a high-demand healthcare setting like operating theatre. This study aimed to assess effect of organizational and environmental stressors on surgical team member's performance and patient safety in a Northwest Nigerian tertiary hospital. Methods: A secondary analysis of a cross-sectional study was conducted among 177 surgical healthcare professionals. Data were collected using the National Institute for Occupational Safety and Health (NIOSH) Generic Job Stress adopted questionnaire and the Perceived Stress Scale. Both descriptive (mean and standard deviation) and inferential (chi-square tests, t-test and regression) statistical analyses were performed with statistical significance set at $p< 0.05$.

Results: The majority of the surgical team members reported experiencing moderate stress (65.0%) while 20.3% reported severe stress levels. Organizational stressors was ranked highest with overall mean score of 4.038, this was followed by environmental (3.981) and interpersonal (3.945) related. Common stress-related outcomes reported are musculoskeletal pains and fatigue (4.09 ± 0.79), poor job satisfaction (4.02 ± 0.78) and low motivation (4.01 ± 0.79). No statistically significant associated were found between stress levels and the years of experience ($\beta = -0.100$, $p = 0.254$) and weekly call hours ($\beta = 0.067$, $p = 0.385$).

Conclusion: The findings indicate that organizational and environmental factors have a greater impact on team stress compared to demographic variables. Implementing targeted interventions to improve workplace policies, environmental conditions, and support systems is critical for reducing stress, enhancing team performance, and maintaining patient safety.

Keywords: Stress, Surgical team, Patient safety, Organizational stressors, Nigeria, Job Demand-Control model.

BACKGROUND

Work-related stress is a significant occupational hazard in healthcare settings, particularly within operating theatres (OTs), where high-pressure settings can affect both surgical team members' performance and patient safety(1). Surgical teams are prone to many stressors that negatively impact their ability to function optimally, which could be caused by fatigue, time demands, interpersonal conflicts, and the complexity of surgical procedures (2). These stressors, if left unaddressed, can impair surgical outcomes, hinder learning opportunities for trainees, and pose a serious risk to patient safety (3). For instance, research has shown that high stress levels among healthcare workers are associated with increased medical errors, longer hospital stays, and higher readmission rates (4).

The operating theatre setting works as a multidimensional contributing factor to stress, surrounding ergonomic design, technological demands, and interpersonal dynamics. Environmental stressors such as excessive noise from power equipment, poor lighting, cramped space and equipment malfunctions have been shown to increase cognitive workload and impair situational awareness among surgical teams (5-7). These factors could be further compounded by hierarchical pressures and communication failure can also increase the psychological stress and fatigue among the surgical teams (8). Moderate to severe stress levels have impacted the performance, impaired decision-making, and increased risk of adverse events in the theatre (9). According to Sonoda and others (10), revealed that the impact of stress among the surgical team members varies across their professional roles and responsibilities. The study also showed that scrub nurses are frequently experiencing stress related to the technical aspects of surgery, while circulating nurses face higher stress due to collaboration and coordination demands, while surgeons and anaesthesiologists, on the other hand, are often stressed by time pressure and the complexity of surgical cases.

This study is guided by the Job Demand-Control (JDC) Model, proposed by Karasek [11], which posits that work stress arises from the interaction between job demands (workload, time pressure) and job control (decision-making autonomy and task management). According to this model, when job demands exceed an individual's capacity to control the work environment, stress levels increase, potentially leading to burnout, decreased performance, and compromised patient safety. In the surgical setting, was both cognitive and physical demands are exceptionally high, maintaining a balance between job demands and job control is crucial to enhancing team performance and patient outcomes.

Despite the recognition of stress as a critical issue in healthcare, there is limited empirical evidence on how stress affects surgical team performance and patient safety in tertiary hospitals in Nigeria. While studies from high-income countries have extensively documented the negative impact of stress on healthcare workers, few have explored how organizational, interpersonal, and environmental stressors uniquely influence Nigerian surgical teams. This gap in knowledge hinders the development of context-specific interventions aimed at mitigating stress and enhancing team performance.

Workplace stress among surgical teams affects not only their well-being but also significantly impacts patient safety and the quality of care rendered to patients undergoing surgical procedures. For instance, a study has reported that high stress levels among surgical teams are linked to decreased job satisfaction, increased burnout, and poor surgical outcomes, which ultimately compromise patient safety[12]. The role-specific stress patterns among the team members highlight the need for tailored interventions to address the unique challenges faced by different team members. Studies have suggested that ergonomic redesign of the OT setting, implementation of structured communication protocols, and supportive leadership practices can mitigate environmental stress, improve teamwork, and enhance both team members' well-being and patient safety[13-14].

Workplace stress among surgical teams has been extensively examined in high-income countries; however, limited research addresses its prevalence and consequences in low- and middle-income settings such as Nigeria. Most of the tertiary hospitals in Nigeria experience persistent challenges, including chronic understaffing, insufficient infrastructure and resources, equipment failures, and unreliable electricity supply. These conditions are likely to intensify the influence of organizational and environmental stressors on surgical teams relative to those in better resourced health systems.

Despite increasing recognition of work-related stress in Nigerian healthcare, existing studies have often focused on specific cadres such as nurses or physicians, or on general hospital environments rather than surgical settings. To our knowledge, no prior study in Nigeria has simultaneously examined both organizational and environmental stressors among surgical teams and linked them to team performance and patient safety using validated tools. This study addresses the gap by applying the NIOSH Generic Job Stress Questionnaire, adapted for the Nigerian setting, to provide new evidence that can guide interventions to strengthen occupational health, improve team performance, and promote patient safety in resource-constrained hospitals. Thus, this study is to investigate the effect of organizational and environmental stress on surgical team performance and patient safety in a northwest Nigerian tertiary hospital.

METHODS

Study Setting, Design, and Population

This study was conducted at the Ahmadu Bello University Teaching Hospital (ABUTH), Zaria, located in Shika-Zaria, Kaduna State. ABUTH offers all three tiers of healthcare services, as well as training and research. The hospital provides a wide range of services, including general outpatient care, 24-hour accident and emergency services, and inpatient medical and surgical care. The study employed a cross-sectional descriptive design and the population of the study included 45 consultants, 97 resident trainees, and 47 nurses (189).

This study is based on the secondary use of data originally collected to assess occupational stress among team members between March 24 and April 15, 2020. This approach was taken to maximize existing data resources and enable a focused investigation of organizational and environmental stressors in surgical teams. However, reliance on secondary analysis presents certain limitations: the data were not specifically tailored to all the research questions examined in this study, which may restrict the depth of interpretation and limit the generalizability of the findings.

Sample Size and Sampling Technique

The sample size was calculated using Yamane's formula, and participants were drawn through stratified sampling to ensure representation of three groups: consultants (surgeons and anaesthesiologists), resident doctors, and perioperative nurses (including nurse anaesthetists). From these strata, 177 eligible surgical team members were proportionately recruited using random balloting.

Eligibility was limited to permanent or contracted surgical team members with at least six months' operating room experience. Interns, students, those on temporary rotations, individuals with less than six months' experience, or those with prior stress-related diagnoses were excluded.

Tools and Methods of Data Collection

Data were collected using a self-administered questionnaire comprising three sections: socio-demographics, stress-contributing factors, and perceived stress outcomes. The tool was adapted from the National Institute for Occupational Safety and Health (NIOSH) Generic Job Stress Questionnaire (15) and the Perceived Stress Scale (PSS) (16), reviewed by experts in surgery and perioperative nursing, and pilot tested among 15 surgical staff in a similar tertiary hospital. Minor modifications ensured contextual relevance. Reliability was confirmed with a Cronbach's alpha of 0.89.

Items were rated on a five-point Likert scale (0 = strongly disagree to 5 = strongly agree) with a benchmark mean of 2.5. To minimize bias, data collection was anonymous and supported by two trained perioperative nurse research assistants. Participants were informed about the study objectives, and completion of the questionnaire required an average of 15 minutes during the data collection period between March 24 and April 15, 2020.

Data Analysis

After retrieving all the questionnaires, the data were cleaned, coded, and entered into IBM SPSS version 26.0 for statistical analysis. Data accuracy and reliability were ensured through frequency checks and correction of entry errors. Descriptive statistics were used to summarize variables with frequency and percentage tables. Chi-square test was conducted to examine associations between dependent and independent variables. Predictor variables that showed statistically significant associations at the bivariate level, as well as those identified from prior literature as theoretically relevant, were entered into the multivariate model. Multiple regression analysis was then performed to identify independent predictors of stress. The level of statistical significance was set at $p < 0.05$. Odds ratios (OR) with 95% confidence intervals were reported, where ORs greater than 1.0 indicated an increased likelihood of stress relative to the reference category, and ORs less than 1.0 indicated a decreased likelihood. Both significant and non-significant findings are presented and interpreted in line with the regression tables to ensure consistency and transparency.

Ethical Consideration

Ethical approval for the study was sought and obtained from the Health Research Ethics Committee of Ahmadu Bello University Teaching Hospital (ABUTH), Zaria, with reference number ABUTH 954524802 (Dated 16th March, 2020). Written informed consent was obtained from all participants and participation in the study was entirely voluntary. Participants in the study were assured that any information provided would remain strictly confidential and all the participants were identified. To safeguard confidentiality, questionnaires were anonymized with unique codes instead of personal identifiers, and data were stored securely with access restricted to the research team. Only participants who consented were included in the study, ensuring full adherence to ethical research standards.

RESULTS

A total sample size of 177 respondents successfully participated in the study and were included in the final analysis.

Table 1: Socio-demographic Data of the Respondents

Variable	Category	Frequency	Percentage
Gender	Male	106	59.9
	Female	71	40.1
Ethnicity	Hausa/Fulani	48	27.1
	Yoruba	25	14.1
	Igbo	20	11.3
	Others	84	47.5
Religion	Islam	95	53.7
	Christianity	82	46.3
Cadre	Doctor	116	66.3
	Nurse	59	33.7
Highest Qualification	PhD	1	0.6
	Fellowship	39	22.0
	MSc/Masters	22	12.4

Variable	Category	Frequency	Percentage
	PGD	15	8.5
	BSc.	44	24.9
	HND/Equivalent	5	2.7
	Diploma	7	4.0
	Others	38	21.5
	No response	6	3.4
Marital Status	Single	60	33.9
	Married	110	62.1
	Separated	1	0.6
	Divorcee	5	2.8
	Widow	1	0.6
Mean Age		**39.4**	**SD = 7.8**
Mean Weekly Hours Worked		**53.0**	**SD = 23.6**

As shown in Table 1, most respondents were male (59.9%) with diverse ethnic backgrounds, including Hausa/Fulani (27.1%), Yoruba (14.1%), Igbo (11.3%), and others (47.5%). Over half identified as Muslim (53.7%), while 46.3% were Christian. Medical doctors formed the majority of the sample (66.3%), compared to nurses (33.7%). In terms of education, 24.9% held bachelor's degrees, 22.0% fellowships, and very few had PhDs (0.6%). Most participants were married (62.1%), with 33.9% single and a small minority separated, divorced, or widowed. The mean age of respondents is 39.4 years with a standard deviation (SD) of 7.8, indicating a moderately diverse age distribution and the mean of weekly call hours worked is 53.0 hours, with an SD of 23.6, suggesting a broad range of weekly working hours, likely reflecting differing job roles or personal circumstances within the sample.

Table 2: The Level of Stress among Surgical Team Members

Level of stress	Frequency	Percentage
Lack of stress	5	2.8%
Low stress	21	11.9%
Moderate stress	115	65.0%
Severe stress	36	20.3%

The findings on the level of stress (see Table 2) among the participants indicate that the majority of the team members (65.0%) are exposed to a moderate level of stress, followed by (20.3%) who experience severe stress and (12%) low stress. Only a small percentage (3%) reported a lack of stress. This suggests that most respondents perceived their work has been stressful, with a significant portion facing moderate to severe levels of stress, highlighting the need for interventions aimed at managing stress among the team members.

Table 3: Organizational, Interpersonal and Environment Stressors

Stressors	StrA*	A*	N*	D*	StrD*	Mean ± SD	Rank
Organizational Related							
Job policy and procedure	31	134	8	3	1	4.08±0.58	1
Lack of promotion	26	128	14	7	2	3.96±0.69	2
Lack of availability of supplies and equipment	52	96	22	5	2	4.08±0.79	1
Cumulative mean						**4.038**	
Interpersonal Related							
Lack of peer support	34	107	22	10	4	3.89±0.86	4
Lack of supervisors support	29	117	19	10	2	3.91±0.77	3
Communications problem	43	104	23	5	2	3.54±0.41	1

Lack of balance between personal and work life	49	90	24	10	4	3.96±0.92	2
Cumulative mean						**3.945**	
Working/physical environment Related							
Poor housekeeping of the theatre	38	109	13	14	3	3.93±0.87	8
Lack of equipment to work with	51	95	26	1	4	4.06±0.81	3
Space for work	40	98	22	14	3	3.89±0.90	10
Safety of your personal belongings	39	103	23	12	0	3.96±0.79	7
The level of noise in the theatre	34	99	28	15	1	3.85±0.85	11
The level of lightning in the theatre	42	92	27	14	2	3.89±0.89	10
The temperature (cooling system) of the theatre	46	93	21	12	5	3.92±0.95	9
Risk for injury	51	97	25	4	0	4.10±0.72	2
Exposure to dangerous chemicals	60	77	24	11	5	3.99±0.99	6
The nature of the convenience	56	97	19	4	1	4.15±0.74	1
The nature of the changing room	50	96	19	10	2	4.03±0.85	4
Safety in the theatre	55	88	19	9	6	4.00±0.97	5
Cumulative mean						**3.981**	
Aggregate mean %	**79.8%**						
Aggregate mean score			**3.99**				
t=-statistic = 36.49, p-value = 0.00075 = Statistically significant							

Note. StrA = Strongly Agree; A = Agree; N = Neutral; D = Disagree; StrD = Strongly Disagree.

Table 3 provides an overview of various organizational, interpersonal, and working environment-related factors contributing to stress, as assessed by respondents. The organizational-related stressors, such as job policy and procedure (mean = 4.08) and lack of promotion (mean = 3.96), are ranked highly, suggesting that structural and policy-related issues within the workplace are significant sources of stress. Cumulative mean for organizational-related stressors is 4.038, indicating that, overall, organizational factors tend to be a major contributor to stress.

Among the interpersonal-related stressors, lack of peer support (mean = 3.89) and lack of supervisor support (mean = 3.91) are notable contributors to stress, ranked 4th and 3rd, respectively. The cumulative mean for interpersonal-related stressors is 3.945, reflecting the importance of support systems at work in affecting employees' stress levels. Communication problems and lack of work-life balance also contribute, with means of 3.85 and 3.96, respectively, pointing to issues in relationships and personal life balance as significant stress factors. Environmental stressors showed notable effects on participants' stress levels. The highest-ranked factors were workplace convenience (mean = 4.15) and risk of injury (mean = 4.10), underscoring safety and suitability of the work environment as key concerns. The cumulative mean score (3.98) further highlights the significant role of the physical environment in stress generation. Additional contributors included poor housekeeping, inadequate equipment, and unfavourable conditions such as noise and temperature, each with varying levels of impact.

The finding of the independent samples t-test shows that the aggregate mean stressor score was statistically significantly (t = 36.49, p < 0.001), which is higher than the neutral midpoint of 3 on the Likert scale. These findings suggested that the respondents in this study perceived the environmental and institutional stressors as impactful.

Table 4: Outcomes of Stress among the Surgical Team Members

Outcomes	StrA*	A*	N*	D*	StrD*	Mean ± SD	Rank
Interpersonal conflict	43	104	18	10	2	3.99±0.82	4
Poor performance	29	113	22	12	1	3.89±0.78	5
Low motivation	42	109	14	11	1	4.01±0.79	3
Poor job satisfaction	43	107	16	10	1	4.02±0.78	2
Poor client/patient outcome	39	91	32	14	1	3.86±0.89	7
Sleeping disorders	42	88	32	14	1	3.88±0.88	6
Increase medical errors	43	87	29	15	3	3.86±0.94	7
Increased health workers turnout	43	82	27	17	8	3.76±1.07	10
Job absenteeism	33	83	34	18	9	3.64±1.06	11
Musculoskeletal pains and fatigue	53	96	19	8	1	4.09±0.79	1
High blood pressure	40	97	22	17	1	3.89±0.88	5
Depression	41	88	25	22	1	3.83±0.95	9
Anxiety	33	104	20	19	1	3.84±0.87	8
Aggregate mean %	**77.78%**						
Aggregate mean score	**3.889**						
t= **19.86**, df=8, p < **0.0001t = Statistically significant**							

Note. StrA = Strongly Agree; A = Agree; N = Neutral; D = Disagree; StrD = Strongly Disagree

Table 4 above shows the findings on the outcome of stress among the surgical team members. Musculoskeletal pains and fatigue have the highest outcome of work related stress as this item attracted the highest mean and SD value of4.09±0.79, poor job satisfaction has the second rated highest value with mean and SD value of 4.02±0.78 while job absenteeism has the lowest value of mean re and SD value of 3.64±1.06. The one-sample t-test results in Table 4 further indicated that the mean outcome score was statistically significantly higher than the neutral point $t(8) = 19.86$, $p < 0.001$. This implies that workplace stressors exert a substantial and consistent antagonistic effect on team members' work performance, well-being, and the quality of care to patients.

Table 5: Multiple regression analysis between years of experience, call hours and level of work related stress among surgical team members

Variables	Coefficient	Beta	t-cal	Sig.
Years of experience	-.087	-.100	-1.144	.254
Call hours per week	.013	.067	.870	.385
Constant	**27.336**	**-**	**12.29**	**.000**
R=0.211				
R^2 =0.044				
R^2 (adj) = 0.028				
F- ratio = 2.80				.064

The results in (Table 5) show that the regression model analysis established a correlation coefficient of R = 0.211, which indicates a weak positive relationship between the overall set of predictors and the outcome variable. The coefficient of determination (R^2 = 0.044) showed that 4.4% of the variance in the dependent variable is explained by the two predictors, while the adjusted R^2 (0.028) suggested that, after adjusting for the number of predictors, the model still established only 2.8% of the variance.

The F ratio of (2, 174) = 2.80 with a significance value of $p = 0.064$ indicates that the model is not statistically significant at the 0.05 level. This means that, years of experience and weekly on call hours do not significantly predict the dependent variable in this sample while, independently, years of experience ($\beta = -0.100$, $p = 0.254$) and call duty hours per week ($\beta = 0.067$, $p = 0.385$) were not statistically significant predictors, as the p-values were greater than the 0.05 threshold.

DISCUSSION

This study found that most surgical team members in a Nigerian tertiary hospital reported moderate to severe workplace stress, with organizational and environmental stressors such as unclear policies, inadequate supplies, poor housekeeping, and risk of injury emerging as the most significant. These findings highlight that in this setting, institutional conditions rather than demographic characteristics drive stress, underscoring the decisive influence of the work environment. Compared with high-income countries where stress is often linked to litigation risk, advanced technologies, or complex case management [8, 14], our results show that Nigerian teams contend with systemic stressors such as erratic utilities, inadequate staffing, and equipment breakdowns. These contextual realities amplify the negative impact of stress on patient safety, as surgical delays, fatigue, and reduced precision are more likely in resource-constrained environments. Similar observations have been noted in other LMICs, including Ghana and Ethiopia, was limited resources intensified stress among surgical staff [17, 18], but the present study extends this evidence by specifically examining both organizational and environmental stressors in Nigeria.

The practical implications are clear. Simple, low-cost interventions can help reduce stress in this environment. Regular equipment maintenance, structured staff rotation, and improved housekeeping are realistic steps at the facility level. Organizational changes, such as clearer task delegation, supportive leadership, and structured communication protocols, could further ease stress and strengthen team performance. These strategies are particularly suited to resource-limited hospitals was financial investment is constrained but organizational reform is feasible.

Our findings also align with the Job Demand–Control (JDC) model, which emphasizes that stress arises when high job demands are coupled with low decision-making autonomy [11]. In this study, surgical teams faced long working hours, heavy caseloads, inadequate supplies, and unsafe environments (high demands) while having little control over resource allocation or institutional policies (low control). This imbalance likely contributed to the moderate to severe stress levels reported. Enhancing staff autonomy, redistributing workload, and strengthening peer and supervisory support systems could help rebalance demand and control, thereby improving both staff wellbeing and patient safety.

The study also revealed negative stress outcomes, including fatigue, musculoskeletal pain, and diminished job satisfaction, consistent with evidence linking occupational stress to absenteeism, medical errors, and poor safety culture [12, 22]. Importantly, these effects were consistent across demographic groups, reinforcing that systemic factors, not individual resilience alone, are the key drivers of stress in Nigerian surgical practice.
The implications for practice and policy are therefore significant. Hospital administrators should prioritize ergonomic improvements in operating theatres, adequate staffing and supply chains, and structured peer support. At the policy level, investment in occupational health services, stress monitoring, and leadership training would be critical. These interventions are practical within the Nigerian context and have broader relevance for LMICs facing similar challenges.

This study has some limitations that should be considered when interpreting the findings. It relied on secondary analysis of data originally collected for a broader investigation of occupational stress, which may

not have been specifically tailored to address all the research questions examined. This limits the depth of interpretation and may affect generalizability. Nonetheless, the use of existing data allowed for the timely assessment of organizational and environmental stressors in surgical teams during a critical period. The use of validated tools, an adequate sample, and application of the JDC framework strengthen the reliability of the findings. Future studies should adopt longitudinal designs and evaluate the effectiveness of targeted interventions in reducing stress and improving patient safety.

CONCLUSION

This study revealed the levels of stress among surgical team members in a tertiary hospital, with most participants reporting moderate to severe stress levels. This study also shows that organizational and environmental stressors, such as inadequate supplies, unsafe conditions, and unclear policies, are the major drivers of stress among surgical teams in a Nigerian tertiary hospital. These findings highlight the need for locally feasible interventions to reduce stress and strengthen patient safety in resource-limited surgical settings.

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Assessment of Mental Health of Pregnant and Postpartum Women Attending Antenatal and Postnatal Service in Tertiary Health Institutions in Anambra State.

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ABSTRACT

Background: Pregnancy and the postpartum period are associated with heightened vulnerability to mental health disorders such as depression, anxiety, psychosis, and post-traumatic stress disorder (PTSD). In low- and middle-income settings like Nigeria, these conditions are often underdiagnosed and undertreated due to stigma, poor integration into maternal health services, and limited awareness. This study aimed to assess the mental health status of pregnant and postpartum women attending antenatal and postnatal services in tertiary health institutions in Anambra State, Nigeria.

Methods: This study adopted a cross-sectional analytical design. A total of 310 pregnant and postpartum women attending antenatal and postnatal clinics were recruited from tertiary health institutions in Anambra State. Data were collected using self-report instruments. Data were collected using a structured questionnaire "Assessment of Mental Health of Pregnant and Postpartum Women Questionnaire" developed by the researchers. Data obtained were analyzed using descriptive statistics, and inferential statistics of Independent T-test. Alpha level was set at 0.05.

Results: The findings of this study revealed a high extent of depression ($\bar{x} = 2.60$), anxiety ($\bar{x} = 3.16$), psychotic symptoms ($\bar{x} = 3.14$) as well as post-traumatic stress disorder ($\bar{x} = 3.15$). There was significant difference in the opinion of pregnant and postpartum women on the extent of occurrence of anxiety disorder ($p = 0.047$). There were no significant differences in the opinion of pregnant and postpartum women on the extent of occurrence of depression ($p = 0.064$), psychotic symptoms ($p = 0.83$) and post-traumatic stress disorder ($p = 0.91$).

Conclusion: Mental health disorders are prevalent among pregnant and postpartum women in tertiary health facilities in Anambra State, underscoring the need for routine psychological assessment as part of maternal care. Strengthening the capacity of healthcare providers through targeted training in perinatal mental health, alongside integrating mental and physical health services, can improve early detection and management.

Keywords: Maternal Mental Health; Pregnancy; Perinatal Care; Postpartum Depression; Anxiety Disorders.

INTRODUCTION

Pregnancy is a transitional period to motherhood during which expectant mothers experience significant hormonal, emotional, and physical changes. These transitions can result in psychological distress, with some women reporting uncertainty and anxiety as they approach childbirth, particularly those living in poverty or exposed to violence and abuse[1]. The burden of maternal mental health problems in low- and middle-income countries (LMICs) is substantial[2], and these conditions are major contributors to maternal morbidity and mortality. They also have long-term adverse effects on fetal development, birth outcomes, and the health and development of children[3]. Mental health is a fundamental component of overall well-being, influencing emotions, cognition, behaviour, and interpersonal relationships. According to the World Health Organization[4], mental health is "a state of well-being in which the individual realizes his or her abilities, can cope with the normal stresses of life, can work productively and fruitfully, and can contribute to his or her community." However, compromised mental health impairs daily functioning, decision-making, and quality of life[5].

The perinatal period, comprising pregnancy and the first year postpartum, is a particularly vulnerable phase for the onset of mental health disorders such as anxiety and depression. Globally, prevalence rates vary antenatal depression has been reported at 28.5% in China[6], and 24.5% in Nigeria[7]. Despite the burden, perinatal mental health remains under-recognized in Nigeria. Antenatal care (ANC) and postnatal care (PNC) offer opportunities to integrate mental health screening, yet routine assessments are rarely implemented in tertiary health facilities. As noted by Vogel et al[8], high maternal mortality in Nigeria is partly attributable to poor quality prenatal and postnatal care, with mental health issues often neglected. This gap is worsened by socio-cultural stigma, lack of awareness, domestic violence, and economic challenges that prevent women from seeking help[9].

Anambra State, in southeastern Nigeria, has limited data on the mental health of pregnant and postpartum women. Anecdotal reports and hospital records suggest a high level of psychological distress among women attending tertiary health facilities, but there is no systematic evidence to guide interventions. Understanding the prevalence and associated factors is essential for integrating mental health into maternal services and achieving Nigeria's Sustainable Development Goals on maternal health. Therefore, this study assessed the mental health of pregnant and postpartum women attending antenatal and postnatal services in tertiary health institutions in Anambra State. Findings are expected to inform evidence-based interventions, strengthen screening protocols, and guide policy in addressing perinatal mental health disorders.

METHODS

Study Design

This study employed a descriptive cross-sectional survey design to assess the mental health of pregnant and postpartum women attending antenatal and postnatal services in tertiary health institutions in Anambra State, Nigeria. Data were collected from two major tertiary facilities, Nnamdi Azikiwe University Teaching Hospital (NAUTH), Nnewi, and Federal Medical Centre (FMC), Onitsha.

Study Population

The study population comprised 1,649 pregnant and postpartum women attending antenatal and postnatal clinics in the selected institutions. Eligible participants were pregnant women in any trimester and postpartum women within six months after delivery who provided informed consent. Women with pre-existing psychiatric diagnoses prior to pregnancy, those critically ill, or those receiving care in private facilities were excluded. A total of 310 participants were recruited for this study. Proportionate stratified sampling

determined the number of participants recruited from each facility, and systematic random sampling was then used to select respondents.

Instrument for Data Collection

Data were collected using a self-developed structured questionnaire, the Assessment of Mental Health of Pregnant and Postpartum Women Questionnaire (AMHPPWQ). The tool consisted of two sections:

i. Section A: socio-demographic and obstetric characteristics.

ii. Section B: 40 items assessing depression, anxiety, psychotic symptoms, and post-traumatic stress disorder, rated on a four-point Likert scale (1 = strongly disagree to 4 = strongly agree).

Ethical approval was obtained from the University Ethics Committee, Chukwuemeka Odumegwu Ojukwu University, Anambra, Nigeria. Participants were approached during clinic visits, informed about the study, and assured of confidentiality. Questionnaires were self-administered or researcher-assisted when necessary and retrieved immediately or via a designated hospital officer.

Data Analysis

Completed questionnaires were coded and analysed using SPSS version 25. Descriptive statistics (mean, standard deviation, frequencies, percentages) were used to summarize data. Independent T-tests, were applied to test hypotheses. Alpha value was set at $p < 0.05$.

RESULTS

The respondents were predominantly within the reproductive age group of 25–31 years (155; 50%), married (50%), and had attained tertiary education (50%). Most were employed in the public sector (50%), while 186 (60%) were pregnant and 144 (40%) were postpartum women (Table 4.1). The assessment of mental health symptoms revealed a generally high occurrence across all domains. Depression symptoms were reported to a high extent (mean = 2.60), with common manifestations including persistent sadness, anhedonia, fatigue, sleep disturbances, and suicidal ideation. Anxiety disorders also occurred to a high extent (mean = 3.16), with excessive worry, restlessness, irritability, physiological arousal (e.g., palpitations and sweating), and difficulty controlling fear or worry being prominent. Psychotic symptoms were similarly prevalent (mean = 3.14), with respondents indicating experiences of hallucinations, delusional thoughts, disconnection from reality, extreme mood swings, and interpersonal mistrust. Post-traumatic stress disorder was also reported at a high extent (mean = 3.15), characterized by flashbacks, hypervigilance, avoidance behaviors, intrusive thoughts, and emotional detachment.

Independent t-tests showed no significant differences between pregnant and postpartum women ($p > 0.05$) for opinion on the occurrence of depression, psychotic symptoms and post-traumatic stress disorder, indicating that both groups are similarly vulnerable to perinatal mental health challenges. There was, however, a significant difference in the opinion of both groups on the occurrence of anxiety disorders ($p = 0.047$) (Table 6).

Table 1: Sociodemographic characteristics of the respondents

	Frequency	Percentage
Age (years)		
18 – 24	46	14.8
25 – 31	155	50
32 – 38	62	20

≥ 39	47	15.2
Marital status		
Single	31	10
Married	155	50
Separated/Divorced	62	20
Widowed	62	20
Educational background		
No formal education	31	10
Primary education	62	20
Secondary education	62	20
Tertiary education	155	50
Employment status		
Public sector	155	50
Private sector	62	20
Self-employed	62	20
Unemployed	31	10
Maternal status		
Pregnant	186	60
Post-partum	144	40

Table 2: Occurrence of depression among the respondents

VHE = Very High Extent; HE = High Extent; LE = Low Extent; VLE = Very Low Extent

Statements	VHE	HE	LE	VLE	Mean	Remark
I often feel persistent sadness or hopelessness.	170	70	60	10	2.74	High extent
I have lost interest in activities I used to enjoy.	150	70	70	20	2.64	High extent
I experience feelings of worthlessness or excessive guilt.	130	70	80	30	2.54	High extent
I feel fatigued or lack energy most of the time.	110	90	70	40	2.51	High extent
I have difficulty sleeping or sleep too much.	190	70	10	40	2.71	High extent
I have experienced sudden changes in my appetite and weight.	110	100	60	40	2.55	High extent
I find it difficult to concentrate or make decisions.	120	100	20	70	2.59	High extent
I have had thoughts of harming myself or suicide.	130	70	80	30	2.55	High extent
Average mean					2.60	High extent

Table 3: Occurrence of anxiety disorder among the respondents

Statements	VHE	HE	LE	VLE	Mean	Remark
I frequently experience excessive worry about my pregnancy or baby.	160	70	60	20	3.19	High extent
I often feel restless, tense, or nervous.	200	50	40	20	3.38	High extent
I experience sudden and unexplained feelings of panic.	180	50	60	20	3.25	High extent
I feel irritable or easily annoyed.	158	52	60	40	3.05	High extent
I have difficulty relaxing, even when I have the opportunity.	190	70	10	40	3.32	High extent
My heart races, I sweat, or I tremble when I am anxious.	210	10	50	40	3.25	High extent
I avoid certain situations out of fear or worry.	120	100	20	70	2.87	High extent
I find it difficult to control my thoughts of fear or worry.	150	40	80	40	2.96	High extent
Average Mean					3.16	High extent

VHE = Very High Extent; HE = High Extent; LE = Low Extent; VLE = Very Low Extent

Table 4: Occurrence of psychotic symptoms among the respondents

Statements	VHE	HE	LE	VLE	Mean	Remark
I have had unusual thoughts or beliefs that others do not share.	140	70	70	30	3.03	High extent
I hear voices or see things that others cannot.	200	50	40	20	3.38	High extent
I sometimes feel disconnected from reality.	180	60	65	5	3.33	High extent
I have difficulty distinguishing between what is real and what is not.	158	52	60	40	3.05	High extent
I experience extreme mood swings.	200	60	10	40	3.35	High extent
I feel like someone is watching or controlling me.	210	10	50	40	3.25	High extent
I have had aggressive or violent thoughts or behaviors.	120	100	20	70	2.87	High extent
I find it hard to trust people, even my loved ones.	130	50	90	40	2.87	High extent
Average Mean					3.14	High extent

VHE = Very High Extent; HE = High Extent; LE = Low Extent; VLE = Very Low Extent

Table 5: Occurrence of post-traumatic stress disorder among the respondents

Statements	VHE	HE	LE	VLE	Mean	Remark
I have experienced traumatic or distressing events related to my pregnancy or childbirth.	120	100	60	30	3.00	High extent
I frequently have flashbacks or nightmares about past traumatic experiences.	210	40	40	20	3.40	High extent
I avoid places, people, or activities that remind me of distressing events.	150	50	70	40	3.00	High extent
I feel emotionally numb or detached from loved ones.	160	50	80	20	3.13	High extent
I experience sudden outbursts of anger or irritability.	200	60	10	40	3.35	High extent
I am constantly on high alert or easily startled.	210	10	50	40	3.26	High extent

I have trouble concentrating due to intrusive distressing memories.	170	80	20	40	3.22	High extent
I struggle with persistent negative thoughts about myself or the world.	130	50	90	40	2.87	High extent
Average Mean					3.15	High extent

VHE = Very High Extent; HE = High Extent; LE = Low Extent; VLE = Very Low Extent

Table 6: Independent T-test for difference in occurrence of mental health symptoms between pregnant and postpartum women

		95% CI			
	Mean Diff. ± SD	**Lower**	**Upper**	**t**	**p-value**
Depression	0.091 ± 0.052	-0.035	0.047	0.322	0.064
Anxiety disorder	0.057 ± 0.028	-0.024	0.091	0.725	0.047
Psychotic symptoms	0.187 ± 0.017	-0.0144	0.058	0.215	0.83
PTSD	0.071 ± 0.057	-0.474	0.087	0.115	0.091

DISCUSSION

This study assessed the mental health of pregnant and postpartum women attending antenatal and postnatal services in tertiary health institutions in Anambra State. The findings reveal a notable occurrence of depression, anxiety disorders, psychotic symptoms, and post-traumatic stress disorder (PTSD) within this population, reflecting trends reported in global and regional literature.

The prevalence of depression observed in this study is consistent with reports that antenatal depression is a strong predictor of postpartum depression[10,11]. Factors such as interpersonal stress, societal expectations, and limited screening during antenatal visits may contribute to the burden[12,13]. In resource-limited settings such as Anambra State, inadequate integration of mental health into routine maternal care further compounds the problem.

Similarly, the occurrence of anxiety disorders among participants aligns with previous studies reporting high perinatal anxiety rates, ~20%[14,15]. The association of anxiety with socioeconomic stressors, domestic violence, and weak social support systems[16] may explain the elevated rates in this setting. The frequent co-occurrence of anxiety and depression highlights the complex interplay of mental health disorders in the perinatal period and emphasizes the need for integrated maternal mental health care. The presence of psychotic symptoms highlights a critical risk, especially as postpartum psychosis, though rare, can have severe consequences. Consistent with prior reports[17], these symptoms may be influenced by hormonal fluctuations, prior psychiatric history, bereavement, and social isolation[18]. Inadequate screening and poor access to mental health resources in Anambra may contribute to under-detection and late management of such conditions.

The occurrence of PTSD among participants further illustrates the psychological vulnerability associated with traumatic childbirth experiences. Literature indicates that fear of childbirth, obstetric complications, and prior trauma are significant predictors of PTSD[19,20]. The absence of structured psychosocial support in many maternal health services likely increases the risk of untreated PTSD in this population.

CONCLUSION

This study demonstrates that mental health disorders, including depression, anxiety, psychotic symptoms, and post-traumatic stress disorder, are prevalent among pregnant and postpartum women in tertiary health facilities in Anambra State. These findings highlight the critical need to incorporate routine psychological assessment into standard maternal health care. Beyond routine screening, strengthening the capacity of healthcare providers through targeted training in perinatal mental health is essential to ensure early identification and appropriate management of these conditions. Integrating mental and physical health services within antenatal and postnatal care pathways will not only improve maternal wellbeing but also contribute to better neonatal and family health outcomes. Addressing mental health during the perinatal period should therefore be prioritized in policy and practice, particularly in resource-constrained settings such as Anambra State, where the burden of undetected and untreated conditions remains high.

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Anxiety and Depression Among Rural Population Due to Lockdowns During COVID-19 Pandemic.

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ABSTRACT

Background: The COVID-19 pandemic has been unprecedented both in magnitude and in the fallout. While considerable attention has been given to the mental health of patients, less is known about the effects of mitigation strategies like lockdowns on the general population. We conducted a study in a rural set-up to evaluate anxiety and depression consequent upon the imposition of lockdowns during the epidemic.
Aims: To analyze the relation between COVID-19 lockdowns and anxiety and depression among the rural population.
Materials and methods: A cross-sectional survey was conducted telephonically and online through e-forms. Two study tools, GAD-7 and PHQ-9, were used to objectively evaluate anxiety and depression, respectively, among the study participants. Data was collected by the snowball sampling technique and subjected to statistical analysis.
Results: Adolescents, females, unmarried, students and those living in families with more than four members and hailing from plains were more likely to be depressed, while middle-aged, females, married, private employees, those living in families with more than four members and hailing from plains had higher anxiety levels.
Conclusion: COVID-19 mitigation strategies had significant effects on the mental health of the general population, even in rural areas, with some particular groups affected more than others.
Key Messages: What is already known on this topic Mental health effects of COVID-19 have been well studied, however predominantly in patients. Some studies have studied the fallout on the general population as well. Less is known about the impact of mitigation strategies on the mental health of the general population.
What this study adds. This research finds that specific population groups did experience adverse effects on their mental health due to lockdowns employed during the COVID-19 pandemic.
How this study might affect research, practice and/or policy. The study revealed the impacts of mitigation strategies on the general population and identified certain vulnerable groups. This can be used to institute policy changes, not only to cater to the present demands but to have better preparations should such a pandemic befall again.
Keywords: Anxiety, Depression, COVID-19, Lockdown, Rural.

INTRODUCTION

The novel coronavirus disease, or COVID-19, has been the most serious medical challenge in recent history. The World Health Organization declared it a public health emergency of international concern on 30 January 2020[1]. The disease is predominantly mild but can cause severe illness in the older population and people with comorbidities such as diabetes mellitus, cardiovascular disease, chronic respiratory disease, or malignancy[2]. During the last two years, extensive research has been conducted on a multitude of issues related to the disease, ranging from clinical aspects to pharmacological interventions, including anti-viral drugs[3], preventive strategies including vaccines[4], etc. An important subject of study has been the mental health of not only the patients but the general population as well. There are various reasons for that. Firstly, the crisis has been enormous and unprecedented, leading to widespread fear and apprehension among the people.

Secondly, the mitigation strategies and responses of the administrations contributed to social and economic problems, especially in the developing countries, which had a huge bearing on the mental well-being of the population in general. While several studies have been conducted on the effects of lockdown on the mental health of the general public[5,6] most of these studies have either been conducted in developed countries[7,8] or urban areas of developing countries[9,10]. None of these studies focuses entirely on the mental health of the rural population. As the local social and economic dynamics differ between rural and urban areas, more so in developing countries, the effects on mental health are variable. According to the Centre for Urban Design and Mental Health (UD/MH), mental health problems are more prevalent in cities than rural areas, including a nearly 40% higher risk of depression, a 20% higher incidence of anxiety, and a twofold higher risk of schizophrenia, as well as loneliness, isolation, and stress[11]. Furthermore, rural areas face distinct challenges in terms of connectivity, communication, availability, and access to necessities. The current study was thus conducted in a rural setup and quite interestingly with variable altitudes as well. High altitude produces adverse alterations in human mood states, behavior, and cognitive functioning[12]. This study includes analyses and comparisons between the incidence of anxiety and depression in plain and hilly areas of a rural region in a developing country. Other demographic factors like age, gender, marital status, educational qualifications, and occupation were also studied for possible associations or otherwise.

Most of the mental health intervention strategies were instituted to cater to the urban population. The present research is focused on the rural setup will thus bring rural health management into play, which most of the time it is faced with different constraints in terms of resources and demographic challenges. Effective mental health management interventions can thereby be tailored to the rural landscape and will involve meticulous planning and execution by practitioners and policymakers.

Objective

To analyze the relation between COVID-19 lockdowns and anxiety and depression among the rural population.

MATERIALS AND METHODS

Study Design:

This is a cross-sectional survey-based study conducted telephonically and through e-forms wherever feasible.

Study Population:

The study participants included the rural population of India from hilly regions of the country invited to participate in the study via the snowball sampling technique. Active/recovered COVID-19 patients or patients known to be suffering from any psychiatric disorder were excluded.

Consent: A verbal consent was taken from all the participants, telephonically explaining to them the methodology and implications of the study. The participants were assured of complete confidentiality, and they could opt out anytime during the survey.

Study Tools:

1. Generalized Anxiety Disorder - 7 (GAD-7) - This is a validated, public domain, scaled questionnaire recommended by the Diagnostic and Statistical Manual-5 (DSM-5) for identifying possible cases of generalized anxiety disorder with a sensitivity of 89% and specificity of 82%. It is composed of 7 questions, each carrying a minimum of 0 and a maximum of 3 points. A GAD-7 score of < 5 indicates no anxiety, 5 - 9 indicates mild anxiety, 10 - 14 indicates moderate anxiety and > 14 indicates severe anxiety.

2. Public health questionnaire - 9 (PHQ-9) - This is a validated, public domain, scaled questionnaire recommended by the Diagnostic and Statistical Manual-5 (DSM-5) for screening and evaluation of the severity of depression with a sensitivity of 88% and specificity of 88%. It is composed of 9 questions, each carrying a minimum of 0 and a maximum of 3 points. A PHQ-9 score of 1-4 indicates minimal depression, 5 - 9 indicates mild depression, 10 - 14 indicates moderate depression, 15-19 indicates moderately severe depression and 20-27 indicates severe depression.

METHODOLOGY

Data was collected through the snowball sampling technique. We contacted the participants via telephone and before we asked them any questions, we took their verbal consent. The questionnaire included questions regarding:

1. Participant particulars.
2. Anxiety and depression questionnaire.
3. Some voluntary questions

Setting and Duration of Study: The data collection took place over two weeks during the initial phases of the COVID-19 lockdown in India. The duration of the study was one year, i.e., from April 2020 to April 2021, during which the number of COVID-19 cases was exponentially increasing in India.

Statistical analysis:

The demographic distribution of the participants was analyzed by SPSS v20.0 software (IBM Corp., Armonk, NY). Participants' responses to questions of each scaled questionnaire were converted into the discrete interval variables and the total score of the participant in each category, namely anxiety and depression, was calculated. This data was tabulated into Microsoft Excel 2019 and checked for normal distribution by applying the Shapiro-Wilk Test. Mann-Whitney U Test (also called Wilcoxon Rank Sum Test or Mann-Whitney Wilcoxon test) was used to analyze the correlation of anxiety and depression with marital status, members of a family, hills v/s plains.

Furthermore, the Mann-Whitney U test was used to understand the difference in the extent of anxiety and depression in participants who thought they were well-informed or given enough time to prepare for the lockdown, v/s those who didn't feel the same and for the participants who were constantly worried if someone from their family showed symptoms of COVID-19, v/s those who were not. The difference between groups was considered significant if the absolute value of $Z > 1.96$, equivalent to $P < .05$. The Kruskal-Wallis H test (also called the "one-way ANOVA on ranks") is a rank-based nonparametric test that can be used to determine statistically significant differences between two or more groups of the independent variable, it was used for the correlation of anxiety and depression with various age groups (ie adolescents, young adults, middle-aged,

older), occupation (student, businessmen, govt. employee, private employee, others), qualification (Undergraduate, graduate, post-graduate).

Lastly, the Kruskal-Wallis H test was used to understand the difference in the extent of anxiety and depression in participants regarding the source of information about the lockdown and corresponding events (television, internet, social media, friends and family members, newspaper), and it was also used to determine how difficult lockdown made it for them to do their regular work, take care of things at home or to get along with other people (not difficult at all/ somewhat difficult/ very difficult/ extremely difficult). The difference between groups was considered significant if the absolute value of $Z > 1.96$, equivalent to $P < .05$.

RESULTS

The study involved 252 participants (Table 1), the majority of whom, 165 (65.45%), were males with a mean GAD-7 score of 5.13, whereas the number of females was 87 (34.55%) with a mean GAD-7 score of 6.9. Results showed that females had a mean PHQ-9 of 7.97, whereas males had a mean PHQ-9 of 6.38. Most of the participants, that is 147 (58.33 %), were young adults and hence the commonest age group involved was of young adults (18 to 26 years)(Fig 1). The mean GAD-& and PHQ-9 scores in this age group were 5.66 and 7.4. In our study, there were 30 adolescents, 64 middle-aged and 11 older-aged participants, accounting for 11.90%, 25.39% and 4.36% of the total participants with GAD-7 and PHQ-9 scores of 5.43, 6.30, 4.36 and 8.10, 5.86, 3.64, respectively. Out of all the age groups, adolescents had the maximum mean PHQ-9 score and old people seemed to be the least depressed. Out of the 252 participants, 145 (57.53%) were unmarried and 107(42.47%) were married (Fig. 2). The mean GAD-7 score for unmarried participants was 5.48 and that for married participants was 6.09. Both groups had mild grade anxiety. Unmarried people had a mean PHQ-9 score of 7.65, which was higher than that of married people with a mean PHQ-9 score of 5.95.

In the study, 122 (48.41%) participants were students with a mean GAD-7 score of 5.62 and PHQ-9 score of 8.16, whereas 26 (10.31%) participants were businessmen a mean GAD-7 score of 6.12 and PHQ-9 score of 7.08 (Fig. 3). The number of government employees was 48 (19.04%) with a mean GAD-7 score of 4.54 and a mean PHQ-9 score of 4.44. The number of private sector employees was 44(17.46%) with a mean GAD-7 score of 6.77 and a mean PHQ-9 score of 6.93. The remaining 22 (8.73%) participants belonged to other professions and had a mean GAD-7 score of 6.45 and a mean PHQ-9 score of 5.93. Out of all the occupations, private sector employees reported the highest level of anxiety, whereas students had the highest level of depression.

Out of 252 participants, 187 (74.20%) people lived in a nuclear family (family with fewer than equal to 4 members). They had a mean GAD-7 score of 5.70 and a mean PHQ-9 score of 6.69. The remaining 65 (25.79%) participants had more than 4 members in their family, and they had a mean GAD-7 score of 5.94 and a PHQ-9 score of 7.73. Lastly, there were participants from the hills and plains. There were 75 (29.76%) participants who resided in hilly areas and they had a mean GAD-7 score of 5.09 and a mean PHQ-9 score of 6.83, whereas the major portion of the study population, 177 (70.23%), was from the plain areas and they had a mean GAD-7 score of 6.01 and a mean PHQ-9 score of 6.97. People living in plain areas had higher levels of anxiety and depression than those in hilly areas (Fig. 4).

In addition, a voluntary question was asked to evaluate anxiety and depression, furthermore. Of all the participants, 109 (43.3%) did not find it difficult at all to cope with work or personal life, even during lockdown. The mean GAD-7 score for these participants came out to be 3.24, and the mean PHQ-9 score turned out to be 3.80. While 110 (43.7%) people found it somewhat difficult, with a mean GAD-7 score of 6.48 and a mean PHQ-9 score of 7.44. 24 (9.5%) participants found it very difficult, with a mean GAD-7 score of 11.83 and a PHQ-9 score of 15.58. 9 (3.6%) individuals found it extremely difficult to take care of things at home or

get along with people, for whom the mean GAD-7 and PHQ-9 scores came out to be 10.67 and 15.56, respectively.

Table 1

Anxiety : GAD-7 Score							*Depression : PHQ -9 Score*				
	N	**Mean**	**Level**	**SD**	**Z**	**p value**	**Mean**	**Level**	**SD**	**Z**	**p value**
Gender											
Male	165	5.13	Mild	4.788	-3.583	0.000	6.38	Mild	5.838	-2.042	0.041
Female	87	6.90	Mild	4.335			7.97	Mild	6.347		
Marital status											
Unmarried	145	5.48	Mild	4.340	-0.593	0.553	7.65	Mild	5.842	-2.824	0.005
Married	107	6.09	Mild	5.157			5.95	Mild	6.223		
Hills v/s plains											
Hills	75	5.09	Mild	5.076	-2.073	0.038	6.83	Mild	6.943	-1.006	0.315
Plains	177	6.01	Mild	4.525			6.97	Mild	5.655		
Members in family											
<=4	187	5.70	Mild	4.622	-0.229	0.819	6.69	Mild	5.926	-1.145	0.252
>4	65	5.94	Mild	4.953			7.73	Mild	6.380		
Age group	**N**	**Mean**	**Level**	**SD**	**Df**	**p value**	**Mean**	**Level**	**SD**	**Df**	**p value**
Adolescents	30	5.43	Mild	3.626	3	0.617	8.10	Mild	6.536	3	0.029
Young adults	147	5.66	Mild	4.613			7.40	Mild	5.930		
Middle aged	64	6.30	Mild	5.288			5.86	Mild	6.192		
Older	11	4.36	Mild	5.104			3.64	Mild	3.776		
Occupation											
Student	122	5.62	Mild	4.356	4	0.536	8.16	Mild	6.143	4	0.007
Businessman	26	6.12	Mild	5.962			7.08	Mild	6.374		
Govt employee	48	4.54	Mild	3.195			4.44	Mild	3.941		
Private employee	44	6.77	Mild	5.705			6.93	Mild	6.414		
Others	22	6.45	Mild	5.106			5.91	Mild	6.907		

Voluntarily asked question											
How difficult had lockdown made it to do your work/ take care of things at home or get along with people?	**N**	**Mean**	**Level**	**SD**	**Df**	**p value**	**Mean**	**Level**	**SD**	**Df**	**p value**
Not difficult at all	109	3.24	-	3.413	3	0.000	3.80	-	4.161	3	0.000
Somewhat difficult	110	6.48	Mild	3.770			7.44	Mild	4.796		
Very difficult	24	11.83	Moderate	5.715			15.58	Moderate/severe	6.283		
Extremely difficult	9	10.67	Moderate	4.243			15.56	Moderate/severe	6.598		

FIG. 1

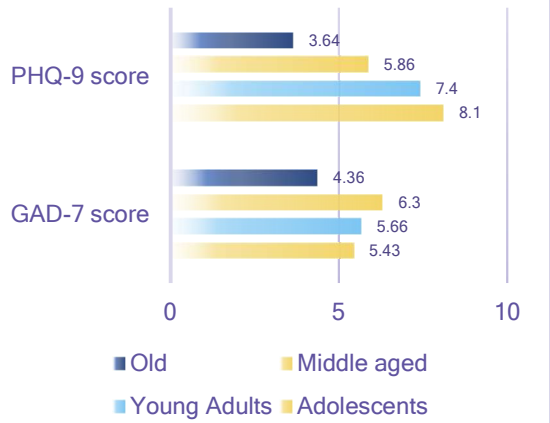


FIG. 2

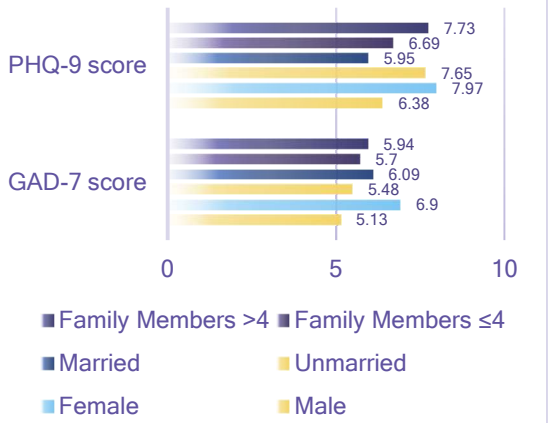


FIG. 3

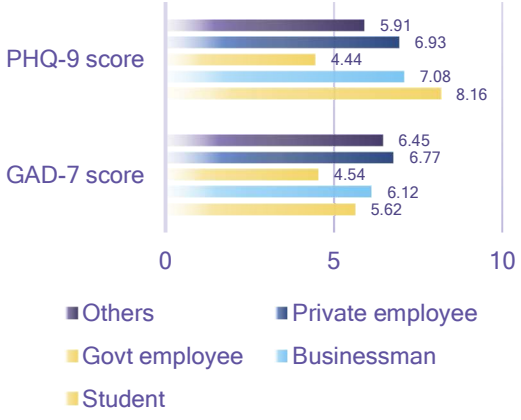
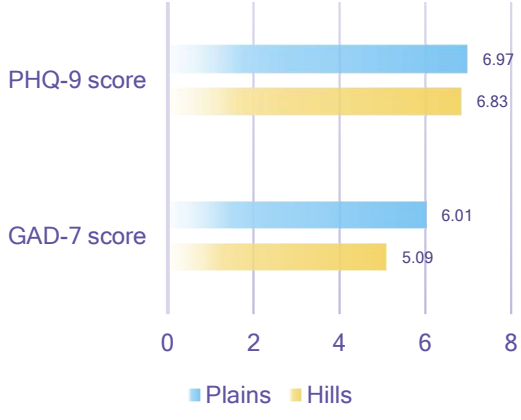


FIG. 4



DISCUSSION

Almost all countries adopted lockdown as a potentially effective strategy to fight against the COVID-19 pandemic. India was no exception, and in the shortest framework of time, i.e., within two weeks of the declaration of the pandemic by the WHO, a near-total lockdown was imposed by India on March 25th, 2020. This strategy effectively tackled its rapid spread, at least immediately. However, there was a huge impact on the social structure, economy, and mental well-being of the public. In this backdrop, the current study was planned to evaluate the public anxiety and depression levels, particularly among the rural areas of northern India, due to lockdowns during the COVID-19 outbreak.

The results of this study show a high incidence of depression among the young adults in the age group 19-24, and the depression score is highest for the adolescent age group of 10-19. This could possibly be because of confinement to homes, as the educational institutes and recreational facilities were largely shut for in-person attendance. Free movement and interaction with friends and classmates did not happen. The results of our study are consistent with a systematic review of COVID-19 leaving an impact on the mental health of adolescents held in 2021[13,14]. The study found that females were at a higher risk of developing mental health issues like anxiety and depression. The mean score of depression for the females was 7.97, compared to 6.38 for male participants, and the mean anxiety score for female participants was 6.90, compared to 5.13 for male participants. This suggests that females are at greater risk of developing anxiety and depression symptoms.

Females are also predisposed to mental health issues. Studies have found that there is a relationship between health anxiety and metacognitive beliefs about the uncontrollability of worry, which means that if an individual thinks that worry is uncontrollable, s/he is affected by health and social anxiety more considerably. Girls have meta worries than boys because metacognitive beliefs about the uncontrollability of worry are more prevalent in girls[15,16]. There are pieces of evidence for pervasive sex differences in pathological conditions, including anxiety and depressive disorders, where females are more than twice as likely to be afflicted. Gonadal hormones are found to be a major factor in this disparity, given that women are more likely to experience mood disturbances during times of hormonal flux, and testosterone may have protective benefits against mental health conditions like anxiety and depression[17].

Furthermore, females were taking care of family members, including the working members and school-going children, who otherwise would attend normal offices and schools, but are now confined to home due to travel prohibitions. This puts additional stress on the females who are otherwise vulnerable to mental health problems. Our study is in accordance with studies from Italy and China[18,19], which suggested younger people and females are at greater risk of developing mental health issues. While considering the occupation, the depression score was highest for the students. The closure of educational institutes and the switch over to online mode meant only a limited interaction among students. Also, limited access to gadgets and the lack of familiarity with the online mode of teaching put additional stress on the students, with a sizeable proportion unable to afford smart gadgets for online learning. The only mode of interaction was through mobile phones, on which parents frequently impose restrictions, especially in a relatively conservative rural society. A similar study conducted in Taiwan and China in 2020 found increased incidence of depression among students[20,21].

Followed by students were businessmen, whereas the government and private employees reported low prevalence of anxiety and depression. The lockdowns had a massive economic fallout, and some sectors, like logistics were badly affected, especially small businesses. Thus, it is quite expected that businessmen would have a higher incidence of anxiety and depression. Employees, particularly those working in the government sector, had more stable income, and this possibly accounts for the lesser risk of anxiety and depression in them. This study suggests that during the pandemic and subsequently imposed lockdowns, the population

in the working-age group, particularly those who are involved in some business or people who are exposed to stress-related lifestyles, which includes students & young adults facing the pressures related to career development, are more likely to have mental health problems. A global study conducted in the year 2020 to assess the impact of COVID-19 on mental health among the general population across 18 countries showed a high prevalence of mental health issues among females, young adults, students and people with low family support[22,23,24]. Due to the COVID-19 pandemic and subsequent lockdowns, there was a disruption of daily routines that had a great impact on mental health[25]. In this study, it was found that unmarried participants reported a high incidence of depression because they did not have a spouse to talk to and share his/ her feelings. Rapp and Stauder (2020) found similar results in their study[26,27].

Whereas when considering the role of the number of members in the family, it was seen that the anxiety and depression scores were similar in the groups with ≥4 members in the family and those with < 4 members in the family. This could be due to varying family structures in terms of age of family members, marital status of the members and possibly other more important factors like occupation, financial condition, etc.
Our study also revealed that people living in hilly areas had a low mean score of anxiety (5.09) and depression (6.83) when compared to the people living in plains, with a mean score of anxiety being 6.01 and depression being 6.97. The probable reason for such an observation could be the presence of congenial climatic conditions for better health and state of mind, and a closely knit local population in high altitude areas. Similar observation was made in a study done in Germany by Isolde Daig, Andreas Hinz et. al[28].

Some of the strengths of this study were that it included well-validated scales, which are commonly used for community surveys, such as GAD-7 and PHQ-9[29,30,31]. Apart from the actual survey format, there was a self-designed questionnaire that evaluated the anxiety of people when they could not get along with friends or take care of things at home due to the lockdown. Further, this study deals with the evaluation of the levels of anxiety and depression specifically among the rural population of a mountainous region in India, which no other study has yet evaluated. Since all the communication was done through mobile phones, the study had limitations in reaching a wider segment of the public. The methodology adopted could be exercised through a limited number of people possessing mobile phones, which covers a relatively smaller portion of the rural population.

CONCLUSION

This study reveals the impact of the pandemic and the mitigation strategies, particularly the lockdowns imposed to counter the spread of the disease, on the mental health of the rural population in a unique setting where comparisons could be made based on altitude as well. Young people, females, unmarried individuals, students and businessmen were more likely to have anxiety and depression due to the lockdowns. There is an urgent need to institute policy changes to cater to mental health challenges in the rural setup as well particularly in the backdrop of the pandemic and the subsequent mitigation strategies. This could help to prepare better for possible future pandemics.

Figure legends:

Fig 1 : Variation of PHQ-9 and GAD-7 scores with respect to age
Fig 2 : Variation of PHQ-9 and GAD-7 scores with respect to gender, marital status and family composition
Fig 3 : Variation of PHQ-9 and GAD-7 scores with respect to occupation
Fig 4 : Variation of PHQ-9 and GAD-7 scores with respect to topography

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Assessment of Knowledge and Practices of Operation Theatre Professionals Regarding Infection Control Protocols at PINS Hospital in Lahore.

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ABSTRACT

Background: Infections are the main reason for the high rates of patient mortality and morbidity in developing nations like Pakistan. Operating Theatres (OTs) are the main hospital areas where strict adherence to infection control protocols is required. Standard precautions, which are based on good practices, adequate knowledge, and healthy self-care practices, can lessen the impact of illnesses.
Objective: To assess the knowledge, attitude and practice of OT professionals regarding infection control protocols.
Methods: A cross-sectional study was conducted in PINS Hospital, Lahore. Ethical approval from the institutional review board committee was obtained. A well-structured questionnaire was used to gather data. 104 healthcare professionals, including OT technologists, nurses, anaesthesiologist, surgeons, house officers, OT managers and sweepers were chosen using a simple random sampling technique. Statistical value between variables was examined using the chi-square test. Data interpretation was done using SPSS version 27.
Results: knowledge, attitude and practice of 104 healthcare workers were assessed in the study. Out of 104 total participants, 5, 89 and 10 exhibited high, moderate and low awareness regarding infection control protocols, respectively. Regarding infection control protocols, 45 healthcare workers had a moderate practice rate, 10 had a high practice rate, and 49 had a poor practice rate. Conclusion: According to the study's findings, staff nurses and sweepers expressed a low level of infection control knowledge and practice, while surgeons expressed the highest.
Key words: knowledge, practices, infection control, neurological center, patient safety.

INTRODUCTION

Infection is the term used to describe the invasion and proliferation of germs within the body. The microbes could be bacteria, fungi, viruses, or other microorganisms. It can lead to infection and spread to any part of the body. One of the most significant issues facing healthcare facilities around the world is hospital-acquired infections. Among the exposed groups, it was the primary cause of both mortality and morbidity. Every individual, but especially healthcare workers, is susceptible to infection because they frequently come into contact with blood and body fluids [(1)]. Hospital-acquired infections currently affect about 1.4 million individuals globally, with the risk being 2–20 times higher in developing countries.

The World Health Organization estimates that 3 million people are exposed to blood-borne viruses annually, with 90% of all exposures occurring in underdeveloped countries. Blood-borne infections are a serious risk for healthcare workers in underdeveloped countries [2]. To avoid spreading germs from one patient to another, healthcare workers should wash their hands with soap and water, use an alcohol-based hand rub, and wear gloves before touching a patient. Gowns are used to prevent the transmission of microbes on healthcare personnel's attire. The patient's surroundings and medical equipment should be properly cleansed and disinfected in order to prevent transmission by indirect touch. By using a face mask or other suitable facial protection, healthcare professionals can lessen their exposure to infectious agents. Whether infection transmission can happen through airborne or droplet methods, such as using N95 respirators, masks, and eyeglasses, respectively [3].

Poor working environment, a lack of hand washing stations, a lack of personal protection equipment (PPEs), unsafe worker behaviors, and a lack of awareness regarding transmission are some of the challenges that healthcare professionals have observed. The training should emphasize the application of a number of common precautionary measures and enforce routine safe practices to protect HCWs. Consequently, methods to promote the use of standard precautions for infection prevention and control have been established [4]. Healthcare equipment and the contaminated hands of healthcare workers have been connected to HAIs. When healthcare workers fail to properly wash their hands after treating a patient, bacteria that can cause infection are transmitted from one patient to the next [5]. Activities include the creation of guidelines and standard protocols for operating rooms. Hand hygiene, use of personal protective equipment, proper use and disposal of sharps/needles, safe handling and disposal of clinical waste, spillages of blood, and body fluids, and the decontamination of equipment and surroundings are all necessary standard safety practices to control the spread of infection [6]. When it comes to worldwide concern morbidity, mortality, duration of hospital stays, and total direct and indirect expenditures, surgical site infections (SSIs) represent a significant clinical issue.

The knowledge, attitudes, and awareness of infection prevention and control strategies among surgeons vary widely [7]. Teaching and encouraging healthcare workers to follow standard operating precautions (SOPs), which are a set of infection prevention measures that apply to all patients regardless of infection status, is crucial to lowering occupational risks for HCWs [8]. In order to prevent nosocomial infections from spreading among hospitalized patients, strict adherence to infection prevention protocols is crucial and important. One of the primary goals of anesthetic practice should be the prevention of infections by limiting the spread of infection-causing organisms from patient to anesthetist or between patients [9]. Effective implementation of infection prevention strategies in healthcare facilities results in a notable reduction of more than 30.0% in infections linked to healthcare. Poor adherence to safety measures is caused by insufficient protective equipment and a dismissive work environment [10].

The World Health Organization states that one of the primary markers of HAIs is inadequate knowledge and practice. Knowledge is required to change practices, and good practices are a powerful catalyst for change [11]. Evidence regarding the degree of knowledge and behaviors among healthcare workers in the research area is currently lacking, despite the fact that safety is an essential part of delivering high-quality healthcare. Already available literature has focused on infection-related knowledge and practices of health care professionals in general, with no study targeted to the OT team. To date, no data has been published at PINS hospital, a central institution in the region for neurological care. This research was therefore conducted to assess healthcare professionals' safety-related knowledge and practice scores directly. Unlike previous studies, this research was conducted encompassing the whole OT team, rather than focusing on a single cadre.

OBJECTIVE

To assess the knowledge and practice of operating theatre professionals regarding infection control protocols.

LITERATURE REVIEW

A study was conducted at Indus Hospital, Korangi Campus and Sheikh Saeed Memory Campus. This study involved 33 healthcare providers. They gave them guidelines on hand hygiene practices according to the World Health Organization (WHO). 16.0% of them carefully followed the guidelines, but 83.0% did not follow the guidelines. Failure of hand hygiene practice was high in all age groups [12]. Another study was conducted in the Operation Theater of Teaching Hospital, Bharatpur. The results showed that only 36.7% of the medical staff met the requirements for surgical gowning and gloving. The two mistakes made in the research were not picking up the folded gown in its entirety from the wrapper (31.1%) and not holding the gown close to the neck so that it may contact with potentially contaminated things(18.9%) [13].

A parallel study was conducted at Gondar University referral hospital in northwest Ethiopia. This study covered 282 students of both genders. 176 Nurses, 31 Doctors, and 40 laboratorians working as health care workers. 126 of them took training regarding infection prevention and safety. 156 participants were vaccinated for HBV[14]. A study was conducted in 24 operating rooms of 11 hospitals in the city of Izmir, Turkey. The outcomes were recorded and contrasted against evidence-based recommendations [15]. Data indicated that the recommendation was not being followed. Hand/forearm antisepsis and the use of surgical gowns and drapes were the areas where the recommendation was followed the most. A similar study was conducted by a pre-test questionnaire using online-based techniques. Only 67 (47.5%) of respondents showed good practices against infection prevention, whereas half (49.6%) of anesthetists were deemed to be informed. 22.0% of participants stated that there was an adequate quantity of infection prevention materials. Knowledge of infection prevention was strongly correlated with in-service training. Working eight hours or less per day, having access to resources for infection control, and following infection control recommendations were all factors in the practice of infection prevention [16].

A study was conducted among HCWs in two tertiary care-level hospitals in Nigeria. A total of 290 HCWs (76.0% response rate) took part in the study, including 32 laboratory scientists, 147 nurses, and 111 physicians. Although the scores for knowledge and attitude about common precautions were above 90.0% overall, the median practice score was only 50.8%. The majority of workers complained of lacking resources to practice recommended measures and of having poor awareness about injection safety. Compared to doctors and nurses with more experience, house officers, laboratory scientists, and junior cadres of nurses demonstrated less understanding of and adherence to conventional precautions [17]. A similar study was conducted using two groups produced via a two-step group analysis. 54% and 46% of participants made groups 1 and 2, respectively. In comparison to group 2 respondents, group 1 subjects were younger, had greater educational levels, and held more senior positions. They cited good information, optimistic attitudes, and effective practices. Subjects in group 2 were distinguished by very little knowledge, a poor attitude, and behaviors. With the exception of attitudes towards selecting personal protective equipment ($p = 0.095$) and behaviors on the use of gowns and eye shields ($p = 0.759$), there were significant variations in practices for conventional and transmission-based precautions among groups. Staff members from group 2 had attitudes that were very significant but only moderately connected with practices ($P=0.05$) [18].

A similar study showed that after surgery vaginal swab was placed before the operation. The results showed that vaginal swab was present in 88 of the 291 patients that was transferred to the operating room. According to the policy, the theatre personnel are informed of the swab's presence by using one of three methods (verbally, in writing, or by transferring opened swab packs). In the post-intervention period, 56 women with vaginal packs in place were transported from the operating room to the high-dependency unit; 52 of these

women had stickers in place to serve as a continual reminder to staff of the vaginal pack's existence. Only one near miss has occurred in the 15 months since the interventions were put into place, compared to a baseline of four in two months (33.3% vs. 1.1%); its significance value was (P= 0.0001). Since the initiative was started, there have been no incidents involving retained swabs [19].

According to a study conducted in Pakistan, 78 nurses had strong awareness of IPC precautions, whereas 116 nurses had low understanding. Of the doctors, 76 lacked good knowledge, whereas 121 possessed it. Sweepers and other support personnel, 39 employees are well-versed in standard measures when handling infectious material, while 59 employees are not. Regarding IPC-related practices, 122 have safe practices and 70 have unsafe practices. When caring for patients, 61 doctors adhere to safe procedures while 135 engage in risky ones. Of the supporting workers, 44 adhered to safe infection control procedures, while 53 engaged in risky behaviour. Only 199 healthcare professionals have strong knowledge overall, whereas 332 have inadequate knowledge. While 244 healthcare professionals adhere to safe methods, 283 use unsafe practices in infection control [20].

This study was carried out in a tertiary care hospital in Lahore to assess nurses' knowledge levels. Of the 48 participants (36.9%) in this study, it was found that nurses had a low degree of aseptic technique understanding. At the same time, 41 nurses (31.5%) had a high degree of expertise, while 41 nurses (31.5%) had a moderate level of understanding. Despite the fact that many nurses had high or acceptable knowledge, this suggests that a significant portion still lacked enough understanding [21].

METHODOLOGY

Study design and setting

A Cross-sectional study was conducted in PINS Lahore.

Sampling Technique

A non-probability simple random sampling technique was used to collect the sample size. By using Cochran's formula and selecting a margin of error of 5% and a prevalence ratio of 0.07 sample size of 104 was calculated. After the approval of the chairman ethical review board committees, reference number 1920/IRB/PINS/Approval/2024, data was gathered from operating room staff members after they were informed of the study's purpose and asked to participate voluntarily. All participants had the right to withdraw at any stage of the study. To safeguard the privacy of the participants, no personal identifiers were noted. Data was gathered using ID numbers only. Health care personnel were given a well-structured questionnaire to complete, which was based on hospital-standard infection control procedures.

The study included nurses, anaesthesiologists, house officers, surgeons, sweepers, OT technologists, and managers. The study did not include healthcare workers who were on maternity or annual leave during the study period. Additionally, those medical professionals who declined to answer the questionnaire were not included in the study. The percentage of the total possible score was used to categorize the various levels of knowledge. Participants were categorized as having low knowledge if their overall score was less than 50%. Participants with scores above 75% were classified as having high knowledge, while those with scores between 50% and 75% were deemed to have moderate knowledge.

Data analysis

Data interpretation was done using SPSS version 29. For healthcare personnel with low, moderate, and high levels of knowledge, frequency and percentage were calculated. The significance level between the profession and knowledge and practices categories was examined using the chi-squared test. A P value was deemed significant if it was less than 0.05.

RESULTS

Table 1.1: Distribution Of Knowledge Level Among Health Care Workers

Knowledge	Frequency	Percentage
Low	10	9.6%
Moderate	89	85.6%
High	5	4.8%
Total	**104**	**100.0%**

Out of 104 healthcare personnel, the study found that 10 (9.6%) had low knowledge, 89 (85.6%) had intermediate knowledge, and 5 (4.8%) had high knowledge. (Table 1.1).

Table 1.2: Distribution Of Level of Practices Among Health Care Workers

Practice	Frequency	Percentage
Low	49	47.1%
Moderate	45	43.3%
High	10	9.6%
Total	**104**	**100.0%**

10 participants (9.6%) had a high degree of adherence to infection control standards, 45 participants (43.3%) had a moderate level, and 49 participants (47.1%) had a poor level. (Table 1.2).

Table 1.3: Knowledge Distribution of Health Care Professionals: Low, Moderate, and High

Professionals	Knowledge			Total	P value
	Low	Moderate	High		
Surgeon	1(4.3%)	21(91.3%)	1(4.3%)	23(100.0%)	**0.966**
Anesthesiologist	3(12.0%)	20(80.0%)	2(8.0%)	25(100.0%)	
OT Technologist	2(12.5%)	13(81.2%)	1(6.2%)	16(100.0%)	
OT manager	0(0.0%)	2(100.0%)	0(0.0%)	2(100.0%)	
Staff nurse	1(7.7%)	12(92.3%)	0(0.0%)	13(100.0%)	
HO	3(13.0%)	19(82.6%)	1(4.3%)	23(100.0%)	
Sweepers	0(0.0%)	2(100.0%)	0(0.0%)	2(100.0%)	
Total	**10(9.6%)**	**89(85.6%)**	**5(4.8%)**	**104(100.0%)**	

According to the study, just one surgeon had a high degree of expertise regarding infection prevention, while twenty-one had a moderate level and one had a low level. Two of the sixteen OT technologists had a low degree of knowledge, thirteen had a moderate level, and one had a higher level. (Table 1.3)

Table 1.4: Standard Practices Distribution of Health Care Professionals: Low, Moderate, and High

Professionals	Practice			Total	P value
	Low	Moderate	High		
Surgeon	9(39.1%)	11(47.8%)	3(13.0%)	23(100.0%)	
Anesthesiologist	13(52.0%)	9(36.0%)	3(12.0%)	25(100.0%)	
OT Technologist	6(37.5%)	8(50.0%)	2(12.5%)	16(100.0%)	
OT manager	2(100.0%)	0(0.0%)	0(0.0%)	2(100.0%)	
Staff nurse	7(53.8%)	6(46.2%)	0(0.0%)	13(100.0%)	
HOs	11(47.8%)	10(43.5%)	2(8.7%)	23(100.0%)	0.786
Sweepers	1(50.0%)	1(50.0%)	0(0.0%)	2(100.0%)	
Total	**49(47.1%)**	**45(43.3%)**	**10(9.6%)**	**104(100.0%)**	

Nine surgeons implemented standard measures against infection prevention during patient care at a low level, eleven at a moderate level, and three at a high level, according to the study. Six of the sixteen OT technologists had low levels of standard practice application in the operating room, eight had moderate levels, and two had higher levels. (Table 1.4)

DISCUSSION

Bacteria, viruses, fungi, and microbes are examples of pathogens that can infect and spread to any region of the body. Infection was one of the main issues that healthcare facilities around the world were dealing with. It was essential to make sure that experts have the requisite information regarding infection control procedures in the operating room. They must understand the significance of infection control and the possible dangers of using subpar procedures. Nevertheless, efficient measures to prevent infections also heavily depend on practices, not merely rely on information [22]. Training, experience, and the importance of infection control are some of the factors that can affect their attitudes. Assessing whether healthcare professionals are putting their knowledge and procedures into practice was crucial. Finding any weaknesses or difficulties in the way infection control procedures are being implemented can lead to better practices and, eventually, increased patient safety.

According to this study, 89 out of 104 medical professionals had a high percentage of moderate knowledge. Regarding standard practices, 49 healthcare professionals execute them to a low degree. Among healthcare workers, surgeons have the highest levels of infection control practice and knowledge. However, the knowledge and practices of infection control were lowest among staff nurses and sweepers. Knowledge and standard procedures do not statistically significantly correlate with the type of profession. A previous study was conducted [12] to assess the knowledge and practices of OT professionals regarding infection control protocols. The findings of this study, which involved 33 healthcare professionals who worked in operating rooms, showed that over 46 % of them lacked sufficient knowledge and practice of hand hygiene. The others are highly knowledgeable and skilled. The surgeons' extensive training and expertise were emulated by other medical professionals. Our findings were supported by another study that found no correlation between profession type and knowledge. These earlier findings were significant in relation to this one [23].

A study was conducted in 2021 that analyzed infection knowledge and practices among healthcare workers. The results showed that only 36.7% of the medical staff met the requirements for surgical gowning and gloving. The total 42 results revealed that high levels (31.1%) and low levels (18.9%) of knowledge and practice of gowning and gloving. This study is correlated with this study, that all health care workers in OT had moderate levels (47.8%) and low levels (12.5%) of gowning and gloving in the OT regarding infection control protocols [24]. The awareness and understanding of injection safety were ascertained by another related investigation. He mentioned the 290 healthcare workers who worked in the operating room. The total outcome of standard safety measures for injections and sharps was 50.7%. Furthermore, the study we conducted found that 84.6% of the 104 participants in the operating room are aware of the proper, prompt actions that should be taken in the event of a sharp injury and how to dispose of sharps after giving a patient medication [25]. According to a single-centre aligned study, sweepers don't know much about infection control and don't follow best practices when doing their jobs [26].

Lack of educational training, educational background, and updating programs are the reasons why nurses and sweepers have the lowest knowledge scores. Higher patient loads, a stressful work environment, and uncooperative patient and attendant behaviour are the reasons for lower practice scores. Lower practice scores might also be attributed to inaccurate equipment and poor staff communication. Knowledge by itself does not ensure behavioral change, and putting it into practice requires sufficient motivation, encouraging supervision, and a supportive atmosphere. Effective infection control in the operating room required a thorough strategy that included both knowledge and practices. It is possible to improve patient safety and overall healthcare results by emphasizing education, cultivating positive attitudes, and consistently assessing and refining methods [27].

CONCLUSION

According to the study's findings, surgeons had the highest levels of infection control knowledge and practice among healthcare professionals, followed by anesthesiologists and HOs. Staff nurses and sweepers had the lowest levels of infection control knowledge and practices. There was no significant association found among employment roles within the health care team and practices. In the same way, knowledge of infection control protocols and the occupational category of health care workers are not statistically significant.

RECOMENDATIONS

It is crucial to give operating room personnel ongoing education and training in order to solve these problems. Provide workers with monthly and quarterly training, establish standard operating room protocols for all employees, and put them into practice to raise the bar for operating protocols. This could help bridge any knowledge gaps and ensure proper implementation of infection control protocols. By taking health care workers' attitudes into account, this study can be further expanded. The study will be expanded by determining the years of experience of the employees and then examining their knowledge and practices.

LIMITATIONS

The single-centred study reflects non-negligible findings that cannot be applied to other contexts. Different types of Bias, like selection and reporting bias, are possible. Shorter study conduction time also reflects the presence of bias. The research sample was too small to adequately reflect the overall findings, especially the subgroups of health care workers.

CONFLICT OF INTEREST

There are no disclosed conflicts of interest for any of the writers.

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Scaling Laparoscopic Surgery in LMICs: Barriers, innovations and Policy Recommendations

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ABSTRACT

Background: Laparoscopic surgery has transformed surgical care by reducing morbidity, shortening hospital stays, and improving recovery. However, its adoption in low- and middle-income countries remains limited.

Objective: This article assesses the current landscape, challenges, and enablers of laparoscopic surgery in LMICs and provides policy and research recommendations for sustainable expansion.

Methods: A narrative review was conducted across PubMed, Embase, Google Scholar, and institutional/grey literature sources for English-language records between January 2013 and March 2024. Search terms included: ("laparoscopic surgery" OR "minimally invasive surgery" OR "MIS") AND ("low- and middle-income" OR "LMIC" OR "developing country") AND ("training" OR "cost" OR "barrier" OR "implementation"). Titles/abstracts and full texts were screened independently by two reviewers, with discrepancies resolved by consensus. A total of 78 articles met the inclusion criteria. Themes were synthesized using an iterative thematic analysis.

Results: Key barriers identified were limited infrastructure (reported in about 75% of included studies), inadequate training programs (62%), and high equipment costs (65%). Cultural resistance. Ongoing initiatives for locally manufactured or refurbished laparoscopic equipment are emerging in regions like Nigeria and India, helping to mitigate cost barriers. Cultural resistance and weak financing mechanisms were also noted. Promising enablers included low-cost laparoscopic kits, mobile simulation platforms, and NGO-supported programs. Evidence gaps persist in cost-effectiveness research, comparative evaluation of training models, and assessment of policy interventions.

Conclusion: Scaling up laparoscopic surgery in LMICs is an urgent priority. Targeted investments, supportive policies, and cultural engagement are essential to overcome barriers. Closing knowledge gaps and embedding laparoscopic techniques into national surgical plans will reduce disparities and strengthen surgical systems in resource-limited settings.

Keywords: Global Surgery, Healthcare Policy, Laparoscopic Surgery, Low and Middle-Income Countries (LMICs), Minimally Invasive Surgery (MIS), Surgical Training, Policy Implementation, Capacity Building.

INTRODUCTION

Laparoscopic surgery, also known as minimally invasive surgery (MIS), is a modern technique in which operations are performed through small incisions using a camera and specialized instruments. It has become the standard approach in high-income countries (HICs) for procedures such as cholecystectomy, appendectomy, and hysterectomy. Compared with traditional open surgery, laparoscopy offers clear benefits, including reduced postoperative pain, shorter hospital stays, quicker recovery, fewer surgical site infections (SSIs), and improved cosmetic outcomes. In HICs, more than 80% of common abdominal procedures are now performed laparoscopically. In contrast, in many low- and middle-income countries (LMICs, defined by the World Bank as nations with a gross national income per capita between $1,136 and $13,845), penetration rates remain below 20%, reflecting persistent disparities in surgical access and outcomes. Barriers include inadequate infrastructure, a shortage of trained personnel, financial constraints, and cultural resistance.

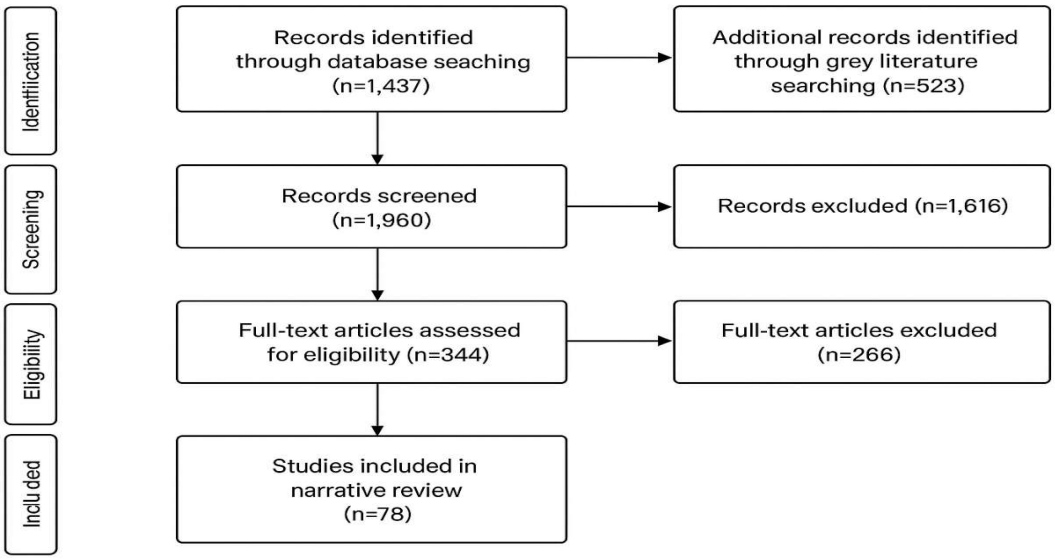
Despite these challenges, momentum is being built to expand laparoscopic services in LMICs, aligned with global commitments to equitable healthcare and the Sustainable Development Goals (SDGs), with recent global surgery reports (WHO 2022; Lancet Commission 2023) emphasizing minimally invasive surgery as a critical component of universal access to safe, affordable surgical care.

This review aims to assess the current landscape of laparoscopic surgery in LMICs, identify major barriers and enablers, and provide evidence-based recommendations for policy, training, and future research.

METHODOLOGY

A narrative review was conducted using a comprehensive search strategy across PubMed, Google Scholar, Embase, and institutional databases to identify relevant literature published between January 2013 and March 2024. Grey literature, including NGO and government reports, was also reviewed when full texts were available and met inclusion standards.

The search strategy combined Medical Subject Headings (MeSH) and keywords, including: ("laparoscopic surgery" OR "minimally invasive surgery" OR "MIS") AND ("LMIC" OR "low- and middle-income countries" OR "developing countries") AND ("surgical training" OR "health systems" OR "cost-effectiveness" OR "implementation"). Titles and abstracts were screened independently by two reviewers. Full texts of potentially eligible studies were assessed, with discrepancies resolved through discussion and consensus. A PRISMA-like flow diagram (Figure 1) illustrates the selection process. The final database search was conducted in March 2024, ensuring reproducibility and transparency.



Inclusion criteria:

- Peer-reviewed English-language publications
- Studies conducted in LMICs or directly comparing LMICs with HICs
- Publications addressing at least one of the following: training, cost, outcomes, barriers, or implementation strategies in laparoscopic surgery

Exclusion criteria:

- Conference abstracts without accessible full texts
- Studies focusing solely on robotic or open surgery without comparative analysis
- Opinion pieces or reports lacking original data or methodology

A total of 78 studies were included. Of these, approximately 40% originated from sub-Saharan Africa, 35% from Asia, and 25% from Latin America and the Caribbean. Study designs were diverse, including observational studies (45%), cost-effectiveness analyses (20%), training evaluations (15%), and mixed-methods or qualitative studies (20%).

Data were synthesized thematically under four domains: (1) implementation barriers, (2) cost analyses, (3) training models, and (4) health system integration. This approach enabled a structured, yet flexible narrative synthesis aligned with the study objectives.

CLINICAL AND ECONOMIC ADVANTAGES OF LAPAROSCOPIC SURGERY

Laparoscopic procedures are associated with significant patient benefits. These include decreased postoperative morbidity, fewer wound complications, and shortened hospitalizations, all contributing to cost savings for both patients and healthcare systems[1,3]. A study conducted across several African countries reported reduced hospital bed occupancy and improved surgical throughout following the introduction of laparoscopic cholecystectomy[4].

From a systems perspective, the economic efficiency of laparoscopic surgery derives not only from reduced hospital stays but also from quicker return-to-work timelines and decreased caregiver burden[2]. However, most LMICs lack comprehensive cost-effectiveness analyses tailored to their specific health systems, creating a significant gap in local evidence for policymakers.

BARRIERS TO EXPANSION IN DEVELOPING COUNTRIES

1 Infrastructure and Equipment: Laparoscopic surgery requires specialized equipment, including insufflators, laparoscopes, light sources, and electrosurgical devices. Many public hospitals in LMICs lack the infrastructure to support these tools due to frequent power outages, inadequate maintenance systems, and limited access to consumables such as CO_2[3]. In some sub-Saharan African countries, the cost of a standard laparoscopic tower (USD $50,000–$100,000) is equivalent to several times the GDP per capita, making procurement and upkeep prohibitive.

2 Training and Human Resources: A major barrier is the lack of adequately trained surgeons and support staff. Many LMICs lack structured, standardized training programs, resulting in low procedural volumes and poor skill retention[2]. Ghana's experience with overseas training and in-country workshops showed promise, but these initiatives are often donor-dependent and unsustainable without systemic integration[5].

3 Financial and Organizational Constraints: Healthcare financing in many LMICs is heavily reliant on out-of-pocket payments, which discourage patients from opting for laparoscopic procedures that are perceived as costlier than open surgeries.[4] Weak national insurance frameworks and inconsistent governmental support further undermine the scale-up of laparoscopic services. Additionally, decision-making is often centralized and resistant to change, which stifles innovation.[2] For instance, in Nigeria and Kenya, out-of-pocket

expenditure accounts for more than 60% of total health spending, making advanced surgical procedures inaccessible for the majority of patients.

4 Cultural and Institutional Resistance:

Ingrained surgical traditions, hierarchical training systems, and skepticism towards new techniques impede the adoption of laparoscopic surgery. Surgeons trained primarily in open techniques may be reluctant to adopt minimally invasive procedures due to concerns about safety, learning curves, and institutional inertia[5]. This reluctance is reinforced by the shortage of skilled mentors, with surgeon-to-population ratios as low as 0.5 per 100,000 in some LMICs, compared with 20–40 per 100,000 in HICs.

INNOVATIONS AND INTERVENTIONS SUPPORTING EXPANSION

Several innovative approaches are helping to mitigate these barriers. Low-cost laparoscopic devices such as the KeySuite have demonstrated safety and feasibility in resource-constrained settings.[3] Compared to traditional laparoscopic towers that cost between USD $50,000–$100,000, the KeySuite and similar portable kits can be acquired for less than USD $5,000, making them up to 90% more affordable while maintaining functionality. Mobile surgical simulation platforms and digital learning tools are also making training more accessible and scalable.[1]

Non-governmental organizations (NGOs) and international collaborations have successfully piloted laparoscopic services in countries like Haiti, Tanzania, and Ghana. In Tanzania, an NGO-supported program trained over 40 surgeons across five hospitals, resulting in a reported 60% increase in laparoscopic cholecystectomies within three years. In India, a partnership between local medical schools and international donors introduced low-cost simulation training, which reduced skill acquisition costs by nearly 70% compared with overseas fellowships. These examples demonstrate that while external support can catalyze progress, sustainable impact depends on integration into national surgical plans and long-term government commitment.[5]

POLICY AND HEALTH RECOMMENDATIONS

To achieve sustainable scale-up of laparoscopic surgery in LMICs, a multifaceted policy approach is required. Organizing recommendations according to the WHO Health System Building Blocks provides clarity and prioritization.

Service Delivery (Immediate win): Integrate laparoscopic procedures into national surgical plans and expand pilot projects in district and teaching hospitals where minimal infrastructure upgrades are needed.

Health Workforce (Immediate win): Embed laparoscopic skills into national surgical training curricula using low-cost simulation platforms and mentorship programs. Continuous professional development can be implemented rapidly and at low cost.

Health Financing (Long-term reform): Develop public–private partnerships and pooled procurement systems to reduce the cost of laparoscopic equipment. Strengthen national health insurance schemes to cover minimally invasive procedures and reduce out-of-pocket expenditure.

Health Governance & Regulation (Long-term reform): Establish standardized accreditation and quality assurance protocols to ensure patient safety, monitor outcomes, and maintain provider competence. National surgical societies should take leadership roles in this process.

Infrastructure and Technology (Long-term reform): Invest in reliable electricity supply, biomedical maintenance systems, and procurement of durable laparoscopic equipment. While costly, these reforms are essential for sustainable expansion.

Cultural and Behavioral Change (Immediate win): Engage surgical leaders and peer influencers to address resistance and encourage adoption of minimally invasive techniques through workshops, role modelling, and early-adopter advocacy.

Combining short-term interventions (training, pilot service delivery, cultural change) with long-term reforms (financing, governance, and infrastructure) allows LMICs to progressively and sustainably scale laparoscopic surgery.

Table 1: Summary of Barriers, Solutions, and Recommendations

Barrier	Solution/Innovation	Recommended Action	Evidence/Examples
Inadequate equipment	Low-cost laparoscopic tools (e.g., KeySuite)	Government procurement and pooled purchasing	KeySuite trial in Ghana showed safety and feasibility
Lack of structured training	Digital simulations, hybrid training models	Integrate MIS into national curricula; local mentorship	Mobile simulation platforms used in Tanzania and India
High out-of-pocket patient costs	Subsidies, insurance expansion, pooled financing	Strengthen national health financing schemes	In Nigeria, laparoscopic procedures remain mostly out-of-pocket
Cultural/institutional resistance	Peer mentorship, surgeon advocacy, leadership engagement	Launch behavioral change campaigns targeting surgical societies	Case study: peer-led adoption in Kenya improved uptake
Weak regulation/accreditation	National standards and credentialing frameworks	Develop and enforce quality assurance protocols	WHO Global Surgery guidelines recommend standardized accreditation

KNOWLEDGE GAPS AND FUTURE RESEARCH

Although interest in laparoscopic surgery in LMICs is growing, several critical gaps remain. Addressing them requires not only identifying missing evidence but also proposing rigorous, context-appropriate study designs.

Safety and Effectiveness Data: Current evidence is limited to small-scale studies with short-term follow-up. *Future priority:* multicenter prospective cohort studies and pragmatic randomized controlled trials (RCTs) in LMIC hospitals to evaluate long-term complication rates, reoperation needs, and patient-reported outcomes.

Cost-Effectiveness and Cost-Utility: Few studies comprehensively assess affordability and value. *Future priority:* economic evaluations using cost-utility analyses (e.g., quality-adjusted life years [QALYs] or disability-adjusted life years [DALYs]) tailored to LMIC-specific health budgets and procurement models.

Training Model Comparisons: Evidence on how different modalities affect skill retention is sparse. *Future priority:* cluster RCTs comparing simulation-only, hybrid (simulation + supervised surgery), and mobile training platforms, with follow-up testing at 6–12 months to assess skill decay and patient outcomes.

Policy Impact Evaluations: There is little empirical evidence on how surgical policies influence adoption. *Future priority:* mixed-methods evaluations combining interrupted time-series analyses of service uptake with qualitative interviews of policymakers, surgeons, and patients.

Cultural and Behavioral Barriers: Adoption is shaped by institutional norms and professional hierarchies. *Future priority:* ethnographic studies and organizational behavior research to understand resistance or enablers, complemented by implementation science trials testing behavior-change interventions (e.g., peer champion models, incentives).

CONCLUSION

Laparoscopic surgery offers a viable pathway to improving surgical care quality and efficiency in low- and middle-income countries. Overcoming current barriers will require targeted investments in infrastructure, workforce training, financing models, and policy reforms. At the same time, closing key knowledge gaps through rigorous, context-specific research will build the evidence needed for scale-up. Ministries of health, academic institutions, and non-governmental organizations should act collaboratively to integrate

laparoscopic surgery into national surgical plans, ensuring that its benefits reach patients equitably and sustainably.

ETHICS STATEMENT

This study is a narrative review and did not involve human or animal subjects. Ethics approval was not required.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest related to this work.

AUTHOR CONTRIBUTIONS

Oluwatobiloba O. Aweda conceptualized the study and led the writing process. Emmanuel A. Owolabi contributed to the literature review and drafting. Olorunwa B. Alalade participated in data synthesis and critical revisions. All authors reviewed and approved the final manuscript.

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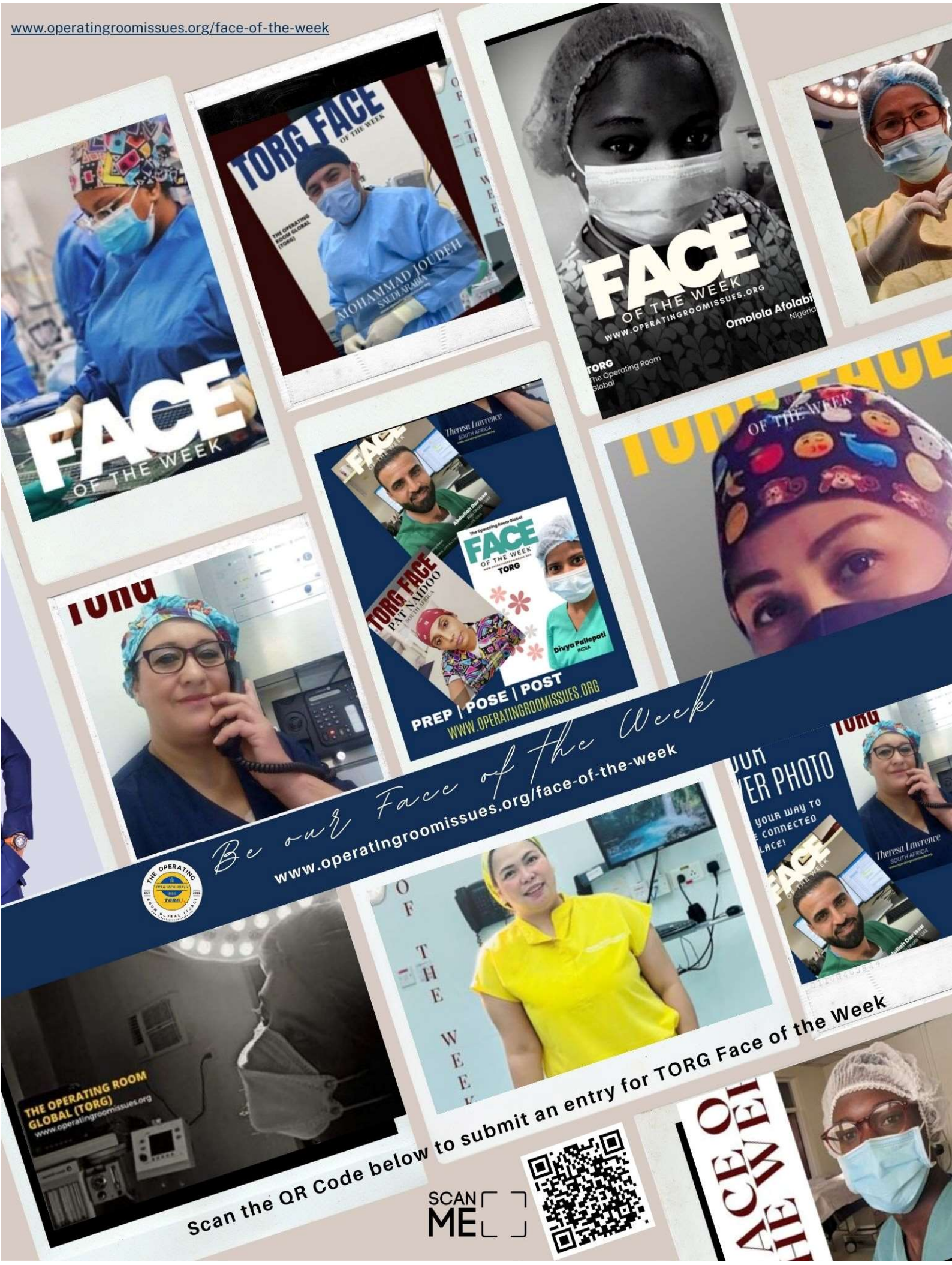

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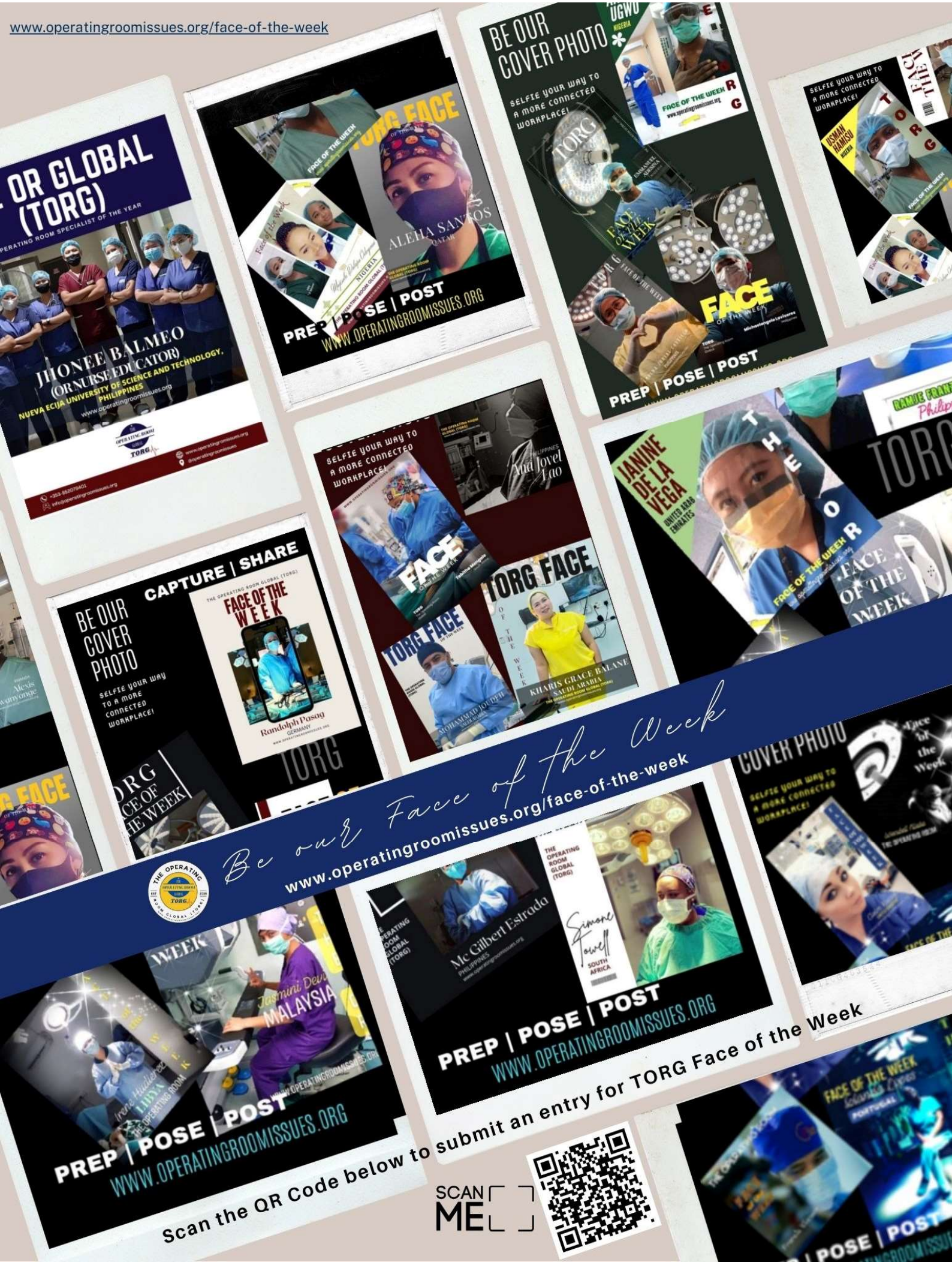

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